Agilent EasyEXPERT

Application Library Reference

Agilent Technologies

Notices

Manual Part Number

B1500-90050

Edition

Edition 1, August 2006

Agilent Technologies
1601 California Street
Palo Alto, CA 94304 USA

Warranty

The material contained in this document is provided "as is," and is subject to being changed, without notice, in future editions. Further, to the maximum extent permitted by applicable law, Agilent disclaims all warranties, either express or implied, with regard to this manual and any information contained herein, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. Agilent shall not be liable for errors or for incidental or consequential damages in connection with the furnishing, use, or performance of this document or of any information contained herein. Should Agilent and the user have a separate written agreement with warranty terms covering the material in this document that conflict with these terms, the warranty terms in the separate agreement shall control.

Technology Licenses

The hardware and/or software described in this document are furnished under a license and may be used or copied only in accordance with the terms of such license.

Restricted Rights Legend

If software is for use in the performance of a U.S. Government prime contract or subcontract, Software is delivered and licensed as "Commercial computer software" as defined in DFAR 252.227-7014 (June 1995), or as a "commercial item" as defined in FAR 2.101(a) or as "Restricted computer software" as defined in FAR 52.227-19 (June 1987) or any equivalent agency regulation or contract clause. Use, duplication or disclosure of Software is subject to Agilent Technologies' standard commercial license terms, and non-DOD Departments and Agencies of the U.S. Government will receive no greater than Restricted Rights as defined in FAR 52.227-19(c)(1-2) (June 1987). U.S. Government users will receive no greater than Limited Rights as defined in FAR 52.227-14 (June 1987) or DFAR 252.227-7015 (b)(2) (November 1995), as applicable in any technical data.

In This Document

Agilent EasyEXPERT software contains the application library which supports the characteristic measurements of CMOS devices, TFT, BJT, diode, resistor, capacitor, varactor, memory, nanotechnology devices such as CNT FET, and so on. The application library includes more than one hundred test definitions. And they are classified into the following categories.

This document consists of the chapters corresponding to the categories. And each chapter lists and describes all test definitions belonging to the category.

1. BJT
2. CMOS
3. Discrete
4. Memory
5. Mixed Signal
6. Nano Tech
7. Power Device
8. Reliability
9. Structure
10. TFT
11. Utility

NOTE

Application Library

The application library is a set of test definitions effective for the EasyEXPERT application test execution mode. The application test can be performed by selecting a test definition and setting the test condition for the actual DUT (device under test). And the setup can be saved as the dedicated test setup for the DUT.

All test definitions are just sample. If the samples damage your devices, Agilent Technologies is NOT LIABLE for the damage.

What is described in the reference sections

Reference section contains detailed description of test definitions. The test definitions are listed in alphabetical order. Each entry explains one test definition and provides the information following to the next terms. Some sections may not follow to some terms and may follow to the terms not in this table.

Term	Description
Description	Brief explanation of the test definition.
Device Under Test	DUT name. The number of terminals, the connection information, and the other information may be included.
Device Parameters	Lists the parameters changeable in the Device Parameters area of the EasyEXPERT Application Test screen.
Test Parameters	Lists the parameters changeable in the Test Parameters area of the EasyEXPERT Application Test screen.
Extended Test Parameters	Lists the parameters changeable in the dialog box opened by clicking the Extended Setup button.
Measurement Parameters	Lists the parameters measured by this test definition.
User Function and Analysis Function	Lists the parameters used for the user function or the analysis function.
X-Y Plot or X-Y Graph	Lists the parameters to be displayed in the X-Y Graph Plot area, List Display area, or Parameters area on the Data Display window.
List Display	
Parameters Display Area	
Auto Analysis	Lists the parameters used for the auto analysis function.
Test Output: X-Y Graph	Lists the parameters defined in the Test Output tab screen of the Test Definition window. The parameters will be displayed in the X-Y Graph Plot area, List Display area, or Parameters area on the Data Display window.
Test Output: List Display	
Test Output: Parameters	

Revision number

The test definitions are managed by using the revision number shown below.

Revision Number	Description
A.01.xx	Test definitions supported by EasyEXPERT A.01.xx and later.
A.01.20	Test definitions updated from A.01.xx or supported by EasyEXPERT A.02.00 and later.
A.02.00	This number is used by the Subsite move test definition only.

1 BJT

1. BC Diode Fwd: Base-Collector junction forward characteristics (A.01.20)
2. BC Diode Reverse: Base-Collector junction reverse characteristics (A.01.20)
3. BVcbo: Base-Collector junction breakdown voltage (A.01.20)
4. BVcei: Emitter-Collector breakdown voltage (A.01.20)
5. BVceo: Emitter-Collector breakdown voltage, opened base (A.01.20)
6. BVebo: Emitter-Base breakdown voltage (A.01.20)
7. CS Diode Fwd: Collector-Substrate junction forward characteristics (A.01.20)
8. CS Diode Reverse: Collector-Substrate junction reverse characteristics (A.01.20)
9. Ctc-Freq Log: Ctc-f characteristics (A.01.20)
10. Ctc-Vc: Ctc-Vcb characteristics (A.01.20)
11. Cte-Ve: Cte-Veb characteristics (A.01.20)
12. Cts: Cts-Vsc characteristics (A.01.20)
13. EB Diode Fwd: Emitter-Base junction forward characteristics (A.01.20)
14. EB Diode Rev: Emitter-Base junction reverse characteristics (A.01.20)
15. G-Plot ConstVce Pulse: Ic-Vb characteristics, Vce=const, SMU Pulse (A.01.11)
16. G-Plot ConstVce Pulse[3]: Ic-Vb characteristics, Vce=const, 3-terminal, SMU Pulse (A.01.11)
17. G-Plot ConstVce: Gummel characteristics, Vce=constant (A.01.20)
18. G-Plot ConstVce[3]: Gummel characteristics, Vce=constant, 3-terminal (A.01.20)
19. G-Plot Vbc=0V Pulse: Ic-Ve characteristics, Vbc=0, SMU Pulse (A.01.11)
20. G-Plot Vbc=0V Pulse[3]: Ic-Ve characteristics, Vbc=0, 3-terminal, SMU Pulse (A.01.11)
21. G-Plot Vbc=0V: Gummel characteristics, Vbc=0 (A.01.20)
22. G-Plot Vbc=0V[3]: Gummel characteristics, Vbc=0, 3-terminal (A.01.20)
23. hfe-Vbe ConstVce: hfe-Ic characteristics, Vce=constant (A.01.20)
24. hfe-Vbe Vbc=0V: hfe-Ic characteristics, Vbc=0 (A.01.20)
25. Ic-Vc Ib: Ic-Vc characteristics, Ib sweep (A.01.20)
26. Ic-Vc Ib[3]: Ic-Vc characteristics, 3-terminal, Ib sweep (A.01.20)
27. Ic-Vc Pulse Ib: Ic-Vc characteristics, Ib sweep, SMU Pulse (A.01.11)
28. Ic-Vc Pulse Ib[3]: Ic-Vc characteristics, 3-terminal, Ib sweep, SMU Pulse (A.01.11)
29. Ic-Vc Pulse Vb: Ic-Vc characteristics, Vb sweep, SMU Pulse (A.01.11)
30. Ic-Vc Pulse Vb[3]: Ic-Vc characteristics, 3-terminal, Vb sweep, SMU Pulse (A.01.11)
31. Ic-Vc Vb: Ic-Vc characteristics, Vb sweep (A.01.20)
32. Ic-Vc Vb[3]: Ic-Vc characteristics, 3-terminal, Vb sweep (A.01.20)
33. Rb: Base resistance (flyback method, 4-terminal) (A.01.20)
34. Re+Rc: Collector resistance (including Emitter resistance, flyback method, 4-terminal) (A.01.20)
35. Re: Emitter resistance (flyback method, 4-terminal) (A.01.20)
36. Simple Gummel Plot: Evaluation of Gummel characteristics (Vce=const) (A.01.10)
37. Vbe-Le: hfe,Vbe-Le characteristics (A.01.20)
38. Vbe-We: hfe,Vbe-Le characteristics (A.01.20)

1.1 BC Diode Fwd: Base-Collector junction forward characteristics (A.01.20)

[Description]
Measures the Base-Collector junction forward characteristics of BJT. Emitter and Substrate are opened.

[Device Under Test]
Bipolar transistor

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Lb: Base length
Wb: Base width
Temp: Temperature
Imax: Current compliance

[Test Parameters]
IntegTime: Integration time
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
Base: SMU connected to Base terminal, constant voltage output

[Extended Test Parameters]
Vb: Base voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current measurement
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase

[User Function]
IcPerArea=Icollector/Lb/Wb
IbPerArea=Ibase/Lb/Wb

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LOG)
Y2 axis: Collector current Icollector (LINEAR)
Y3 axis: Base current Ibase (LOG)
Y4 axis: Base current Ibase (LINEAR)

1.2 BC Diode Reverse: Base-Collector junction reverse characteristics (A.01.20)

[Description]
Measures the Base-Collector junction reverse characteristics of BJT. Emitter and Substrate are opened.

[Device Under Test]
Bipolar transistor

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Lb: Base length
Wb: Base width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
IcLimit: Collector current compliance
Base: SMU connected to Base terminal, constant voltage output

[Extended Test Parameters]
Vb: Base voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current measurement
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase

[User Function]
IcPerArea=Icollector/Lb/Wb
IbPerArea=Ibase/Lb/Wb

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LOG)
Y2 axis: Base current Ibase (LOG)

1.3 BVcbo: Base-Collector junction breakdown voltage (A.01.20)

[Description]
Measures the collector current vs collector voltage characteristics, and extracts the Base-Collector junction breakdown voltage (BVcbo). Emitter and Substrate are opened.

[Device Under Test]
Bipolar transistor

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Lb: Base length
Wb: Base width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Ic@BVcbo: Collector current to decide the breakdown
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
Base: SMU connected to Base terminal, constant voltage output

[Extended Test Parameters]
Vb: Base voltage
HoldTime: Hold time
DelayTime: Delay time
CollectorMinRng: Minimum range for the collector current measurement
BaseMinRng: Minimum range for the base current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase
For the all terminals, the SMU current compliance is set to Ic@BVcbo*1.1.

[User Function]
IcPerArea=Icollector/Lb/Wb
IbPerArea=Ibase/Lb/Wb

[Analysis Function]
BVcbo=@L1X (X interrupt of Line1)

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LOG)
Y2 axis: Base current Ibase (LOG)

[Parameters Display Area]
Base-Collector junction breakdown voltage BVcbo

[Auto Analysis]
Line1: Vertical line through Y1 data at Icollector=Ic@BVcbo

1.4 BVcei: Emitter-Collector breakdown voltage (A.01.20)

[Description]
Measures the collector current vs collector voltage characteristics, and extracts the Emitter-Collector junction breakdown voltage (BVcei). Substrate is opened.

[Device Under Test]
Bipolar transistor

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Ic@BVcei: Collector current to decide the breakdown
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
Base: SMU connected to Base terminal, constant current output
Ib: Base current
VbLimit: Base voltage compliance
Emitter: SMU connected to Emitter terminal, constant voltage output

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current Icollector
Emitter current Iemitter
Base voltage Vbase
For the all terminals, the SMU current compliance is set to Ic@BVcei*1.1.

[User Function]
IcPerArea=Icollector/Le/We
IePerArea=Iemitter/Le/We

[Analysis Function]
BVcei=@L1X (X interrupt of Line1)

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LOG)
Y2 axis: Emitter current Iemitter (LOG)

[Parameters Display Area]
Emitter-Collector junction breakdown voltage BVcei

[Auto Analysis]
Line1: Vertical line through Y1 data at Icollector=Ic@BVcei

1.5 BVceo: Emitter-Collector breakdown voltage, opened base (A.01.20)

[Description]
Measures the collector current vs collector voltage characteristics, and extracts the Emitter-Collector junction breakdown voltage (BVceo). Base and Substrate are opened.

[Device Under Test]
Bipolar transistor

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Ic@BVceo: Collector current to decide the breakdown
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
Emitter: SMU connected to Emitter terminal, constant voltage output

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current Icollector
Emitter current Iemitter
For the all terminals, the SMU current compliance is set to Ic@BVceo*1.1.

[User Function]
IcPerArea=Icollector/Le/We
IePerArea=Iemitter/Le/We

[Analysis Function]
BVceo=@L1X (X interrupt of Line1)

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LOG)
Y2 axis: Emitter current Iemitter (LOG)

[Parameters Display Area]
Emitter-Collector junction breakdown voltage BVceo

[Auto Analysis]
Line1: Vertical line through Y1 data at Icollector=Ic@BVceo

1.6 BVebo: Emitter-Base breakdown voltage (A.01.20)

[Description]
Measures the emitter current vs emitter voltage characteristics, and extracts the Emitter-Base junction breakdown voltage (BVebo). Collector and Substrate are opened.

[Device Under Test]
Bipolar transistor

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Ie@BVebo: Emitter current to decide the breakdown
Emitter: SMU connected to Emitter terminal, primary sweep voltage output
VeStart: Sweep start voltage for Emitter terminal
VeStop: Sweep stop voltage for Emitter terminal
VeStep: Sweep step voltage for Emitter terminal
Base: SMU connected to Base terminal, constant voltage output

[Extended Test Parameters]
Vb: Base voltage
HoldTime: Hold time
DelayTime: Delay time
EmitterMinRng: Minimum range for the emitter current measurement
BaseMinRng: Minimum range for the base current measurement

[Measurement Parameters]
Emitter current Iemitter
Base current Ibase
For the all terminals, the SMU current compliance is set to Ie@BVebo*1.1.

[User Function]
IePerArea=Iemitter/Le/We
IbPerArea=Ibase/Le/We

[Analysis Function]
BVebo=@L1X (X interrupt of Line1)

[X-Y Plot]
X axis: Emitter voltage Vemitter (LINEAR)
Y1 axis: Emitter current Iemitter (LOG)
Y2 axis: Base current Ibase (LOG)

[Parameters Display Area]
Emitter-Base junction breakdown voltage BVebo

[Auto Analysis]
Line1: Vertical line through Y1 data at Iemitter=Ie@BVebo

1.7 CS Diode Fwd: Collector-Substrate junction forward characteristics (A.01.20)

[Description]
Measures the Collector-Substrate junction forward characteristics of BJT. Base and Emitter are opened.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Lc: Collector length
Wc: Collector width
Temp: Temperature
Imax: Current compliance

[Test Parameters]
IntegTime: Integration time
Subs: SMU connected to Substrate, primary sweep voltage output
VsubsStart: Sweep start voltage for Substrate
VsubsStop: Sweep stop voltage for Substrate
VsubsStep: Sweep step voltage for Substrate
Collector: SMU connected to Collector terminal, constant voltage output

[Extended Test Parameters]
Vc: Collector voltage
HoldTime: Hold time
DelayTime: Delay time
CollectorMinRng: Minimum range for the collector current measurement
SubsMinRng: Minimum range for the substrate current measurement

[Measurement Parameters]
Substrate current Isubs
Collector current Icollector

[User Function]
IcPerArea=Icollector/Lc/Wc
IsubsPerArea=Isubs/Lc/Wc

[X-Y Plot]
X axis: Substrate voltage Vsubs (LINEAR)
Y1 axis: Substrate current Isubs (LINEAR)
Y2 axis: Substrate current Isubs (LOG)
Y3 axis: Collector current Icollector (LINEAR)
Y4 axis: Collector current Icollector (LOG)

1.8 CS Diode Reverse: Collector-Substrate junction reverse characteristics (A.01.20)

[Description]
Measures the Collector-Substrate junction reverse characteristics of BJT. Base and Emitter are opened.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Lc: Collector length
Wc: Collector width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Subs: SMU connected to Substrate, primary sweep voltage output
VsubsStart: Sweep start voltage for Substrate
VsubsStop: Sweep stop voltage for Substrate
VsubsStep: Sweep step voltage for Substrate
IsubsLimit: Substrate current compliance
Collector: SMU connected to Collector terminal, constant voltage output

[Extended Test Parameters]
Vc: Collector voltage
HoldTime: Hold time
DelayTime: Delay time
CollectorMinRng: Minimum range for the collector current measurement
SubsMinRng: Minimum range for the substrate current measurement

[Measurement Parameters]
Substrate current Isubs
Collector current Icollector

[User Function]
IcPerArea=Icollector/Lc/Wc
IsubsPerArea=Isubs/Lc/Wc

[X-Y Plot]
X axis: Substrate voltage Vsubs (LINEAR)
Y1 axis: Substrate current Isubs (LOG)
Y2 axis: Collector current Icollector (LOG)

1.9 Ctc-Freq Log: Ctc-f characteristics (A.01.20)

[Description]
Measures BJT's characteristics of base-to-collector capacitance (Ctc, linear) vs frequency (f, log). The measurement frequency is 10 points per decade.

[Device Under Test]
Bipolar transistor, 4 terminals
Connect CMU High and CMU Low to the collector terminal and base terminal respectively. For the emitter and substrate, connect GNDU.

[Required Modules and Accessories]
Agilent B1520A MFCMU 1 unit

[Device Parameters]
Polarity: NPN (CMU forces the specified value) or PNP (CMU forces the negative specified value)
Le: Emitter length
We: Emitter width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Base: CMU connected between Base and Collector
FreqStart: Sweep start frequency
NoOfDecade: Number of decades for data collection
OscLevel: Measurement signal level
Vcb: Collector-Base voltage, constant voltage output

[Extended Test Parameters]
G_Min: Minimum transconductance value for graph
G_Max: Maximum transconductance value for graph
Cp_Min: Minimum capacitance value for graph
Cp_Max: Maximum capacitance value for graph

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
Circular constant PI=3.141592653589
Frequency Frequency=Freq
Dissipation factor D=G/(2*PI*Freq*Cp)
Parallel resistance Rp=1/G
Series capacitance Cs=(1+D^2)*Cp
Reactance X=-1/(2*PI*Freq*Cs)
Series resistance Rs=D*abs(X)
Impedance Z=sqrt(Rs^2+X^2)
Phase Theta=atan(X/Rs)

[X-Y Plot]
X axis: Frequency Freq (LOG)
Y1 axis: Base-Collector capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[List Display]
Frequency Freq
Base-Collector capacitance (parallel capacitance) Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta
Collector voltage Vcollector

[Test Output: X-Y Graph]
X axis: Frequency FreqList (LOG)
Y1 axis: Base-Collector capacitance (parallel capacitance) CpList (LINEAR)
Y2 axis: Conductance GList (LINEAR)

[Test Output: List Display]
Frequency FreqList
Base-Collector capacitance (parallel capacitance) CpList
Conductance GList
Series capacitance CsList
Series resistance RsList
Parallel resistance RpList
Dissipation factor DList
Reactance XList
Impedance ZList
Phase ThetaList
Collector voltage VcList

1.10 Ctc-Vc: Ctc-Vcb characteristics (A.01.20)

[Description]
Measures the Base-Collector capacitance (Ctc), and plots the Ctc-Vcb characteristics.

[Device Under Test]
Bipolar transistor
Connect Base to the CMU Low, Collector to the CMU High, and the other terminals to the GNDU.

[Device Parameters]
Polarity: NPN (CMU forces the specified value) or PNP (CMU forces the negative specified value).
Le: Emitter length
We: Emitter width
Lb: Base length
Wb: Base width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
Base: CMU connected between Base and Collector (CV sweep measurement)
VcbStart: DC bias start voltage
VcbStop: DC bias stop voltage
VcbStep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
Vcb=Vcollector
CtcPerArea=Cp/Lb/Wb

[Analysis Function]
Cj0=@L1Y1 (Y interrupt of Line1)

[X-Y Graph]
X axis: Base-Collector voltage Vcb (LINEAR)
Y1 axis: Base-Collector capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[List Display]
Base-Collector voltage Vcb
Base-Collector capacitance (parallel capacitance) Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta

[Parameter Display Area]
Zero bias capacitance Cj0

[Auto Analysis]
Line1: Horizontal line through Y1 data at Vcb=0

1.11 Cte-Ve: Cte-Veb characteristics (A.01.20)

[Description]
Measures the Base-Emitter capacitance (Cte), and plots the Cte-Veb characteristics.

[Device Under Test]
Bipolar transistor
Connect Base to the CMU Low, Emitter to the CMU High, and the other terminals to the GNDU.

[Device Parameters]
Polarity: NPN (CMU forces the specified value) or PNP (CMU forces the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature

[Test Parameters]
HoldTime: Hold time
DelayTime: Delay time
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
Base: CMU connected between Base and Emitter (CV sweep measurement)
VebStart: DC bias start voltage
VebStop: DC bias stop voltage
VebStep: DC bias step voltage

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
Veb=Vemitter
CtePerArea=Cp/Le/We

[Analysis Function]
Cj0=@L1Y1 (Y interrupt of Line1)

[X-Y Graph]
X axis: Base-Emitter voltage Veb (LINEAR)
Y1 axis: Base-Emitter capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[List Display]
Base-Emitter voltage Veb
Base-Emitter capacitance (parallel capacitance) Cp
Conductance G

Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta

[Parameter Display Area]
Zero bias capacitance Cj0

[Auto Analysis]
Line1: Horizontal line through Y1 data at Veb=0

1.12 Cts: Cts-Vsc characteristics (A.01.20)

[Description]
Measures the Collector-Substrate capacitance (Cts), and plots the Cts-Vsc characteristics.

[Device Under Test]
Bipolar transistor
Connect Collector to the CMU Low, Substrate to the CMU High, and the other terminals to the GNDU.

[Device Parameters]
Polarity: NPN (CMU forces the specified value) or PNP (CMU forces the negative specified value).
Le: Emitter length
We: Emitter width
Lc: Collector length
Wc: Collector width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
Subs: CMU connected between Collector and Substrate (CV sweep measurement)
VscStart: DC bias start voltage
VscStop: DC bias stop voltage
VscStep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
Vsc=Vsubs
CtsPerArea=Cp/Lc/Wc

[Analysis Function]
Cj0=@L1Y1 (Y interrupt of Line1)

[X-Y Graph]
X axis: Collector-Substrate voltage Vsc (LINEAR)
Y1 axis: Collector-Substrate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[List Display]
Collector-Substrate voltage Vsc
Collector-Substrate capacitance (parallel capacitance) Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta

[Parameter Display Area]
Zero bias capacitance Cj0

[Auto Analysis]
Line1: Horizontal line through Y1 data at Vsub(=Vsc)=0

1.13 EB Diode Fwd: Emitter-Base junction forward characteristics (A.01.20)

[Description]
Measures the Emitter-Base junction forward characteristics of BJT. Collector and Substrate are opened.

[Device Under Test]
Bipolar transistor

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
Imax: Current compliance

[Test Parameters]
IntegTime: Integration time
Emitter: SMU connected to Emitter terminal, primary sweep voltage output
VeStart: Sweep start voltage for Emitter terminal
VeStop: Sweep stop voltage for Emitter terminal
VeStep: Sweep step voltage for Emitter terminal
Base: SMU connected to Base terminal, constant voltage output

[Extended Test Parameters]
Vb: Base voltage
HoldTime: Hold time
DelayTime: Delay time
EmitterMinRng: Minimum range for the emitter current measurement
BaseMinRng: Minimum range for the base current measurement

[Measurement Parameters]
Emitter current Iemitter
Base current Ibase

[User Function]
IePerArea=Iemitter/Le/We
IbPerArea=Ibase/Le/We

[X-Y Plot]
X axis: Emitter voltage Vemitter (LINEAR)
Y1 axis: Emitter current Iemitter (LINEAR)
Y2 axis: Emitter current Iemitter (LOG)
Y3 axis: Base current Ibase (LINEAR)
Y4 axis: Base current Ibase (LOG)

1.14 EB Diode Rev: Emitter-Base junction reverse characteristics (A.01.20)

[Description]
Measures the Emitter-Base junction reverse characteristics of BJT. Collector and Substrate are opened.

[Device Under Test]
Bipolar transistor

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Emitter: SMU connected to Emitter terminal, primary sweep voltage output
VeStart: Sweep start voltage for Emitter terminal
VeStop: Sweep stop voltage for Emitter terminal
VeStep: Sweep step voltage for Emitter terminal
IeLimit: Emitter current compliance
Base: SMU connected to Base terminal, constant voltage output

[Extended Test Parameters]
Vb: Base voltage
HoldTime: Hold time
DelayTime: Delay time
EmitterMinRng: Minimum range for the emitter current measurement
BaseMinRng: Minimum range for the base current measurement

[Measurement Parameters]
Emitter current Iemitter
Base current Ibase

[User Function]
IePerArea=Iemitter/Le/We
IbPerArea=Ibase/Le/We

[X-Y Plot]
X axis: Emitter voltage Vemitter (LINEAR)
Y1 axis: Emitter current Iemitter (LOG)
Y2 axis: Base current Ibase (LOG)

1.15 G-Plot ConstVce Pulse: Ic-Vb characteristics, Vce=const, SMU Pulse (A.01.11)

[Description]
Measures the collector current vs base voltage characteristics. The SMU pulse is used for the Collector voltage output.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
Base: SMU connected to Base terminal, primary sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Collector: SMU connected to Collector terminal, constant voltage output
Vc: Collector voltage
PulsePeriod: Pulse period
PulseWidth: Pulse width
BaseValue: Pulse base value
Emitter: SMU connected to Emitter terminal, constant voltage output
Subs: SMU connected to Substrate terminal, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Collector current Icollector

[User Function]
IcPerArea=Icollector/Le/We

[X-Y Plot]
X axis: Base voltage Vbase (LINEAR)
Y1 axis: Collector current Icollector (LINEAR)

1.16 G-Plot ConstVce Pulse[3]: Ic-Vb characteristics, Vce=const, 3-terminal, SMU Pulse (A.01.11)

[Description]
Measures the collector current vs base voltage characteristics. The SMU pulse is used for the Collector voltage output.

[Device Under Test]
Bipolar transistor, 3 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
Base: SMU connected to Base terminal, primary sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Collector: SMU connected to Collector terminal, constant voltage output
Vc: Collector voltage
PulsePeriod: Pulse period
PulseWidth: Pulse width
BaseValue: Pulse base value
Emitter: SMU connected to Emitter terminal, constant voltage output

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Collector current Icollector

[User Function]
IcPerArea=Icollector/Le/We

[X-Y Plot]
X axis: Base voltage Vbase (LINEAR)
Y1 axis: Collector current Icollector (LINEAR)

1.17 G-Plot ConstVce: Gummel characteristics, Vce=constant (A.01.20)

[Description]
Measures the collector current vs base voltage characteristics and the base current vs base voltage characteristics, extracts the current amplification factor hfe, and plots the gummel characteristics.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
Base: SMU connected to Base terminal, primary sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Collector: SMU connected to Collector terminal, constant voltage output
Vc: Collector voltage
Emitter: SMU connected to Emitter terminal, constant voltage output
Subs: SMU connected to Substrate terminal, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current measurement
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase

[User Function]
IbPerArea=Ibase/Le/We
IcPerArea=Icollector/Le/We
hfe=Icollector/Ibase
hfeMax=max(hfe)

[X-Y Plot]
X axis: Base voltage Vbase (LINEAR)
Y1 axis: Base current Ibase (LOG)
Y2 axis: Collector current Icollector (LOG)
Y3 axis: Current amplification factor hfe (LINEAR)

[Parameters Display Area]
Current amplification factor maximum value hfeMax

1.18 G-Plot ConstVce[3]: Gummel characteristics, Vce=constant, 3-terminal (A.01.20)

[Description]
Measures the collector current vs base voltage characteristics and the base current vs base voltage characteristics, extracts the current amplification factor hfe, and plots the gummel characteristics.

[Device Under Test]
Bipolar transistor, 3 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
Base: SMU connected to Base terminal, primary sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Collector: SMU connected to Collector terminal, constant voltage output
Vc: Collector voltage
Emitter: SMU connected to Emitter terminal, constant voltage output

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current measurement
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase

[User Function]
IbPerArea=Ibase/Le/We
IcPerArea=Icollector/Le/We
hfe=Icollector/Ibase
hfeMax=max(hfe)

[X-Y Plot]
X axis: Base voltage Vbase (LINEAR)
Y1 axis: Base current Ibase (LOG)
Y2 axis: Collector current Icollector (LOG)
Y3 axis: Current amplification factor hfe (LINEAR)

[Parameters Display Area]
Current amplification factor maximum value hfeMax

1.19 G-Plot Vbc=0V Pulse: Ic-Ve characteristics, Vbc=0, SMU Pulse (A.01.11)

[Description]
Measures the collector current vs emitter voltage characteristics. The SMU pulse is used for the Emitter voltage output.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
Base: SMU connected to Base terminal, constant voltage output
Collector: SMU connected to Collector terminal, constant voltage output
Emitter: SMU connected to Emitter terminal, primary sweep voltage output
VeStart: Sweep start voltage for Emitter terminal
VeStop: Sweep stop voltage for Emitter terminal
VeStep: Sweep step voltage for Emitter terminal
PulsePeriod: Pulse period
PulseWidth: Pulse width
Subs: SMU connected to Substrate terminal, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
BaseValue: Pulse base value
Vb: Base voltage
Vc: Collector voltage
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Collector current Icollector

[User Function]
IcPerArea=Icollector/Le/We

[X-Y Plot]
X axis: Emitter voltage Vemitter (LINEAR)
Y1 axis: Collector current Icollector (LINEAR)

1.20 G-Plot Vbc=0V Pulse[3]: Ic-Ve characteristics, Vbc=0, 3-terminal, SMU Pulse (A.01.11)

[Description]
Measures the collector current vs emitter voltage characteristics. The SMU pulse is used for the Emitter voltage output.

[Device Under Test]
Bipolar transistor, 3 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
Base: SMU connected to Base terminal, constant voltage output
Collector: SMU connected to Collector terminal, constant voltage output
Emitter: SMU connected to Emitter terminal, primary sweep voltage output
VeStart: Sweep start voltage for Emitter terminal
VeStop: Sweep stop voltage for Emitter terminal
VeStep: Sweep step voltage for Emitter terminal
PulsePeriod: Pulse period
PulseWidth: Pulse width

[Extended Test Parameters]
BaseValue: Pulse base value
Vb: Base voltage
Vc: Collector voltage
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Collector current Icollector

[User Function]
IcPerArea=Icollector/Le/We

[X-Y Plot]
X axis: Emitter voltage Vemitter (LINEAR)
Y1 axis: Collector current Icollector (LINEAR)

1.21 G-Plot Vbc=0V: Gummel characteristics, Vbc=0 (A.01.20)

[Description]
Measures the collector current vs emitter voltage characteristics and the base current vs emitter voltage characteristics, extracts the current amplification factor hfe, and plots the gummel characteristics.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
Base: SMU connected to Base terminal, constant voltage output
Collector: SMU connected to Collector terminal, constant voltage output
Emitter: SMU connected to Emitter terminal, primary sweep voltage output
VeStart: Sweep start voltage for Emitter terminal
VeStop: Sweep stop voltage for Emitter terminal
VeStep: Sweep step voltage for Emitter terminal
Subs: SMU connected to Substrate terminal, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Vb: Base voltage
Vc: Collector voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current measurement
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase

[User Function]
IbPerArea=Ibase/Le/We
IcPerArea=Icollector/Le/We
hfe=Icollector/Ibase
hfeMax=max(hfe)

[X-Y Plot]
X axis: Emitter voltage Vemitter (LINEAR)
Y1 axis: Base current Ibase (LOG)
Y2 axis: Collector current Icollector (LOG)
Y3 axis: Current amplification factor hfe (LINEAR)

[Parameters Display Area]
Current amplification factor maximum value hfeMax

1.22 G-Plot Vbc=0V[3]: Gummel characteristics, Vbc=0, 3-terminal (A.01.20)

[Description]
Measures the collector current vs emitter voltage characteristics and the base current vs emitter voltage characteristics, extracts the current amplification factor hfe, and plots the gummel characteristics.

[Device Under Test]
Bipolar transistor, 3 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
Base: SMU connected to Base terminal, constant voltage output
Collector: SMU connected to Collector terminal, constant voltage output
Emitter: SMU connected to Emitter terminal, primary sweep voltage output
VeStart: Sweep start voltage for Emitter terminal
VeStop: Sweep stop voltage for Emitter terminal
VeStep: Sweep step voltage for Emitter terminal

[Extended Test Parameters]
Vb: Base voltage
Vc: Collector voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current measurement
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase
Emitter current Iemitter

[User Function]
IbPerArea=Ibase/Le/We
IcPerArea=Icollector/Le/We
hfe=Icollector/Ibase
hfeMax=max(hfe)

[X-Y Plot]
X axis: Emitter voltage Vemitter (LINEAR)
Y1 axis: Base current Ibase (LOG)
Y2 axis: Collector current Icollector (LOG)
Y3 axis: Current amplification factor hfe (LINEAR)

[Parameters Display Area]
Current amplification factor maximum value hfeMax

1.23 hfe-Vbe ConstVce: hfe-Ic characteristics, Vce=constant (A.01.20)

[Description]
Measures the collector current vs base voltage characteristics and the base current vs base voltage characteristics, extracts the current amplification factor hfe, and plots the hfe-Ic characteristics.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
Base: SMU connected to Base terminal, primary sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Collector: SMU connected to Collector terminal, constant voltage output
Vc: Collector voltage
Emitter: SMU connected to Emitter terminal, constant voltage output
Subs: SMU connected to Substrate terminal, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current measurement
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase

[User Function]
IbPerArea=Ibase/Le/We
IcPerArea=Icollector/Le/We
hfe=Icollector/Ibase
hfeMax=max(hfe)

[Analysis Function]
Ic@hfeMax=@L1X (X intercept of Line1)

[X-Y Plot]
X axis: Collector current Icollector (LOG)
Y1 axis: Current amplification factor hfe (LINEAR)

[Parameters Display Area]

Current amplification factor maximum value hfeMax
Collector current at hfeMax Ic@hfeMax

[Auto Analysis]
Line1: Vertical line through Y1 data at hfe=hfeMax

1.24 hfe-Vbe Vbc=0V: hfe-Ic characteristics, Vbc=0 (A.01.20)

[Description]
Measures the collector current vs emitter voltage characteristics and the base current vs emitter voltage characteristics, extracts the current amplification factor hfe, and plots the hfe-Ic characteristics.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
Base: SMU connected to Base terminal, constant voltage output
Collector: SMU connected to Collector terminal, constant voltage output
Emitter: SMU connected to Emitter terminal, primary sweep voltage output
VeStart: Sweep start voltage for Emitter terminal
VeStop: Sweep stop voltage for Emitter terminal
VeStep: Sweep step voltage for Emitter terminal
Subs: SMU connected to Substrate terminal, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Vb: Base voltage
Vc: Collector voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current measurement
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase

[User Function]
IbPerArea=Ibase/Le/We
IcPerArea=Icollector/Le/We
hfe=Icollector/Ibase
hfeMax=max(hfe)

[Analysis Function]
Ic@hfeMax=@L1X (X intercept of Line1)

[X-Y Plot]
X axis: Collector current Icollector (LOG)
Y1 axis: Current amplification factor hfe (LINEAR)

[Parameters Display Area]

Current amplification factor maximum value hfeMax
Collector current at hfeMax Ic@hfeMax

[Auto Analysis]
Line1: Vertical line through Y1 data at hfe=hfeMax

1.25 Ic-Vc Ib: Ic-Vc characteristics, Ib sweep (A.01.20)

[Description]
Measures the collector current vs collector voltage characteristics.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
Base: SMU connected to Base terminal, secondary sweep voltage output
IbStart: Sweep start current for Base terminal
IbStop: Sweep stop current for Base terminal
IbStep: Sweep step current for Base terminal
Emitter: SMU connected to Emitter terminal, constant voltage output
Subs: SMU connected to Substrate terminal, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Ve: Emitter voltage
VbLimit: Base voltage compliance
HoldTime: Hold time
DelayTime: Delay time
CollectorMinRng: Minimum range for the collector current measurement
SubsMinRng: Minimum range for the substrate current measurement

[Measurement Parameters]
Collector current Icollector
Base voltage Vbase
Substrate current Isubs

[User Function]
IbPerArea=Ibase/Le/We
IcPerArea=Icollector/Le/We
hfe=Icollector/Ibase
VA=Icollector*diff(Vcollector,Icollector)-Vcollector

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LINEAR)

1.26 Ic-Vc Ib[3]: Ic-Vc characteristics, 3-terminal, Ib sweep (A.01.20)

[Description]
Measures the collector current vs collector voltage characteristics.

[Device Under Test]
Bipolar transistor, 3 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
Base: SMU connected to Base terminal, secondary sweep voltage output
IbStart: Sweep start current for Base terminal
IbStop: Sweep stop current for Base terminal
IbStep: Sweep step current for Base terminal
Emitter: SMU connected to Emitter terminal, constant voltage output

[Extended Test Parameters]
Ve: Emitter voltage
VbLimit: Base voltage compliance
HoldTime: Hold time
DelayTime: Delay time
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current Icollector
Base voltage Vbase

[User Function]
IbPerArea=Ibase/Le/We
IcPerArea=Icollector/Le/We
hfe=Icollector/Ibase
VA=Icollector*diff(Vcollector,Icollector)-Vcollector

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LINEAR)

1.27 Ic-Vc Pulse Ib: Ic-Vc characteristics, Ib sweep, SMU Pulse (A.01.11)

[Description]
Measures the collector current vs collector voltage characteristics. The SMU pulse is used for the collector voltage output.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
PulsePeriod: Pulse period
PulseWidth: Pulse width
Base: SMU connected to Base terminal, secondary sweep voltage output
IbStart: Sweep start current for Base terminal
IbStop: Sweep stop current for Base terminal
IbStep: Sweep step current for Base terminal
Emitter: SMU connected to Emitter terminal, constant voltage output
Subs: SMU connected to Substrate terminal, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Ve: Emitter voltage
BaseValue: Pulse base value
VbLimit: Base voltage compliance
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Collector current Icollector

[User Function]
IcPerArea=Icollector/Le/We
VA=Icollector*diff(Vcollector,Icollector)-Vcollector

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LINEAR)

1.28 Ic-Vc Pulse Ib[3]: Ic-Vc characteristics, 3-terminal, Ib sweep, SMU Pulse (A.01.11)

[Description]
Measures the collector current vs collector voltage characteristics. The SMU pulse is used for the collector voltage output.

[Device Under Test]
Bipolar transistor, 3 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
PulsePeriod: Pulse period
PulseWidth: Pulse width
Base: SMU connected to Base terminal, secondary sweep voltage output
IbStart: Sweep start current for Base terminal
IbStop: Sweep stop current for Base terminal
IbStep: Sweep step current for Base terminal
Emitter: SMU connected to Emitter terminal, constant voltage output

[Extended Test Parameters]
Ve: Emitter voltage
BaseValue: Pulse base value
VbLimit: Base voltage compliance
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Collector current Icollector

[User Function]
IcPerArea=Icollector/Le/We
VA=Icollector*diff(Vcollector,Icollector)-Vcollector

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LINEAR)

1.29 Ic-Vc Pulse Vb: Ic-Vc characteristics, Vb sweep, SMU Pulse (A.01.11)

[Description]
Measures the collector current vs collector voltage characteristics. The SMU pulse is used for the collector voltage output.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
PulsePeriod: Pulse period
PulseWidth: Pulse width
Base: SMU connected to Base terminal, secondary sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Emitter: SMU connected to Emitter terminal, constant voltage output
Subs: SMU connected to Substrate terminal, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Ve: Emitter voltage
BaseValue: Pulse base value
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Collector current Icollector

[User Function]
IcPerArea=Icollector/Le/We
VA=Icollector*diff(Vcollector,Icollector)-Vcollector

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LINEAR)

1.30 Ic-Vc Pulse Vb[3]: Ic-Vc characteristics, 3-terminal, Vb sweep, SMU Pulse (A.01.11)

[Description]
Measures the collector current vs collector voltage characteristics. The SMU pulse is used for the collector voltage output.

[Device Under Test]
Bipolar transistor, 3 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
PulsePeriod: Pulse period
PulseWidth: Pulse width
Base: SMU connected to Base terminal, secondary sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Emitter: SMU connected to Emitter terminal, constant voltage output

[Extended Test Parameters]
Ve: Emitter voltage
BaseValue: Pulse base value
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Collector current Icollector

[User Function]
IcPerArea=Icollector/Le/We
VA=Icollector*diff(Vcollector,Icollector)-Vcollector

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LINEAR)

1.31 Ic-Vc Vb: Ic-Vc characteristics, Vb sweep (A.01.20)

[Description]
Measures the collector current vs collector voltage characteristics.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
Base: SMU connected to Base terminal, secondary sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Emitter: SMU connected to Emitter terminal, constant voltage output
Subs: SMU connected to Substrate terminal, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
CollectorMinRng: Minimum range for the collector current measurement
BaseMinRng: Minimum range for the base current measurement
SubsMinRng: Minimum range for the substrate current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase

[User Function]
IbPerArea=Ibase/Le/We
IcPerArea=Icollector/Le/We
hfe=Icollector/Ibase
VA=Icollector*diff(Vcollector,Icollector)-Vcollector

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LINEAR)

1.32 Ic-Vc Vb[3]: Ic-Vc characteristics, 3-terminal, Vb sweep (A.01.20)

[Description]
Measures the collector current vs collector voltage characteristics.

[Device Under Test]
Bipolar transistor, 3 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
Base: SMU connected to Base terminal, secondary sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Emitter: SMU connected to Emitter terminal, constant voltage output

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
CollectorMinRng: Minimum range for the collector current measurement
BaseMinRng: Minimum range for the base current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase

[User Function]
IbPerArea=Ibase/Le/We
IcPerArea=Icollector/Le/We
hfe=Icollector/Ibase
VA=Icollector*diff(Vcollector,Icollector)-Vcollector

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LINEAR)

1.33 Rb: Base resistance (flyback method, 4-terminal) (A.01.20)

[Description]
Measures the base voltage, collector voltage vs base current characteristics, and extracts the Base resistance in the high current region. Uses the flyback method.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Base: SMU connected to Base terminal, primary sweep current output
IbStart: Sweep start current for Base terminal
IbStop: Sweep stop current for Base terminal
IbStep: Sweep step current for Base terminal
VbLimit: Base voltage compliance
Collector: SMU connected to Collector terminal, constant current output
VcLimit: Collector voltage compliance
Emitter: SMU connected to Emitter terminal, constant voltage output
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Ve: Emitter voltage
Ic: Collector current
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Base voltage Vbase
Collector voltage Vcollector

[User Function]
Rb=(Vbase-Vcollector)/Ibase
Inv_Ibase=1/Ibase

[X-Y Plot]
X axis: Inversed Base current Inv_Ibase (LINEAR)
Y1 axis: Base resistance Re (LINEAR)
Y2 axis: Base current Ibase (LINEAR)

1.34 Re+Rc: Collector resistance (including Emitter resistance, flyback method, 4-terminal) (A.01.20)

[Description]
Measures the collector voltage vs collector current characteristics, and extracts the combined resistance of the collector resistance and the emitter resistance. Uses the flyback method.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Collector: SMU connected to Collector terminal, primary sweep current output
IcStart: Sweep start current for Collector terminal
IcStop: Sweep stop current for Collector terminal
IcStep: Sweep step current for Collector terminal
VcLimit: Collector voltage compliance
Base: SMU connected to Base terminal, constant current output
Ib: Base current
Emitter: SMU connected to Emitter terminal, constant voltage output
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Ve: Emitter voltage
VbLimit: Base voltage compliance
HoldTime: Hold time
DelayTime: Delay time
EmitterMinRng: Minimum range for the emitter current measurement
SubsMinRng: Minimum range for the substrate current measurement

[Measurement Parameters]
Collector voltage Vcollector

[User Function]
IePerArea=Iemitter/Le/We
IbPerArea=Ibase/Le/We
IsPerArea=Isubs/Le/We
Rc_Re=diff(Vcollector,Icollector)

[X-Y Plot]
X axis: Collector current Icollector (LINEAR)
Y1 axis: Collector voltage Vcollector (LINEAR)
Y2 axis: Combined resistance of Collector resistance and Emitter resistance

1.35 Re: Emitter resistance (flyback method, 4-terminal) (A.01.20)

[Description]
Measures the collector voltage vs base current characteristics, and extracts the Emitter resistance. Uses the flyback method.

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Base: SMU connected to Base terminal, primary sweep current output
IbStart: Sweep start current for Base terminal
IbStop: Sweep stop current for Base terminal
IbStep: Sweep step current for Base terminal
VbLimit: Base voltage compliance
Collector: SMU connected to Collector terminal, constant current output
Ic: Collector current
VcLimit: Collector voltage compliance
Emitter: SMU connected to Emitter terminal, constant voltage output
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
EmitterMinRng: Minimum range for the emitter current measurement
SubsMinRng: Minimum range for the substrate current measurement

[Measurement Parameters]
Collector voltage Vcollector

[User Function]
Emitter current per emitter unit area IePerArea=Iemitter/Le/We
Base current per emitter unit area IbPerArea=Ibase/Le/We
Substrate current per emitter unit area IsPerArea=Isubs/Le/We
Emitter resistance Re=diff(Vcollector,Ibase)

[X-Y Plot]
X axis: Base current Ibase (LINEAR)
Y1 axis: Collector voltage Vcollector (LINEAR)
Y2 axis: Emitter resistance Re (LINEAR)

1.36 Simple Gummel Plot: Evaluation of Gummel characteristics (Vce=const) (A.01.10)

[Application]
This application evaluates the Gummel characteristics of a NPN BJT with three terminals.

[Device Measured]
Single NPN device with three terminals.

[Parameter Setting]
Test parameters are specified for NPN device under test.

[Description of Measurement]
Base and Collector voltage, referenced to emitter voltage (0 V), sweeps synchronously in accordance with the test parameter setting.

Currents flowing in base and collector terminals are measured while the synchronized voltages sweep.

[Plot Display]
Collector and base currents in log scale, as well as the current amplification factor (Beta) in linear scale, are plotted versus base voltage on the linear horizontal axis.

1.37 Vbe-Le: hfe,Vbe-Le characteristics (A.01.20)

[Description]
Measures hfe (current amplification factor)-Vbe (voltage between base and emitter) characteristics of BJT with different Le (emitter length) and plots hfe and Vbe's dependency on Le.

[Device Under Test]
Bipolar transistor, 4 terminals

[Required Modules and Accessories]
Agilent B2200A or B2201A switching matrix 1 unit
GPIB cable

Connect B2200A/B2201A to B1500A with measurement cables and GPIB cable.
Set information on B1500A SMU channel's connection to the B2200A/B2201A input port properly on the Switching Matrix tab screen of the Configuration window.
Set the output channel number of B2200A/B2201A connected to each terminal of a device under test properly in the B#/C#/E#/Sb# field (# is an integer from 1 to 12) of Test Parameters area.
The maximum number of devices connected at once depends on the number of matrix modules mounted on B2200A/B2201A. Maximum three devices can be connected to one module at once.

[Setting of Le#/B#/C#/E#/Sb# field (# is an integer from 1 to 12)]
Set one device for Le#(emitter length)/B#(base)/C#(collector)/E#(emitter)/Sb#(substrate).
Le1<Le2<Le3... must be satisfied. Enter zero for a field with no device.

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value)
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
BaseSMU: SMU connected to Base terminal, constant voltage output
CollectorSMU: SMU connected to Collector terminal, constant voltage output
SbSMU: SMU connected to Substrate terminal, constant voltage output
EmitterSMU: SMU connected to Emitter terminal, primary sweep voltage output
VeStart: Sweep start voltage for Emitter terminal
VeStop: Sweep stop voltage for Emitter terminal
VeStep: Sweep step voltage for Emitter terminal
Vsubs: Substrate voltage
Ic@hfe: Collector current determining the hfe (Calculates hfe on a particular Ic)
Ie@Vbe: Emitter current determining the Vbe voltage (Calculates Vbe on a particular Ie)
We: Emitter width
Le1 - Le12: Emitter length
B1 - B12: SWM Pin Assign setting for Base of devices
C1 - C12: SWM Pin Assign setting for Collector of devices
E1 - E12: SWM Pin Assign setting for Emitter of devices
Sb1 - Sb12: SWM Pin Assign setting for Subs of devices

[Extended Test Parameters]
Vb: Base voltage
Vc: Collector voltage
IsubsLimit: Substrate current compliance
HoldTime: Hold time

DelayTime: Delay time
hfe_Min: Minimum hfe value for graph scale
hfe_Max: Maximum hfe value for graph scale
BaseMinRng: Minimum range for base current measurement
CollectorMinRng: Minimum range for collector current measurement
EmitterMinRng: Minimum range for emitter current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase
Emitter current Iemitter

[User Function]
hfe=Icollector/Ibase

[Analysis Function]
Ic@hfeVal=@L1X (X intercept of Line1)
Ie@VbeVal=@L2X (X intercept of Line2)

[Auto Analysis]
Line1: Vertical line for Y1 at hfe=Ic@hfe*Ratio
Line2: Vertical line for Y2 at Vemitter=Ie@Vbe*Ratio

[X-Y Plot]
X axis: Emitter voltage Vemitter (LINEAR)
Y1 axis: Base current Ibase (LOG)
Y2 axis: Current amplification factor hfe (LINEAR)
Y3 axis: Collector current Icollector (LOG)
Y4 axis: Emitter current Iemitter (LOG)

[List Display]
Emitter voltage Vemitter
Collector current Icollector
Emitter current Iemitter
Base current Ibase
Current amplification factor hfe

[Parameters Display Area]
Collector current determining the hfe (Calculates hfe on a particular Ic) Ic@hfeVal
Emitter current determining the Vbe voltage (Calculates Vbe on a particular Ie) Ie@VbeVal

[Test Output: X-Y Graph]
X axis: Emitter length (Le size) LeList (LINEAR)
Y1 axis: Current amplification factor at Ic@hfe Ic@hfeList (LINEAR)
Y2 axis: Emitter voltage at Ie@Vbe Ie@VbeList (LINEAR)

[Test Output: List Display]
Emitter length (Le size) LeList
Current amplification factor Ic@hfeList
Emitter voltage Ie@VbeList

1.38 Vbe-We: hfe,Vbe-Le characteristics (A.01.20)

[Description]
Measures the hfe (current amplification factor) vs Vbe (voltage between base and emitter) characteristics of BJT with different We (emitter width) and plots hfe and Vbe's dependency on We.

[Device Under Test]
Bipolar transistor, 4 terminals

[Required Modules and Accessories]
Agilent B2200A or B2201A switching matrix 1 unit
GPIB cable

Connect B2200A/B2201A to B1500A with a measuring cable and GPIB cable.
Set information on B1500A SMU channel's connection to the B2200A/B2201A input port properly on the Switching Matrix tab screen of the Configuration window.
Set the output channel number of B2200A/B2201A connected to each terminal of a device under test properly in the B#/C#/E#/Sb# field (# is an integer from 1 to 12) of Test Parameters area.
The maximum number of devices connected at once depends on the number of matrix modules mounted on B2200A/B2201A. Maximum three devices can be connected to one module at once.

[Setting of We#/B#/C#/E#/Sb# field (# is an integer from 1 to 12)]
Set one device for We#(emitter width)/B#(base)/C#(collector)/E#(emitter)/Sb#(sub strate). We1<We2<We3... must be satisfied. Enter zero for a field with no device.

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value)
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
BaseSMU: SMU connected to Base terminal, constant voltage output
CollectorSMU: SMU connected to Collector terminal, constant voltage output
SbSMU: SMU connected to Substrate terminal, constant voltage output
EmitterSMU: SMU connected to Emitter terminal, primary sweep voltage output
VeStart: Sweep start voltage for Emitter terminal
VeStop: Sweep stop voltage for Emitter terminal
VeStep: Sweep step voltage for Emitter terminal
Vsubs: Substrate voltage
Ic@hfe: Collector current determining the hfe (Calculates hfe on a particular Ic)
Ie@Vbe: Emitter current determining the Vbe voltage (Calculates Vbe on a particular Ie)
Le: Emitter length
We1 - We12: Emitter width
B1 - B12: SWM Pin Assign setting for Base of devices
C1 - C12: SWM Pin Assign setting for Collector of devices
E1 - E12: SWM Pin Assign setting for Emitter of devices
Sb1 - Sb12: SWM Pin Assign setting for Subs of devices

[Extended Test Parameters]
Vb: Base voltage
Vc: Collector voltage
IsubsLimit: Substrate current compliance
HoldTime: Hold time

DelayTime: Delay time
hfe_Min: Minimum hfe value for graph scale
hfe_Max: Maximum hfe value for graph scale
BaseMinRng: Minimum range for base current measurement
CollectorMinRng: Minimum range for collector current measurement
EmitterMinRng: Minimum range for emitter current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase
Emitter current Iemitter

[User Function]
hfe=Icollector/Ibase

[Analysis Function]
Ic@hfeVal=@L1X (X intercept of Line1)
Ie@VbeVal=@L2X (X intercept of Line2)

[Auto Analysis]
Line1: Vertical line for Y1 at hfe=Ic@hfe*Ratio
Line2: Vertical line for Y2 at Vemitter=Ie@Vbe*Ratio

[X-Y Plot]
X axis: Emitter voltage Vemitter (LINEAR)
Y1 axis: Base current Ibase (LOG)
Y2 axis: Current amplification factor hfe (LINEAR)
Y3 axis: Collector current Icollector (LOG)
Y4 axis: Emitter current Iemitter (LOG)

[List Display]
Emitter voltage Vemitter
Collector current Icollector
Emitter current Iemitter
Base current Ibase
Current amplification factor hfe

[Parameters Display Area]
Collector current determining the hfe (Calculates hfe on a particular Ic) Ic@hfeVal
Emitter current determining the Vbe voltage (Calculates Vbe on a particular Ie) Ie@VbeVal

[Test Output: X-Y Graph]
X axis: Emitter width (We size) WeList (LINEAR)
Y1 axis: Current amplification factor at Ic@hfe Ic@hfeList (LINEAR)
Y2 axis: Emitter voltage at Ie@Vbe Ie@VbeList (LINEAR)

[Test Output: List Display]
Emitter width (We size) WeList
Current amplification factor Ic@hfeList
Emitter voltage Ie@VbeList

2 CMOS

1. BVdss: Breakdown voltage between source and drain (A.01.20)
2. BVgso: Breakdown voltage between gate and source (A.01.20)
3. Cgb-AC Level: Cgb-Vosc characteristics (A.01.11)
4. Cgb-Freq Log: Cgb-f characteristics (A.01.20)
5. Cgb-Vg HighVoltage: Cgb-Vg characteristics using SCUU (A.01.11)
6. Cgb-Vg: Cgb-Vg characteristics (A.01.11)
7. Cgc-Freq Log: Cgc-f characteristics (A.01.20)
8. Cgc-Vg: Cgc-Vg characteristics (A.01.11)
9. Cgg-Freq Linear: Cgg-f characteristics (A.01.20)
10. Cgg-Freq Log: Cgg-f characteristics (A.01.20)
11. Cgg-Vg 2Freq: Cgg-Vg characteristics, 2-frequency method (A.01.11)
12. Cgg-Vg: Cgg-Vg characteristics (A.01.11)
13. IdRdsGds: Drain resistance/conductance (A.01.20)
14. Id-Vd pulse: Id-Vd characteristics, SMU Pulse (A.01.11)
15. Id-Vd pulse[3] : Id-Vd characteristics (3-terminal), SMU Pulse (A.01.11)
16. Id-Vd: Id-Vd Characteristics (A.01.20)
17. Id-Vd[3]: Id-Vd Characteristics (3-terminal) (A.01.20)
18. Id-Vg pulse: Id-Vg characteristics, SMU Pulse (A.01.12)
19. Id-Vg Vpulse[3]: Id-Vg characteristics (3-terminal), SMU Pulse (A.01.11)
20. Id-Vg: Id-Vg Characteristics (A.01.20)
21. Id-Vg[3]: Id-Vg Characteristics (3-terminal) (A.01.20)
22. IonIoffSlope: On current, off current, and subthreshold slope (A.01.20)
23. Isub-Vg: Isub-Lg characteristics (A.01.20)
24. Simple Cgb : Evaluation of gate-substrate capacitance versus gate voltage (A.01.10)
25. Simple Vth : Evaluation of Threshold Voltage (Vth) (A.01.10)
26. Vth Const Id: Constant current Vth (A.01.20)
27. Vth gmMax : Linear region Vth (A.01.20)
28. VthAndCgg-Vg ASU: Cgg-Vg, Id-Vg, using ASU (A.01.20)
29. VthAndCgg-Vg SCUU: Cgg-Vg, Id-Vg, using SCUU (A.01.20)
30. Vth-Lg: Vth-Lg characteristics (A.01.20)
31. Vth-Wg: Vth-Wg characteristics (A.01.20)

2.1 BVdss: Breakdown voltage between source and drain (A.01.20)

[Description]
Measures the breakdown voltage between source and drain of MOSFET.

[Device Under Test]
MOSFET, 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Is@BVdss: Source current to decide the breakdown
Drain: SMU connected to Drain, primary sweep voltage output
VdStart: Sweep start voltage for Drain
VdStop: Sweep stop voltage for Drain
VdStep: Sweep step voltage for Drain
Gate: SMU connected to Gate, constant voltage output
Subs: SMU connected to Substrate, constant voltage output
Source: SMU connected to Source, constant voltage output

[Extended Test Parameters]
Vg: Gate voltage
Vs: Source voltage
Vsubs: Substrate voltage
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement
GateMinRng: Minimum range for the gate current measurement
SubsMinRng: Minimum range for the substrate current measurement

[Measurement Parameters]
Drain current Idrain
Source current Isource
Gate current Igate
Substrate current Isubs
For the source terminal, the SMU current compliance is set to Is@BVdss*1.1.

[User Function]
Source current per unit gate width IsourcePerWg=Isource/Wg
Drain current per unit gate width IdrainPerWg=Idrain/Wg

[Analysis Function]
BVdss=@L1X (X intercept of Line1)

[X-Y Plot]
X axis: Drain voltage Vdrain (LINEAR)
Y1 axis: Drain current Idrain (LOG)
Y2 axis: Source current Isource (LOG)

[List Display]
Gate current Igate
Substrate current Isubs

[Parameters Display Area]
Breakdown voltage between source and drain BVdss

[Auto Analysis]
Line1: Vertical line through Y2 data at Isource=Is@BVdss

2.2 BVgso: Breakdown voltage between gate and source (A.01.20)

[Description]
Measures the breakdown voltage between gate and source of MOSFET when drain is opened.

[Device Under Test]
MOSFET, 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Is@BVgso: Source current to decide the breakdown
Gate: SMU connected to Gate, primary sweep voltage output
VgStart: Sweep start voltage for Gate
VgStop: Sweep stop voltage for Gate
VgStep: Sweep step voltage for Gate
Subs: SMU connected to Substrate, constant voltage output
Source: SMU connected to Source, constant voltage output

[Extended Test Parameters]
Vsubs: Substrate voltage
Vs: Source voltage
HoldTime: Hold time
DelayTime: Delay time
GateMinRng: Minimum range for the gate current measurement
SourceMinRng: Minimum range for the source current measurement
SubsMinRng: Minimum range for the substrate current measurement

[Measurement Parameters]
Source current Isource
Gate current Igate
Substrate current Isubs
For the all terminals, the SMU current compliance is set to Is@BVgso*1.1.

[User Function]
Gate current per Gate unit area IgatePerGateArea=Igate/Lg/Wg

[Analysis Function]
BVgso=@L1X (X intercept of Line1)

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Source current Isource (LOG)
Y2 axis: Gate current Igate (LOG)

[List Display]
Substrate current Isubs

[Parameters Display Area]

Breakdown voltage between gate and source BVgso

[Auto Analysis]
Line1: Vertical line through Y1 data at Isource=Is@BVgso

2.3 Cgb-AC Level: Cgb-Vosc characteristics (A.01.11)

[Description]
Measures the Gate-Substrate capacitance (Cgs), and plots the Cgs-Vosc characteristics.
DC bias output is fixed at -Vgs. Oscillator level (Vosc) is changed from -OscStart to -OscStop in -OscStep steps. The CMU performs spot measurement of the parallel capacitance (Cp) and conductance (G) at each oscillator level.

[Device Under Test]
MOSFET, 4 terminals
Connect Gate to the CMU Low and Substrate to the CMU High. And connect Drain and Source to the specified SMU.

[Device Parameters]
Polarity: Nch (CMU/SMU forces the specified value) or Pch (CMU/SMU forces the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
OscStart: Oscillator level (Vosc) start voltage
OscStop: Vosc stop voltage
OscStep: Vosc step voltage
FREQ: Measurement frequency
Gate: CMU connected between Gate and Substrate (CV spot measurement)
Vgs: DC bias. Gate-Substrate voltage.
Source: SMU connected to Source terminal (constant voltage output)

[Extended Test Parameters]
Vs: Source voltage
IsLimit: Source current compliance
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance cp
Conductance g

[User Function]
PI=3.141592653589
d=g/(2*PI*FREQ*cp)
rp=1/g
cs=(1+d^2)*cp
x=-1/(2*PI*FREQ*cs)
rs=d*abs(x)
z=sqrt(rs^2+x^2)
theta=atan(x/rs)
V_gs=-Vsubs
osclevel=OscLevel

[Display Setup: X-Y Graph]
X axis: Oscillator level Vosc (LINEAR)
Y1 axis: Gate-Substrate capacitance (parallel capacitance) cp (LINEAR)

Y2 axis: Conductance g (LINEAR)

[Display Setup: List Display]
Oscillator level osclevel
Oscillator level Vosc
Gate-Substrate capacitance (parallel capacitance) cp
Conductance g
Gate-Substrate voltage V_gs

[Test Output: X-Y Graph]
X axis: Oscillator level OSCLEVEL (LINEAR)
Y1 axis: Gate-Substrate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[Test Output: List Display]
Oscillator level OSCLEVEL
Parallel capacitance Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Th

2.4 Cgb-Freq Log: Cgb-f characteristics (A.01.20)

[Description]
Measures MOSFET's characteristics of gate-to-substrate capacitance (Cgb, linear) vs frequency (f, log). The measurement frequency is 10 points per decade.

[Device Under Test]
MOSFET, 4 terminals
Connect Gate to the CMU Low and Substrate to the CMU High. And connect Drain and Source to the GNDU.

[Required Modules and Accessories]
Agilent B1520A MFCMU 1 unit

[Device Parameters]
Polarity: Nch (CMU forces the specified value) or Pch (CMU forces the negative specified value)
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Gate: CMU connected to Gate terminal, CV sweep measurement
Source: SMU connected to Source terminal, constant voltage output
FreqStart: Sweep start frequency
NoOfDecade: Number of decades for data collection
OscLevel: Measurement signal level
Vgs: Voltage for Gate terminal, constant voltage output

[Extended Test Parameters]
G_Min: Minimum transconductance value for graph
G_Max: Maximum transconductance value for graph
Cp_Min: Minimum capacitance value for graph
Cp_Max: Maximum capacitance value for graph
Vs: Voltage for Source terminal
IsLimit: Source current compliance

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
Circular constant PI=3.141592653589
Frequency Frequency=Freq
Dissipation factor D=G/(2*PI*Freq*Cp)
Parallel resistance Rp=1/G
Series capacitance Cs=(1+D^2)*Cp
Reactance X=-1/(2*PI*Freq*Cs)
Series resistance Rs=D*abs(X)
Impedance Z=sqrt(Rs^2+X^2)
Phase Theta=atan(X/Rs)

[X-Y Plot]
X axis: Frequency Freq (LOG)
Y1 axis: Gate-Substrate capacitance (parallel capacitance) Cp (LINEAR)

Y2 axis: Conductance G (LINEAR)

[List Display]
Frequency Freq
Gate-Substrate capacitance Cp
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta
Substrate voltage Vsubs
Conductance G

[Test Output: X-Y Graph]
X axis: Frequency list FreqList (LOG)
Y1 axis: Gate-Substrate capacitance (parallel capacitance) list CpList (LINEAR)
Y2 axis: Conductance list GList (LINEAR)

[Test Output: List Display]
Frequency FreqList
Gate-Substrate capacitance (parallel capacitance) CpList
Conductance GList
Series capacitance CsList
Series resistance RsList
Parallel resistance RpList
Dissipation factor DList
Reactance XList
Impedance ZList
Phase ThetaList
Substrate voltage VsubsList

2.5 Cgb-Vg HighVoltage: Cgb-Vg characteristics using SCUU (A.01.11)

[Description]
Measures the Gate-Substrate capacitance (Cgs), and plots the Cgs-Vg characteristics.
DC bias output is performed from -VgsStart to -VgsStop in -VgsStep steps. The CMU performs spot measurement of the parallel capacitance (Cp) and conductance (G) at each bias output. SCUU enables the maximum 100 V DC bias.

[Device Under Test]
MOSFET, 4 terminals
Connect Gate and Substrate to the SCUU. And connect Drain and Source to the specified SMU.

[Required Modules and Accessories]
One MFCMU module, three SMU modules, and a set of SCUU/GSWU are required.
SCUU connections: Output1: Substrate, Output2: Gate
Connection wire must be connected between the GSWU and the DUT interface High/Low guard lines.

[Device Parameters]
Polarity: Nch (CMU/SMU forces the specified value) or Pch (CMU/SMU forces the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
Gate: CMU connected between Gate and Substrate (CV spot measurement)
VgsStart: DC bias start voltage
VgsStop: DC bias stop voltage
VgsStep: DC bias step voltage
Source: SMU connected to Source terminal (constant voltage output)

[Extended Test Parameters]
IsLimit: Source current compliance
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
Subs=Vstart*Polarity

[Display Setup: X-Y Graph]

X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Gate-Substrate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[Display Setup: List Display]
Substrate voltage Subs
Gate voltage Vgate
Gate-Substrate capacitance (parallel capacitance) Cp

[Test Output: X-Y Graph]
X axis: Gate voltage VgList (LINEAR)
Y1 axis: Gate-Substrate capacitance (parallel capacitance) CpList (LINEAR)
Y2 axis: Conductance GList (LINEAR)

[Test Output: List Display]
Gate voltage VgList
Gate-Substrate capacitance (parallel capacitance) CpList
Conductance GList
Series capacitance CsList
Series resistance RsList
Parallel resistance RpList
Dissipation factor DList
Reactance XList
Impedance ZList
Phase ThetaList

2.6 Cgb-Vg: Cgb-Vg characteristics (A.01.11)

[Description]
Measures the Gate-Substrate capacitance (Cgs), and plots the Cgs-Vg characteristics.
DC bias output is performed from -VgsStart to -VgsStop in -VgsStep steps. The CMU performs spot measurement of the parallel capacitance (Cp) and conductance (G) at each bias output.

[Device Under Test]
MOSFET, 4 terminals
Connect Gate to the CMU Low, and Substrate to the CMU High. And connect Drain and Source to the specified SMU.

[Device Parameters]
Polarity: Nch (CMU/SMU forces the specified value) or Pch (CMU/SMU forces the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
Gate: CMU connected between Gate and substrate (CV spot measurement)
VgsStart: DC bias start voltage
VgsStop: DC bias stop voltage
VgsStep: DC bias step voltage
Source: SMU connected to Source terminal (constant voltage output)

[Extended Test Parameters]
Vs: Source voltage
IsLimit: Source current compliance
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
Vsubs=Vstart*Polarity

[Display Setup: X-Y Graph]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Gate-Substrate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[Display Setup: List Display]
Substrate voltage Vsubs
Source voltage Vsource
Gate-Substrate capacitance (parallel capacitance) Cp

[Test Output: X-Y Graph]
X axis: Gate voltage VgList (LINEAR)
Y1 axis: Gate-Substrate capacitance (parallel capacitance) CpList (LINEAR)
Y2 axis: Conductance GList (LINEAR)

[Test Output: List Display]
Gate voltage VgList
Gate-Substrate capacitance (parallel capacitance) CpList
Conductance GList
Series capacitance CsList
Series resistance RsList
Parallel resistance RpList
Dissipation factor DList
Reactance XList
Impedance ZList
Phase ThetaList

2.7 Cgc-Freq Log: Cgc-f characteristics (A.01.20)

[Description]
Measures MOSFET's characteristics of gate-to-channel capacitance (Cgc, linear) vs frequency (f, log). The measurement frequency is 10 points per decade.

[Device Under Test]
MOSFET, 4 terminals
Connect Gate to the CMU Low, and Drain-Source to the CMU High. And connect Substrate to the GNDU.

[Required Modules and Accessories]
Agilent B1520A MFCMU 1 unit

[Device Parameters]
Polarity: Nch (CMU forces the specified value) or Pch (CMU forces the negative specified value)
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Gate: CMU connected to Gate terminal, CV sweep measurement
Subs: SMU connected to Substrate terminal, constant voltage output
FreqStart: Sweep start frequency
NoOfDecade: Number of decades for data collection
OscLevel: Measurement signal level
Vgs: Voltage for Gate terminal, constant voltage output

[Extended Test Parameters]
Vsubs: Voltage for Substrate terminal
IsubsLimit: Substrate current compliance
G_Min: Minimum transconductance value for graph
G_Max: Maximum transconductance value for graph
Cp_Min: Minimum capacitance value for graph
Cp_Max: Maximum capacitance value for graph

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
Circular constant PI=3.141592653589
Frequency Frequency=Freq
Dissipation factor D=G/(2*PI*Freq*Cp)
Parallel resistance Rp=1/G
Series capacitance Cs=(1+D^2)*Cp
Reactance X=-1/(2*PI*Freq*Cs)
Series resistance Rs=D*abs(X)
Impedance Z=sqrt(Rs^2+X^2)
Phase Theta=atan(X/Rs)

[X-Y Plot]
X axis: Frequency Freq (LOG)
Y1 axis: Gate-Channel capacitance (parallel capacitance) Cp (LINEAR)

Y2 axis: Conductance G (LINEAR)

[List Display]
Frequency Freq
Gate-Channel capacitance Cp
Gate voltage G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta
Source voltage Vsource

[Test Output: X-Y Graph]
X axis: Frequency list FreqList (LOG)
Y1 axis: Gate-Channel capacitance (parallel capacitance) list CpList (LINEAR)
Y2 axis: Conductance list GList (LINEAR)

[Test Output: List Display]
Frequency FreqList
Gate-Channel capacitance (parallel capacitance) CpList
Conductance GList
Series capacitance CsList
Series resistance RsList
Parallel resistance RpList
Dissipation factor DList
Reactance XList
Impedance ZList
Phase ThetaList
Source voltage VsourceList

2.8 Cgc-Vg: Cgc-Vg characteristics (A.01.11)

[Description]
Measures the Gate-Channel capacitance (Cgc), and plots the Cgc-Vg characteristics.
DC bias output is performed from -VgsStart to -VgsStop in -VgsStep steps. The CMU performs spot measurement of the parallel capacitance (Cp) and conductance (G) at each bias output. The substrate voltage is changed simultaneously with the DC bias output to keep the Channel-Substrate voltage constant. The SMU works as the constant voltage source and realizes the secondary sweep by repeating the output change every DC bias sweep.

[Device Under Test]
MOSFET, 4 terminals
Connect Gate to the CMU Low, and Drain-Source to the CMU High. And connect Substrate to the specified SMU.

[Device Parameters]
Polarity: Nch (CMU/SMU forces the specified value) or Pch (CMU/SMU forces the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
Gate: CMU connected between Gate and channel (CV spot measurement)
VgsStart: DC bias start voltage (primary sweep)
VgsStop: DC bias stop voltage (primary sweep)
VgsStep: DC bias step voltage (primary sweep)
Subs: SMU connected to Substrate terminal (constant voltage output)
VbsStart: Substrate start voltage (secondary sweep)
VbsStop: Substrate stop voltage (secondary sweep)
VbsStep: Substrate step voltage (secondary sweep)
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
Vgate=-Vsource

[Display Setup: X-Y Graph]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Gate-Channel capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[Display Setup: List Display]
Gate voltage Vgate
Substrate voltage Vsubs
Gate-Channel capacitance (parallel capacitance) Cp
Conductance G

[Test Output: X-Y Graph]
X axis: Gate voltage VgList (LINEAR)
Y1 axis: Gate-Channel capacitance (parallel capacitance) CpList (LINEAR)
Y2 axis: Conductance GList (LINEAR)

[Test Output: List Display]
Gate voltage VgList
Channel-Substrate voltage VbsList
Gate-Channel capacitance (parallel capacitance) CpList
Conductance GList
Series capacitance CsList
Series resistance RsList
Parallel resistance RpList
Dissipation factor DList
Reactance XList
Impedance ZList
Phase ThetaList

2.9 Cgg-Freq Linear: Cgg-f characteristics (A.01.20)

[Description]
Measures the gate capacitance (Cgg, linear) vs frequency (f, linear) characteristics of MOSFET.

[Device Under Test]
MOSFET, 4 terminals
Connect Gate to the CMU Low, and Drain-Source-Substrate to the CMU High.

[Required Modules and Accessories]
Agilent B1520A MFCMU 1 unit

[Device Parameters]
Polarity: Nch (CMU forces the specified value) or Pch (CMU forces the negative specified value)
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FreqStart: Sweep start frequency
NoOfPoint: Number of measurement points
OscLevel: Measurement signal level
Gate: CMU connected to Gate terminal, CV sweep measurement
Vgs: Voltage for Gate terminal, constant voltage output

[Extended Test Parameters]
G_Min: Minimum transconductance value for graph
G_Max: Maximum transconductance value for graph
Cp_Min: Minimum capacitance value for graph
Cp_Max: Maximum capacitance value for graph

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
Circular constant PI=3.141592653589
Frequency Frequency=Freq
Dissipation factor D=G/(2*PI*Freq*Cp)
Parallel resistance Rp=1/G
Series capacitance Cs=(1+D^2)*Cp
Reactance X=-1/(2*PI*Freq*Cs)
Series resistance Rs=D*abs(X)
Impedance Z=sqrt(Rs^2+X^2)
Phase Theta=atan(X/Rs)

[X-Y Plot]
X axis: Frequency Freq (LINEAR)
Y1 axis: Gate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[List Display]
Frequency Freq

Gate capacitance (parallel capacitance) Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta
Substrate voltage Vsubs

[Test Output: X-Y Graph]
X axis: Frequency list FreqList (LINEAR)
Y1 axis: Gate capacitance (parallel capacitance) list CpList (LINEAR)
Y2 axis: Conductance list GList (LINEAR)

[Test Output: List Display]
Frequency FreqList
Gate capacitance (parallel capacitance) CpList
Conductance GList
Series capacitance CsList
Series resistance RsList
Parallel resistance RpList
Dissipation factor DList
Reactance XList
Impedance ZList
Phase ThetaList
Substrate voltage VsubsList

2.10 Cgg-Freq Log: Cgg-f characteristics (A.01.20)

[Description]
Measures the gate capacitance (Cgg, linear) vs frequency (f, log) characteristics of MOSFET. The measurement frequency is 10 points per decade.

[Device Under Test]
MOSFET, 4 terminals
Connect Gate to the CMU Low, and Drain-Source-Substrate to the CMU High.

[Required Modules and Accessories]
Agilent B1520A MFCMU 1 unit

[Device Parameters]
Polarity: Nch (CMU forces the specified value) or Pch (CMU forces the negative specified value)
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FreqStart: Sweep start frequency
NoOfDecade: Number of decades for data collection
OscLevel: Measurement signal level
Gate: CMU connected to Gate terminal, CV sweep measurement
Vgs: Voltage for Gate terminal, constant voltage output

[Extended Test Parameters]
G_Min: Minimum transconductance value for graph
G_Max: Maximum transconductance value for graph
Cp_Min: Minimum capacitance value for graph
Cp_Max: Maximum capacitance value for graph

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
Circular constant PI=3.141592653589
Frequency Frequency=Freq
Dissipation factor D=G/(2*PI*Freq*Cp)
Parallel resistance Rp=1/G
Series capacitance Cs=(1+D^2)*Cp
Reactance X=-1/(2*PI*Freq*Cs)
Series resistance Rs=D*abs(X)
Impedance Z=sqrt(Rs^2+X^2)
Phase Theta=atan(X/Rs)

[X-Y Plot]
X axis: Frequency Freq (LOG)
Y1 axis: Gate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[List Display]

Frequency Freq
Gate capacitance (parallel capacitance) Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta
Substrate voltage Vsubs

[Test Output: X-Y Graph]
X axis: Frequency measurement list FreqList (LOG)
Y1 axis: Gate capacitance (parallel capacitance) list CpList (LINEAR)
Y2 axis: Conductance list GList (LINEAR)

[Test Output: List Display]
Frequency FreqList
Gate capacitance (parallel capacitance) CpList
Conductance GList
Series capacitance CsList
Series resistance RsList
Parallel resistance RpList
Dissipation factor DList
Reactance XList
Impedance ZList
Phase ThetaList
Substrate voltage VsubsList

2.11 Cgg-Vg 2Freq: Cgg-Vg characteristics, 2-frequency method (A.01.11)

[Description]
Measures the Gate capacitance (Cgg), and plots the Cgg-Vg characteristics. The Cgg value is given by the following formula. Then C1 and C2 are capacitance, D1 and C2 are dissipation factor measured at the frequency (f1 and f2).

Cgg = [f1^2*C1*(1+D1^2)-f2^2*C2*(1+D2^2)]/[f2^2-f1^2]

[Device Under Test]
MOSFET, 4 terminals
Connect Gate to the CMU Low, and the other terminals to the CMU High.

[Device Parameters]
Polarity: Nch (CMU forces the specified value) or Pch (CMU forces the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
OscLevel: Measurement signal level
FREQ1: Measurement frequency
FREQ2: Measurement frequency
Gate: CMU connected to Gate terminal (CV sweep measurement)
VgsStart: DC bias start voltage
VgsStop: DC bias stop voltage
VgsStep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Dissipation factor D

[User Function]
Vgs=-Vsubs

[Display Setup: X-Y Graph]
X axis: Gate voltage Vgs (LINEAR)
Y1 axis: Gate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Dissipation factor D (LINEAR)

[Display Setup: List Display]
Gate voltage Vgs
Gate capacitance (parallel capacitance) Cp
Dissipation factor D

[Test Output: X-Y Graph]
X axis: Gate voltage VGS (LINEAR)
Y1 axis: Gate capacitance (parallel capacitance) Cgg (LINEAR)
Y2 axis: Gate capacitance (parallel capacitance) Cp_FREQ1 (LINEAR)

Y3 axis: Gate capacitance (parallel capacitance) Cp_FREQ2 (LINEAR)

[Test Output: List Display]
Gate voltage VGS
Gate capacitance (parallel capacitance) Cgg
Gate capacitance (parallel capacitance) Cp_FREQ1
Gate capacitance (parallel capacitance) Cp_FREQ2
Dissipation factor D_FREQ1
Dissipation factor D_FREQ2

2.12 Cgg-Vg: Cgg-Vg characteristics (A.01.11)

[Description]
Measures the Gate capacitance (Cgg), and plots the Cgg-Vg characteristics.

[Device Under Test]
MOSFET, 4 terminals
Connect Gate to the CMU Low, and the other terminals to the CMU High.

[Device Parameters]
Polarity: Nch (CMU forces the specified value) or Pch (CMU forces the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
Gate: CMU connected to Gate terminal (CV sweep measurement)
VgsStart: DC bias start voltage
VgsStop: DC bias stop voltage
VgsStep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
Dval=Gval/(2*PI*FREQ*Cpval)
Rpval=1/Gval
Csval=(1+Dval^2)*Cpval
Xval=-1/(2*PI*FREQ*Csval)
Rsval=Dval*abs(Xval)
Zval=sqrt(Rsval^2+Xval^2)
Thetaval=atan(Xval/Rsval)
Vgateval=-Vsubs

[X-Y Graph]
X axis: Gate voltage Vgateval (LINEAR)
Y1 axis: Gate capacitance (parallel capacitance) Cpval (LINEAR)
Y2 axis: Conductance Gval (LINEAR)

[List Display]
Gate voltage Vgateval
Gate capacitance (parallel capacitance) Cpval
Conductance Gval
Series capacitance Csval
Series resistance Rsval

Parallel resistance Rpval
Dissipation factor Dval
Reactance Xval
Impedance Zval
Phase Thetaval

2.13 IdRdsGds: Drain resistance/conductance (A.01.20)

[Description]
Extracts the early voltage, drain resistance, and drain conductance from the drain current vs drain voltage characteristics of MOSFET.

[Device Under Test]
MOSFET, 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Drain: SMU connected to Drain terminal, primary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
Gate: SMU connected to Gate terminal, secondary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
IsubsLimit: Substrate current compliance
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain
Drain resistance Rds
Early voltage VA
Drain conductance gds

[User Function]
gds=diff(Idrain,Vdrain)
Rds=1/gds
VA=Rds*abs(Idrain)-abs(Vdrain)

[X-Y Plot]
X axis: Drain voltage Vdrain (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Drain resistance Rds (LOG)
Y3 axis: Early voltage VA (LINEAR)

[List Display]
Drain conductance gds

2.14 Id-Vd pulse: Id-Vd characteristics, SMU Pulse (A.01.11)

[Description]
Measures the drain current vs drain voltage characteristics of MOSFET. SMU pulse output is used for applying the drain voltage.

[Device Under Test]
MOSFET, 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
Drain: SMU connected to Drain terminal, primary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
PulsePeriod: Pulse period
PulseWidth: Pulse width
Gate: SMU connected to Gate terminal, secondary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
IgLimit: Gate current compliance
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
BaseValue: Pulse base voltage
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Drain current Idrain

[User Function]
IdrainPerWg: Drain current per unit gate width IdrainPerWg=Idrain/Wg

[X-Y Plot]
X axis: Drain voltage Vdrain (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)

[List Display]
Drain current per unit gate width IdrainPerWg

2.15 Id-Vd pulse[3] : Id-Vd characteristics (3-terminal), SMU Pulse (A.01.11)

[Description]
Measures the drain current vs drain voltage characteristics of MOSFET. SMU pulse is used for the drain voltage output.

[Device Under Test]
MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
Drain: SMU connected to Drain terminal, primary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
PulsePeriod: Pulse period
PulseWidth: Pulse width
Gate: SMU connected to Gate terminal, secondary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
IgLimit: Gate current compliance
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
BaseValue: Pulse base voltage
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Drain current Idrain

[User Function]
IdrainPerWg: Drain current per unit gate width IdrainPerWg=Idrain/Wg

[X-Y Plot]
X axis: Drain voltage Vdrain (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)

[List Display]
Drain current per unit gate width IdrainPerWg

2.16 Id-Vd: Id-Vd Characteristics (A.01.20)

[Description]
Measures the drain current vs drain voltage characteristics of MOSFET.

[Device Under Test]
MOSFET, 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
Drain: SMU connected to Drain terminal, primary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
Gate: SMU connected to Gate terminal, secondary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
IsubsLimit: Substrate current compliance
IntegTime: Integration time
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
IdrainPerWg: Drain current per unit gate width IdrainPerWg=Idrain/Wg

[X-Y Plot]
X axis: Drain voltage Vdrain (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)

[List Display]
Drain current per unit gate width IdrainPerWg

2.17 Id-Vd[3]: Id-Vd Characteristics (3-terminal) (A.01.20)

[Description]
Measures the drain current vs drain voltage characteristics of MOSFET.

[Device Under Test]
MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
Drain: SMU connected to Drain terminal, primary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
Gate: SMU connected to Gate terminal, secondary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
IntegTime: Integration time
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
IdrainPerWg: Drain current per unit gate width IdrainPerWg=Idrain/Wg

[X-Y Plot]
X axis: Drain voltage Vdrain (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)

[List Display]
Drain current per unit gate width IdrainPerWg

2.18 Id-Vg pulse: Id-Vg characteristics, SMU Pulse (A.01.12)

[Description]
Measures the drain current vs gate voltage characteristics of MOSFET by using SMU pulse.

[Device Under Test]
MOSFET, 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Drain: SMU connected to Drain terminal, constant voltage output
Vd: Drain voltage
PulsePeriod: Pulse period
PulseWidth: Pulse width
Subs: SMU connected to Substrate, secondary sweep voltage output
VsubsStart: Sweep start voltage for Substrate terminal
VsubsStop: Sweep stop voltage for Substrate terminal
VsubsStep: Sweep step voltage for Substrate terminal
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
BaseValue: Pulse base voltage
IgLimit: Gate current compliance
IsubsLimit: Substrate current compliance
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Drain current Idrain

[User Function]
IdrainPerWg: Drain current per unit gate width IdrainPerWg=Idrain/Wg
gm: Transconductance gm=diff(Idrain,Vgate)
gmPerWg: Transconductance per unit gate width gmPerWg=diff(IdrainPerWg,Vgate)

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Transconductance gm (LINEAR)

[List Display]
Drain current per unit gate width IdrainPerWg
Transconductance per unit gate width gmPerWg

2.19 Id-Vg Vpulse[3]: Id-Vg characteristics (3-terminal), SMU Pulse (A.01.11)

[Description]
Measures the drain current vs gate voltage characteristics of MOSFET.

[Device Under Test]
MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Drain: SMU connected to Drain terminal, secondary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
PulsePeriod: Pulse period
PulseWidth: Pulse width
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
BaseValue: Pulse base voltage
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Drain current Idrain

[User Function]
IdrainPerWg: Drain current per unit gate width IdrainPerWg=Idrain/Wg
gm: Transconductance gm=diff(Idrain,Vgate)
gmPerWg: Transconductance per unit gate width gmPerWg=diff(IdrainPerWg,Vgate)

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Transconductance gm (LINEAR)

[List Display]
Drain current per unit gate width IdrainPerWg
Transconductance per unit gate width gmPerWg

2.20 Id-Vg: Id-Vg Characteristics (A.01.20)

[Description]
Measures the drain current vs gate voltage characteristics of MOSFET.

[Device Under Test]
MOSFET, 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Drain: SMU connected to Drain terminal, constant voltage output
Vd: Drain voltage
Subs: SMU connected to Substrate, secondary sweep voltage output
VsubsStart: Sweep start voltage for Substrate terminal
VsubsStop: Sweep stop voltage for Substrate terminal
VsubsStep: Sweep step voltage for Substrate terminal
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
IsubsLimit: Substrate current compliance
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Measurement minimum range of drain current
SubsMinRng: Measurement minimum range of substrate current

[Measurement Parameters]
Drain current Idrain
Substrate current Isubs

[User Function]
IdrainPerWg: Drain current per unit gate width IdrainPerWg=Idrain/Wg
IsubsPerWg: Substrate current per unit gate width IsubsPerWg=Isubs/Wg
gm: Transconductance gm=diff(Idrain,Vgate)
gmPerWg: Transconductance per unit gate width gmPerWg=diff(IdrainPerWg,Vgate)

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Drain current Idrain (LOG)
Y3 axis: Substrate current Isubs (LINEAR)
Y4 axis: Substrate current Isubs (LOG)

[List Display]

- Drain current per unit gate width IdrainPerWg
- Substrate current per unit gate width IsubsPerWg
- Transconductance gm
- Transconductance per unit gate width gmPerWg

2.21 Id-Vg[3]: Id-Vg Characteristics (3-terminal) (A.01.20)

[Description]
Measures the drain current vs gate voltage characteristics of MOSFET.

[Device Under Test]
MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Drain: SMU connected to Drain terminal, secondary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
IdrainPerWg: Drain current per unit gate width IdrainPerWg=Idrain/Wg
gm: Transconductance gm=diff(Idrain,Vgate)
gmPerWg: Transconductance per unit gate width gmPerWg=diff(IdrainPerWg,Vgate)

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Drain current Idrain (LOG)

[List Display]
Drain current per unit gate width IdrainPerWg
Transconductance gm
Transconductance per unit gate width gmPerWg

2.22 IonIoffSlope: On current, off current, and subthreshold slope (A.01.20)

[Description]
Extracts the on current, off current, and subthreshold slope from the Id-Vg characteristics.

[Device Under Test]
MOSFET, 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal, VgStart < 0
VgStop: Sweep stop voltage for Gate terminal, VgStop=Vd
VgStep: Sweep step voltage for Gate terminal
Drain: SMU connected to Drain terminal, constant voltage output
Vd: Drain voltage
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
IsubsLimit: Substrate current compliance
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
Slope=1/diff(lgt(Idrain),Vgate)
SlopeMin=min(abs(Slope))

[Analysis Function]
Ion=@L1Y1 (Y1 intercept of Line1)
Ioff=@L2Y1 (Y1 intercept of Line2)

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LOG)
Y2 axis: Slope (LINEAR)

[Parameters Display Area]
SlopeMin: minimum Slope value
Ion: on current (drain current at Vg=VgStop)

Ioff: off current (drain current at Vg=0)

[Auto Analysis]
Line1: Horizontal line through the Y1 data at Vgate=Vd(=VgStop)
Line2: Horizontal line through the Y1 data at Vgate=0
Marker: Point of Slope=SlopeMin

2.23 Isub-Vg: Isub-Lg characteristics (A.01.20)

[Description]
Measures the substrate current vs gate voltage characteristics of MOSFET.

[Device Under Test]
MOSFET, 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value)
Lg: Gate length
Wg: Gate width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time (SHORT, MEDIUM, LONG) default: MEDIUM
Gate: SMU connected to Gate terminal, primary sweep voltage output
Drain: SMU connected to Drain terminal, secondary sweep voltage output
Subs: SMU connected to Substrate terminal, constant voltage output
Source: SMU connected to Source terminal, constant voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time
Vsubs: Substrate terminal voltage
IgLimit: Gate current compliance
IdLimit: Drain current compliance
IsubsLimit: Substrate current compliance
Vs: Source terminal voltage
DrainMinRng: Minimum range for drain current measurement
SubsMinRng: Minimum range for substrate current measurement
GateMinRng: Minimum range for gate current measurement

[Measurement Parameters]
Substrate current Isubs

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Substrate current Isubs (LOG)

[List Display]
Gate voltage Vgate
Substrate current Isubs
Drain current Idrain
Gate current Igate

2.24 Simple Cgb : Evaluation of gate-substrate capacitance versus gate voltage (A.01.10)

[Application]
This application evaluates the gate-substrate capacitance of a Nch MOSFET.

[Device Measured]
Single device with four terminals.

[Parameter Setting]
Test parameters are specified for NMOS device under test.
Swept bias voltage parameters are specified by the gate voltage referenced to the source voltage (Vgs).

[Description of Measurement]
Gate voltage (Vgs) sweeps in accordance with the test parameter setting.
Gate capacitances are measured with Cp-G model applied while the bias voltage sweeps.

[Plot Display]
Measured gate capacitances in linear scale are plotted versus substrate voltage on the linear horizontal axis.

2.25 Simple Vth : Evaluation of Threshold Voltage (Vth) (A.01.10)

[Application]
This application evaluates the threshold voltage (Vth) of a Nch MOSFET.

[Device Measured]
Single device with four terminals.

[Parameter Setting]
Test parameters are specified for NMOS device under test.
Swept bias voltage parameters are specified by the gate voltage referenced to the source voltage (Vg).

[Description of Measurement]
Gate voltage (Vg) sweeps in accordance with the test parameter setting.
Currents flowing in drain terminal are measured while the gate voltage sweeps.

[Plot Display]
Measured drain currents and transconductance in linear scale are plotted versus gate voltage on the linear horizontal axis.
Maximum transconductance value (Gmmax) and threshold voltage (Vth) are extracted from the measurement data, then displayed in the parameters display area.

2.26 Vth Const Id: Constant current Vth (A.01.20)

[Description]
Measures the drain current vs gate voltage characteristics, and extracts the threshold voltage (Vth) by using the constant current method.

[Device Under Test]
MOSFET, 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Id@Vth: Drain current to decide the Vth
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Drain: SMU connected to Drain terminal, constant voltage output
Vd: Drain voltage
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
IsubsLimit: Substrate current compliance
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
gm=diff(Idrain,Vgate)

[Analysis Function]
Vth=@L1X (X intercept of Line1)

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Drain current Idrain (LOG)

[List Display]
Transconductance gm

[Parameters Display Area]
Threshold voltage Vth

[Auto Analysis]
Line1: Vertical line for Y1 at Idrain=Id@Vth

2.27 Vth gmMax : Linear region Vth (A.01.20)

[Description]
Extracts the threshold voltage (Vth) by using the extrapolation method for the linear region of the drain current vs gate voltage characteristics.

[Device Under Test]
MOSFET, 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Drain: SMU connected to Drain terminal, constant voltage output
Vd: Drain voltage
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
IsubsLimit: Substrate current compliance
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
gm=diff(Idrain,Vgate)

[Analysis Function]
gmMax=max(gm)
Von=@L1X (X intercept of Line1)
Vth=Von-Vd/2

Vth is given by the following formula.
Vth=Vg(gmMax)-Id(gmMax)/gmMax
Vd/2 is necessary to compensate the secondary term of Vd in theory.

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)

Y2 axis: Transconductance gm (LINEAR)
Y3 axis: Drain current Idrain (LOG)

[Parameters Display Area]
Threshold voltage Vth
Maximum gm value gmMax

[Auto Analysis]
Line1: Tangent line for Y1 at gm=gmMax

2.28 VthAndCgg-Vg ASU: Cgg-Vg, Id-Vg, using ASU (A.01.20)

[Description]
Measures the gate capacitance vs gate voltage characteristics, the drain current vs gate voltage measurement by using one MFCMU, two sets of HRSMU/ASU, and one SMU.

[Device Under Test]
MOSFET, 4 terminals

[Required Modules and Accessories]
One MFCMU module, two sets of HRSMU/ASU, and one SMU module are required.
ASU#1 connections: Output: Gate, SMU: HRSMU, AUX: MFCMU Low
ASU#2 connections for Cgg-Vg: Output: other 3 terminals, SMU: HRSMU, AUX: MFCMU High
ASU#2 connections for Id-Vg: Output: Source and Substrate, SMU: HRSMU, AUX: MFCMU High
Connection wire must be connected between the CMU Return terminals of ASUs.
Setting of ASU I/O Path, ASU tab, Configuration window: AUX

[Device Parameters]
Polarity: Nch (CMU/SMU forces the specified value) or Pch (CMU/SMU forces the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
GateAC: CMU connected to Gate terminal (CV sweep measurement)
GateDC: SMU connected to Gate terminal (primary sweep, voltage output)
SourceDC: SMU connected to Source and Substrate terminal (constant voltage output)
Drain: SMU connected to Drain terminal (constant voltage output)
IntegTime: Integration time
IgLimit: Gate current compliance
IdLimit: Drain current compliance
IsubsLimit: Substrate current compliance
HoldTime: Hold time
DelayTime: Delay time
VgsBiasStart: Cgg-Vg measurement start voltage
VgsBiasStop: Cgg-Vg measurement stop voltage
VgsBiasStep: Cgg-Vg measurement step voltage
OscLevel: Cgg-Vg measurement signal level
FREQ: Cgg-Vg measurement frequency
VgsStartDC: Id-Vg measurement start voltage
VgsStopDC: Id-Vg measurement stop voltage
VgsStepDC: Id-Vg measurement step voltage
Vd: Drain current

[Extended Test Parameters]
DrainMinRng: Minimum range for the drain current measurement
GateMinRng: Minimum range for the gate current measurement

[Cgg-Vg: Measurement Parameters]
Parallel capacitance Cp
Conductance G

[Cgg-Vg: User Function]
PI=3.141592653589

D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
Vgate=-Vsource
Cp_S=Cp/Lg/Wg
Cp_W=Cp/Wg

[Cgg-Vg: X-Y Graph]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Gate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[Cgg-Vg: List Display]
Gate voltage Vgate
Parallel capacitance Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta

[Id-Vg: Measurement Parameters]
Drain current Idrain

[Id-Vg: User Function]
gm=delta(Idrain)/delta(Vgate)
gmMax=max(gm)

[Id-Vg: Analysis Function]
Vth=@L1X (X intercept of Line1)

[Id-Vg: X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Transconductance gm (LINEAR)

[Id-Vg: List Display]
Gate current Igate

[Id-Vg: Parameters Display Area]
Maximum gm value gmMax
Threshold voltage Vth

[Id-Vg: Auto Analysis]
Line1: Tangent line for Y1 at gm=gmMax

2.29 VthAndCgg-Vg SCUU: Cgg-Vg, Id-Vg, using SCUU (A.01.20)

[Description]
Measures the gate capacitance vs gate voltage characteristics, the drain current vs gate voltage measurement by using one MFCMU, three SMUs, and a set of SCUU/GSWU.

[Device Under Test]
MOSFET, 4 terminals

[Required Modules and Accessories]
One MFCMU module, three SMU modules, and a set of SCUU/GSWU are required.
SCUU connections (Cgg-Vg): Output1: terminals other than Gate, Output2: Gate
SCUU connections (Id-Vg): Output1: Source and Substrate, Output2: Gate
Connection wire must be connected between the GSWU and the DUT interface High/Low guard lines for the capacitance measurements.

[Device Parameters]
Polarity: Nch (CMU/SMU forces the specified value) or Pch (CMU/SMU forces the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
GateAC: CMU connected to Gate terminal (CV sweep measurement)
GateDC: SMU connected to Gate terminal (primary sweep, voltage output)
SourceDC: SMU connected to Source and Substrate terminal (constant voltage output)
Drain: SMU connected to Drain terminal (constant voltage output)
Vd: Drain current
IntegTime: Integration time
IgLimit: Gate current compliance
IdLimit: Drain current compliance
IsLimit: Source current compliance
HoldTime: Hold time
DelayTime: Delay time
VgsBiasStart: Cgg-Vg measurement start voltage
VgsBiasStop: Cgg-Vg measurement stop voltage
VgsBiasStep: Cgg-Vg measurement step voltage
OscLevel: Cgg-Vg measurement signal level
FREQ: Cgg-Vg measurement frequency
VgsStartDC: Id-Vg measurement start voltage
VgsStopDC: Id-Vg measurement stop voltage
VgsStepDC: Id-Vg measurement step voltage

[Extended Test Parameters]
DrainMinRng: Minimum range for the drain current measurement
GateMinRng: Minimum range for the gate current measurement

[Cgg-Vg: Measurement Parameters]
Parallel capacitance Cp
Conductance G

[Cgg-Vg: User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)

Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
Vgate=-Vsource
Cp_S=Cp/Lg/Wg
Cp_W=Cp/Wg

[Cgg-Vg: X-Y Graph]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Gate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[Cgg-Vg: List Display]
Gate voltage Vgate
Parallel capacitance Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta

[Id-Vg: Measurement Parameters]
Drain current Idrain

[Id-Vg: User Function]
gm=delta(Idrain)/delta(Vgate)
gmMax=max(gm)

[Id-Vg: Analysis Function]
Vth=@L1X (X intercept of Line1)

[Id-Vg: X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Transconductance gm (LINEAR)

[Id-Vg: List Display]
Gate current Igate

[Id-Vg: Parameters Display Area]
Maximum gm value gmMax
Threshold voltage Vth

[Id-Vg: Auto Analysis]
Line1: Tangent line for Y1 at gm=gmMax

2.30 Vth-Lg: Vth-Lg characteristics (A.01.20)

[Description]
Measures the Id-Vg characteristics of MOSFET with different Lg (gate length) and plots the Vth's dependency on Lg (threshold voltage).

[Device Under Test]
MOSFET, 4 terminals

[Required Modules and Accessories]
Agilent B2200A or B2201A switching matrix 1 unit
GPIB cable

Connect B2200A/B2201A to B1500A with a measuring cable and GPIB cable.
Set information on B1500A SMU channel's connection to the B2200A/B2201A input port properly on the Switching Matrix tab screen of the Configuration window.
Set the output channel number of B2200A/B2201A connected to each terminal of a device under test properly in the G#/D#/E#/S#/Sb# field (# is an integer from 1 to 12) of Test Parameters area.
The maximum number of devices connected at once depends on the number of matrix modules mounted on B2200A/B2201A. Maximum three devices can be connected to one module at once.

[Setting of Lg#/G#/D#/S#/Sb# field (# is an integer from 1 to 12)]
Set one device for Lg#(gate length)/G#(gate)/D#(drain)/S#(source)/Sb#(substrate). Lg1<Lg2<Lg3… must be satisfied. Enter zero for a field with no device.

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value)
Temp: Temperature (deg)
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
GateSMU: SMU connected to Gate terminal, primary sweep voltage output
DrainSMU: SMU connected to Drain terminal, constant voltage output
SbSMU: SMU connected to Substrate, constant voltage output
SourceSMU: SMU connected to Source terminal, constant voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Vd: Drain voltage, ideally at around 100mV
Vsubs: Substrate voltage
Wg: Gate width
Lg1 - Lg12: Gate length for MOSFETs
G1 - G12: SWM Pin Assign setting for Gate of devices
D1 - D12: SWM Pin Assign setting for Drain of devices
S1 - S12: SWM Pin Assign setting for Source of devices
Sb1 - Sb12: SWM Pin Assign setting for Subs of devices

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
IsubsLimit: Substrate current compliance
HoldTime: Hold time
DelayTime: Delay time

Vth_Min: Minimum Vth value for graph scale
Vth_Max: Maximum Vth value for graph scale
gmMax_Min: Minimum gmMax value for graph scale
gmMax_Max: Maximum gmMax value for graph scale
DrainMinRng: Minimum range for drain current measurement

[Measurement Parameters]
Idrain: Drain current

[User Function]
gm=diff(Idrain,Vgate)

[Analysis Function]
gmMax=max(gm)
Von=@L1X (X intercept of Line1)
Vth=Von-Vd/2

Vth is given by the following formula.
Vth=Vg(gmMax)-Id(gmMax)/gmMax
Vd/2 is for compensation of the secondary term of Vd in the theoretical formula.

[Auto Analysis]
Line1: Tangent line for Y1 at gm=gmMax

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Transconductance gm (LINEAR)
Y3 axis: Drain current Idrain (LOG)

[List Display]
Gate voltage Vgate
Source voltage Vsource
Drain voltage Vdrain
Substrate voltage Vsubs
Drain current Idrain
Transconductance gm

[Parameters Display Area]
Threshold voltage Vth
Maximum transconductance value gmMax

[Test Output: X-Y Graph]
X axis: Gate length LgList (LINEAR)
Y1 axis: Threshold voltage VthList (LINEAR)
Y2 axis: Maximum transconductance value gmMaxList (LINEAR)

[Test Output: List Display]
Gate length LgList
Threshold voltage VthList
Maximum transconductance value gmMaxList

2.31 Vth-Wg: Vth-Wg characteristics (A.01.20)

[Description]
Measures the Id-Vg characteristics of MOSFET with different Wg (gate width) and plots the Vth's dependency on Wg (threshold voltage).

[Device Under Test]
MOSFET, 4 terminals

[Required Modules and Accessories]
Agilent B2200A or B2201A switching matrix 1 unit
GPIB cable

Connect B2200A/B2201A to B1500A with a measuring cable and GPIB cable.
Set information on B1500A SMU channel's connection to the B2200A/B2201A input port properly on the Switching Matrix tab screen of the Configuration window.
Set the output channel number of B2200A/B2201A connected to each terminal of a device under test properly in the G#/D#/E#/S#/Sb# field (# is an integer from 1 to 12) of Test Parameters area.
The maximum number of devices connected at once depends on the number of matrix modules mounted on B2200A/B2201A. Maximum three devices can be connected to one module at once.

[Setting of Wg#/G#/D#/S#/Sb# field (# is an integer from 1 to 12)]
Set one device for Wg#(gate width)/G#(gate)/D#(drain)/S#(source)/Sb#(substrate). Wg1<Wg2<Wg3… must be satisfied. Enter zero for a field with no device.

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value)
Temp: Temperature (deg)
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
GateSMU: SMU connected to Gate terminal, primary sweep voltage output
DrainSMU: SMU connected to Drain terminal, constant voltage output
SbSMU: SMU connected to Substrate, constant voltage output
SourceSMU: SMU connected to Source terminal, constant voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Vd: Drain voltage, ideally at around 100mV
Vsubs: Substrate voltage
Lg: Gate length
Wg1 - Wg12: Gate width for MOSFETs
G1 - G12: SWM Pin Assign setting for Gate of devices
D1 - D12: SWM Pin Assign setting for Drain of devices
S1 - S12: SWM Pin Assign setting for Source of devices
Sb1 - Sb12: SWM Pin Assign setting for Subs of devices

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
IsubsLimit: Substrate current compliance
HoldTime: Hold time
DelayTime: Delay time

Vth_Min: Minimum Vth value for graph scale
Vth_Max: Maximum Vth value for graph scale
gmMax_Min: Minimum gmMax value for graph scale
gmMax_Max: Maximum gmMax value for graph scale
DrainMinRng: Minimum range for drain current measurement

[Measurement Parameters]
Idrain: Drain current

[User Function]
gm=diff(Idrain,Vgate)

[Analysis Function]
gmMax=max(gm)
Von=@L1X (X intercept of Line1)
Vth=Von-Vd/2

Vth is given by the following formula.
Vth=Vg(gmMax)-Id(gmMax)/gmMax
Vd/2 is for compensation of the secondary term of Vd in the theoretical formula.

[Auto Analysis]
Line1: Tangent line for Y1 at gm=gmMax

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Transconductance gm (LINEAR)
Y3 axis: Drain current Idrain (LOG)

[List Display]
Gate voltage Vgate
Source voltage Vsource
Drain voltage Vdrain
Substrate voltage Vsubs
Drain current Idrain
Transconductance gm

[Parameters Display Area]
Threshold voltage Vth
Maximum transconductance value gmMax

[Test Output: X-Y Graph]
X axis: Gate width WgList (LINEAR)
Y1 axis: Threshold voltage VthList (LINEAR)
Y2 axis: Maximum transconductance value gmMaxList (LINEAR)

[Test Output: List Display]
Gate width WgList
Threshold voltage VthList
Maximum transconductance value gmMaxList

3 Discrete

1.	BJT GummelPlot:	Bipolar transistor gummel characteristics (A.01.20)
2.	BJT Ic-Vc Ib :	Bipolar transistor Ic-Vc characteristics (A.01.20)
3.	Diode IV Fwd:	Diode forward bias characteristics (A.01.20)
4.	Diode IV Rev:	Diode reverse bias characteristics (A.01.20)
5.	FET Id-Vd:	MOSFET Id-Vd characteristics (A.01.20)
6.	FET Id-Vg :	MOSFET Id-Vg characteristics (A.01.20)

3.1 BJT GummelPlot: Bipolar transistor gummel characteristics (A.01.20)

[Description]
Measures the gummel characteristics of bipolar transistor.

[Device Under Test]
Bipolar junction transistor

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance
Pmax: Power compliance

[Test Parameters]
IntegTime: Integration time
Base: SMU connected to Base terminal, primary sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Collector: SMU connected to Collector terminal, constant voltage output
Vc: Collector voltage
Emitter: SMU connected to Emitter terminal, constant voltage output

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current measurement
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Base current Ibase
Collector current Icurrent

[User Function]
IePerArea=Iemitter/Le/We
IbPerArea=Ibase/Le/We
IcPerArea=Icollector/Le/We
hfe=Icollector/Ibase

[Analysis Function]
hfemax=max(hfe)

[X-Y Plot]
X axis: Base voltage Vbase (LINEAR)
Y1 axis: Base current Ibase (LOG)
Y2 axis: Collector current Icollector (LOG)
Y3 axis: Current amplificaiton factor hfe (LINEAR)

[User Function]
Emitter current per unit area of Emitter IePerArea

Base current per unit area of Emitter IbPerArea
Collector current per unit area of Emitter IcPerArea

[Parameters Display Area]
hfe maximum value hfemax

3.2 BJT Ic-Vc Ib : Bipolar transistor Ic-Vc characteristics (A.01.20)

[Description]
Measures the collector current vs collector voltage characteristics of bipolar transistor.

[Device Under Test]
Bipolar junction transistor

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Temp: Temperature
IcMax: Collector current compliance
Pmax: Power compliance

[Test Parameters]
IntegTime: Integration time
Collector: SMU connected to Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
Base: SMU connected to Base terminal, secondary sweep voltage output
IbStart: Sweep start current for Base terminal
IbStop: Sweep stop current for Base terminal
IbStep: Sweep step current for Base terminal
VbLimit: Base voltage compliance
Emitter: SMU connected to Emitter terminal, constant voltage output

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current Icollector
Base current Ibase

[User Function]
hfe=Icollector/Ibase
VA=Icollector*diff(Vcollector,Icollector)-Vcollector

[X-Y Plot]
X axis: Collector voltage Vcollector (LINEAR)
Y1 axis: Collector current Icollector (LINEAR)

[User Function]
Current amplifier factor hfe
Early voltage VA

[List Display]
Base current Ibase

3.3 Diode IV Fwd: Diode forward bias characteristics (A.01.20)

[Description]
Measures the forward bias anode voltage vs anode current characteristics.

[Device Under Test]
Diode

[Device Parameters]
Temp: Temperature
Imax: Current compliance

[Test Parameters]
IntegTime: Integration time
Anode: SMU connected to Anode terminal, primary sweep voltage output
VanodeStart: Sweep start voltage for Anode terminal
VanodeStop: Sweep stop voltage for Anode terminal
VanodeStep: Sweep step voltage for Anode terminal
Cathode: SMU connected to Cathode terminal, constant voltage output

[Extended Test Parameters]
Vcathode: Cathode voltage
HoldTime: Hold time
DelayTime: Delay time
AnodeMinRng: Minimum range for the anode current measurement

[Measurement Parameters]
Anode current Ianode

[X-Y Plot]
X axis: Anode voltage Vanode (LINEAR)
Y1 axis: Anode current Ianode (LINEAR)
Y2 axis: Anode current Ianode (LOG)

3.4 Diode IV Rev: Diode reverse bias characteristics (A.01.20)

[Description]
Measures the reverse bias anode voltage vs anode current characteristics.

[Device Under Test]
Diode

[Device Parameters]
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Anode: SMU connected to Anode terminal, primary sweep voltage output
VanodeStart: Sweep start voltage for Anode terminal
VanodeStop: Sweep stop voltage for Anode terminal
VanodeStep: Sweep step voltage for Anode terminal
IanodeLimit: Anode current compliance
Cathode: SMU connected to Cathode terminal, constant voltage output

[Extended Test Parameters]
Vcathode: Cathode voltage
HoldTime: Hold time
DelayTime: Delay time
AnodeMinRng: Minimum range for the anode current measurement

[Measurement Parameters]
Anode current Ianode

[X-Y Plot]
X axis: Anode voltage Vanode (LINEAR)
Y1 axis: Anode current Ianode (LOG)

3.5 FET Id-Vd: MOSFET Id-Vd characteristics (A.01.20)

[Description]
Measures the drain current vs drain voltage characteristics of MOSFET.

[Device Under Test]
MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Drain: SMU connected to Drain terminal, primary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
Gate: SMU connected to Gate terminal, secondary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
IgLimit: Gate current compliance
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain

[X-Y Plot]
X axis: Drain voltage Vdrain (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)

3.6 FET Id-Vg : MOSFET Id-Vg characteristics (A.01.20)

[Description]
Measures the drain current vs gate voltage characteristics of MOSFET.

[Device Under Test]
MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
IgLimit: Gate current compliance
Drain: SMU connected to Drain terminal, secondary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
gm: Transconductance gm=diff(Idrain,Vgate)

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Drain current Idrain (LOG)
Y3 axis: Transconductance gm (LINEAR)

4 Memory

1. Flash Ccf-V: Flash memory cell Control Gate to Floating Gate capacitance (A.01.11)
2. Flash Cfb-V: Flash memory cell Floating Gate-Substrate capacitance (A.01.11)
3. Flash Cgg-Vcg: Flash memory cell Gate capacitance (A.01.11)
4. NandFlash2 Endurance 3devices:
   Repeatedly tests write/erase on a NAND-type flash memory cell, simultaneously using three devices (A.01.20).
5. NandFlash2 Endurance: NAND flash memory cell endurance test (A.01.20)
6. NandFlash2 IV-Erase-IV: NAND flash memory cell Id-Vg, Erase, Id-Vg (A.01.20)
7. NandFlash2 IV-Write-IV: NAND flash memory cell Id-Vg, Write, Id-Vg (A.01.20)
8. NandFlash2 Retention(ErasedCell):
   NAND flash memory cell Data retention test after Erase (A.01.20)
9. NandFlash2 Retention(WrittenCell):
   NAND flash memory cell Data retention test after Write (A.01.20)
10. NandFlash2 Vth(ErasingTimeDependence):
    NAND flash memory cell erasing time dependence test (A.01.20)
11. NandFlash2 Vth(WritingTimeDependence):
    NAND flash memory cell writing time dependence test (A.01.20)
12. NandFlash2 WordDisturb(ErasedCell):
    NAND flash memory cell erase-disturb test (A.01.20)
13. NandFlash2 WordDisturb(WrittenCell):
    NAND flash memory cell read-disturb test (A.01.20)

4.1 Flash Ccf-V: Flash memory cell Control Gate to Floating Gate capacitance (A.01.11)

[Description]
Measures the Control Gate to Floating Gate capacitance (Ccf), and plots the Ccf-V characteristics.

[Device Under Test]
Flash memory cell
Connect the Control Gate to CMU High and the Floating Gate to CMU Low.
Connect the other terminals to the ground unit (GNDU).

[Device Parameters]
Lg: Gate length
Wg: Gate width
Temp: Temperature
M: Number of cells connected in parallel. M=1 for the single cell.

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
ControlGate: CMU connected between Control Gate and Floating Gate (CV sweep measurement)
VcfStart: DC bias start voltage
VcfStop: DC bias stop voltage
VcfStep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
CsPerCell=Cs/M
CpPerCell=Cp/M

[X-Y Graph]
X axis: DC bias Vcontrolgate (LINEAR)
Y1 axis: Control Gate to Floating Gate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Dissipation factor D (LINEAR)
Y3 axis: Conductance G (LINEAR)

[List Display]

Measurement frequency Freq
DC bias Vcontrolgate
Control Gate to Floating Gate capacitance (parallel capacitance) Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta
Series capacitance per cell CsPerCell
Parallel capacitance per cell CpPerCell

4.2 Flash Cfb-V: Flash memory cell Floating Gate-Substrate capacitance (A.01.11)

[Description]
Measures the Floating Gate-Substrate capacitance (Ccf), and plots the Cfb-V characteristics.
DC bias output is performed from -VfbStart to -VfbStop in -VfbStep steps.

[Device Under Test]
Flash memory cell
Connect the Control Gate to ground unit (GNDU), the Floating Gate to CMU Low, and the other terminals to CMU High.

[Device Parameters]
Lg: Gate length
Wg: Gate width
Temp: Temperature
M: Number of cells connected in parallel. M=1 for the single cell.

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
FloatingGate: CMU connected between Floating Gate and Substrate (CV sweep measurement)
VfbStart: DC bias start voltage
VfbStop: DC bias stop voltage
VfbStep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
CsPerCell=Cs/M
CpPerCell=Cp/M
Vfb=-Vsubs

[X-Y Graph]
X axis: DC bias Vfb (LINEAR)
Y1 axis: Floating Gate-Substrate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Dissipation factor D (LINEAR)
Y3 axis: Conductance G (LINEAR)

[List Display]
Measurement frequency Freq
DC bias Vfb
Floating Gate-Substrate capacitance (parallel capacitance) Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta
Series capacitance per cell CsPerCell
Parallel capacitance per cell CpPerCell

4.3 Flash Cgg-Vcg: Flash memory cell Gate capacitance (A.01.11)

[Description]
Measures the Gate capacitance (Cgg), and plots the Cgg-Vcs characteristics.
DC bias output is performed from -VcsStart to -VcsStop in -VcsStep steps.

[Device Under Test]
Flash memory cell
Open the Floating Gate, and connect the Control Gate to CMU Low and the other terminals to CMU High.

[Device Parameters]
Lg: Gate length
Wg: Gate width
Temp: Temperature
M: Number of cells connected in parallel. M=1 for the single cell.

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
ControlGate: CMU connected between Control Gate and Substrate (CV sweep measurement)
VcsStart: DC bias start voltage
VcsStop: DC bias stop voltage
VcsStep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
CsPerCell=Cs/M
CpPerCell=Cp/M
Vcs=-Vsubs

[X-Y Graph]
X axis: DC bias Vcs (LINEAR)
Y1 axis: Gate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Dissipation factor D (LINEAR)
Y3 axis: Conductance G (LINEAR)

[List Display]
Measurement frequency Freq

DC bias Vcs
Gate capacitance (parallel capacitance) Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta
Series capacitance per cell CsPerCell
Parallel capacitance per cell CpPerCell

4.4 NandFlash2 Endurance 3devices: Repeatedly tests write/erase on a NAND-type flash memory cell, simultaneously using three devices (A.01.20)

[Description]
Repeatedly tests write/erase on a NAND-type flash memory cell. Plots the number of writes/erases vs threshold voltage characteristic. Maximum three devices can be measured at once.

[Device Under Test]
NAND-type flash memory cell, 4 terminals x 3 devices
When some device is destroyed during write/erase, a desired voltage may not be applied to other devices.

[Required Modules and Accessories]
Agilent B2200A or B2201A switching matrix 1 unit
Agilent 81110A pulse generator (2-output, PGU1 and PGU2) 1 unit
GPIB cable

Connect 81110A, B2200A/B2201A and B1500A with a measuring cable and GPIB cable.
Set information on B1500A SMU channel's connection to the B2200A/B2201A input port properly on the Switching Matrix tab screen of the Configuration window.
Set information on 811100A output channel's connection to B2200A/B2201A input port properly in the Parameters area of PulseGate and PulseDrain fields. Set B2200A/B2201A input ports connected to the output channel of a gate pulse and drain pulse in these fields.
Set the output channel number of B2200A/B2201A connected to each terminal of a measured device properly in the Tr#Gate/Tr#Drain/Tr#Source/Tr#Subs field (# is an integer from 1 to 3) of the Test Parameters area.

[Device Parameters]
Lg: Gate length
Wg: Gate width
Temp: Temperature (deg)
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
TotalWriteAndEraseCycles: Number of write/erase cycles
Tr1Gate - Tr3Gate: SWM Pin Assign setting for Gate of devices
Tr1Drain - Tr3Drain: SWM Pin Assign setting for Drain of devices
Tr1Source - Tr3Source: SWM Pin Assign setting for Source of devices
Tr1Subs - Tr3Subs: SWM Pin Assign setting for Subs of devices

PgAdd: GPIB address of pulse generator
PulseGate: SMU connected to Gate terminal
PulseDrain: SMU connected to Drain terminal
ErasePeriod: Write/Erase pulse period
EraseDelay: Write/Erase pulse delay
EraseWidth: Write/Erase pulse width
EraseLeadTime: Pulse leading edge transition time
EraseTrailTime: Pulse trailing edge transition time
Verase: Pulse voltage output level, High
BaseValue: Pulse voltage output level, Low

[Test Parameters for Vth Acquisition]
MeasGate: SMU connected to Gate terminal
MeasDrain: SMU connected to Drain terminal

MeasSource: SMU connected to Source terminal
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Vd: Drain voltage
IgLimit: Gate current compliance
Id@Vth: Current determining the threshold voltage

[Extended Test Parameters for Vth Acquisition]
Vs: Source voltage
HoldTime: Hold time
DelayTime: Delay time
Vth_Min: Minimum Vth value for graph scale
Vth_Max: Maximum Vth value for graph scale
DrainMinRng1: Minimum range for drain current measurement on device 1
DrainMinRng2: Minimum range for drain current measurement on device 2
DrainMinRng3: Minimum range for drain current measurement on device 3

[Measurement Parameters]
[Measurement Paramaters for Vth Acquisition after Write Operation]
Drain current: Idrain

[Measurement Parameters for Vth Acquisition after Erase Operation]
Drain current: Idrain

[Analysis Function]
[Analysis Function for Vth Acquisition after Write Operation]
Vth@Id=@L1X (X intercept of Line1)

[Analysis Function for Vth Acquisition after Erase Operation]
Vth@Id=@L1X (X intercept of Line1)

[Auto Analysis]
[Auto Analysis for Vth Acquisition after Write Operation]
Line1: Idrain=X intercept of Id@Vth

[Auto Analysis for Vth Acquisition after Erase Operation]
Line1: Idrain=X intercept of Id@Vth

[X-Y Plot]
[X-Y Plot for Vth Acquisition after Write Operation]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LOG)

[X-Y Plot for Vth Acquisition after Erase Operation]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LOG)

[List Display]
[List Display for Vth Acquisition after Write Operation]
Gate voltage Vgate
Drain current Idrain

[List Display for Vth Acquisition after Erase Operation]
Gate voltage Vgate

Drain current Idrain

[Test Output: X-Y Graph]
X axis: Number of write/erase cycles CycleList (LOG)
Y1 axis: Vth value after write operation on device 1 Dev1_VthWrittenList (LINEAR)
Y2 axis: Vth value after write operation on device 2 Dev2_VthWrittenList (LINEAR)
Y3 axis: Vth value after write operation on device 3 Dev3_VthWrittenList (LINEAR)
Y4 axis: Vth value after erase operation on device 1 Dev1_VthErasedList (LINEAR)
Y5 axis: Vth value after erase operation on device 2 Dev2_VthErasedList (LINEAR)
Y6 axis: Vth value after erase operation on device 3 Dev3_VthErasedList (LINEAR)

[Test Output: List Display]
Number of write/erase cycles CycleList
Vth value after write operation on device 1 Dev1_VthWrittenList
Vth value after write operation on device 2 Dev2_VthWrittenList
Vth value after write operation on device 3 Dev3_VthWrittenList
Vth value after erase operation on device 1 Dev1_VthErasedList
Vth value after erase operation on device 2 Dev2_VthErasedList
Vth value after erase operation on device 3 Dev3_VthErasedList

[Test Setup Details]
Refer to "NandFlash2 IV-Write-IV" and "NandFlash2 IV-Erase-IV."

4.5 NandFlash2 Endurance: NAND flash memory cell endurance test (A.01.20)

[Description]
Performs the endurance test for the NAND type flash memory cell and plots the number of write/erase operation vs threshold voltage characteristics.

[Device Under Test]
NAND-type flash memory cell
Connect the Control Gate to the ASU1 Output, and the Drain to the ASU2 Output.
Open the Floating Gate, and connect the other terminals to the ASU3 Output.

[Required Modules and Accessories]
Agilent 81110A pulse generator (2-output, PGU1 and PGU2) 1 unit
HRSMU/ASU 3 sets (ASU1, ASU2, and ASU3)

ASU1 connections: Output: Control Gate, SMU: HRSMU, AUX: PGU1
ASU2 connections: Output: Drain, SMU: HRSMU, AUX: PGU2
ASU3 connections: Output: Source and Substrate, SMU: HRSMU, AUX: PGU2
Setting of ASU I/O Path, ASU tab, Configuration window: AUX

[Device Parameters]
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
Gate: SMU connected to Gate terminal, primary sweep voltage output
Drain: SMU connected to Drain terminal, constant voltage output
Source: SMU connected to Source and Substrate terminals, constant voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Vd: Drain voltage
Id@Vth: Drain current to decide the Vth
IntegTime: Integration time
TotalWriteAndEraseCycles: Total number of write/erase operation
WritePulsePeriod: Write pulse period
WritePulseDelay: Write pulse delay
WritePulseWidth: Write pulse width
WriteLeadingTime: Write pulse leading edge transition time
WriteTrailingTime: Write pulse trailing edge transition time
Vwrite: Write pulse output level
ErasePulsePeriod: Erase pulse period
ErasePulseDelay: Erase pulse delay
ErasePulseWidth: Erase pulse width
EraseLeadingTime: Erase pulse leading edge transition time
EraseTrailingTime: Erase pulse trailing edge transition time
Verase: Erase pulse output level

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
HoldTime: Hold time

DelayTime: Delay time
PgAdd: GPIB address of pulse generator
BaseValue: Pulse base value
NoOfPulse: Number of output pulses

[Test Output: X-Y Graph]
X axis: Number of write/erase operation (LOG)
Y1 axis: Threshold voltage after write VthWrittenList (LINEAR)
Y2 axis: Threshold voltage after erase VthErasedList (LINEAR)

[Test Setup Details]
See NandFlash2 IV-Write-IV and NandFlash2 IV-Erase-IV.

4.6 NandFlash2 IV-Erase-IV: NAND flash memory cell Id-Vg, Erase, Id-Vg (A.01.20)

[Description]
Measures the Id-Vg characteristics of NAND-type flash memory cell, performs the data erase operation, measures the Id-Vg characteristics again, and plots the both Id-Vg characteristics on a graph. Uses pulse generator (2-output) 1 unit and HRSMU/ASU 2 sets.
Before the Id-Vg measurements, the initial pulse will be applied to the device under test.

[Device Under Test]
NAND-type flash memory cell
Connect the Control Gate to a SMU and the Drain to the ASU1 Output.
Open the Floating Gate. And connect the other terminals to the ASU2 Output.

[Required Modules and Accessories]
Agilent 81110A pulse generator (2-output, PGU1 and PGU2) 1 unit
HRSMU/ASU 2 sets (ASU1 and ASU2)

ASU1 connections: Output: Drain, SMU: HRSMU, AUX: PGU1
ASU2 connections: Output: Source and Substrate, SMU: HRSMU, AUX: PGU1
Setting of ASU I/O Path, ASU tab, Configuration window: AUX

PGU1 is connected to keep the setup for the data write operation.

[Device Parameters]
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep voltage output
Drain: SMU connected to Drain terminal, constant voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Vd: Drain voltage
Id@Vth: Drain current to decide the Vth
Source: SMU connected to Source and Substrate terminals, constant voltage output
PulsePeriod: Erase pulse period
PulseDelay: Erase pulse delay
PulseWidth: Erase pulse width
LeadingTime: Pulse leading edge transition time
TrailingTime: Pulse trailing edge transition time
Verase: Erase pulse output level

[Extended Test Parameters]
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
BaseValue: Erase pulse base value
PgAdd: GPIB address of pulse generator

NoOfPulse: Number of output pulses for the erase operation

[Initial pulse setup parameters]
Pulse period Period2=50 s
Pulse delay Delay2=0 s
Pulse duty cycle Dcyc2=50 %
Pulse output level Level2=0 V
Pulse base value Base2=200 mV
Number of output pulses TrigCount=1
The parameters are defined in the ForcePG2 setup of the Test Contents, and can be changed by using the Test Definition editor.

[Measurement Parameters]
Drain current Idrain (defined in Id-Vg_Initial and Id-Vg_Erased setup)

[User Function]
IdrainPerWg=Idrain/Wg (defined in Id-Vg_Initial and Id-Vg_Erased setup)

[Analysis Function]
VthBefore=@L1X (X intercept of Line1, defined in Id-Vg_Initial setup)
VthAfter=@L1X (X intercept of Line1, defined in Id-Vg_Erased setup)

[Auto Analysis]
Line1: Vertical line for Y1 at Idrain=Id@Vth

[Test Output: X-Y Graph]
X axis: Gate voltage VgateList (LINEAR)
Y1 axis: Drain current before Erase operation IdInitialList (LOG)
Y2 axis: Drain current after Erase operation IdErasedList (LOG)

[Test Output: Parameters]
Threshold voltage before Erase operation VthInitial
Threshold voltage after Erase operation VthErased

4.7 NandFlash2 IV-Write-IV: NAND flash memory cell Id-Vg, Write, Id-Vg (A.01.20)

[Description]
Measures the Id-Vg characteristics of NAND-type flash memory cell, performs the data write operation, measures the Id-Vg characteristics again, and plots the both Id-Vg characteristics on a graph. Uses pulse generator (2-output) 1 unit and HRSMU/ASU 1 set.
Before the Id-Vg measurements, the initial pulse will be applied to the device under test.

[Device Under Test]
NAND-type flash memory cell
Connect the Control Gate to the ASU Output, and the Drain to a SMU.
Open the Floating Gate. And connect the other terminals to a SMU.

[Required Modules and Accessories]
Agilent 81110A pulse generator (2-output, PGU1 and PGU2) 1 unit
HRSMU/ASU 1 set

ASU connections: Output: Control Gate, SMU: HRSMU, AUX: PGU1
Setting of ASU I/O Path, ASU tab, Configuration window: AUX

[Device Parameters]
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep voltage output
Drain: SMU connected to Drain terminal, constant voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Vd: Drain voltage
Id@Vth: Drain current to decide the Vth
Source: SMU connected to Source and Substrate terminals, constant voltage output
PulsePeriod: Write pulse period
PulseDelay: Write pulse delay
PulseWidth: Write pulse width
LeadingTime: Pulse leading edge transition time
TrailingTime: Pulse trailing edge transition time
Vwrite: Write pulse output level

[Extended Test Parameters]
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
BaseValue: Write pulse base value
PgAdd: GPIB address of pulse generator
NoOfPulse: Number of output pulses for the write operation

[Initial pulse setup parameters]

Pulse period Period2=50 s
Pulse delay Delay2=0 s
Pulse duty cycle Dcyc2=50 %
Pulse output level Level2=0 V
Pulse base value Base2=200 mV
Number of output pulses TrigCount=1
The parameters are defined in the ForcePG2 setup of the Test Contents, and can be changed by using the Test Definition editor.

[Measurement Parameters]
Drain current Idrain (defined in Id-Vg_Initial and Id-Vg_Written setup)

[User Function]
IdrainPerWg=Idrain/Wg (defined in Id-Vg_Initial and Id-Vg_Written setup)

[Analysis Function]
VthBefore=@L1X (X intercept of Line1, defined in Id-Vg_Initial setup)
VthAfter=@L1X (X intercept of Line1, defined in Id-Vg_Written setup)

[Auto Analysis]
Line1: Vertical line for Y1 at Idrain=Id@Vth

[Test Output: X-Y Graph]
X axis: Gate voltage VgateList (LINEAR)
Y1 axis: Drain current before Write operation IdInitialList (LOG)
Y2 axis: Drain current after Write operation IdWrittenList (LOG)

[Test Output: Parameters]
Threshold voltage before Write operation VthInitial
Threshold voltage after Write operation VthWritten

4.8 NandFlash2 Retention(ErasedCell): NAND flash memory cell Data retention test after Erase (A.01.20)

[Description]
Performs the data retention test for the NAND type flash memory cell after the erase operation, and plots the accumulated time vs threshold voltage characteristics. The test is performed as follows.

1. Applies the erase pulse.
2. Measures the Id-Vg characteristics, and extracts the threshold voltage (Vth).
3. If the accumulated time is 100 seconds or less:
   Performs the drain current sampling measurement, 10 seconds in 1 second step.
   After the sampling measurement, measures the Id-Vg characteristics and extracts Vth.
4. If the accumulated time is more than 100 seconds:
   Performs the drain current sampling measurement, 100 seconds in 10 seconds step.
   After the sampling measurement, measures the Id-Vg characteristics and extracts Vth.
5. Repeats 3 or 4 until that the accumulated time overs the specified TotalRetentionTime.
   The available TotalRetentionTime value is 10 to 10000 seconds.

[Device Under Test]
NAND-type flash memory cell
Connect the Source and Substrate to the ASU1 Output, and the Drain to the ASU2 Output.
Open the Floating Gate, and connect the other terminals to the PGU2 output terminal.

[Required Modules and Accessories]
Agilent 81110A pulse generator (2-output, PGU1 and PGU2) 1 unit
HRSMU/ASU 2 sets (ASU1 and ASU2)

ASU1 connections: Output: Source and Substrate, SMU: HRSMU, AUX: PGU1
ASU2 connections: Output: Drain, SMU: HRSMU, AUX: PGU1
Setting of ASU I/O Path, ASU tab, Configuration window: AUX
PGU1 is connected to keep the setup for the data write operation.

[Device Parameters]
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
Gate: SMU connected to Gate terminal, primary sweep voltage output
Drain: SMU connected to Drain terminal, constant voltage output
Source: SMU connected to Source and Substrate terminals, constant voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Vd: Drain voltage
Id@Vth: Drain current to decide the Vth
IntegTime: Integration time
PulsePeriod: Erase pulse period
PulseDelay: Erase pulse delay
PulseWidth: Erase pulse width
Verase: Erase pulse output level
LeadingTime: Pulse leading edge transition time

TrailingTime: Pulse trailing edge transition time
TotalRetentionTime: Time to continue the test. 10 to 10000 seconds.

[Extended Test Parameters]
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
BaseValue: Erase pulse base value
PgAdd: GPIB address of pulse generator
NoOfPulse: Number of output pulses for the erase operation

[Test Output: X-Y Graph]
X axis: Time TimeList (LOG)
Y1 axis: Threshold voltage VthList (LINEAR)

[Test Setup Details]
See NandFlash2 IV-Erase-IV.

4.9 NandFlash2 Retention(WrittenCell): NAND flash memory cell Data retention test after Write (A.01.20)

[Description]

Performs the data retention test for the NAND type flash memory cell after the write operation, and plots the accumulated time vs threshold voltage characteristics. The test is performed as follows.

1. Applies the write pulse.
2. Measures the Id-Vg characteristics, and extracts the threshold voltage (Vth).
3. If the accumulated time is 100 seconds or less:
   Performs the drain current sampling measurement, 10 seconds in 1 second step.
   After the sampling measurement, measures the Id-Vg characteristics and extracts Vth.
4. If the accumulated time is more than 100 seconds:
   Performs the drain current sampling measurement, 100 seconds in 10 seconds step.
   After the sampling measurement, measures the Id-Vg characteristics and extracts Vth.
5. Repeats 3 or 4 until that the accumulated time overs the specified TotalRetentionTime.
   The available TotalRetentionTime value is 10 to 10000 seconds.

[Device Under Test]

NAND-type flash memory cell
Connect the Control Gate to the ASU Output, and the Drain to a SMU.
Open the Floating Gate, and connect the other terminals to a SMU.

[Required Modules and Accessories]

Agilent 81110A pulse generator (2-output, PGU1 and PGU2) 1 unit
HRSMU/ASU 1 set

ASU connections: Output: Control Gate, SMU: HRSMU, AUX: PGU1
Setting of ASU I/O Path, ASU tab, Configuration window: AUX

[Device Parameters]

Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]

Gate: SMU connected to Gate terminal, primary sweep voltage output
Drain: SMU connected to Drain terminal, constant voltage output
Source: SMU connected to Source and Substrate terminals, constant voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Vd: Drain voltage
Id@Vth: Drain current to decide the Vth
IntegTime: Integration time
PulsePeriod: Write pulse period
PulseDelay: Write pulse delay
PulseWidth: Write pulse width
Vwrite: Write pulse output level
LeadingTime: Pulse leading edge transition time
TrailingTime: Pulse trailing edge transition time
TotalRetentionTime: Time to continue the test. 10 to 10000 seconds.

[Extended Test Parameters]
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
PgAdd: GPIB address of pulse generator
BaseValue: Write pulse base value
NoOfPulse: Number of output pulses for the write operation

[Test Output: X-Y Graph]
X axis: Time TimeList (LOG)
Y1 axis: Threshold voltage VthList (LINEAR)

[Test Setup Details]
See NandFlash2 IV-Write-IV.

4.10 NandFlash2 Vth(ErasingTimeDependence): NAND flash memory cell erasing time dependence test (A.01.20)

[Description]
Performs the erasing time dependence test of the NAND-type flash memory cell, and plots the accumulated erasing time (accumulated pulse width) vs threshold voltage characteristics.

[Device Under Test]
NAND-type flash memory cell
Connect the Control Gate to a SMU, and the Drain to the ASU2 Output.
Open the Floating Gate, and connect the other terminals to the ASU1 Output.

[Required Modules and Accessories]
Agilent 81110A pulse generator (2-output, PGU1 and PGU2) 1 unit
HRSMU/ASU 2 sets (ASU1 and ASU2)

ASU1 connections: Output: Source and Substrate, SMU: HRSMU, AUX: PGU1
ASU2 connections: Output: Drain, SMU: HRSMU, AUX: PGU1
Setting of ASU I/O Path, ASU tab, Configuration window: AUX

[Device Parameters]
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
Gate: SMU connected to Gate terminal, primary sweep voltage output
Drain: SMU connected to Drain terminal, constant voltage output
Source: SMU connected to Source terminal, constant voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Vd: Drain voltage
Vs: Source voltage
Id@Vth: Drain current to decide the Vth
IntegTime: Integration time
PulsePeriod: Erase pulse period
PulseDelay: Erase pulse delay
PulseWidth: Total accumulated pulse width
CheckNoOfTimes: Number of Vth measurement operation
Verase: Erase pulse output level
LeadingTime: Pulse leading edge transition time
TrailingTime: Pulse trailing edge transition time

[Extended Test Parameter]
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
BaseValue: Erase pulse base value
PgAdd: GPIB address of pulse generator
NoOfPulse: Number of output pulses for the erase operation

[Measurement Parameters]
Drain current Idrain

[Analysis Function]
Vth=@L1X (X intercept of Line1)

[Auto Analysis]
Line1: Vertical line for Y1 at Idrain=Id@Vth

[Test Output: X-Y Graph]
X axis: Accumulated erasing pulse width EraseTimeList (LOG)
Y1 axis: Threshold voltage Vth (LINEAR)

4.11 NandFlash2 Vth(WritingTimeDependence): NAND flash memory cell writing time dependence test (A.01.20)

[Description]
Performs the writing time dependence test of the NAND-type flash memory cell, and plots the accumulated writing time (accumulated pulse width) vs threshold voltage characteristics.

[Device Under Test]
NAND-type flash memory cell
Connect the Control Gate to the ASU Output, and the Drain to a SMU.
Open the Floating Gate, and connect the other terminals to a SMU.

[Required Modules and Accessories]
Agilent 81110A pulse generator (2-output, PGU1 and PGU2) 1 unit
HRSMU/ASU 1 set

ASU connections: Output: Control Gate, SMU: HRSMU, AUX: PGU1
Setting of ASU I/O Path, ASU tab, Configuration window: AUX

[Device Parameters]
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
Gate: SMU connected to Gate terminal, primary sweep voltage output
Drain: SMU connected to Drain terminal, constant voltage output
Source: SMU connected to Source terminal, constant voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Vd: Drain voltage
Vs: Source voltage
Id@Vth: Drain current to decide the Vth
IntegTime: Integration time
PulsePeriod: Write pulse period
PulseDelay: Write pulse delay
PulseWidth: Total accumulated pulse width
CheckNoOfTimes: Number of Vth measurement operation
Vwrite: Write pulse output level
LeadingTime: Pulse leading edge transition time
TrailingTime: Pulse trailing edge transition time

[Extended Test Parameter]
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
BaseValue: Write pulse base value
PgAdd: GPIB address of pulse generator
NoOfPulse: Number of output pulses for the write operation

[Measurement Parameters]

Drain current Idrain

[Analysis Function]
Vth=@L1X (X intercept of Line1)

[Auto Analysis]
Line1: Vertical line for Y1 at Idrain=Id@Vth

[Test Output: X-Y Graph]
X axis: Accumulated writing pulse width WriteTimeList (LOG)
Y1 axis: Threshold voltage Vth (LINEAR)

4.12 NandFlash2 WordDisturb(ErasedCell): NAND flash memory cell erase-disturb test (A.01.20)

[Description]
Performs the erase-disturb test of the NAND-type flash memory cell, and plots the accumulated stress time vs threshold voltage characteristics.

[Device Under Test]
NAND-type flash memory cell
Connect the Control Gate to the ASU1 Output, and the Drain to the ASU2 Output.
Open the Floating Gate, and connect the other terminals to the ASU3 Output.

[Required Modules and Accessories]
Agilent 81110A pulse generator (2-output, PGU1 and PGU2) 1 unit
HRSMU/ASU 3 sets (ASU1, ASU2, and ASU3)

ASU1 connections: Output: Control Gate, SMU: HRSMU, AUX: PGU1
ASU2 connections: Output: Drain, SMU: HRSMU, AUX: PGU2
ASU3 connections: Output: Source and Substrate, SMU: HRSMU, AUX: PGU2
Setting of ASU I/O Path, ASU tab, Configuration window: AUX

[Device Parameters]
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
Gate: SMU connected to Gate terminal, primary sweep voltage output
Drain: SMU connected to Drain terminal, constant voltage output
Source: SMU connected to Source terminal, constant voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Vd: Drain voltage
Vs: Source voltage
Id@Vth: Drain current to decide the Vth
IntegTime: Integration time
TotalStressTime: Total accumulated stress time
CheckNoOfTimes: Number of Vth measurement operation
PulsePeriod: Erase pulse period
PulseDelay: Erase pulse delay
PulseWidth: Erase pulse width
Verase: Erase pulse output level
LeadingTime: Pulse leading edge transition time
TrailingTime: Pulse trailing edge transition time

[Extended Test Parameter]
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
BaseValue: Erase pulse base value
PgAdd: GPIB address of pulse generator

NoOfPulse: Number of output pulses for the erase operation

[Measurement Parameters]
Drain current Idrain

[Analysis Function]
Vth=@L1X (X intercept of Line1)

[Auto Analysis]
Line1: Vertical line for Y1 at Idrain=Id@Vth

[Test Output: X-Y Graph]
X axis: Accumulated stress time StressTimeList (LOG)
Y1 axis: Threshold voltage Vth (LINEAR)

4.13 NandFlash2 WordDisturb(WrittenCell): NAND flash memory cell read-disturb test (A.01.20)

[Description]
Performs the read-disturb test of the NAND-type flash memory cell, and plots the accumulated stress time vs threshold voltage characteristics.

[Device Under Test]
NAND-type flash memory cell
Connect the Control Gate to the ASU Output, and the Drain to a SMU.
Open the Floating Gate, and connect the other terminals to a SMU.

[Required Modules and Accessories]
Agilent 81110A pulse generator (2-output, PGU1 and PGU2) 1 unit
HRSMU/ASU 1 set

ASU connections: Output: Control Gate, SMU: HRSMU, AUX: PGU1
Setting of ASU I/O Path, ASU tab, Configuration window: AUX

[Device Parameters]
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
Gate: SMU connected to Gate terminal, primary sweep voltage output
Drain: SMU connected to Drain terminal, constant voltage output
Source: SMU connected to Source terminal, constant voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Vd: Drain voltage
Vs: Source voltage
Id@Vth: Drain current to decide the Vth
IntegTime: Integration time
TotalStressTime: Total accumulated stress time
CheckNoOfTimes: Number of Vth measurement operation
PulsePeriod: Write pulse period
PulseDelay: Write pulse delay
PulseWidth: Write pulse width
Vwrite: Write pulse output level
LeadingTime: Pulse leading edge transition time
TrailingTime: Pulse trailing edge transition time

[Extended Test Parameter]
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
BaseValue: Write pulse base value
PgAdd: GPIB address of pulse generator
NoOfPulse: Number of output pulses for the write operation

[Measurement Parameters]
Drain current Idrain

[Analysis Function]
Vth=@L1X (X intercept of Line1)

[Auto Analysis]
Line1: Vertical line for Y1 at Idrain=Id@Vth

[Test Output: X-Y Graph]
X axis: Accumulated stress time StressTimeList (LOG)
Y1 axis: Threshold voltage Vth (LINEAR)

5 Mixed Signal

1. BJT Varactor CV Mismatch:
   BJT Varactor capacitance CV characteristics mismatch (A.01.11)
2. Diff-R Mismatch: Diffusion resistor R-I characteristics mismatch, Kelvin conneciton (A.01.11)
3. Diode IV Fwd Mismatch: Diode forward bias characteristics mismatch (A.01.20)
4. Diode IV Rev Mismatch: Diode reverse bias characteristics mismatch (A.01.20)
5. G-Plot ConstVce Mismatch:
   Gummel characteristics mismatch, Vce=Const (A.01.20)
6. G-Plot ConstVce Mismatch[3]:
   Gummel characteristics mismatch, Vce=Const, 3-terminal (A.01.20)
7. G-Plot Vbc=0V Mismatch: Gummel characteristics mismatch, Vbc=0 V (A.01.20)
8. G-Plot Vbc=0V Mismatch[3]:
   Gummel characteristics mismatch, Vbc=0, 3-terminal (A.01.20)
9. Ic-Vc Ib Mismatch: Ic-Vce characteristics mismatch, Ib sweep (A.01.20)
10. Ic-Vc Ib Mismatch[3]: Ic-Vce characteristics mismatch, Ib sweep, 3-terminal (A.01.20)
11. Ic-Vc Vb Mismatch: Ic-Vce characteristics mismatch, Vb sweep (A.01.20)
12. Ic-Vc Vb Mismatch[3]: Ic-Vce characteristics mismatch, Vb sweep, 3-terminal (A.01.20)
13. Id-Vd Mismatch: Id-Vd characteristics mismatch (A.01.20)
14. Id-Vd Mismatch[3]: Id-Vd characteristics mismatch, 3-terminal (A.01.20)
15. Id-Vg Mismatch: Id-Vg characteristics mismatch (A.01.20)
16. Id-Vd Mismatch[3]: Id-Vd characteristics mismatch, 3-terminal (A.01.20)
17. MIM CV Mismatch: MIM capacitor C-V characteristics mismatch (A.01.11)
18. MOS Varactor CV Mismatch:
    MOS Varactor capacitance CV characteristics mismatch (A.01.11)
19. Poly-R Mismatch: Resistor R-I characteristics mismatch, Kelvin connection (A.01.11)

5.1 BJT Varactor CV Mismatch: BJT Varactor capacitance CV characteristics mismatch (A.01.11)

[Description]
Measures the BJT varactor capacitance (C-Vce characteristics) of device A, and measures the C-Vce characteristics of device B. After that, calculates the differences between capacitance values by using the following formula, and plots the results.
DeltaCp=(CpBList-CpAList)/CpAList*100 for parallel capacitance
DeltaCs=(CsBList-CsAList)/CsAList*100 for series capacitance

[Device Under Test]
Bipolar junction transistor, 4 terminals, 2 ea.
Connect Base to the CMU Low, Collector to the CMU High, and the other terminals to the GNDU.

[Device Parameters]
Polarity: NPN (CMU forces the specified value) or PNP (CMU forces the negative specified value).
Lb: Base length
Wb: Base width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
Collector: CMU connected between Collector and Base (CV sweep measurement)
VcbStart: DC bias start voltage
VcbStop: DC bias stop voltage
VcbStep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
To specify the device, A or B is added to the actual variable names.
PI=3.141592653589
Dval=Gval/(2*PI*FREQ*Cpval)
Rpval=1/Gval
Csval=(1+Dval^2)*Cpval
Xval=-1/(2*PI*FREQ*Csval)
Rsval=Dval*abs(Xval)
Zval=sqrt(Rsval^2+Xval^2)
Thetaval=atan(Xval/Rsval)
Vceval=Vcollector

[X-Y Graph]
To specify the device, A or B is added to the actual variable names.
X axis: Collector-Emitter voltage Vceval (LINEAR)
Y1 axis: Collector capacitance (parallel capacitance) Cpval (LINEAR)

Y2 axis: Conductance Gval (LINEAR)

[List Display]
To specify the device, A or B is added to the actual variable names.
Collector-Emitter voltage Vceval
Parallel capacitance Cpval
Conductance Gval
Series capacitance Csval
Series resistance Rsval
Parallel resistance Rpval
Dissipation factor Dval
Reactance Xval
Impedance Zval
Phase Thetaval

[Test Output: X-Y Graph]
X axis: Collector-Emitter voltage VceList (LINEAR)
Y1 axis: Collector capacitance (parallel capacitance) CpAList (LINEAR)
Y2 axis: Collector capacitance (parallel capacitance) CpBList (LINEAR)
Y3 axis: Differences between Cp DeltaCp (LINEAR)

5.2 Diff-R Mismatch: Diffusion resistor R-I characteristics mismatch, Kelvin conneciton (A.01.11)

[Description]
Measures the resistance vs input current characteristics of diffusion resistors, and plots the differences between the devices.

[Device Under Test]
Resistor, 2 terminals, 2 ea.
with substrate

[Device Parameters]
Polarity: Ntype (SMUs force the specified value) or Ptype (SMUs force the negative specified value).
L: Resistor length
W: Resistor width
Temp: Temperature

[Test Parameters]
IntegTime: Integration Time
Port1: SMU connected to device A high terminal, primary sweep current output
Port2: SMU connected to device B high terminal, synchronous sweep current output
I1Start: Port1/Port2 sweep start current
I1Stop: Port1/Port2 sweep stop current
I1Step: Port1/Port2 sweep step current
Port3: SMU connected to device A/B low terminal, constant voltage output
Subs: SMU connected to Substrate, constant voltage output
VM1: SMU connected to device A high terminal, constant current output
VM2: SMU connected to device A low terminal, constant current output
VM3: SMU connected to device B high terminal, constant current output
VM4: SMU connected to device B low terminal, constant current output

[Extended Test Parameters]
IM1: VM1 output current
IM2: VM2 output current
IM3: VM3 output current
IM4: VM4 output current
V3: Port3 output voltage
Vsubs: Substrate voltage
V1Limit: Port1 voltage compliance
VM1Limit: VM1 voltage compliance
I3Limit: Port3 current compliance
IsubsLimit: Substrate current compliance
HoldTime: Hold time
DelayTime: Deley time

[Measurement Parameters]
Device A input current Iport1
Device B input current Iport2
Device A terminal voltage Vvm1, Vvm2
Device B terminal voltage Vvm3, Vvm4

[User Function]
DeltaV_A = Vvm1-Vvm2

DeltaV_B = Vvm3-Vvm4
R_A = DeltaV_A / Iport1
R_B = DeltaV_B / Iport2
Rsheet_A = R_A / (W/L)
Rsheet_B = R_B / (W/L)
Delta_R = (R_A - R_B) / R_A * 100

[X-Y Plot]
X axis: Device input current Iport1 (LINEAR)
Y1 axis: Device A voltage between terminals DeltaV_A (LINEAR)
Y2 axis: Device B voltage between terminals DeltaV_B (LINEAR)
Y3 axis: Device A resistance R_A (LINEAR)
Y4 axis: Device A resistance R_B (LINEAR)
Y5 axis: Rate-of-change between R_A and R_B Delta_R (LINEAR)

5.3 *Diode IV Fwd Mismatch: Diode forward bias characteristics mismatch (A.01.20)*

[Description]
Measures the forward bias anode voltage vs anode current characteristics, and plots the differences between the devices.

[Device Under Test]
Diode, 2 ea.

[Device Parameters]
L: Junction length
W: Junction width
Temp: Temperature
IMax: Current compliance

[Test Parameters]
IntegTime: Integration time
AnodeA: SMU connected to the device A Anode terminal, primary sweep voltage output
AnodeB: SMU connected to the device B Anode terminal, synchronous sweep voltage output
VanodeStart: Sweep start voltage for Anode terminal
VanodeStop: Sweep stop voltage for Anode terminal
VanodeStep: Sweep step voltage for Anode terminal
Cathode: SMU connected to Cathode terminal, constant voltage output

[Extended Test Parameters]
Vcathode: Cathode voltage
HoldTime: Hold time
DelayTime: Delay time
AnodeMinRng: Minimum range for the anode current measurement

[Measurement Parameters]
Anode current IanodeA, IanodeB

[User Function]
Delta_Ianode=(IanodeA-IanodeB)/IanodeA*100

[X-Y Plot]
X axis: Anode voltage VanodeA (LINEAR)
Y1 axis: Anode current IanodeA (LINEAR)
Y2 axis: Anode current IanodeB (LINEAR)
Y3 axis: Differences between anode current Delta_Ianode (LINEAR)

5.4 Diode IV Rev Mismatch: Diode reverse bias characteristics mismatch (A.01.20)

[Description]
Measures the reverse bias anode voltage vs anode current characteristics, and plots the differences between the devices.

[Device Under Test]
Diode, 2 ea.

[Device Parameters]
L: Junction length
W: Junction width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
AnodeA: SMU connected to the device A Anode terminal, primary sweep voltage output
AnodeB: SMU connected to the device B Anode terminal, synchronous sweep voltage output
VanodeStart: Sweep start voltage for Anode terminal
VanodeStop: Sweep stop voltage for Anode terminal
VanodeStep: Sweep step voltage for Anode terminal
IanodeLimit: Anode current compliance
Cathode: SMU connected to Cathode terminal, constant voltage output

[Extended Test Parameters]
Vcathode: Cathode voltage
HoldTime: Hold time
DelayTime: Delay time
AnodeMinRng: Minimum range for the anode current measurement

[Measurement Parameters]
Anode current IanodeA, IanodeB

[User Function]
Delta_Ianode=(IanodeA-IanodeB)/IanodeA*100

[X-Y Plot]
X axis: Anode voltage VanodeA (LINEAR)
Y1 axis: Anode current IanodeA (LINEAR)
Y2 axis: Anode current IanodeB (LINEAR)
Y3 axis: Differences between anode current Delta_Ianode (LINEAR)

5.5 G-Plot ConstVce Mismatch: Gummel characteristics mismatch, Vce=Const (A.01.20)

[Description]
Measures the collector current vs base voltage characteristics and the base current vs base voltage characteristics, extracts the current amplification factor hfe, and plots the gummel characteristics.

[Device Under Test]
Bipolar transistor, 4 terminals, 2 ea.

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
BaseA: SMU connected to Device A Base terminal, primary sweep voltage output
BaseB: SMU connected to Device B Base terminal, synchronous sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Emitter: SMU connected to Emitter terminal, constant voltage output
CollectorA: SMU connected to Device A Collector terminal, constant voltage output
CollectorB: SMU connected to Device B Collector terminal, constant voltage output
Vc: Collector voltage
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current measurement
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current IcollectorA
Collector current IcollectorB
Base current IbaseA
Base current IbaseB

[User Function]
hfe_A=IcollectorA/IbaseA
hfe_B=IcollectorB/IbaseB
Delta_hfe=(hfe_A-hfe_B)/hfe_A*100
Delta_Icollector=(IcollectorA-IcollectorB)/IcollectorA*100
Vbe=VbaseA

[X-Y Plot]

X axis: Base-Emitter voltage Vbe (LINEAR)
Y1 axis: Collector current IcollectorA (LOG)
Y2 axis: Base current IbaseA (LOG)
Y3 axis: Collector current IcollectorB (LOG)
Y4 axis: Base current IbaseB (LOG)
Y5 axis: Current amplification factor hfe_A (LINEAR)
Y6 axis: Current amplification factor hfe_B (LINEAR)
Y7 axis: Differences of hfe Delta_hfe (LINEAR)

5.6 G-Plot ConstVce Mismatch[3]: Gummel characteristics mismatch, Vce=Const, 3-terminal (A.01.20)

[Description]
Measures the collector current vs base voltage characteristics and the base current vs base voltage characteristics, extracts the current amplification factor hfe, and plots the gummel characteristics.

[Device Under Test]
Bipolar transistor, 3 terminals, 2 ea.

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
BaseA: SMU connected to Device A Base terminal, primary sweep voltage output
BaseB: SMU connected to Device B Base terminal, synchronous sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Emitter: SMU connected to Emitter terminal, constant voltage output
CollectorA: SMU connected to Device A Collector terminal, constant voltage output
CollectorB: SMU connected to Device B Collector terminal, constant voltage output
Vc: Collector voltage

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current measurement
CollectorrMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current IcollectorA
Collector current IcollectorB
Base current IbaseA
Base current IbaseB

[User Function]
hfe_A=IcollectorA/IbaseA
hfe_B=IcollectorB/IbaseB
Delta_hfe=(hfe_A-hfe_B)/hfe_A*100
Delta_Icollector=(IcollectorA-IcollectorB)/IcollectorA*100
Vbe=VbaseA

[X-Y Plot]
X axis: Base-Emitter voltage Vbe (LINEAR)
Y1 axis: Collector current IcollectorA (LOG)
Y2 axis: Base current IbaseA (LOG)

Y3 axis: Collector current IcollectorB (LOG)
Y4 axis: Base current IbaseB (LOG)
Y5 axis: Current amplification factor hfe_A (LINEAR)
Y6 axis: Current amplification factor hfe_B (LINEAR)
Y7 axis: Differences of hfe Delta_hfe (LINEAR)

5.7 G-Plot Vbc=0V Mismatch: Gummel characteristics mismatch, Vbc=0 V (A.01.20)

[Description]
Measures the collector current vs emitter voltage characteristics and the base current vs emitter voltage characteristics, extracts the current amplification factor hfe, and plots the gummel characteristics.

[Device Under Test]
Bipolar transistor, 4 terminals, 2 ea.

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
Emitter: SMU connected to Emitter terminal, primary sweep voltage output
VeStart: Sweep start voltage for Emitter terminal
VeStop: Sweep stop voltage for Emitter terminal
VeStep: Sweep step voltage for Emitter terminal
BaseA: SMU connected to Device A Base terminal, constant voltage output
BaseB: SMU connected to Device B Base terminal, constant voltage output
CollectorA: SMU connected to Device A Collector terminal, constant voltage output
CollectorB: SMU connected to Device B Collector terminal, constant voltage output
Vc: Collector voltage
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Vb: Base voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current measurement
CollectorMinRng: Minimum range for the collector current measurement

[Measurement Parameters]
Collector current IcollectorA
Collector current IcollectorB
Base current IbaseA
Base current IbaseB

[User Function]
hfe_A=IcollectorA/IbaseA
hfe_B=IcollectorB/IbaseB
Delta_hfe=(hfe_A-hfe_B)/hfe_A*100
Delta_Icollector=(IcollectorA-IcollectorB)/IcollectorA*100
Vbe=-Vemitter

[X-Y Plot]

X axis: Base-Emitter voltage Vbe (LINEAR)
Y1 axis: Collector current IcollectorA (LOG)
Y2 axis: Base current IbaseA (LOG)
Y3 axis: Collector current IcollectorB (LOG)
Y4 axis: Base current IbaseB (LOG)
Y5 axis: Current amplification factor hfe_A (LINEAR)
Y6 axis: Current amplification factor hfe_B (LINEAR)
Y7 axis: Differences of hfe Delta_hfe (LINEAR)

5.8 G-Plot Vbc=0V Mismatch[3]: Gummel characteristics mismatch, Vbc=0, 3-terminal (A.01.20)

[Description]
Measures the collector current vs emitter voltage characteristics and the base current vs emitter voltage characteristics, extracts the current amplification factor hfe, and plots the gummel characteristics.

[Device Under Test]
Bipolar transistor, 3 terminals, 2 ea.

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
Emitter: SMU connected to Emitter terminal, primary sweep voltage output
VeStart: Sweep start voltage for Emitter terminal
VeStop: Sweep stop voltage for Emitter terminal
VeStep: Sweep step voltage for Emitter terminal
BaseA: SMU connected to Device A Base terminal, constant voltage output
BaseB: SMU connected to Device B Base terminal, constant voltage output
CollectorA: SMU connected to Device A Collector terminal, constant voltage output
CollectorB: SMU connected to Device B Collector terminal, constant voltage output

[Extended Test Parameters]
Vb: Base voltage
Vc: Collector voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimumu range for the base current measurement
CollectorMinRng: Minimumu range for the collector current measurement

[Measurement Parameters]
Collector current IcollectorA
Collector current IcollectorB
Base current IbaseA
Base current IbaseB

[User Function]
hfe_A=IcollectorA/IbaseA
hfe_B=IcollectorB/IbaseB
Delta_hf=(hfe_A-hfe_B)/hfe_A*100
Delta_Icollector=(IcollectorA-IcollectorB)/IcollectorA*100
Vbe=-Vemitter

[X-Y Plot]
X axis: Base-Emitter voltage Vbe (LINEAR)
Y1 axis: Collector current IcollectorA (LOG)
Y2 axis: Base current IbaseA (LOG)

Y3 axis: Collector current IcollectorB (LOG)
Y4 axis: Base current IbaseB (LOG)
Y5 axis: Current amplification factor hfe_A (LINEAR)
Y6 axis: Current amplification factor hfe_B (LINEAR)
Y7 axis: Differences of hfe Delta_hfe (LINEAR)

5.9 *Ic-Vc Ib Mismatch: Ic-Vce characteristics mismatch, Ib sweep (A.01.20)*

[Description]
Measures the collector current vs collector voltage (Ic-Ice) characteristics of device A, and measures the Ic-Ice characteristics of device B. After that, calculates the differences between Ic values by using the following formula, and plots the results.
Delta_Ic=(Icollector_A-Icollector_B)/Icollector_A*100

[Device Under Test]
Bipolar transistor, 4 terminals, 2 ea.

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
CollectorA: SMU connected to Device A Collector terminal, primary sweep voltage output
CollectorB: SMU connected to Device B Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
BaseA: SMU connected to Device A Base terminal, secondary sweep current output
BaseB: SMU connected to Device B Base terminal, secondary sweep current output
IbStart: Sweep start current for Base terminal
IbStop: Sweep stop current for Base terminal
IbStep: Sweep step current for Base terminal
VbLimit: Base voltage compliance
Emitter: SMU connected to Emitter terminal, constant voltage output
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
CollectorMinRng: Minimum range for the collector current measurement

[Device A: Measurement Parameters]
Collector current IcollectorA

[Device A: User Function]
hfe_A=IcollectorA/IbaseA

[Device A: X-Y Plot]
X axis: Collector voltage VcollectorA (LINEAR)
Y1 axis: Collector current IcollectorA (LINEAR)

[Device B: Measurement Parameters]
Collector current IcollectorB

[Device B: User Function]
hfe_B=IcollectorB/IbaseB

[Device B: X-Y Plot]
X axis: Collector voltage VcollectorB (LINEAR)
Y1 axis: Collector current IcollectorB (LINEAR)

[Test Output: X-Y Graph]
X axis: Collector-Emitter voltage Vce (LINEAR)
Y1 axis: Collector current Icollector_A (LINEAR)
Y2 axis: Collector current Icollector_B (LINEAR)
Y3 axis: Differences between Ic Delta_Ic (LINEAR)

5.10 Ic-Vc Ib Mismatch[3]: Ic-Vce characteristics mismatch, Ib sweep, 3-terminal (A.01.20)

[Description]
Measures the collector current vs collector voltage (Ic-Ice) characteristics of device A, and measures the Ic-Ice characteristics of device B. After that, calculates the differences between Ic values by using the following formula, and plots the results.
Delta_Ic=(Icollector_A-Icollector_B)/Icollector_A*100

[Device Under Test]
Bipolar transistor, 3 terminals, 2 ea.

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
CollectorA: SMU connected to Device A Collector terminal, primary sweep voltage output
CollectorB: SMU connected to Device B Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
BaseA: SMU connected to Device A Base terminal, secondary sweep current output
BaseB: SMU connected to Device B Base terminal, secondary sweep current output
IbStart: Sweep start current for Base terminal
IbStop: Sweep stop current for Base terminal
IbStep: Sweep step current for Base terminal
VbLimit: Base voltage compliance
Emitter: SMU connected to Emitter terminal, constant voltage output

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
CollectorMinRng: Minimum range for the collector current measurement

[Device A: Measurement Parameters]
Collector current IcollectorA

[Device A: User Function]
hfe_A=IcollectorA/IbaseA

[Device A: X-Y Plot]
X axis: Collector voltage VcollectorA (LINEAR)
Y1 axis: Collector current IcollectorA (LINEAR)

[Device B: Measurement Parameters]
Collector current IcollectorB

[Device B: User Function]
hfe_B=IcollectorB/IbaseB

[Device B: X-Y Plot]
X axis: Collector voltage VcollectorB (LINEAR)
Y1 axis: Collector current IcollectorB (LINEAR)

[Test Output: X-Y Graph]
X axis: Collector-Emitter voltage Vce (LINEAR)
Y1 axis: Collector current Icollector_A (LINEAR)
Y2 axis: Collector current Icollector_B (LINEAR)
Y3 axis: Differences between Ic Delta_Ic (LINEAR)

5.11 Ic-Vc Vb Mismatch: Ic-Vce characteristics mismatch, Vb sweep (A.01.20)

[Description]
Measures the collector current vs collector voltage (Ic-Ice) characteristics of device A, and measures the Ic-Ice characteristics of device B. After that, calculates the differences between Ic values by using the following formula, and plots the results.
Delta_Ic=(Icollector_A-Icollector_B)/Icollector_A*100

[Device Under Test]
Bipolar transistor, 4 terminals, 2 ea.

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
CollectorA: SMU connected to Device A Collector terminal, primary sweep voltage output
CollectorB: SMU connected to Device B Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
BaseA: SMU connected to Device A Base terminal, secondary sweep voltage output
BaseB: SMU connected to Device B Base terminal, secondary sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Emitter: SMU connected to Emitter terminal, constant voltage output
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current measurement
CollectorMinRng: Minimum range for the collector current measurement

[Device A: Measurement Parameters]
Collector current IcollectorA
Base current IbaseA

[Device A: User Function]
hfe_A=IcollectorA/IbaseA

[Device A: X-Y Plot]
X axis: Collector voltage VcollectorA (LINEAR)
Y1 axis: Collector current IcollectorA (LINEAR)

[Device B: Measurement Parameters]

Collector current IcollectorB
Base current IbaseB

[Device B: User Function]
hfe_B=IcollectorB/IbaseB

[Device B: X-Y Plot]
X axis: Collector voltage VcollectorB (LINEAR)
Y1 axis: Collector current IcollectorB (LINEAR)

[Test Output: X-Y Graph]
X axis: Collector-Emitter voltage Vce (LINEAR)
Y1 axis: Collector current Icollector_A (LINEAR)
Y2 axis: Collector current Icollector_B (LINEAR)
Y3 axis: Differences between Ic Delta_Ic (LINEAR)

5.12 Ic-Vc Vb Mismatch[3]: Ic-Vce characteristics mismatch, Vb sweep, 3-terminal (A.01.20)

[Description]
Measures the collector current vs collector voltage (Ic-Ice) characteristics of device A, and measures the Ic-Ice characteristics of device B. After that, calculates the differences between Ic values by using the following formula, and plots the results.
Delta_Ic=(Icollector_A-Icollector_B)/Icollector_A*100

[Device Under Test]
Bipolar transistor, 3 terminals, 2 ea.

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value).
Le: Emitter length
We: Emitter width
Temp: Temperature
IcMax: Collector current compliance

[Test Parameters]
IntegTime: Integration time
CollectorA: SMU connected to Device A Collector terminal, primary sweep voltage output
CollectorB: SMU connected to Device B Collector terminal, primary sweep voltage output
VcStart: Sweep start voltage for Collector terminal
VcStop: Sweep stop voltage for Collector terminal
VcStep: Sweep step voltage for Collector terminal
BaseA: SMU connected to Device A Base terminal, secondary sweep voltage output
BaseB: SMU connected to Device B Base terminal, secondary sweep voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Emitter: SMU connected to Emitter terminal, constant voltage output

[Extended Test Parameters]
Ve: Emitter voltage
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for the base current meausrement
CollectorMinRng: Minimum range for the collector current meausrement

[Device A: Measurement Parameters]
Collector current IcollectorA
Base current IbaseA

[Device A: User Function]
hfe_A=IcollectorA/IbaseA

[Device A: X-Y Plot]
X axis: Collector voltage VcollectorA (LINEAR)
Y1 axis: Collector current IcollectorA (LINEAR)

[Device B: Measurement Parameters]
Collector current IcollectorB

Base current IbaseB

[Device B: User Function]
hfe_B=IcollectorB/IbaseB

[Device B: X-Y Plot]
X axis: Collector voltage VcollectorB (LINEAR)
Y1 axis: Collector current IcollectorB (LINEAR)

[Test Output: X-Y Graph]
X axis: Collector-Emitter voltage Vce (LINEAR)
Y1 axis: Collector current Icollector_A (LINEAR)
Y2 axis: Collector current Icollector_B (LINEAR)
Y3 axis: Differences between Ic Delta_Ic (LINEAR)

5.13 Id-Vd Mismatch: Id-Vd characteristics mismatch (A.01.20)

[Description]
Measures the drain current vs drain voltage characteristics of two MOSFETs, and plots the differences of them.

[Device Under Test]
MOSFET, 4 terminals, 2 ea.

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
DrainA: SMU connected to the device A Drain terminal, primary sweep voltage output
DrainB: SMU connected to the device B Drain terminal, synchronous sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
Gate: SMU connected to Gate terminal, secondary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
IgLimit: Gate current compliance
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current meaurement
SubsMinRng: Minimum range for the substrate current meaurement

[Measurement Parameters]
Device A Drain current IdrainA
Device B Drain current IdrainB
Substrate current Isubs
Source current Isource

[User Function]
Drain conductance gds_A=diff(IdrainA,VdrainA)
Drain conductance gds_B=diff(IdrainB,VdrainB)
Drain resistance Rds_A=1/gds_A
Drain resistance Rds_B=1/gds_B
Delta_Ids=(IdrainA-IdrainB)/IdrainA*100
Delta_gds=(gds_A-gds_B)/gds_A*100
Delta_Rds=(Rds_A-Rds_B)/Rds_A*100

[X-Y Graph]
X axis: Drain voltage VdrainA (LINEAR)
Y1 axis: Device A Drain current IdrainA (LINEAR)
Y2 axis: Device B Drain current IdrainB (LINEAR)
Y3 axis: Difference of Drain current Delta_Ids (LINEAR)

[List Display]
Drain voltage VdrainA
Gate voltage Vgate
Device A Drain current IdrainA
Device B Drain current IdrainB
Differences of Drain current Delta_Ids
Substrate current Isubs
Source current Isource

5.14 Id-Vd Mismatch[3]: Id-Vd characteristics mismatch, 3-terminal (A.01.20)

[Description]
Measures the drain current vs drain voltage characteristics of two MOSFETs, and plots the differences of them.

[Device Under Test]
MOSFET, 3 terminals, 2 ea.

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
DrainA: SMU connected to the device A Drain terminal, primary sweep voltage output
DrainB: SMU connected to the device B Drain terminal, synchronous sweep voltage output
Gate: SMU connected to Gate terminal, secondary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
IgLimit: Gate current compliance
Source: SMU connected to Source terminal, constant voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal

[Extended Test Parameters]
Vs: Source voltage
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Device A Drain current IdrainA
Device B Drain current IdrainB

[User Function]
Drain conductance gds_A=diff(IdrainA,VdrainA)
Drain conductance gds_B=diff(IdrainB,VdrainB)
Drain resistance Rds_A=1/gds_A
Drain resistance Rds_B=1/gds_B
Delta_Ids=(IdrainA-IdrainB)/IdrainA*100
Delta_gds=(gds_A-gds_B)/gds_A*100
Delta_Rds=(Rds_A-Rds_B)/Rds_A*100

[X-Y Graph]
X axis: Drain voltage VdrainA (LINEAR)
Y1 axis: Device A Drain current IdrainA (LINEAR)
Y2 axis: Device B Drain current IdrainB (LINEAR)
Y3 axis: Difference of Drain current Delta_Ids (LINEAR)

[List Display]
Drain voltage VdrainA
Gate voltage Vgate
Device A Drain current IdrainA
Device B Drain current IdrainB
Differences of Drain current Delta_Ids

5.15 Id-Vg Mismatch: Id-Vg characteristics mismatch (A.01.20)

[Description]
Measures the drain current vs gate voltage characteristics of two MOSFETs, and plots the differences of them.

[Device Under Test]
MOSFET, 4 terminals, 2 ea.

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
IgLimit: Gate current compliance
DrainA: SMU connected to the device A Drain terminal, constant voltage output
DrainB: SMU connected to the device B Drain terminal, constant voltage output
Vd: Drain voltage
Subs: SMU connected to Substrate, secondary sweep voltage output
VsubsStart: Sweep start voltage for Substrate terminal
VsubsStop: Sweep stop voltage for Substrate terminal
VsubsStep: Sweep step voltage for Substrate terminal
IsubsLimit: Substrate current compliance
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement
GateMinRng: Minimum range for the gate current measurement
SubsMinRng: Minimum range for the Substrate current measurement

[Measurement Parameters]
Device A Drain current IdrainA
Device B Drain current IdrainB
Gate current Igate
Substrate current Isubs

[User Function]
gm_A=diff(IdrainA,Vgate)
gm_B=diff(IdrainB,Vgate)
Delta_Id=(IdrainA-IdrainB)/IdrainA*100
Delta_gm=(gm_A-gm_B)/gm_A*100

[X-Y Graph]
X axis: Gate voltage Vgate (LINEAR)

Y1 axis: Device A Drain current IdrainA (LINEAR)
Y2 axis: Device B Drain current IdrainB (LINEAR)
Y3 axis: Difference of Drain current Delta_Id (LINEAR)

[List Display]
Gate voltage Vgate
Drain voltage VdrainA
Device A Drain current IdrainA
Device B Drain current IdrainB
Differences of Drain current Delta_Id
Gate current Igate
Substrate current Isubs

5.16 Id-Vd Mismatch[3]: Id-Vd characteristics mismatch, 3-terminal (A.01.20)

[Description]
Measures the drain current vs drain voltage characteristics of two MOSFETs, and plots the differences of them.

[Device Under Test]
MOSFET, 3 terminals, 2 ea.

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
DrainA: SMU connected to the device A Drain terminal, primary sweep voltage output
DrainB: SMU connected to the device B Drain terminal, synchronous sweep voltage output
Gate: SMU connected to Gate terminal, secondary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
IgLimit: Gate current compliance
Source: SMU connected to Source terminal, constant voltage output
Vd: Drain voltage

[Extended Test Parameters]
Vs: Source voltage
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Device A Drain current IdrainA
Device B Drain current IdrainB

[User Function]
Drain conductance gds_A=diff(IdrainA,VdrainA)
Drain conductance gds_B=diff(IdrainB,VdrainB)
Drain resistance Rds_A=1/gds_A
Drain resistance Rds_B=1/gds_B
Delta_Ids=(IdrainA-IdrainB)/IdrainA*100
Delta_gds=(gds_A-gds_B)/gds_A*100
Delta_Rds=(Rds_A-Rds_B)/Rds_A*100

[X-Y Graph]
X axis: Drain voltage VdrainA (LINEAR)
Y1 axis: Device A Drain current IdrainA (LINEAR)
Y2 axis: Device B Drain current IdrainB (LINEAR)
Y3 axis: Difference of Drain current Delta_Ids (LINEAR)

[List Display]
Drain voltage VdrainA

Gate voltage Vgate
Device A Drain current IdrainA
Device B Drain current IdrainB
Differences of Drain current Delta_Ids

5.17 MIM CV Mismatch: MIM capacitor C-V characteristics mismatch (A.01.11)

[Description]
Measures the MIM capacitance (C-V characteristics) of device A, and measures the C-V characteristics of device B. After that, calculates the differences between capacitance values by using the following formula, and plots the results.
DeltaCp=(CpBList-CpAList)/CpAList*100 for parallel capacitance
DeltaCs=(CsBList-CsAList)/CsAList*100 for series capacitance

[Device Under Test]
MIM capacitor, 2 terminals, 2 ea.

[Device Parameters]
Lg: Device length
Wg: Device width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
Port1: CMU connected to the device (CV sweep measurement)
V1Start: DC bias start voltage
V1Stop: DC bias stop voltage
V1Step: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
To specify the device, A or B is added to the actual variable names.
PI=3.141592653589
Dval=Gval/(2*PI*FREQ*Cpval)
Rpval=1/Gval
Csval=(1+Dval^2)*Cpval
Xval=-1/(2*PI*FREQ*Csval)
Rsval=Dval*abs(Xval)
Zval=sqrt(Rsval^2+Xval^2)
Thetaval=atan(Xval/Rsval)

[X-Y Graph]
To specify the device, A or B is added to the actual variable names.
X axis: DC bias Vport1 (LINEAR)
Y1 axis: MIM capacitance (parallel capacitance) Cpval (LINEAR)
Y2 axis: Conductance Gval (LINEAR)

[List Display]
To specify the device, A or B is added to the actual variable names.
DC bias Vport1

Parallel capacitance Cpval
Conductance Gval
Series capacitance Csval
Series resistance Rsval
Parallel resistance Rpval
Dissipation factor Dval
Reactance Xval
Impedance Zval
Phase Thetaval

[Test Output: X-Y Graph]
X axis: DC bias Vport1List (LINEAR)
Y1 axis: MIM capacitance (parallel capacitance) CpAList (LINEAR)
Y2 axis: MIM capacitance (parallel capacitance) CpBList (LINEAR)
Y3 axis: Differences between Cp DeltaCp (LINEAR)

5.18 MOS Varactor CV Mismatch: MOS Varactor capacitance CV characteristics mismatch (A.01.11)

[Description]
Measures the MOS varactor capacitance (C-Vg characteristics) of device A, and measures the C-Vg characteristics of device B. After that, calculates the differences between capacitance values by using the following formula, and plots the results.

DeltaCp=(CpBList-CpAList)/CpAList*100 for parallel capacitance
DeltaCs=(CsBList-CsAList)/CsAList*100 for series capacitance

[Device Under Test]
MOSFET, 4 terminals, 2 ea.
Connect Gate to the CMU Low, and the other terminals to the CMU High.

[Device Parameters]
Polarity: Nch (CMU forces the specified value) or Pch (CMU forces the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
Gate: CMU connected to Gate terminal (CV sweep measurement)
VgsStart: DC bias start voltage
VgsStop: DC bias stop voltage
VgsStep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
To specify the device, A or B is added to the actual variable names.
PI=3.141592653589
Dval=Gval/(2*PI*FREQ*Cpval)
Rpval=1/Gval
Csval=(1+Dval^2)*Cpval
Xval=-1/(2*PI*FREQ*Csval)
Rsval=Dval*abs(Xval)
Zval=sqrt(Rsval^2+Xval^2)
Thetaval=atan(Xval/Rsval)
Vgateval=-Vsubs

[X-Y Graph]
To specify the device, A or B is added to the actual variable names.
X axis: Gate voltage Vgateval (LINEAR)
Y1 axis: Gate capacitance (parallel capacitance) Cpval (LINEAR)

Y2 axis: Conductance Gval (LINEAR)

[List Display]
To specify the device, A or B is added to the actual variable names.
Gate voltage Vgateval
Parallel capacitance Cpval
Conductance Gval
Series capacitance Csval
Series resistance Rsval
Parallel resistance Rpval
Dissipation factor Dval
Reactance Xval
Impedance Zval
Phase Thetaval

[Test Output: X-Y Graph]
X axis: Gate voltage VgList (LINEAR)
Y1 axis: Gate capacitance (parallel capacitance) CpAList (LINEAR)
Y2 axis: Gate capacitance (parallel capacitance) CpBList (LINEAR)
Y3 axis: Differences between Cp DeltaCp (LINEAR)

5.19 Poly-R Mismatch: Resistor R-I characteristics mismatch, Kelvin connection (A.01.11)

[Description]
Measures the resistance vs input current characteristics of resistors, and plots the differences between the devices.

[Device Under Test]
Resistor, 2 terminals, 2 ea.

[Device Parameters]
L: Resistor length
W: Resistor width
Temp: Temperature

[Test Parameters]
IntegTime: Integration Time
Port1: SMU connected to device A high terminal, primary sweep current output
Port2: SMU connected to device B high terminal, synchronous sweep current output
I1Start: Port1/Port2 sweep start current
I1Stop: Port1/Port2 sweep stop current
I1Step: Port1/Port2 sweep step current
V1Limit: Maximum voltage
Port3: SMU connected to device A/B low terminal, constant voltage output
VM1: SMU connected to device A high terminal, constant current output
VM2: SMU connected to device A low terminal, constant current output
VM3: SMU connected to device B high terminal, constant current output
VM4: SMU connected to device B low terminal, constant current output

[Extended Test Parameters]
V3: Port3 output voltage
IM1: VM1 output current
IM2: VM2 output current
IM3: VM3 output current
IM4: VM4 output current
HoldTime: Hold time
DelayTime: Deley time

[Measurement Parameters]
Device A input current Iport1
Device B input current Iport2
Device A terminal voltage Vvm1, Vvm2
Device B terminal voltage Vvm3, Vvm4

[User Function]
DeltaV_A = Vvm1-Vvm2
DeltaV_B = Vvm3-Vvm4
R_A = DeltaV_A / Iport1
R_B = DeltaV_B / Iport2
Rsheet_A = R_A / (W/L)
Rsheet_B = R_B / (W/L)
Delta_R = (R_A - R_B) / R_A * 100

[X-Y Plot]
X axis: Device A input current Iport1 (LINEAR)
Y1 axis: Device A resistance R_A (LINEAR)
Y2 axis: Device B resistance R_B (LINEAR)
Y3 axis: Rate-of-change between R_A and R_B Delta_R (LINEAR)
Y4 axis: Device A voltage between terminals DeltaV_A (LINEAR)
Y5 axis: Device B voltage between terminals DeltaV_B (LINEAR)

6 NanoTech

1. CNT Differential R[AC]: CNT Differential R-V characteristics (A.01.20)
2. CNT Gate Leak: CNT FET Ig-Vg characteristics (A.01.20)
3. CNT Id-Time: CNT FET Id-Time Characteristic (A.01.20)
4. CNT Id-Vd: CNT FET Id-Vd characteristics (A.01.20)
5. CNT Id-Vg: Carbon Nano Tube FET Id-Vg characteristics (A.01.20)
6. CNT Id-Vg-Time: CNT FET Ig-Vg characteristics (A.01.20)
7. CNT IV Sweep: CNT Differential I-V characteristics (A.01.20)
8. CNT R-I Kelvin 2SMU: CNT R-I characteristics, Kelvin connection (A.01.20)
9. CNT R-V Kelvin 2SMU: CNT R-V characteristics, Kelvin connection (A.01.20)
10. CNT Vth gmMax: CNT FET linear region Vth (A.01.20)

6.1 CNT Differential R[AC]: CNT Differential R-V characteristics (A.01.20)

[Description]
Measures the conductance of a CNT 2-terminal device and plots differential R-V (resistance vs voltage) characteristics. This test is designed to calculate resistance as the inverse of conductance. Additionally, the level of a measurement signal is specified by a peak-to-peak value (normally effective value).

[Device Under Test]
Carbon Nano Tube FET, 2 terminals

[Required Modules and Accessories]
Agilent B1520A MFCMU 1 unit

[Device Parameters]
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Port1: CMU connected to device under test, CV sweep measurement
V1Start: Sweep output start voltage
V1Stop: Sweep output stop voltage
V1Step: Sweep output step voltage
FREQ: Measurement frequency
Meas_Vpp: Measurement signal level, Peak to Peak value of oscillation

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time
AxisY_RMin: Minimum Y axis (resistance) value
AxisY_RMax: Maximum Y axis (resistance) value

[Measurement Parameters]
Conductance G

[User Function]
Differential resistance R=1/G

[X-Y Plot]
X axis: Port1 input voltage Vport1 (LINEAR)
Y1 axis: Differential resistance R (LINEAR)

[List Display]
Port1 input voltage Vport1
Differential resistance R
Conductance G

6.2 CNT Gate Leak: CNT FET Ig-Vg characteristics (A.01.20)

[Description]
Measures the gate current vs gate voltage (Ig-Vg) characteristics of CNT FET.
Measures Ig before and after applying Vg by using the primary sweep SMU that forces the start and stop voltages only, and extracts the Ig-Vg characteristics by altering the stop value repeatedly.

[Device Under Test]
Carbon Nano Tube FET capacitor, 2 terminals
Connect SMU to the back gate and side gate and make the source and drain open.

[Device Parameters]
Polarity: Forward (SMUs force the specified value) or Reverse (SMUs force the negative specified value)
L: CNT length
D: CNT diameter
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
BackGate: SMU connected to Back Gate terminal, primary sweep voltage output
SideGate: SMU connected to Side Gate terminal, constant voltage output
VbgStart: Pulse peak start (sweep start) voltage for Back Gate terminal
VbgStop: Pulse peak stop (sweep stop) voltage for Back Gate terminal
VbgStep: Pulse peak step (sweep step) voltage for Back Gate terminal
VbgLow: Pulse base voltage (primary sweep start voltage)

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time
Vsg: Side Gate terminal voltage
IbgLimit: Back Gate current compliance
BackGateMinRng: Minimum range for Back Gate current measurement
SideGateMinRng: Minimum range for Side Gate current measurement

[Measurement Parameters]
Ibackgate: Back Gate current

[X-Y Plot]
X axis: Back Gate voltage Vbackgate (LINEAR)
Y1 axis: Back Gate current Ibackgate (LOG)

[List Display]
Vbackgate: Back Gate voltage
Ibackgate: Back Gate current

[Test Output: X-Y Graph]
X axis: Back Gate voltage Vbackgate (LINEAR)
Y1 axis: Back Gate current Ibackgate (LOG)
Y2 axis: Back Gate current with pulse base voltage applied Ibackgate@LowVbg (LOG)

[Test Output: List Display]
V_backgate: Back Gate voltage
I_backgate: Back Gate current
I_backgate@LowVbg: Back Gate current with pulse base voltage applied

[Test Output: Parameters]
V_backgate: Back Gate voltage
I_backgate: Back Gate current
I_backgate@LowVbg: Back Gate current with pulse base voltage applied

6.3 CNT Id-Time: CNT FET Id-Time Characteristic (A.01.20)

[Description]
This Algorithm evaluates the drain current with drain voltage for the gate condition change which is used as the DNA or the antibody sensor.
The IV curves between drain and source is measured with the gate condition change which indicat amunt of the DNA or the antibody on the gate surface as a sensor.
The Algorithm is applied the time dependent measurement.

[Device Under Test]
CNT FET, 4 terminals

[Device Parameters]
Polarity: Forward (SMUs force the specified value) or Reverse (SMUs force the negative specified value).
L: CNT length
D: CNT diameter
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
BackGate: SMU connected to Backgate terminal, secondary sweep voltage output
Source: SMU connected to Source terminal, constant voltage output
Drain: SMU connected to Drain terminal, primary sweep voltage output
SideGate: SMU connected to Sidegate, constant voltage output
VbgStart: Sweep start voltage for Backgate terminal
VbgStop: Sweep stop voltage for Backgate terminal
VbgStep: Sweep step voltage for Backgate terminal
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
Vsg: Sidegate voltage
IntegTime: Integration time
T1Stop: T1 stop time
T1Step: T1 step time
T2Stop: T2 stop time
T2Step: T2 step time

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Backgate current compliance
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain
Time ACC_TIME

ACC_TIME shows total time of T1Step or T2Step and measured time.
ACC_TIME = ACC_TIME + T1Step or T2Step + Measured time of Id-Vd

[X-Y Plot]
X axis: Drain voltage Vdrain (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)

6.4 CNT Id-Vd: CNT FET Id-Vd characteristics (A.01.20)

[Description]
Measures the drain current vs drain voltage characteristics of Carbon Nano Tube FET.

[Device Under Test]
Carbon Nano Tube FET, 4 terminals

[Device Parameters]
Polarity: Forward (SMUs force the specified value) or Reverse (SMUs force the negative specified value).
L: CNT length
D: CNT diameter
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Drain: SMU connected to Drain, primary sweep voltage output
VdStart: Sweep start voltage for Drain
VdStop: Sweep stop voltage for Drain
VdStep: Sweep step voltage for Drain
BackGate: SMU connected to Backgate, secondary sweep voltage output
VbgStart: Sweep start voltage for Backgate
VbgStop: Sweep stop voltage for Backgate
VbgStep: Sweep step voltage for Backgate
IgLimit: Backgate current compliance
SideGate: SMU connected to Sidegate, constant voltage output
Source: SMU connected to Source, constant voltage output

[Extended Test Parameters]
Vsg: Sidegate voltage
Vs: Source voltage
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain

[X-Y Plot]
X axis: Drain voltage Vdrain (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)

6.5 CNT Id-Vg: Carbon Nano Tube FET Id-Vg characteristics (A.01.20)

[Description]
Measures the drain current vs gate voltage characteristics of Carbon Nano Tube FET.

[Device Under Test]
Carbon Nano Tube FET, 4 terminals

[Device Parameters]
Polarity: Forward (SMUs force the specified value) or Reverse (SMUs force the negative specified value).
L: CNT length
D: CNT diameter
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
BackGate: SMU connected to Backgate, primary sweep voltage output
VbgStart: Sweep start voltage for Backgate
VbgStop: Sweep stop voltage for Backgate
VbgStep: Sweep step voltage for Backgate
IgLimit: Backgate current compliance
Drain: SMU connected to Drain, secondary sweep voltage output
VdStart: Sweep start voltage for Drain
VdStop: Sweep stop voltage for Drain
VdStep: Sweep step voltage for Drain
SideGate: SMU connected to Sidegate, constant voltage output
Source: SMU connected to Source, constant voltage output

[Extended Test Parameters]
Vsg: Sidegate voltage
Vs: Source voltage
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain

[X-Y Plot]
X axis: Backgate voltage Vbackgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Drain current Idrain (LOG)

6.6 *CNT Id-Vg-Time: CNT FET Ig-Vg characteristics (A.01.20)*

[Description]
Measures the Id-Vg characteristics of CNT FET repeatedly at a specified interval until specified time elapses. This test is designed to use a gate electrode as a sensor and consider the adsorption of DNA and antibody to the gate electrode as a change in Ids. Used for evaluation of a time change in characteristics.

[Device Under Test]
Carbon Nano Tube FET, 4 terminals

[Device Parameters]
Polarity: Forward (SMUs force the specified value) or Reverse (SMUs force the negative specified value)
L: CNT length
D: CNT diameter
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Drain: SMU connected to Drain, primary sweep voltage output
VdStart: Sweep start voltage for Drain
VdStop: Sweep stop voltage for Drain
VdStep: Sweep step voltage for Drain
BackGate: SMU connected to Back Gate, secondary sweep voltage output
VbgStart: Sweep start voltage for Back Gate
VbgStop: Sweep stop voltage for Back Gate
VbgStep: Sweep step voltage for Back Gate
SideGate: SMU connected to Side Gate, constant voltage output
Vsg: Side Gate voltage
Source: SMU connected to Source, constant voltage output
T1Stop: T1 stop time
T1Step: T1 step time
T2Stop: T2 stop time
T2Step: T2 step time

[Extended Test Parameters]
Vs: Source voltage
IbgLimit: Back Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for drain current measurement

[Measurement Parameters]
Drain current Idrain
Time ACC_TIME

ACC_TIME is displayed after adding the sum of T1Step (or T2Step) and the actual measurement time.
ACC_TIME = ACC_TIME + T1Step (or T2Step) + Id-Vg measurement time

[User Function]
ACC_TIME: Elapsed time
MaxTS: Maximum time stamp value

[X-Y Plot]

X axis: Back Gate voltage Vbackgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)

[List Display]
Vbackgate: Back Gate voltage
Idrain: Drain current
Vsidegate: Side Gate voltage
ACC_TIME: Elapsed time

[Test Setup Details]
Refer to "CNT Id_Vg."

6.7 CNT IV Sweep: CNT Differential I-V characteristics (A.01.20)

[Description]
Measures the I-V (current vs voltage) characteristics of a CNT 2-terminal device.
This test definition allows one to select the direction of a sweep from "Single" and "Double." When the sweep start/stop value is not 0 V, outputs a sweep from 0 V to the start value or from the stop value to 0 V to protect a device.

[Device Under Test]
Carbon Nano Tube FET, 2 terminals

[Device Parameters]
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to device under test, primary sweep voltage output
Port2: SMU connected to device under test, constant voltage output
V1Start: Sweep output start voltage
V1Stop: Sweep output stop voltage
V1Step: Sweep output step voltage
I1Limit: Port1 current compliance
SweepDirection: Sweep direction

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time
V2: Port2 voltage
Y_Min: Minimum Y axis value
Y_Max: Maximum Y axis value
R_Max: Maximum Y axis resistance value
Port1MinRng: Minimum range for Port1 current measurement

[Measurement Parameters]
Iport1: Port1 current

[User Function]
Resistor terminal voltage DeltaV=Vport1-Vport2
Resistance R=DeltaV/Iport1

[X-Y Plot]
X axis: Voltage DeltaV (LINEAR)
Y1 axis: Measured current Iport1 (LINEAR)
Y2 axis: Resistance R (LINEAR)

[List Display]
DeltaV: Voltage
Iport1: Measured current
R: Resistance value

6.8 CNT R-I Kelvin 2SMU: CNT R-I characteristics, Kelvin connection (A.01.20)

[Description]
Measures the electric resistance of a CNT 2-terminal device and plots R-I (resistance vs current) characteristics. This test is designed to apply a current between terminals of devices, measure a voltage and calculate resistance. Kelvin connection is used for connecting SMU to a device.

[Device Under Test]
Carbon Nano Tube FET, 2 terminals

[Device Parameters]
L: CNT length
D: CNT diameter
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to resistor, primary sweep current output
I1Start: Sweep output start current
I1Stop: Sweep output stop current
I1Step: Sweep output step current
V1Limit: Port1 voltage compliance
Port2: SMU connected to resistor, constant voltage output

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time
V2: Port2 voltage

[Measurement Parameters]
Vport1: Port1 voltage

[User Function]
Circular constant PI=3.141592653589
Resistor terminal voltage DeltaV=Vport1-Vport2
Resistance R=DeltaV/Iport1
Sheet resistance Rsheet=R*((PI*D)/L)

[X-Y Plot]
X axis: Current Iport1 (LINEAR)
Y1 axis: Resistance R (LINEAR)
Y2 axis: Measured voltage DeltaV (LINEAR)

[List Display]
Iport1: Input current
R: Resistance value
DeltaV: Resistor terminal voltage
Rsheet: Sheet resistance

6.9 CNT R-V Kelvin 2SMU: CNT R-V characteristics, Kelvin connection (A.01.20)

[Description]
Measures the electric resistance of a CNT 2-terminal device and plots R-V (resistance vs voltage) characteristics. This test is designed to apply a voltage between terminals of devices, measure a current and calculate the resistance. Kelvin connection is used for connecting SMU to a device.

[Device Under Test]
Carbon Nano Tube FET, 2 terminals

[Device Parameters]
L: CNT length
D: CNT diameter
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to resistor, primary sweep voltage output
V1Start: Sweep output start voltage
V1Stop: Sweep output stop voltage
V1Step: Sweep output step voltage
I1Limit: Port1 current compliance
Port2: SMU connected to resistor, constant voltage output
V2: Port2 voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time
Port1MinRng: Minimum range for Port1 current measurement

[Measurement Parameters]
Iport1: Port1 current

[User Function]
Circular constant PI=3.141592653589
Resistor terminal voltage DeltaV=Vport1-Vport2
Resistance R=DeltaV/Iport1
Sheet resistance Rsheet=R*((PI*D)/L)

[X-Y Plot]
X axis: Voltage DeltaV (LINEAR)
Y1 axis: Measured current Iport1 (LINEAR)
Y2 axis: Resistance R (LINEAR)

[List Display]
DeltaV: Input voltage
Iport1: Measured current
R: Resistance value
Rsheet: Sheet resistance

6.10 CNT Vth gmMax: CNT FET linear region Vth (A.01.20)

[Description]
Extracts the threshold voltage (Vth) from linear region data by using the extrapolation method for the measurement of CNT FET Id-Vg characteristics.

[Device Under Test]
Carbon Nano Tube FET, 4 terminals

[Device Parameters]
Polarity: Forward (SMUs force the specified value) or Reverse (SMUs force the negative specified value)
L: CNT length
D: CNT diameter
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
BackGate: SMU connected to Back Gate, primary sweep voltage output
VbgStart: Sweep start voltage for Back Gate
VbgStop: Sweep stop voltage for Back Gate
VbgStep: Sweep step voltage for Back Gate
Drain: SMU connected to Drain, constant voltage output
Vd: Drain voltage, ideally at around 100mV
SideGate: SMU connected to Side Gate, constant voltage output
Source: SMU connected to Source, constant voltage output

[Extended Test Parameters]
Vsg: Side Gate voltage
Vs: Source voltage
IbgLimit: Back Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
gm_Min: Minimum transconductance value for Y axis
gm_Max: Maximum transconductance value for Y axis
DrainMinRng: Minimum range for drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
gm=diff(Idrain,Vbackgate)

[Analysis Function]
gmMax=max(gm)
Von=@L1X (X intercept of Line1)
Vth=Von-Vd/2

Vth is given by the following formula.
Vth=Vg(gmMax)-Id(gmMax)/gmMax
Vd/2 is for compensation of the secondary term of Vd in the theoretical formula.

[Auto Analysis]
Line1: Tangent line for Y1 at gm=gmMax

[X-Y Plot]
X axis: Back Gate voltage Vbackgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Transconductance gm (LINEAR)
Y3 axis: Drain current Idrain (LOG)

[List Display]
Vbackgate: Back Gate voltage
Vsource: Source voltage
Vdrain: Drain voltage
Vsidegate: Side Gate voltage
Idrain: Drain current
gm: Transconductance

[Parameters Display Area]
Threshold voltage Vth
Maximum transconductance value gmMax

7 Power Device

1. BVdss[3] PwrDevice: Breakdown voltage between source and drain (A.01.20)
2. BVgso[3] PwrDevice: Breakdown voltage between gate and source (A.01.20)
3. Id-Vd pulse[3] PwrDevice: Id-Vd characteristics (3-terminal), SMU Pulse (A.01.20)
4. Id-Vd[3] PwrDevice: Id-Vd Characteristics (3-terminal) (A.01.20)
5. Id-Vg pulse[3] PwrDevice: Id-Vg characteristics (3-terminal), SMU Pulse (A.01.20)
6. Id-Vg[3] PwrDevice: Id-Vg Characteristics (3-terminal) (A.01.20)
7. Vth Const Id[3] PwrDevice:
   Constant current Vth (A.01.20)
8. Vth gmMax[3] PwrDevice: Linear region Vth (A.01.20)

7.1 BVdss[3] PwrDevice: Breakdown voltage between source and drain (A.01.20)

[Description]
Measures the breakdown voltage between source and drain of a power MOSFET. Forces drain sweep voltage in the direction of FET on, and monitors breakdown.

[Device Under Test]
Power MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Is@BVdss: Source current deemed to be a breakdown
Drain: SMU connected to Drain, primary sweep voltage output
VdStart: Sweep start voltage for Drain
VdStop: Sweep stop voltage for Drain
VdStep: Sweep step voltage for Drain
Gate: SMU connected to Gate, constant voltage output
Vg: Gate voltage
Source: SMU connected to Source, constant voltage output
BaseOffsetV: Base offset voltage

Base offset voltage is added to the specified voltage. For example, the gate start voltage will be VgStart+BaseOffsetV.

[Extended Test Parameters]
Vs: Source voltage
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for drain current measurement
GateMinRng: Minimum range for gate current measurement
IgLimit: Gate current compliance

[Measurement Parameters]
Drain current Idrain
Source current Isource

For the Source terminal, the SMU current compliance is set to Is@BVdss*1.1.

[User Function]
IsourcePerWg=Isource/Wg: Source current per unit gate width
IdrainPerWg=Idrain/Wg: Drain current per unit gate width

[Analysis Function]
BVdss=@L1X (X intercept of Line1)

[Auto Analysis]

Line1: Vertical line for Y2 at Isource=Is@BVdss

[X-Y Plot]
X axis: Drain voltage Vdrain (LINEAR)
Y1 axis: Drain current Idrain (LOG)
Y2 axis: Source current Isource (LOG)

[List Display]
Drain voltage Vdrain
Drain current Idrain
Source current Isource
Gate current Igate
Gate voltage Vgate
Source voltage Vsource

[Parameters Display Area]
Source-Drain breakdown voltage BVdss

7.2 BVgso[3] PwrDevice: Breakdown voltage between gate and source (A.01.20)

[Description]
Measures the breakdown voltage between gate and source of a power MOSFET when drain is opened. Forces gate sweep voltage in the direction of FET off, and monitors breakdown.

[Device Under Test]
Power MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Is@BVgso: Source current deemed to be a breakdown
Gate: SMU connected to Gate, primary sweep voltage output
VgStart: Sweep start voltage for Gate
VgStop: Sweep stop voltage for Gate
VgStep: Sweep step voltage for Gate
Source: SMU connected to Source, constant voltage output
BaseOffsetV: Base offset voltage

Base offset voltage is added to the specified voltage. For example, the gate start voltage will be VgStart+BaseOffsetV.

[Extended Test Parameters]
Vs: Source voltage
HoldTime: Hold time
DelayTime: Delay time
GateMinRng: Minimum range for gate current measurement
SourceMinRng: Minimum range for source current measurement

[Measurement Parameters]
Source current Isource
Gate current Igate

For the terminals, the SMU current compliance is set to Is@BVgso*1.1.

[User Function]
IgatePerGateArea=Igate/Lg/Wg: Gate current per unit gate area

[Analysis Function]
BVgso=@L1X (X intercept of Line1)

[Auto Analysis]
Line1: Vertical line for Y1 at Isource=Is@BVgso

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Source current Isource (LOG)
Y2 axis: Gate current Igate (LOG)

[List Display]
Gate voltage Vgate
Source current Isource
Gate current Igate
Source voltage Vsource

[Parameters Display Area]
Gate-Source breakdown voltage BVgso

7.3 Id-Vd pulse[3] PwrDevice: Id-Vd characteristics (3-terminal), SMU Pulse (A.01.20)

[Description]
Measures the drain current vs drain voltage characteristics of a power MOSFET.

[Device Under Test]
Power MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Drain: SMU connected to Drain terminal, primary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
PulsePeriod: Pulse period
PulseWidth: Pulse width
Gate: SMU connected to Gate terminal, secondary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Source: SMU connected to Source terminal, constant voltage output
BaseOffsetV: Base offset voltage

Base offset voltage is added to the specified voltage. For example, the gate start voltage will be VgStart+BaseOffsetV.

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
BaseValue: Pulse base voltage
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Drain current Idrain

[User Function]
IdrainPerWg=Idrain/Wg: Drain current per unit gate width

[X-Y Plot]
X axis: Drain voltage Vdrain (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)

[List Display]
Drain voltage Vdrain

Drain current Idrain
Source voltage Vsource
Gate voltage Vgate
Drain current per unit gate width IdrainPerWg

7.4 Id-Vd[3] PwrDevice: Id-Vd Characteristics (3-terminal) (A.01.20)

[Description]
Measures the drain current vs drain voltage characteristics of a power MOSFET.

[Device Under Test]
Power MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Drain: SMU connected to Drain terminal, primary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
Gate: SMU connected to Gate terminal, secondary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Source: SMU connected to Source terminal, constant voltage output
BaseOffsetV: Base offset voltage

Base offset voltage is added to the specified voltage. For example, the gate start voltage will be VgStart+BaseOffsetV.

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
IdrainPerWg=Idrain/Wg: Drain current per unit gate width

[X-Y Plot]
X axis: Drain voltage Vdrain (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)

[List Display]
Drain voltage Vdrain
Drain current Idrain
Gate voltage Vgate
Source voltage Vsource
Drain current per unit gate width IdrainPerWg

7.5 Id-Vg pulse[3] PwrDevice: Id-Vg characteristics (3-terminal), SMU Pulse (A.01.20)

[Description]
Measures the drain current vs gate voltage characteristics of a power MOSFET.

[Device Under Test]
Power MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Drain: SMU connected to Drain terminal, secondary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
PulsePeriod: Pulse period
PulseWidth: Pulse width
Source: SMU connected to Source terminal, constant voltage output
BaseOffsetV: Base offset voltage

Base offset voltage is added to the specified voltage. For example, the gate start voltage will be VgStart+BaseOffsetV.

[Extended Test Parameters]
Vs: Source voltage
BaseValue: Pulse base voltage
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Drain current Idrain

[User Function]
IdrainPerWg=Idrain/Wg: Drain current per unit gate width
gm=diff(Idrain,Vgate): gm: Transconductance
gmPerWg=diff(IdrainPerWg,Vgate): Transconductance per unit gate width

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Drain current Idrain (LOG)

[List Display]
  Gate voltage Vgate
  Source voltage Vsource
  Drain voltage Vdrain
  Drain current Idrain
  Transconductance gm
  Drain current per unit gate width IdrainPerWg
  Transconductance per unit gate width gmPerWg

7.6 Id-Vg[3] PwrDevice: Id-Vg Characteristics (3-terminal) (A.01.20)

[Description]
Measures the drain current vs gate voltage characteristics of a power MOSFET.

[Device Under Test]
Power MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Drain: SMU connected to Drain terminal, secondary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
Source: SMU connected to Source terminal, constant voltage output
BaseOffsetV: Base offset voltage

Base offset voltage is added to the specified voltage. For example, the gate start voltage will be VgStart+BaseOffsetV.

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
IdrainPerWg=Idrain/Wg: Drain current per unit gate width
gm=diff(Idrain,Vgate): gm: Transconductance
gmPerWg=diff(IdrainPerWg,Vgate): Transconductance per unit gate width

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Drain current Idrain (LOG)

[List Display]
Gate voltage Vgate
Source voltage Vsource

Drain voltage Vdrain
Drain current Idrain
Transconductance gm
Drain current per unit gate width IdrainPerWg
Transconductance per unit gate width gmPerWg

7.7 Vth Const Id[3] PwrDevice: Constant current Vth (A.01.20)

[Description]
Measures the drain current vs gate voltage characteristics, and extracts the threshold voltage (Vth) by using the constant current method.

[Device Under Test]
Power MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Id@Vth: Drain current to decide the Vth
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Drain: SMU connected to Drain terminal, constant voltage output
Vd: Drain voltage
Source: SMU connected to Source terminal, constant voltage output
BaseOffsetV: Base offset voltage

Base offset voltage is added to the specified voltage. For example, the gate start voltage will be VgStart+BaseOffsetV.

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
gm=diff(Idrain,Vgate)

[Analysis Function]
Vth=@L1X (X intercept of Line1)

[Auto Analysis]
Line1: Vertical line for Y1 at Idrain=Id@Vth

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Drain current Idrain (LOG)

[List Display]
  Gate voltage Vgate
  Drain current Idrain
  Source voltage Vsource
  Drain voltage Vdrain
  Transconductance gm

[Parameters Display Area]
  Threshold voltage Vth

7.8 Vth gmMax[3] PwrDevice: Linear region Vth (A.01.20)

[Description]
Extracts the threshold voltage (Vth) by using the extrapolation method for the linear region of the drain current vs gate voltage characteristics.

[Device Under Test]
Power MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Drain: SMU connected to Drain terminal, constant voltage output
Vd: Drain voltage, ideally at around 100mV
Source: SMU connected to Source terminal, constant voltage output
BaseOffsetV: Base offset voltage

Base offset voltage is added to the specified voltage. For example, the gate start voltage will be VgStart+BaseOffsetV.

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
gm_Min: Minimum gm value for graph scale
gm_Max: Maximum gm value for graph scale
DrainMinRng: Minimum range for drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
gm=diff(Idrain,Vgate)

[Analysis Function]
gmMax=max(gm)
Von=@L1X (X intercept of Line1)
Vth=Von-Vd/2

Vth is given by the following formula.
Vth=Vg(gmMax)-Id(gmMax)/gmMax
Vd/2 is for compensation of the secondary term of Vd in the theoretical formula.

[Auto Analysis]
  Line1: Tangent line for Y1 at gm=gmMax

[X-Y Plot]
  X axis: Gate voltage Vgate (LINEAR)
  Y1 axis: Drain current Idrain (LINEAR)
  Y2 axis: Transconductance gm (LINEAR)
  Y3 axis: Drain current Idrain (LOG)

[List Display]
  Gate voltage Vgate
  Source voltage Vsource
  Drain voltage Vdrain
  Drain current Idrain
  Transconductance gm

[Parameters Display Area]
  Threshold voltage Vth
  Maximum transconductance value gmMax

8 Reliability

1. BJT EB RevStress 3devices: Emitter-Base junction Reverse bias Stress test, 4 terminals, 3 devices (A.01.20)
2. BJT EB RevStress 3devices[3]: Emitter-Base junction Reverse bias Stress test, 3 terminals, 3 devices (A.01.20)
3. BJT EB RevStress: Emitter-Base junction Reverse bias Stress test, 4 terminals (A.01.20)
4. BJT EB RevStress[3]: Emitter-Base junction Reverse bias Stress test, 3 terminals (A.01.20)
5. BTI 3devices: Bias Temperature Instability test, 4 terminals, 3 devices (A.01.20)
6. BTI 3devices[3]: Bias Temperature Instability test, 3 terminals, 3 devices (A.01.20)
7. BTI: Bias Temperature Instability test, 4 terminals (A.01.20)
8. BTI[3]: Bias Temperature Instability test, 3 terminals (A.01.20)
9. Charge Pumping: Evaluation of the interface state using charge pumping method (A.01.20)
10. EM Istress: Electromigration test, current stressed, 4 SMUs (A.01.20)
11. EM Istress[2]: Electromigration test, current stressed, 2 SMUs (A.01.20)
12. EM Istress[6]: Electromigration test, current stressed, 6 SMUs (A.01.20)
13. EM Vstress: Electromigration test, voltage stressed, 4 SMUs (A.01.20)
14. EM Vstress[2]: Electromigration test, voltage stressed, 2 SMUs (A.01.20)
15. EM Vstress[6]: Electromigration test, voltage stressed, 6 SMUs (A.01.20)
16. HCI 3devices: Hot Carrier Injection test, 4 terminals, 3 devices (A.01.20)
17. HCI: Hot Carrier Injection test, 4 terminals (A.01.20)
18. J-Ramp: Insulator lifetime evaluation, current stressed (A.01.20)
19. TDDB Istress 3devices: TDDB Test, current stressed, 3 devices (A.01.20)
20. TDDB Istress: TDDB Test, current stressed (A.01.20)
21. TDDB Vstress 3devices: TDDB Test, voltage stressed, 3 devices (A.01.20)
22. TDDB Vstress: TDDB Test, voltage stressed (A.01.20)
23. TZDB: TZDB Test of oxide layer (A.01.20)
24. V-Ramp: Insulator lifetime evaluation, voltage stressed (A.01.20)

8.1 BJT EB RevStress 3devices: Emitter-Base junction Reverse bias Stress test, 4 terminals, 3 devices (A.01.20)

[Description]

Performs the bipolar transistor Emitter-Base junction reverse bias stress test, and plots the accumulated stress time vs collector current/base current/current amplification factor characteristics. Maximum three devices can be measured by a test execution. This test is performed as follows.

1. performs initial characterization
2. applies stress voltage
3. performs interim characterization
4. saves measurement data
5. repeats 2 to 4 until TotalStressTime elapses

[Device Under Test]

Bipolar transistor, 4 terminals, 3 devices

[Required Accessories]

Agilent B2200A or B2201A switching matrix 1 unit
GPIB cable

Connect B2200A/B2201A to B1500A with a measuring cable and GPIB cable.

Set information on B1500A SMU channel's connection to the B2200A/B2201A input port properly on the Switching Matrix tab screen of the Configuration window.

Set the output channel number of B2200A/B2201A connected to each terminal of a device under test properly in the Tr#Base/Tr#Collector/Tr#Emitter/Tr#Subs field (# is an integer from 1 to 3) of Test Parameters area.

[Device Parameters]

Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value)
Le: Emitter length
We: Emitter width
Temp: Temperature (deg)
IcMax: Maximum collector current value

[Test Parameters]

IntegTime: Integration time (SHORT, MEDIUM, LONG)
Tr#Base: SWM Pin Assign setting for Base of devices
Tr#Collector: SWM Pin Assign setting for Collector of devices
Tr#Emitter: SWM Pin Assign setting for Emitter of devices
Tr#Subs: SWM Pin Assign setting for Subs of devices

where, # is an integer from 1 to 3.

[Test Parameters for Sampling_Stress]

TotalStrsTime: Total stress time
Tr#StrsEmitter: SMU connected to Emitter terminal of devices, constant voltage output
StrsBase: SMU connected to Base terminal, constant voltage output
StrsCollector: SMU connected to Collector terminal, constant voltage output
StrsSubs: SMU connected to Substrate terminal, constant voltage output
Tr#VeStrs: Stress voltage for Emitter terminal of devices

where, # is an integer from 1 to 3.

[Test Parameters for IvSweep_hfe]

MeasCollector: SMU connected to Collector terminal, constant voltage output
MeasBase: SMU connected to Base terminal, voltage output
MeasEmitter: SMU connected to Emitter terminal, primary sweep constant voltage output
MeasSubs: SMU connected to Substrate terminal, constant voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Ic@hfe: Collector current determining the hfe
Vc: Collector voltage

[Extended Test Parameters]
[Extended Test Parameters for Sampling_Stress]
VbStrs: Stress voltage for Base terminal
VcStrs: Stress voltage for Collector terminal
VsubsStrs: Stress voltage for Substrate terminal
IeStrsLimit: Emitter current compliance

[Extended Test Parameters for IvSweep_hfe]
IsubsLimit: Substrate current compliance
Ve: Emitter voltage
Vsubs: Substrate voltage
hfe_Min: Minimum hfe value for graph scale
hfe_Max: Maximum hfe value for graph scale
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng1: Minimum range for base current measurement on device 1
BaseMinRng2: Minimum range for base current measurement on device 2
BaseMinRng3: Minimum range for base current measurement on device 3
CollectorMinRng1: Minimum range for collector current measurement on device 1
CollectorMinRng2: Minimum range for collector current measurement on device 2
CollectorMinRng3: Minimum range for collector current measurement on device 3

[User Function]
[User Function for Sampling_Stress]
Maximum elapsed time value MaxTime=max(Time)
Stress time StressTime=AccTime+Time

[User Function for IvSweep_hfe]
Current amplification factor hfe=Icollector/Ibase

[Analysis Function]
[Analysis Function for IvSweep_hfe]
Ib@Ic=@L1X (X intercept of Line1)
hfe@Ic=@L2Y3 (X intercept of Line2)

[Auto Analysis]
[Auto Analysis for IvSweep_hfe]
Line1: Horizontal line for Y1 at Icollector=Ic@hfe
Line2: Horizontal line for Y3 at Icollector=Ic@hfe

[Test Output: X-Y Graph]
X axis: Accumulated stress time TimeList (LOG)
Y1 axis: Collector current for device 1 Dev1_IcList (LINEAR)
Y2 axis: Collector current for device 2 Dev2_IcList (LINEAR)
Y3 axis: Collector current for device 3 Dev3_IcList (LINEAR)

Y4 axis: Y3 accumulation data at Icollector=Ic@hfe for device 1 Dev1_hfe@IcList (LINEAR)
Y5 axis: Y3 accumulation data at Icollector=Ic@hfe for device 2 Dev2_hfe@IcList (LINEAR)
Y6 axis: Y3 accumulation data at Icollector=Ic@hfe for device 3 Dev3_hfe@IcList (LINEAR)

[Test Output: List Display]
TimeList: Accumulated stress time
Dev1_IcList: Collector current for device 1
Dev2_IcList: Collector current for device 2
Dev3_IcList: Collector current for device 3
Dev1_hfe@IcList: Y3 accumulation data at Icollector=Ic@hfe for device 1
Dev2_hfe@IcList: Y3 accumulation data at Icollector=Ic@hfe for device 2
Dev3_hfe@IcList: Y3 accumulation data at Icollector=Ic@hfe for device 3
Dev1_Ib@IcList: Y1 accumulation data at Icollector=Ic@hfe for device 1
Dev2_Ib@IcList: Y1 accumulation data at Icollector=Ic@hfe for device 2
Dev3_Ib@IcList: Y1 accumulation data at Icollector=Ic@hfe for device 3

8.2 BJT EB RevStress 3devices[3]: Emitter-Base junction Reverse bias Stress test, 3 terminals, 3 devices (A.01.20)

[Description]
Performs the bipolar transistor Emitter-Base junction reverse bias stress test, and plots the accumulated stress time vs collector current/base current/current amplification factor characteristics.
This test is performed as follows.
1. performs initial characterization
2. applies stress voltage
3. performs interim characterization
4. saves measurement data
5. repeats 2 to 4 until TotalStressTime elapses

[Device Under Test]
Bipolar transistor, 3 terminals, 3 devices

[Required Accessories]
Agilent B2200A or B2201A switching matrix 1 unit
GPIB cable

Connect B2200A/B2201A to B1500A with a measuring cable and GPIB cable.
Set information on B1500A SMU channel's connection to the B2200A/B2201A input port properly on the Switching Matrix tab screen of the Configuration window.
Set the output channel number of B2200A/B2201A connected to each terminal of a device under test properly in the Tr#Base/Tr#Collector/Tr#Emitter field (# is an integer from 1 to 3) of Test Parameters area.

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value)
Le: Emitter length
We: Emitter width
Temp: Temperature (deg)
IcMax: Maximum collector current value

[Test Parameters]
IntegTime: Integration time (SHORT, MEDIUM, LONG)
Tr#Base: SWM Pin Assign setting for Base of devices
Tr#Collector: SWM Pin Assign setting for Collector of devices
Tr#Emitter: SWM Pin Assign setting for Emitter of devices

where, # is an integer from 1 to 3.

[Test Parameters for Sampling_Stress]
TotalStrsTime: Total stress time
Tr#StrsEmitter: SMU connected to Emitter terminal of devices, constant voltage output
StrsBase: SMU connected to Base terminal, constant voltage output
StrsCollector: SMU connected to Collector terminal, constant voltage output
Tr#VeStrs: Stress voltage for Emitter terminal of devices

where, # is an integer from 1 to 3.

[Test Parameters for IvSweep_hfe]
MeasCollector: SMU connected to Collector terminal, constant voltage output
MeasBase: SMU connected to Base terminal, voltage output

MeasEmitter: SMU connected to Emitter terminal, primary sweep constant voltage output
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Ic@hfe: Collector current determining the hfe
Vc: Collector voltage

[Extended Test Parameters]
[Extended Test Parameters for Sampling_Stress]
VbStrs: Stress voltage for Base terminal
VcStrs: Stress voltage for Collector terminal
IeStrsLimit: Emitter current compliance

[Extended Test Parameters for IvSweep_hfe]
Ve: Emitter voltage
hfe_Min: Minimum hfe value for graph scale
hfe_Max: Maximum hfe value for graph scale
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng1: Minimum range for base current measurement on device 1
BaseMinRng2: Minimum range for base current measurement on device 2
BaseMinRng3: Minimum range for base current measurement on device 3
CollectorMinRng1: Minimum range for collector current measurement on device 1
CollectorMinRng2: Minimum range for collector current measurement on device 2
CollectorMinRng3: Minimum range for collector current measurement on device 3

[User Function]
[User Function for Sampling_Stress]
Maximum elapsed time value MaxTime=max(Time)
Stress time StressTime=AccTime+Time

[User Function for IvSweep_hfe]
Current amplification factor hfe=Icollector/Ibase

[Analysis Function]
[Analysis Function for IvSweep_hfe]
Ib@Ic=@L1X (X intercept of Line1)
hfe@Ic=@L2Y3 (X intercept of Line2)

[Auto Analysis]
[Auto Analysis for IvSweep_hfe]
Line1: Horizontal line for Y1 at Icollector=Ic@hfe
Line2: Horizontal line for Y3 at Icollector=Ic@hfe

[Test Output: X-Y Graph]
X axis: Accumulated stress time TimeList (LOG)
Y1 axis: Collector current for device 1 Dev1_IcList (LINEAR)
Y2 axis: Collector current for device 2 Dev2_IcList (LINEAR)
Y3 axis: Collector current for device 3 Dev3_IcList (LINEAR)
Y4 axis: Y3 accumulation data at Icollector=Ic@hfe for device 1 Dev1_hfe@IcList (LINEAR)
Y5 axis: Y3 accumulation data at Icollector=Ic@hfe for device 2 Dev2_hfe@IcList (LINEAR)
Y6 axis: Y3 accumulation data at Icollector=Ic@hfe for device 3 Dev3_hfe@IcList (LINEAR)

[Test Output: List Display]
TimeList: Accumulated stress time

Dev1_IcList: Collector current for device 1
Dev2_IcList: Collector current for device 2
Dev3_IcList: Collector current for device 3
Dev1_hfe@IcList: Y3 accumulation data at Icollector=Ic@hfe for device 1
Dev2_hfe@IcList: Y3 accumulation data at Icollector=Ic@hfe for device 2
Dev3_hfe@IcList: Y3 accumulation data at Icollector=Ic@hfe for device 3
Dev1_Ib@IcList: Y1 accumulation data at Icollector=Ic@hfe for device 1
Dev2_Ib@IcList: Y1 accumulation data at Icollector=Ic@hfe for device 2
Dev3_Ib@IcList: Y1 accumulation data at Icollector=Ic@hfe for device 3

8.3 BJT EB RevStress: Emitter-Base junction Reverse bias Stress test, 4 terminals (A.01.20)

[Description]
Performs the bipolar transistor Emitter-Base junction reverse bias stress test, and plots the accumulated stress time vs collector current/base current/current amplification factor characteristics.
This test is performed as follows.
1. performs initial characterization
2. applies stress voltage
3. performs interim characterization
4. saves measurement data
5. repeats 2 to 4 until TotalStressTime elapses

[Device Under Test]
Bipolar transistor, 4 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value)
Le: Emitter length
We: Emitter width
Temp: Temperature (deg)
IcMax: Maximum collector current value

[Test Parameters]
IntegTime: Integration time (SHORT, MEDIUM, LONG)
TotalStressTime: Total stress time
Collector: SMU connected to Collector terminal, constant voltage output
Base: SMU connected to Base terminal, constant voltage output
Emitter: SMU connected to Emitter terminal, primary sweep voltage output
Subs: SMU connected to Substrate terminal, constant voltage output

[Test Parameters for Sampling_Stress]
VeStress: Stress voltage for Emitter terminal

[Test Parameters for IvSweep_hfe]
Ic@hfe: Collector current determining the hfe
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Vc: Collector voltage

[Extended Test Parameters]
[Extended Test Parameters for Sampling_Stress]
IeStressLimit: Emitter current compliance
VbStress: Stress voltage for Base terminal
VcStress: Stress voltage for Collector terminal
VsubsStress: Stress voltage for Substrate terminal

[Extended Test Parameters for IvSweep_hfe]
HoldTime: Hold time
DelayTime: Delay time
IsubsLimit: Substrate current compliance
BaseMinRng: Minimum range for base current measurement

CollectorMinRng: Minimum range for collector current measurement
Ve: Emitter voltage
Vsubs: Substrate voltage
hfe_Min: Minimum hfe value for graph scale
hfe_Max: Maximum hfe value for graph scale

[User Function]
[User Function for Sampling_Stress]
Maximum elapsed time value MaxTime=max(Time)
Stress time StressTime=AccTime+Time

[User Function for IvSweep_hfe]
Current amplification factor hfe=Icollector/Ibase

[Analysis Function]
[Analysis Function for IvSweep_hfe]
Ib@Ic=@L1X (X intercept of Line1)
hfe@Ic=@L2Y3 (X intercept of Line2)

[Auto Analysis]
[Auto Analysis for IvSweep_hfe]
Line1: Horizontal line for Y1 at Icollector=Ic@hfe
Line2: Horizontal line for Y3 at Icollector=Ic@hfe

[Test Output: X-Y Graph]
X axis: Accumulated stress time TimeList (LOG)
Y1 axis: Collector current IcList (LOG)
Y2 axis: Y1 accumulation data at Icollector=Ic@hfe Ib@IcList (LOG)
Y3 axis: Y3 accumulation data at Icollector=Ic@hfe Ihfe@IcList (LINEAR)

[Test Output: List Display]
Accumulated stresss time TimeList
Collector current IcList
Y1 accumulation data at Icollector=Ic@hfe Ib@IcList
Y3 accumulation data at Icollector=Ic@hfe hfe@IcList

8.4 BJT EB RevStress[3]: Emitter-Base junction Reverse bias Stress test, 3 terminals (A.01.20)

[Description]
Performs the bipolar transistor Emitter-Base junction reverse bias stress test, and plots the accumulated stress time vs collector current/base current/current amplification factor characteristics.
This test is performed as follows.
1. performs initial characterization
2. applies stress voltage
3. performs interim characterization
4. saves measurement data
5. repeats 2 to 4 until TotalStressTime elapses

[Device Under Test]
Bipolar transistor, 3 terminals

[Device Parameters]
Polarity: NPN (SMUs force the specified value) or PNP (SMUs force the negative specified value)
Le: Emitter length
We: Emitter width
Temp: Temperature (deg)
IcMax: Maximum collector current value

[Test Parameters]
IntegTime: Integration time (SHORT, MEDIUM, LONG)
TotalStressTime: Total stress time
Collector: SMU connected to Collector terminal, constant voltage output
Base: SMU connected to Base terminal, constant voltage output
Emitter: SMU connected to Emitter terminal, primary sweep voltage output

[Test Parameters for Sampling_Stress]
VeStress: Stress voltage for Emitter terminal

[Test Parameters for IvSweep_hfe]
Ic@hfe: Collector current determining the hfe
VbStart: Sweep start voltage for Base terminal
VbStop: Sweep stop voltage for Base terminal
VbStep: Sweep step voltage for Base terminal
Vc: Collector voltage

[Extended Test Parameters]
[Extended Test Parameters for Sampling_Stress]
IeStressLimit: Emitter current compliance
VbStress: Stress voltage for Base terminal
VcStress: Stress voltage for Collector terminal

[Extended Test Parameters for IvSweep_hfe]
HoldTime: Hold time
DelayTime: Delay time
BaseMinRng: Minimum range for base current measurement
CollectorMinRng: Minimum range for collector current measurement
Ve: Emitter voltage
hfe_Min: Minimum hfe value for graph scale

hfe_Max: Maximum hfe value for graph scale

[User Function]
[User Function for Sampling_Stress]
Maximum elapsed time value MaxTime=max(Time)
Stress time StressTime=AccTime+Time

[User Function for IvSweep_hfe]
hfe=Icollector/Ibase

[Analysis Function]
[Analysis Function for IvSweep_hfe]
Ib@Ic=@L1X (X intercept of Line1)
hfe@Ic=@L2Y3 (X intercept of Line2)

[Auto Analysis]
[Auto Analysis for IvSweep_hfe]
Line1: Horizontal line for Y1 at Icollector=Ic@hfe
Line2: Horizontal line for Y3 at Icollector=Ic@hfe

[Test Output: X-Y Graph]
X axis: Accumulated stress time TimeList (LOG)
Y1 axis: Collector current IcList (LOG)
Y2 axis: Y1 accumulation data at Icollector=Ic@hfe Ib@IcList (LOG)
Y3 axis: Y3 accumulation data at Icollector=Ic@hfe Ihfe@IcList (LINEAR)

[Test Output: List Display]
Accumulated stresss time TimeList
Collector current IcList
Y1 accumulation data at Icollector=Ic@hfe Ib@IcList
Y3 accumulation data at Icollector=Ic@hfe hfe@IcList

8.5 BTI 3devices: Bias Temperature Instability test, 4 terminals, 3 devices (A.01.20)

[Description]
Performs the bias temperature instability test, and plots the accumulated stress time vs threshold voltage/drain current characteristics. Maximum three devices can be measured by a test execution. This test is performed as follows.

1. performs initial characterization
2. applies stress voltage
3. performs interim characterization
4. saves measurement data
5. repeats 2 to 4 until TotalStressTime elapses

[Device Under Test]
MOSFET, 4 terminals, 3 devices

[Required Accessories]
Agilent B2200A or B2201A switching matrix 1 unit
GPIB cable

Connect B2200A/B2201A to B1500A with a measuring cable and GPIB cable.
Set information on B1500A SMU channel's connection to the B2200A/B2201A input port properly on the Switching Matrix tab screen of the Configuration window.
Set the output channel number of B2200A/B2201A connected to each terminal of a device under test properly in the Tr#Gate/Tr#Drain/Tr#Source/Tr#Subs field (# is an integer from 1 to 3) of Test Parameters area.

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value)
Lg: Gate length
Wg: Gate width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time (SHORT, MEDIUM, LONG)
Tr#Gate: SWM Pin Assign settings for Gate terminal of devices
Tr#Drain: SWM Pin Assign settings for Drain terminal of devices
Tr#Source: SWM Pin Assign settings for Source terminal of devices
Tr#Subs: SWM Pin Assign settings for Substrate terminal of devices

where, # is an integer from 1 to 3.

[Test Parameters for Sampling_Stress]
TotalStrsTime: Total stress time
Tr#StrsGate: SMU connected to Gate terminal of devices, constant voltage output
StrsSource: SMU connected to Gate terminal of devices, constant voltage output (drain/subs short)
Tr#VgStrs: Gate terminal stress voltage for the devices
VsStrs: Source terminal stress voltage

where, # is an integer from 1 to 3.

[Test Parameters for IvSweep_ConstId]
MeasGate: SMU connected to the basic characteristics acquisition Gate terminal, primary sweep voltage output

MeasDrain: SMU connected to the basic characteristics acquisition Drain terminal, constant voltage output
MeasSource: SMU connected to the basic characteristics acquisition Source terminal, constant voltage output
Id@Vth: Drain current to decide the Vth, per unit area
VgStart1: Sweep start voltage for Gate terminal
VgStop1: Sweep stop voltage for Gate terminal
VgStep1: Sweep step voltage for Gate terminal
Vd1: Drain terminal voltage, constant value

[Test Parameters for IvSweep_gmmax]
MeasGate: SMU connected to the basic characteristics acquisition Gate terminal, primary sweep voltage output
MeasDrain: SMU connected to the basic characteristics acquisition Drain terminal, constant voltage output
MeasSource: SMU connected to the basic characteristics acquisition Source terminal, constant voltage output
VgStart2: Sweep start voltage for Gate terminal
VgStop2: Sweep stop voltage for Gate terminal
VgStep2: Sweep step voltage for Gate terminal
Vd2: Drain voltage

[Test Parameters for Sampling_Ids]
MeasGate: SMU connected to the basic characteristics acquisition Gate terminal, primary sweep voltage output
MeasDrain: SMU connected to the basic characteristics acquisition Drain terminal, constant voltage output
MeasSource: SMU connected to the basic characteristics acquisition Source terminal, constant voltage output
Vg3: Gate terminal voltage
Vd3: Drain terminal voltage

[Extended Test Parameters]
[Extended Test Parameters for IvSweep_ConstId]
HoldTime: Hold time
DelayTime: Delay time
Vs: Source terminal voltage, constant voltage
IgLimit: Gate current compliance
IdLimit: Drain current compliance
DrainMinRng1: Minimum range for drain current measurement on device 1
DrainMinRng2: Minimum range for drain current measurement on device 1
DrainMinRng3: Minimum range for drain current measurement on device 1

[Extended Test Parameters for IvSweep_gmmax]
HoldTime: Hold time
DelayTime: Delay time
Vs: Source terminal voltage, constant voltage
IgLimit: Gate current compliance
IdLimit: Drain current compliance
Vth_Min: Minimum Vth value for graph scale
Vth_Max: Maximum Vth value for graph scale
gmMax_Min: Minimum gmMax value for graph scale
gmMax_Max: Maximum gmMax value for graph scale
DrainMinRng1: Minimum range for drain current measurement on device 1
DrainMinRng2: Minimum range for drain current measurement on device 1
DrainMinRng3: Minimum range for drain current measurement on device 1

[Extended Test Parameters for Sampling_Ids]
Vs: Source terminal voltage, constant voltage
IgLimit: Gate current compliance
IdLimit: Drain current compliance

DrainMinRng1: Minimum range for drain current measurement on device 1
DrainMinRng2: Minimum range for drain current measurement on device 1
DrainMinRng3: Minimum range for drain current measurement on device 1

[User Function]
[User Function for Sampling_Stress]
Maximum elapsed time value MaxTime=max(Time)
Stress time StressTime=AccTime+Time

[User Function for IvSweep_ConstId]
Maximum drain current value IdMax=max(abs(Idrain)) (For initial measurement only)

[User Function for IvSweep_gmmax]
Transconductance gm=diff(Idrain,Vgate)
Maximum transconductance value gmmax=max(gm)
Maximum drain current value IdMax=max(abs(Idrain)) (For initial measurement only)

[Analysis Function]
[Analysis Function for IvSweep_ConstId]
Vth@Id=@L1X (X intercept of Line1)

[Analysis Function for IvSweep_gmmax]
Vth@Gm=@L1X (X intercept of Line1)

[Auto Analysis]
[Auto Analysis for IvSweep_ConstId]
Line1: Vertical line for Y1 at Idrain=Id@Vth

[Auto Analysis for IvSweep_gmmax]
Line1: Tangent line for Y1 at gm=gmMax

[Test Output: X-Y Graph]
X axis: Elapsed time TimeList (LOG)
Y1 axis: Drain current for device 1 Dev1_IdsList (LOG)
Y2 axis: Drain current for device 2 Dev2_IdsList (LOG)
Y3 axis: Drain current for device 3 Dev3_IdsList (LOG)
Y4 axis: Maximum transconductance value for device 1 Dev1_GmMaxList (LINEAR)
Y5 axis: Maximum transconductance value for device 2 Dev2_GmMaxList (LINEAR)
Y6 axis: Maximum transconductance value for device 3 Dev3_GmMaxList (LINEAR)

[Test Output: List Display]
TimeList: Elapsed time
Dev1_IdsList: Drain current for device 1
Dev2_IdsList: Drain current for device 2
Dev3_IdsList: Drain current for device 3
Dev1_VthIdList: Vth for device 1, determined by constant current method
Dev2_VthIdList: Vth for device 2, determined by constant current method
Dev3_VthIdList: Vth for device 3, determined by constant current method
Dev1_VthGmList: Vth for device 1, determined by extrapolation method
Dev2_VthGmList: Vth for device 2, determined by extrapolation method
Dev3_VthGmList: Vth for device 3, determined by extrapolation method
Dev1_GmMaxList: Maximum transconductance value for device 1
Dev2_GmMaxList: Maximum transconductance value for device 2
Dev3_GmMaxList: Maximum transconductance value for device 3

8.6 BTI 3devices[3]: Bias Temperature Instability test, 3 terminals, 3 devices (A.01.20)

[Description]
Performs the bias temperature instability test, and plots the accumulated stress time vs threshold voltage/drain current characteristics. Maximum three devices can be measured by a test execution. This test is performed as follows.
1. performs initial characterization
2. applies stress voltage
3. performs interim characterization
4. saves measurement data
5. repeats 2 to 4 until TotalStressTime elapses

[Device Under Test]
MOSFET, 3 terminals, 3 devices

[Required Accessories]
Agilent B2200A or B2201A switching matrix 1 unit
GPIB cable

Connect B2200A/B2201A to B1500A with a measuring cable and GPIB cable.
Set information on B1500A SMU channel's connection to the B2200A/B2201A input port properly on the Switching Matrix tab screen of the Configuration window.
Set the output channel number of B2200A/B2201A connected to each terminal of a device under test properly in the Tr#Gate/Tr#Drain/Tr#Source field (# is an integer from 1 to 3) of Test Parameters area.

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value)
Lg: Gate length
Wg: Gate width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time (SHORT, MEDIUM, LONG)
Tr#Gate: SWM Pin Assign settings for Gate terminal of devices
Tr#Drain: SWM Pin Assign settings for Drain terminal of devices
Tr#Source: SWM Pin Assign settings for Source terminal of devices

where, # is an integer from 1 to 3.

[Test Parameters for Sampling_Stress]
TotalStrsTime: Total stress time
Tr#StrsGate: SMU connected to Gate terminal of devices, constant voltage output
StrsSource: SMU connected to Gate terminal of devices, constant voltage output (drain/subs short)
Tr#VgStrs: Gate terminal stress voltage for the devices
VsStrs: Source terminal stress voltage

where, # is an integer from 1 to 3.

[Test Parameters for IvSweep_ConstId]
MeasGate: SMU connected to the basic characteristics acquisition Gate terminal, primary sweep voltage output
MeasDrain: SMU connected to the basic characteristics acquisition Drain terminal, constant voltage output

MeasSource: SMU connected to the basic characteristics acquisition Source terminal, constant voltage output
Id@Vth: Drain current to decide the Vth, per unit area
VgStart1: Sweep start voltage for Gate terminal
VgStop1: Sweep stop voltage for Gate terminal
VgStep1: Sweep step voltage for Gate terminal
Vd1: Drain terminal voltage, constant value

[Test Parameters for IvSweep_gmmax]
MeasGate: SMU connected to the basic characteristics acquisition Gate terminal, primary sweep voltage output
MeasDrain: SMU connected to the basic characteristics acquisition Drain terminal, constant voltage output
MeasSource: SMU connected to the basic characteristics acquisition Source terminal, constant voltage output
VgStart2: Sweep start voltage for Gate terminal
VgStop2: Sweep stop voltage for Gate terminal
VgStep2: Sweep step voltage for Gate terminal
Vd2: Drain voltage

[Test Parameters for Sampling_Ids]
MeasGate: SMU connected to the basic characteristics acquisition Gate terminal, primary sweep voltage output
MeasDrain: SMU connected to the basic characteristics acquisition Drain terminal, constant voltage output
MeasSource: SMU connected to the basic characteristics acquisition Source terminal, constant voltage output
Vg3: Gate terminal voltage
Vd3: Drain terminal voltage

[Extended Test Parameters]
[Extended Test Parameters for IvSweep_ConstId]
HoldTime: Hold time
DelayTime: Delay time
Vs: Source terminal voltage, constant voltage
IgLimit: Gate current compliance
IdLimit: Drain current compliance
DrainMinRng1: Minimum range for drain current measurement on device 1
DrainMinRng2: Minimum range for drain current measurement on device 2
DrainMinRng3: Minimum range for drain current measurement on device 3

[Extended Test Parameters for IvSweep_gmmax]
HoldTime: Hold time
DelayTime: Delay time
Vs: Source terminal voltage, constant voltage
IgLimit: Gate current compliance
IdLimit: Drain current compliance
Vth_Min: Minimum Vth value for graph scale
Vth_Max: Maximum Vth value for graph scale
gmMax_Min: Minimum gmMax value for graph scale
gmMax_Max: Maximum gmMax value for graph scale
DrainMinRng1: Minimum range for drain current measurement on device 1
DrainMinRng2: Minimum range for drain current measurement on device 2
DrainMinRng3: Minimum range for drain current measurement on device 3

[Extended Test Parameters for Sampling_Ids]
Vs: Source terminal voltage, constant voltage
IgLimit: Gate current compliance
IdLimit: Drain current compliance
DrainMinRng1: Minimum range for drain current measurement on device 1

DrainMinRng2: Minimum range for drain current measurement on device 2
DrainMinRng3: Minimum range for drain current measurement on device 3

[User Function]
[User Function for Sampling_Stress]
Maximum elapsed time value MaxTime=max(Time)
Stress time StressTime=AccTime+Time

[User Function for IvSweep_ConstId]
Maximum drain current value IdMax=max(abs(Idrain)) (For initial measurement only)

[User Function for IvSweep_gmmax]
Transconductance gm=diff(Idrain,Vgate)
Maximum transconductance value gmmax=max(gm)
Maximum drain current value IdMax=max(abs(Idrain)) (For initial measurement only)

[Analysis Function]
[Analysis Function for IvSweep_ConstId]
Vth@Id=@L1X (X intercept of Line1)

[Analysis Function for IvSweep_gmmax]
Vth@Gm=@L1X (X intercept of Line1)

[Auto Analysis]
[Auto Analysis for IvSweep_ConstId]
Line1: Vertical line for Y1 at Idrain=Id@Vth

[Auto Analysis for IvSweep_gmmax]
Line1: Tangent line for Y1 at gm=gmMax

[Test Output: X-Y Graph]
X axis: Elapsed time TimeList (LOG)
Y1 axis: Drain current for device 1 Dev1_IdsList (LOG)
Y2 axis: Drain current for device 2 Dev2_IdsList (LOG)
Y3 axis: Drain current for device 3 Dev3_IdsList (LOG)
Y4 axis: Maximum transconductance value for device 1 Dev1_GmMaxList (LINEAR)
Y5 axis: Maximum transconductance value for device 2 Dev2_GmMaxList (LINEAR)
Y6 axis: Maximum transconductance value for device 3 Dev3_GmMaxList (LINEAR)

[Test Output: List Display]
TimeList: Elapsed time
Dev1_IdsList: Drain current for device 1
Dev2_IdsList: Drain current for device 2
Dev3_IdsList: Drain current for device 3
Dev1_VthIdList: Vth for device 1, determined by constant current method
Dev2_VthIdList: Vth for device 2, determined by constant current method
Dev3_VthIdList: Vth for device 3, determined by constant current method
Dev1_VthGmList: Vth for device 1, determined by extrapolation method
Dev2_VthGmList: Vth for device 2, determined by extrapolation method
Dev3_VthGmList: Vth for device 3, determined by extrapolation method
Dev1_GmMaxList: Maximum transconductance value for device 1
Dev2_GmMaxList: Maximum transconductance value for device 2
Dev3_GmMaxList: Maximum transconductance value for device 3

8.7 BTI: Bias Temperature Instability test, 4 terminals (A.01.20)

[Description]
Performs the bias temperature instability test, and plots the accumulated stress time vs threshold voltage/drain current characteristics.
This test is performed as follows.
1. performs initial characterization
2. applies stress voltage
3. performs interim characterization
4. saves measurement data
5. repeats 2 to 4 until TotalStressTime elapses

[Device Under Test]
MOSFET, 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value)
Lg: Gate length
Wg: Gate width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time (SHORT, MEDIUM, LONG)
TotalStressTime: Total stress time
Gate: SMU connected to Gate terminal, primary sweep voltage output
Drain: SMU connected to Drain terminal, constant voltage output
Subs: SMU connected to Substrate terminal, constant voltage output
Source: SMU connected to Source terminal, constant voltage output
VgStress: Gate terminal stress voltage

[Test Parameters for IvSweep_ConstId]
Id@Vth: Drain current to decide the Vth, per unit area
VgStart1: Sweep start voltage for Gate terminal
VgStop1: Sweep stop voltage for Gate terminal
VgStep1: Sweep step voltage for Gate terminal
Vd1: Drain terminal voltage, constant value

[Test Parameters for IvSweep_gmmax]
VgStart2: Sweep start voltage for Gate terminal
VgStop2: Sweep stop voltage for Gate terminal
VgStep2: Sweep step voltage for Gate terminal
Vd2: Drain voltage

[Test Parameters for Sampling_Ids]
Vg3: Gate terminal voltage
Vd3: Drain terminal voltage

[Extended Test Parameters]
[Extended Test Parameters for Sampling_Stress]
Vd: Drain terminal voltage, constant voltage
Vs: Source terminal voltage, constant voltage
Vsubs: Substrate terminal voltage, constant voltage
IgLimit: Gate current compliance

[Extended Test Parameters for IvSweep_ConstId]
HoldTime: Hold time
DelayTime: Delay time
IdLimit: Drain current compliance
IsubsLimit: Substrate current compliance
Vs: Source terminal voltage, constant voltage
Vsubs: Substrate terminal voltage, constant voltage
DrainMinRng: Minimum range for drain current measurement

[Extended Test Parameters for IvSweep_gmmax]
HoldTime: Hold time
DelayTime: Delay time
IgLimit: Gate current compliance
IdLimit: Drain current compliance
IsubsLimit: Substrate current compliance
Vs: Source terminal voltage, constant voltage
Vsubs: Substrate terminal voltage, constant voltage
DrainMinRng: Minimum range for drain current measurement
Vth_Min: Minimum Vth value for graph scale
Vth_Max: Maximum Vth value for graph scale

[Extended Test Parameters for Sampling_Ids]
IgLimit: Gate current compliance
IdLimit: Drain current compliance
IsubsLimit: Substrate current compliance
Vs: Source terminal voltage, constant voltage
Vsubs: Substrate terminal voltage, constant voltage
DrainMinRng: Minimum range for drain current measurement

[User Function]
[User Function for Sampling_Stress]
Maximum elapsed time value MaxTime=max(Time)
Stress time StressTime=AccTime+Time

[User Function for IvSweep_ConstId]
Maximum drain current value IdMax=max(abs(Idrain)) (For initial measurement only)

[User Function for IvSweep_gmmax]
Maximum drain current value IdMax=max(abs(Idrain)) (For initial measurement only)
Transconductance gm=diff(Idrain,Vgate)
Maximum transconductance value gmMax=max(gm)

[Analysis Function]
[Analysis Function for IvSweep_ConstId]
Vth@Id=@L1X (X intercept of Line1)

[Analysis Function for IvSweep_gmmax]
Vth@Gm=@L1X (X intercept of Line1)

[Auto Analysis]
[Auto Analysis for IvSweep_ConstId]
Line1: Vertical line for Y1 at Idrain=Id@Vth

[Auto Analysis for IvSweep_gmmax]
Line1: Tangent line for Y1 at gm=gmMax

[Test Output: X-Y Graph]
X axis: Elapsed time TimeList (LOG)
Y1 axis: Maximum transconductance value gmMaxList (LINEAR)
Y2 axis: Vth by constant current method VthIdList (LINEAR)
Y3 axis: Vth by extrapolation method VthGmList (LINEAR)
Y4 axis: Drain current IdsList (LOG)

[Test Output: List Display]
Elapsed time TimeList
Vth by constant current method VthIdList
Vth by extrapolation method VthGmList
Drain current IdsList
Maximum transconductance value gmMaxList

8.8 BTI[3]: Bias Temperature Instability test, 3 terminals (A.01.20)

[Description]
Performs the bias temperature instability test, and plots the accumulated stress time vs threshold voltage/drain current characteristics.
This test is performed as follows.
1. performs initial characterization
2. applies stress voltage
3. performs interim characterization
4. saves measurement data
5. repeats 2 to 4 until TotalStressTime elapses

[Device Under Test]
MOSFET, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value)
Lg: Gate length
Wg: Gate width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time (SHORT, MEDIUM, LONG)
TotalStressTime: Total stress time
Gate: SMU connected to Gate terminal, primary sweep voltage output
Drain: SMU connected to Drain terminal, constant voltage output
Source: SMU connected to Source terminal, constant voltage output
VgStress: Gate terminal stress voltage

[Test Parameters for IvSweep_ConstId]
Id@Vth: Drain current to decide the Vth, per unit area
VgStart1: Sweep start voltage for Gate terminal
VgStop1: Sweep stop voltage for Gate terminal
VgStep1: Sweep step voltage for Gate terminal
Vd1: Drain terminal voltage, constant value

[Test Parameters for IvSweep_gmmax]
VgStart2: Sweep start voltage for Gate terminal
VgStop2: Sweep stop voltage for Gate terminal
VgStep2: Sweep step voltage for Gate terminal
Vd2: Drain voltage

[Test Parameters for Sampling_Ids]
Vg3: Gate terminal voltage
Vd3: Drain terminal voltage

[Extended Test Parameters]
[Extended Test Parameters for Sampling_Stress]
Vd: Drain terminal voltage, constant voltage
Vs: Source terminal voltage, constant voltage
IgLimit: Gate current compliance

[Extended Test Parameters for IvSweep_ConstId]
HoldTime: Hold time

DelayTime: Delay time
IdLimit: Drain current compliance
Vs: Source terminal voltage, constant voltage
DrainMinRng: Minimum range for drain current measurement

[Extended Test Parameters for IvSweep_gmmax]
HoldTime: Hold time
DelayTime: Delay time
IgLimit: Gate current compliance
IdLimit: Drain current compliance
Vs: Source terminal voltage, constant voltage
DrainMinRng: Minimum range for drain current measurement
Vth_Min: Minimum Vth value for graph scale
Vth_Max: Maximum Vth value for graph scale

[Extended Test Parameters for Sampling_Ids]
IgLimit: Gate current compliance
IdLimit: Drain current compliance
Vs: Source terminal voltage, constant voltage
DrainMinRng: Minimum range for drain current measurement

[User Function]
[User Function for Sampling_Stress]
Maximum elapsed time value MaxTime=max(Time)
Stress time StressTime=AccTime+Time

[User Function for IvSweep_ConstId]
Maximum drain current value IdMax=max(abs(Idrain)) (For initial measurement only)

[User Function for IvSweep_gmmax]
Maximum drain current value IdMax=max(abs(Idrain)) (For initial measurement only)
Transconductance gm=diff(Idrain,Vgate)
Maximum transconductance value gmMax=max(gm)

[Analysis Function]
[Analysis Function for IvSweep_ConstId]
Vth@Id=@L1X (X intercept of Line1)

[Analysis Function for IvSweep_gmmax]
Vth@Gm=@L1X (X intercept of Line1)

[Auto Analysis]
[Auto Analysis for IvSweep_ConstId]
Line1: Vertical line for Y1 at Idrain=Id@Vth

[Auto Analysis for IvSweep_gmmax]
Line1: Tangent line for Y1 at gm=gmMax

[Test Output: X-Y Graph]
X axis: Elapsed time TimeList (LOG)
Y1 axis: Maximum transconductance value gmMaxList (LINEAR)
Y2 axis: Vth by constant current method VthIdList (LINEAR)
Y3 axis: Vth by extrapolation method VthGmList (LINEAR)
Y4 axis: Drain current IdsList (LOG)

[Test Output: List Display]
Elapsed time TimeList
Vth by constant current method VthIdList
Vth by extrapolation method VthGmList
Drain current IdsList
Maximum transconductance value gmMaxList

8.9 Charge Pumping: Evaluation of the interface state using charge pumping method (A.01.20)

[Description]
Measures the Substrate current vs Gate pulse base voltage characteristics, and extracts the interface state density (Nss). This test uses the Agilent 81110A pulse generator.

[Test Setup used in this test definition]
ForcePGC: Used to apply Gate pulse
I/V-t Sampling: Used to perform the Substrate current measurement
ResetPG: Used to reset the pulse generator

[Device Under Test]
MOSFET, 3 terminals or 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Source: SMU connected to Source, constant voltage output
Vs: Source voltage
IsLimit: Source current compliance
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage
IsubsLimit: Substrate current compliance

[Extended Test Parameters]
SubsMinRng: Minimum range for the substrate current measuremnent

[Test Parameters for Gate Pulse]
PulseLevel: Pulse output level
VbaseStart: Sweep start value of Gate pulse base voltage
VbaseStop: Sweep stop value of Gate pulse base voltage
VbaseStep: Sweep step value of Gate pulse base voltage
PulsePeriod: Pulse period
PulseDelay: Pulse delay
DutyCycle: Duty cycle
LeadingTime: Leading transition time
TrailingTime: Trailing transition time
PgAdd: GPIB address of Agilent 81110A

[Test Output: X-Y Graph]
X axis: Gate pulse base voltage VbaseList (LINEAR)
Y1 axis: Substrate current IcpList (LOG)

[Test Output: Parameters]
Interface state density Nss

[Nss calculation]

Nss=IcpMax/q*PulsePeriod/Lg/Wg

8.10 EM Istress: Electromigration test, current stressed, 4 SMUs (A.01.20)

[Description]
Performs the Electromigration (EM) test, and plots the stress time vs resistance characteristics. This test is peformed by the sampling measurement mode.

[Device Under Test]
Wiring (resistor), 2 terminals

[Device Parameters]
L: Length of pattern
W: Width of pattern
Temp: Temperature

[Test Parameters]
Port1: SMU for Port1 stress force
Port2: SMU for Port2 stress force
VM1: SMU for Port1 voltage monitor
VM2: SMU for Port2 voltage monitor
TotalStressTime: Total stress time.
StopCondition: Measurement stop condition
I1Stress: Port1 stress current
NoOfSamples: Number of samples
IntegTime: Integration time

[Extended Test Parameters]
V2: Port2 terminal voltage
V1Limit: Port1 voltage compliance
I2Limit: Port2 current compliance
HoldTime: Hold time

[User Function]
IPort1PerArea (A/cm2) Port1 terminal current per unit area
IPort2PerArea (A/cm2) Port2 terminal current per unit area
R (ohm) Resistance of wiring
DeltaR (%) Difference from initial resistance

[X-Y Plot]
X axis: Stress time TimeList (LOG)
Y1 axis: Port1 terminal voltage Vport1List (LOG)
Y2 axis: Resistance RList (LINEAR)
Y3 axis: Difference from initial resistance DeltaRList (LINEAR)

8.11 EM Istress[2]: Electromigration test, current stressed, 2 SMUs (A.01.20)

[Description]
Performs the Electromigration (EM) test, and plots the stress time vs resistance characteristics. This test is peformed by the sampling measurement mode as shown below.
1. applies stress current
2. performs measurement and saves measurement data
3. calculates the device failure time

[Device Under Test]
Wiring device, 2 terminals

[Device Parameters]
D: Wiring pattern length
W: Wiring pattern width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time
TotalStressTime: Total stress time
StopCondition: Stop condition (%changes of wire resistance)
Port1: SMU connected to Port1, constant current output
Port2: SMU connected to Port2, constant voltage output
I1Stress: Port1 stress current

[Extended Test Parameters]
V2: Port2 voltage
V1Limit: Port1 voltage compliance
I2Limit: Port2 current compliance
HoldTime: Hold time
DelayTime: Delay time

[User Function]
Wiring resistance value R=Vport1/Iport1

[Test Output: X-Y Graph]
X axis: Accumulated stress time TimeList
Y1 axis: Port1 voltage Vport1List
Y2 axis: Wiring resistance value RList
Y3 axis: Offset from initial resistance value DeltaRList

[Test Output: List Display]
Accumulated stresss time TimeList
Port1 voltage Vport1List
Wiring resistance value RList
Offset from initial resistance value DeltaRList

[Test Output: Parameters]
FailureTime: Time to failure

8.12 EM Istress[6]: Electromigration test, current stressed, 6 SMUs (A.01.20)

[Description]
Performs the Electromigration (EM) test for a wiring device with extrusion lines, and plots the stress time vs resistance characteristics. This test is peformed by the sampling measurement mode as shown below.
1. applies stress current
2. performs measurement and saves measurement data
3. calculates the device failure time

[Device Under Test]
Wiring device with extrusion lines, 6 terminals

[Device Parameters]
D: Wiring pattern length
W: Wiring pattern width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time
TotalStressTime: Total stress time
StopCondition: Stop condition 1 (%changes of wire resistance)
ExtCondition: Stop condition 2 (current to extrusion line)
Port1: SMU connected to Port1, constant current output
Port2: SMU connected to Port2, constant voltage output
Port3: SMU connected to Extrusion Line, constant voltage output
Port4: SMU connected to Extrusion Line, constant voltage output
VM1: SMU for Port1 voltage monitoring, constant voltage output
VM2: SMU for Port2 voltage monitoring, constant voltage output
I1Stress: Port1 stress current

[Extended Test Parameters]
V2: Port2 voltage
V3: Port3 voltage
V4: Port4 voltage
V1Limit: Port1 voltage compliance
I2Limit: Port2 current compliance
I3Limit: Port3 current compliance
I4Limit: Port4 current compliance
HoldTime: Hold time
DelayTime: Delay time
Port2MinRng: Minimum range for Port1 current measurement

[User Function]
Potential difference between lines DeltaV=Vm1-Vm2
Wiring resistance value R=DeltaV/Iport1

[Test Output: X-Y Graph]
X axis: Accumulated stresss time TimeList
Y1 axis: Wiring resistance value RList
Y2 axis: Offset from initial resistance value DeltaRList
Y3 axis: Port2 current Iport2List
Y4 axis: Port3 current Iport3List
Y5 axis: Port4 current Iport4List

[Test Output: List Display]
Accumulated stresss time TimeList
Wiring resistance value RList
Offset from initial resistance value DeltaRList
Port2 current Iport2List
Port3 current Iport3List
Port4 current Iport4List

[Test Output: Parameters]
R_FailureTime: Time to failure (Resistance)
E_FailureTime: Time to failure (Extrusion)

8.13 EM Vstress: Electromigration test, voltage stressed, 4 SMUs (A.01.20)

[Description]
Performs the Electromigration (EM) test, and plots the stress time vs resistance characteristics. This test is peformed by the sampling measurement mode.

[Device Under Test]
Wiring (resistor), 2 terminals

[Device Parameters]
L: Length of pattern
W: Width of pattern
Temp: Temperature

[Test Parameters]
Port1: SMU for Port1 stress force
Port2: SMU for Port2 stress force
VM1: SMU for Port1 voltage monitor
VM2: SMU for Port2 voltage monitor
TotalStressTime: Total stress time.
StopCondition: Measurement stop condition
V1Stress: Port1 stress voltage
NoOfSamples: Number of samples
IntegTime: Integration time

[Extended Test Parameters]
V2: Port2 terminal voltage
I1Limit: Port1 current compliance
HoldTime: Hold time
Port1MinRng: Minimum range for the port1 current measurement

[User Function]
IPort1PerArea (A/cm2) Port1 terminal current per unit area
IPort2PerArea (A/cm2) Port2 terminal current per unit area
R (ohm) Resistance of wiring
DeltaR (%) Difference from initial resistance

[X-Y Plot]
X axis: Stress time TimeList (LOG)
Y1 axis: Port1 terminal current Iport1List (LOG)
Y2 axis: Resistance RList (LINEAR)
Y3 axis: Difference from initial resistance DeltaRList (LINEAR)

8.14 EM Vstress[2]: Electromigration test, voltage stressed, 2 SMUs (A.01.20)

[Description]
Performs the Electromigration (EM) test, and plots the stress time vs resistance characteristics. This test is peformed by the sampling measurement mode as shown below.
1. applies stress voltage
2. performs measurement and saves measurement data
3. calculates the device failure time

[Device Under Test]
Wiring device, 2 terminals

[Device Parameters]
D: Wiring pattern length
W: Wiring pattern width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time
TotalStressTime: Total stress time
StopCondition: Stop condition (%changes of wire resistance)
Port1: SMU connected to Port1, constant voltage output
Port2: SMU connected to Port2, constant voltage output
V1Stress: Port1 stress voltage

[Extended Test Parameters]
V2: Port2 voltage
I1Limit: Port1 current compliance
HoldTime: Hold time
Port1MinRng: Minimum range for Port1 current measurement

[User Function]
Wiring resistance value R=Vport1/Iport1

[Test Output: X-Y Graph]
X axis: Accumulated stress time TimeList
Y1 axis: Port1 current Iport1List
Y2 axis: Wiring resistance value RList
Y3 axis: Offset from initial resistance value DeltaRList

[Test Output: List Display]
Accumulated stresss time TimeList
Port1 current Iport1List
Wiring resistance value RList
Offset from initial resistance value DeltaRList

[Test Output: Parameters]
FailureTime: Time to failure

8.15 EM Vstress[6]: Electromigration test, voltage stressed, 6 SMUs (A.01.20)

[Description]
Performs the Electromigration (EM) test for a wiring device with extrusion lines, and plots the stress time vs resistance characteristics. This test is peformed by the sampling measurement mode as shown below.
1. applies stress voltage
2. performs measurement and saves measurement data
3. calculates the device failure time

[Device Under Test]
Wiring device with extrusion lines, 6 terminals

[Device Parameters]
D: Wiring pattern length
W: Wiring pattern width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time
TotalStressTime: Total stress time
StopCondition: Stop condition 1 (%changes of wire resistance)
ExtCondition: Stop condition 2 (current to extrusion line)
Port1: SMU connected to Port1, constant voltage output
Port2: SMU connected to Port2, constant voltage output
Port3: SMU connected to Extrusion Line, constant voltage output
Port4: SMU connected to Extrusion Line, constant voltage output
VM1: SMU for Port1 voltage monitoring, constant voltage output
VM2: SMU for Port2 voltage monitoring, constant voltage output
V1Stress: Port1 stress voltage

[Extended Test Parameters]
V2: Port2 voltage
V3: Port3 voltage
V4: Port4 voltage
IM1: VM1 output current
IM2: VM2 output current
I1Limit: Port1 current compliance
I3Limit: Port3 current compliance
I4Limit: Port4 current compliance
HoldTime: Hold time
DelayTime: Delay time
Port1MinRng: Minimum range for Port1 current measurement

[User Function]
Potential difference between lines DeltaV=VM1-VM2
Wiring resistance value R=DeltaV/Iport1

[Test Output: X-Y Graph]
X axis: Accumulated stress time TimeList
Y1 axis: Wiring resistance value RList
Y2 axis: Port1 current Iport1List
Y3 axis: Port3 current Iport3List
Y4 axis: Port4 current Iport4List
Y5 axis: Offset from initial resistance value DeltaRList

[Test Output: List Display]
Accumulated stresss time TimeList
Port1 current Iport1List
Wiring resistance value RList
Port3 current Iport3List
Port4 current Iport4List
Offset from initial resistance value DeltaRList

[Test Output: Parameters]
R_FailureTime: Time to failure (Resistance)
E_FailureTime: Time to failure (Extrusion)

8.16 HCI 3devices: Hot Carrier Injection test, 4 terminals, 3 devices (A.01.20)

[Description]
Performs the hot carrier injection test, and plots the accumulated stress time vs threshold voltage/drain current characteristics. Maximum three devices can be measured by a test execution. This test is performed as follows.
1. performs initial characterization
2. applies stress voltage
3. performs interim characterization
4. saves measurement data
5. repeats 2 to 4 until TotalStressTime elapses

[Device Under Test]
MOSFET, 4 terminals, 3 devices

[Required Accessories]
Agilent B2200A or B2201A switching matrix 1 unit
GPIB cable

Connect B2200A/B2201A to B1500A with a measuring cable and GPIB cable.
Set information on B1500A SMU channel's connection to the B2200A/B2201A input port properly on the Switching Matrix tab screen of the Configuration window.
Set the output channel number of B2200A/B2201A connected to each terminal of a device under test properly in the Tr#Gate/Tr#Drain/Tr#Source/Tr#Subs field (# is an integer from 1 to 3) of Test Parameters area.

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value)
Lg: Gate length
Wg: Gate width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time (SHORT, MEDIUM, LONG)
Tr#Gate: SWM Pin Assign settings for Gate terminal of devices
Tr#Drain: SWM Pin Assign settings for Drain terminal of devices
Tr#Source: SWM Pin Assign settings for Source terminal of devices
Tr#Subs: SWM Pin Assign settings for Substrate terminal of devices

where, # is an integer from 1 to 3.

[Test Parameters for Sampling_Stress]
TotalStrsTime: Total stress time
Tr#StrsGate: SMU connected to Gate terminal of devices, constant voltage output
Tr#StrsDrain: SMU connected to Drain terminal of devices, constant voltage output
StrsSource: SMU connected to Source terminal of devices, constant voltage output
StrsSubs: SMU connected to Substrate terminal of devices, constant voltage output
Tr#VgStrs: Gate terminal stress voltage for the devices
Tr#VdStrs: Drain terminal stress voltage for the devices
VsubsStrs: Substrate terminal stress voltage for the devices
VsStrs: Source terminal stress voltage for the devices

where, # is an integer from 1 to 3.

[Test Parameters for IvSweep_ConstId]

MeasGate: SMU connected to the basic characteristics acquisition Gate terminal, primary sweep voltage output
MeasDrain: SMU connected to the basic characteristics acquisition Drain terminal, constant voltage output
MeasSource: SMU connected to the basic characteristics acquisition Source terminal, constant voltage output
MeasSubs: SMU connected to the basic characteristics acquisition Substrate terminal, constant voltage output
Id@Vth: Drain current to decide the Vth, per unit area
VgStart1: Sweep start voltage for Gate terminal
VgStop1: Sweep stop voltage for Gate terminal
VgStep1: Sweep step voltage for Gate terminal
Vd1: Drain terminal voltage

[Test Parameters for IvSweep_gmmax]
MeasGate: SMU connected to the basic characteristics acquisition Gate terminal, primary sweep voltage output
MeasDrain: SMU connected to the basic characteristics acquisition Drain terminal, constant voltage output
MeasSource: SMU connected to the basic characteristics acquisition Source terminal, constant voltage output
MeasSubs: SMU connected to the basic characteristics acquisition Substrate terminal, constant voltage output
VgStart2: Sweep start voltage for Gate terminal
VgStop2: Sweep stop voltage for Gate terminal
VgStep2: Sweep step voltage for Gate terminal
Vd2: Drain voltage

[Test Parameters for Sampling_Ids]
MeasGate: SMU connected to the basic characteristics acquisition Gate terminal, primary sweep voltage output
MeasDrain: SMU connected to the basic characteristics acquisition Drain terminal, constant voltage output
MeasSource: SMU connected to the basic characteristics acquisition Source terminal, constant voltage output
MeasSubs: SMU connected to the basic characteristics acquisition Substrate terminal, constant voltage output
Vg3: Gate terminal voltage
Vd3: Drain terminal voltage

[Extended Test Parameters]
[Extended Test Parameters for IvSweep_ConstId]
HoldTime: Hold time
DelayTime: Delay time
Vsubs: Substrate terminal voltage
Vs: Source terminal voltage
IgLimit: Gate current compliance of devices
IdLimit: Drain current compliance of devices
IsubsLimit: Substrate current compliance
DrainMinRng1: Minimum range for drain current measurement on device 1
DrainMinRng2: Minimum range for drain current measurement on device 2
DrainMinRng3: Minimum range for drain current measurement on device 3

[Extended Test Parameters for IvSweep_gmmax]
HoldTime: Hold time
DelayTime: Delay time
Vsubs: Substrate terminal voltage
Vs: Source terminal voltage
IgLimit: Gate current compliance of devices
IdLimit: Drain current compliance of devices
IsubsLimit: Substrate current compliance
gmMax_Min: Minimum gmMax value for graph scale
gmMax_Max: Maximum gmMax value for graph scale
DrainMinRng1: Minimum range for drain current measurement on device 1

DrainMinRng2: Minimum range for drain current measurement on device 2
DrainMinRng3: Minimum range for drain current measurement on device 3

[Extended Test Parameters for Sampling_Ids]
Vsubs: Substrate terminal voltage
Vs: Source terminal voltage
IgLimit: Gate current compliance of devices
IdLimit: Drain current compliance of devices
IsubsLimit: Substrate current compliance
DrainMinRng1: Minimum range for drain current measurement on device 1
DrainMinRng2: Minimum range for drain current measurement on device 2
DrainMinRng3: Minimum range for drain current measurement on device 3

[User Function]
[User Function for Sampling_Stress]
Maximum elapsed time value MaxTime=max(Time)
Stress time StressTime=AccTime+Time

[User Function for IvSweep_ConstId]
Maximum drain current value IdMax=max(abs(Idrain)) (For initial measurement only)

[User Function for IvSweep_gmmax]
Maximum drain current value IdMax=max(abs(Idrain)) (For initial measurement only)
Transconductance gm=diff(Idrain,Vgate)
Maximum transconductance value gmMax=max(gm)

[Analysis Function]
[Analysis Function for IvSweep_ConstId]
Vth@Id=@L1X (X intercept of Line1)

[Analysis Function for IvSweep_gmmax]
Vth@Gm=@L1X (X intercept of Line1)

[Auto Analysis]
[Auto Analysis for IvSweep_ConstId]
Line1: Vertical line for Y1 at Idrain=Id@Vth

[Auto Analysis for IvSweep_gmmax]
Line1: Tangent line for Y1 at gm=gmMax

[Test Output: X-Y Graph]
X axis: Elapsed time TimeList (LOG)
Y1 axis: Drain current for device 1 Dev1_IdsList (LOG)
Y2 axis: Drain current for device 2 Dev2_IdsList (LOG)
Y3 axis: Drain current for device 3 Dev3_IdsList (LOG)
Y4 axis: Maximum transconductance value for device 1 Dev1_gmMaxList (LINEAR)
Y5 axis: Maximum transconductance value for device 2 Dev2_gmMaxList (LINEAR)
Y6 axis: Maximum transconductance value for device 3 Dev3_gmMaxList (LINEAR)

[Test Output: List Display]
TimeList: Elapsed time
Dev1_IdsList: Drain current for device 1
Dev2_IdsList: Drain current for device 2
Dev3_IdsList: Drain current for device 3
Dev1_VthIdList: Vth for device 1, determined by constant current method

Dev2_VthIdList: Vth for device 2, determined by constant current method
Dev3_VthIdList: Vth for device 3, determined by constant current method
Dev1_VthGmList: Vth for device 1, determined by extrapolation method
Dev2_VthGmList: Vth for device 2, determined by extrapolation method
Dev3_VthGmList: Vth for device 3, determined by extrapolation method
Dev1_gmMaxList: Maximum transconductance value for device 1
Dev2_gmMaxList: Maximum transconductance value for device 2
Dev3_gmMaxList: Maximum transconductance value for device 3

8.17 HCI: Hot Carrier Injection test, 4 terminals (A.01.20)

[Description]
Performs the hot carrier injection test, and plots the accumulated stress time vs threshold voltage/drain current characteristics.
This test is performed as follows.
1. performs initial characterization
2. applies stress voltage
3. performs interim characterization
4. saves measurement data
5. repeats 2 to 4 until TotalStressTime elapses

[Device Under Test]
MOSFET, 4 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value)
Lg: Gate length
Wg: Gate width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time (SHORT, MEDIUM, LONG)
TotalStressTime: Total stress time
Gate: SMU connected to Gate terminal, primary sweep voltage output
Drain: SMU connected to Drain terminal, constant voltage output
Subs: SMU connected to Substrate terminal, constant voltage output
Source: SMU connected to Source terminal, constant voltage output
VgStress: Gate terminal stress voltage
VdStress: Drain terminal stress voltage
VsubsStress: Substrate terminal stress voltage
Vsubs: Substrate terminal voltage

[Test Parameters for IvSweep_ConstId]
Id@Vth: Drain current to decide the Vth, per unit area
VgStart1: Sweep start voltage for Gate terminal
VgStop1: Sweep stop voltage for Gate terminal
VgStep1: Sweep step voltage for Gate terminal
Vd1: Drain terminal voltage, constant value

[Test Parameters for IvSweep_gmmax]
VgStart2: Sweep start voltage for Gate terminal
VgStop2: Sweep stop voltage for Gate terminal
VgStep2: Sweep step voltage for Gate terminal
Vd2: Drain voltage

[Test Parameters for Sampling_Ids]
Vg3: Gate terminal voltage
Vd3: Drain terminal voltage

[Extended Test Parameters]
[Extended Test Parameters for IvSweep_ConstId]
HoldTime: Hold time
DelayTime: Delay time

Vs: Source terminal voltage
IgLimit: Gate current compliance
IdLimit: Drain current compliance
IsubsLimit: Substrate current compliance
DrainMinRng: Minimum range for drain current measurement

[Extended Test Parameters for IvSweep_gmmax]
HoldTime: Hold time
DelayTime: Delay time
Vs: Source terminal voltage
IgLimit: Gate current compliance
IdLimit: Drain current compliance
IsubsLimit: Substrate current compliance
Vth_Min: Minimum Vth value for graph scale
Vth_Max: Maximum Vth value for graph scale
gmMax_Min: Minimum gmMax value for graph scale
gmMax_Max: Maximum gmMax value for graph scale
DrainMinRng: Minimum range for drain current measurement

[Extended Test Parameters for Sampling_Ids]
Vs: Source terminal voltage
IgLimit: Gate current compliance
IdLimit: Drain current compliance
IsubsLimit: Substrate current compliance
DrainMinRng: Minimum range for drain current measurement

[User Function]
[User Function for Sampling_Stress]
Maximum elapsed time value MaxTime=max(Time)
Stress time StressTime=AccTime+Time

[User Function for IvSweep_ConstId]
Maximum drain current value IdMax=max(abs(Idrain)) (For initial measurement only)

[User Function for IvSweep_gmmax]
Maximum drain current value IdMax=max(abs(Idrain)) (For initial measurement only)
Transconductance gm=diff(Idrain,Vgate)
Maximum transconductance value gmMax=max(gm)

[Analysis Function]
[Analysis Function for IvSweep_ConstId]
Vth@Id=@L1X (X intercept of Line1)

[Analysis Function for IvSweep_gmmax]
Vth@Gm=@L1X (X intercept of Line1)

[Auto Analysis]
[Auto Analysis for IvSweep_ConstId]
Line1: Vertical line for Y1 at Idrain=Id@Vth

[Auto Analysis for IvSweep_gmmax]
Line1: Tangent line for Y1 at gm=gmMax

[Test Output: X-Y Graph]
X axis: Elapsed time TimeList (LOG)

Y1 axis: Maximum transconductance value gmMaxList (LINEAR)
Y2 axis: Vth by constant current method VthIdList (LINEAR)
Y3 axis: Vth by extrapolation method VthGmList (LINEAR)
Y4 axis: Drain current IdsList (LOG)

[Test Output: List Display]
Elapsed time TimeList
Vth by constant current method VthIdList
Vth by extrapolation method VthGmList
Drain current IdsList
Maximum transconductance value gmMaxList

8.18 J-Ramp: Insulator lifetime evaluation, current stressed (A.01.20)

[Description]
Measures the time vs current/voltage characteristics with current stress, and extracts the lifetime of the gate oxide, insulator and so on.

[Device Under Test]
MOS capacitor, oxide layer, insulator and so on

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
TimeMax: Maximum value of X axis
Gate: SMU connected to Gate, primary sweep, current output
IgStart: Sweep start current
IgStop: Sweep stop current
VgLimit: Gate voltage compliance
Subs: SMU connected to Substrate, constant voltage output

[Extended Test Parameters]
Vsubs: Substrate voltage
HoldTime: Hold time
DelayTime: Delay time
SubsMinRng: Minimum range for the substrate current measurement

[User Function]
IgatePerArea=Igate/Lg/Wg
IsubsPerArea=Isubs/Lg/Wg
Qbdi=integ(Igate,Time)/Lg/Wg

[Test Output: X-Y Graph]
X axis: Time stamp TimeList (LINEAR)
Y1 axis: Gate current IgateList (LOG)
Y2 axis: Gate voltage VgateList (LINEAR)

[Test Output: List Display]
Time stamp TimeList
Gate current IgateList
Gate voltage VgateList

[Test Output: Parameters]
Breakdown voltage Vbd
Time to breakdown Tbd
Charge to breakdown Qbd

8.19 TDDB Istress 3devices: TDDB Test, current stressed, 3 devices (A.01.20)

[Description]
Performs the TDDB (time dependent dielectric breakdown) test, and plots the stress time vs voltage characteristics. This test is peformed by the sampling measurement mode. This test also supports 3-device connection.

[Device Under Test]
MOS capacitor, insulator, oxide layer, and so on

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
L: Length of pattern
W: Width of pattern
Temp: Temperature

[Test Parameters]
Port1: SMU connected to Port1 terminal
Port2: SMU connected to Port2 terminal
Port3: SMU connected to Port3 terminal
Port4: SMU connected to Port4 terminal
TotalStressTime: Total stress time.
StopCondition: Terminal voltage to decide the breakdown
I1Stress: Port1 stress current
I2Stress: Port2 stress current
I3Stress: Port3 stress current
NoOfSamples: Number of samples
IntegTime: Integration time

[Extended Test Parameters]
V4: Port4 terminal voltage
V1Limit: Port1/Port2/Port3 voltage compliance
I4Limit: Port4 current compliance
HoldTime: Hold time
Port4MinRng: Minimum range for the port4 current measurement

[User Function]
IPort1PerArea=Iport1/L/W
IPort2PerArea=Iport2/L/W
IPort3PerArea=Iport3/L/W
IPort4PerArea=Iport4/L/W

[Test Output: X-Y Graph]
X axis: Stress time TimeList (LOG)
Y1 axis: Port1 terminal voltage Vport1List (LOG)
Y2 axis: Port2 terminal voltage Vport2List (LOG)
Y3 axis: Port3 terminal voltage Vport3List (LOG)

[Test Output: Parameters]
Device1 breakdown voltage Vbd1
Device2 breakdown voltage Vbd2
Device3 breakdown voltage Vbd3
Device1 time to breakdown Tbd1
Device2 time to breakdown Tbd2

Device3 time to breakdown Tbd3
Device1 charge to breakdown Qbd1
Device2 charge to breakdown Qbd2
Device3 charge to breakdown Qbd3

8.20 TDDB Istress: TDDB Test, current stressed (A.01.20)

[Description]
Performs the TDDB (time dependent dielectric breakdown) test, and plots the stress time vs voltage characteristics. This test is peformed by the sampling measurement mode.

[Device Under Test]
MOS capacitor, insulator, oxide layer, and so on

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
L: Port1 terminal length
W: Port1 terminal width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
TotalStressTime: Total stress time. 10 to 10000 seconds.
NoOfSamples: Number of samples
Port1: SMU connected to Port1 terminal
I1Stress: Port1 stress current
Port2: SMU connected to Port2 terminal

[Extended Test Parameters]
V2: Port2 terminal voltage
V1Limit: Port1 voltage compliance
I2Limit: Port2 current compliance
HoldTime: Hold time
Port2MinRng: Minimum range for the port2 current measurement

[User Function]
I1PerArea=Iport1/L/W
I2PerArea=Iport2/L/W

[Test Output: X-Y Graph]
X axis: Stress time TimeList (LOG)
Y1 axis: Port1 terminal voltage Vport1List (LINEAR)

[Test Output: List Display]
Stress time TimeList
Port1 terminal voltage Vport1List

[Test Output: Parameters]
Breakdown voltage Vbd
Time to breakdown Tbd
Charge to breakdown Qbd

[Qbd calculation]
Qbd=I1Stress*Tbd/L/W

8.21 TDDB Vstress 3devices: TDDB Test, voltage stressed, 3 devices (A.01.20)

[Description]
Performs the TDDB (time dependent dielectric breakdown) test, and plots the stress time vs current characteristics. This test is peformed by the sampling measurement mode. This test also supports 3-device connection.

[Device Under Test]
MOS capacitor, insulator, oxide layer, and so on

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
L: Length of pattern
W: Width of pattern
Temp: Temperature

[Test Parameters]
Port1: SMU connected to Port1 terminal
Port2: SMU connected to Port2 terminal
Port3: SMU connected to Port3 terminal
Port4: SMU connected to Port4 terminal
TotalStressTime: Total stress time.
StopCondition: Terminal current to decide the breakdown
V1Stress: Port1 stress voltage
V2Stress: Port2 stress voltage
V3Stress: Port3 stress voltage
NoOfSamples: Number of samples
IntegTime: Integration time

[Extended Test Parameters]
V4: Port4 terminal voltage
I1Limit: Port1/Port2/Port3 current compliance
HoldTime: Hold time
Port1MinRng: Minimum range for the port1 current measurement
Port2MinRng: Minimum range for the port2 current measurement
Port3MinRng: Minimum range for the port3 current measurement
Port4MinRng: Minimum range for the port4 current measurement

[User Function]
IPort1PerArea=Iport1/L/W
IPort2PerArea=Iport2/L/W
IPort3PerArea=Iport3/L/W
IPort4PerArea=Iport4/L/W
Qbd1val=integ(Iport1,Time)/L/W
Qbd2val=integ(Iport2,Time)/L/W
Qbd3val=integ(Iport3,Time)/L/W

[Test Output: X-Y Graph]
X axis: Stress time TimeList (LOG)
Y1 axis: Port1 terminal current Iport1List (LOG)
Y2 axis: Port2 terminal current Iport2List (LOG)
Y3 axis: Port3 terminal current Iport3List (LOG)

[Test Output: Parameters]

Device1 time to breakdown Tbd1
Device2 time to breakdown Tbd2
Device3 time to breakdown Tbd3
Device1 charge to breakdown Qbd1
Device2 charge to breakdown Qbd2
Device3 charge to breakdown Qbd3

8.22 TDDB Vstress: TDDB Test, voltage stressed (A.01.20)

[Description]
Performs the TDDB (time dependent dielectric breakdown) test, and plots the stress time vs current characteristics. This test is peformed by the sampling measurement mode.

[Device Under Test]
MOS capacitor, insulator, oxide layer, and so on

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
L: Port1 terminal length
W: Port1 terminal width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
TotalStressTime: Total stress time. 10 to 10000 seconds.
StopCondition: Port1 terminal current to decide the breakdown
NoOfSamples: Number of samples
Port1: SMU connected to Port1 terminal
V1Stress: Port1 stress voltage
Port2: SMU connected to Port2 terminal

[Extended Test Parameters]
V2: Port2 terminal voltage
I1Limit: Current compliance
HoldTime: Hold time
Port1MinRng: Minimum range for the port1 current measurement

[User Function]
IPort1PerArea=Iport1/L/W
IPort2PerArea=Iport2/L/W
Qbdval=integ(Iport1,Time)/L/W

[Test Output: X-Y Graph]
X axis: Stress time TimeList (LOG)
Y1 axis: Port1 terminal current Iport1List (LOG)

[Test Output: List Display]
Stress time TimeList
Port1 terminal current Iport1List
Charge to breakdown QbdList

[Test Output: Parameters]
Time to breakdown Tbd
Charge to breakdown Qbd

8.23 TZDB: TZDB Test of oxide layer (A.01.20)

[Description]
Performs the TZDB (time zero dielectric breakdown) test, and plots the current vs voltage characteristics.

[Device Under Test]
MOS capacitor, oxide layer, and so on

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate, primary sweep, voltage output
VgStart: Sweep start voltage
VgStop: Sweep stop voltage
VgStep: Sweep step voltage
IgLimit: Gate current compliance
Subs: SMU connected to Substrate, constant voltage output

[Extended Test Parameters]
Vsubs: Substrate voltage
HoldTime: Hold time
DelayTime: Delay time
GateMinRng: Minimum range for the gate current measurement
SubsMinRng: Minimum range for the substrate current measurement

[User Function]
IgatePerArea=Igate/L/W
IsubsPerArea=Isubs/L/W

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Gate current Igate (LOG)
Y2 axis: Gate current per unit area IgatePerArea (LOG)

8.24 V-Ramp: Insulator lifetime evaluation, voltage stressed (A.01.20)

[Description]
Measures the time vs current/voltage characteristics with voltage stress, and extracts the lifetime of the gate oxide, insulator and so on.

[Device Under Test]
MOS capacitor, oxide layer, insulator and so on

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
TimeMax: Maximum value of X axis
Gate: SMU connected to Gate, primary sweep, voltage output
VgStart: Sweep start voltage
VgStop: Sweep stop voltage
VgStep: Sweep step voltage
Ibd: Gate current to decide the breakdown
Subs: SMU connected to Substrate, constant voltage output

[Extended Test Parameters]
Vsubs: Substrate voltage
HoldTime: Hold time
DelayTime: Delay time
GateMinRng: Minimum range for the gate current measurement
SubsMinRng: Minimum range for the substrate current measurement

[User Function]
IgatePerArea=Igate/Lg/Wg
IsubsPerArea=Isubs/Lg/Wg
Qbdi=integ(Igate,Time)/Lg/Wg

[Test Output: X-Y Graph]
X axis: Time stamp TimeList (LINEAR)
Y1 axis: Gate current IgateList (LOG)
Y2 axis: Gate voltage VgateList (LINEAR)

[Test Output: List Display]
Time stamp TimeList
Gate current IgateList
Gate voltage VgateList
Charge to breakdown QbdList

[Test Output: Parameters]
Breakdown voltage Vbd
Charge to breakdown Qbd
Time to breakdown Tbd

9 Structure

1. BVgb ThinOx: MOS capacitor Ig-Vg characteristics (A.01.20)
2. BVgb: MOS capacitor Gate-Substrate breakdown voltage (A.01.20)
3. Cgb-Freq[2] Log: Cgb-f characteristics, 2 terminals (A.01.20)
4. Cgb-Vg 2Freq: MOS capacitor Cgb-Vg characteristics, 2-frequency method (A.01.11)
5. Cgb-Vg[2]: MOS capacitor Cgb-Vg characteristics (A.01.11)
6. Cj-Freq Log: Cj-f characteristics, junction device (A.01.20)
7. Cj-V: Junction capacitance Cj-V characteristics (A.01.11)
8. Diode BVAndCj-V ASU: Diode junction capacitance and breakdown voltage measurement using ASUs (A.01.20)
9. Diode BVAndCj-V SCUU: Diode junction capacitance and breakdown voltage measurement using SCUU (A.01.20)
10. Ig-Vg Iforce: MOS capacitor Ig-Vg characteristics, current sweep (A.01.20)
11. Ig-Vg Vforce: MOS capacitor Ig-Vg characteristics, voltage sweep (A.01.20)
12. Interconnect CouplingCap: Interconnection capacitance (A.01.11)
13. Interconnect OverlapCap: Layer to layer film capacitance (A.01.11)
14. Junction BV: Junction device breakdown voltage (A.01.20)
15. Junction DcParam: Junction device DC parameters (Is,N,Rs) (A.01.20)
16. Junction IV Fwd: Diode forward bias characteristics (A.01.20)
17. Junction IV Rev: Diode reverse bias characteristics (A.01.20)
18. Rdiff-I kelvin: Diffusion resistor R-I characteristics, Kelvin connection (A.01.11)
19. Rdiff-I: Diffusion resistor R-I characteristics (A.01.11)
20. Rdiff-V kelvin: Diffusion resistor R-V characteristics, Kelvin connection (A.01.20)
21. Rdiff-V: Diffusion resistor R-V characteristics (A.01.20)
22. R-I DVM: Low resistance measurement using 3458A, current force (A.01.20)
23. R-I kelvin: Resistor R-I characteristics, Kelvin connection (A.01.11)
24. R-I: Resistor R-I characteristics (A.01.11)
25. R-V DVM: Low resistance measurement using 3458A, voltage force (A.01.20)
26. R-V kelvin: Resistor R-V characteristics, Kelvin connection (A.01.20)
27. R-V: Resistor R-V characteristics (A.01.20)
28. VanDerPauw Square: Van Der Pauw pattern sheet resistance (A.01.11)

9.1 BVgb ThinOx: MOS capacitor Ig-Vg characteristics (A.01.20)

[Description]
Extracts the gate current vs gate voltage (Ig-Vg) characteristics of MOS capacitor which has an ultra thin gate insulator. The primary sweep channel applies the quasi-pulsed voltage to Gate terminal, and measures Gate current at both pulse base and peak. The measurements are repeated ABS(VgStop-VgStart)/VgStep times to extract the Ig-Vg characteristics. The pulse base value is the primary sweep start value and can be set by the VgLow parameter. The pulse peak value is the primary sweep stop value and corresponds to Vg.

[Device Under Test]
MOS capacitor

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate, primary sweep voltage output
VgStart: Pulse peak start value
VgStop: Pulse peak stop value
VgStep: Pulse peak step value
VgLow: Pulse base value, primary sweep start value
IgLimit: Gate current compliance
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage

VgStart, VgStop, VgStep values are used to calculate the primary sweep stop value.

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time
GateMinRng: Minimum range for the gate current measurement
SubsMinRng: Minimum range for the substrate current measurement

[Measurement Parameters]
Gate current Igate
Substrate current Isubs

[User Function]
Gate current per Gate unit area IgatePerArea=Igate/Lg/Wg
Substrate current per Gate unit area IsubsPerArea=Isubs/Lg/Wg

[Calculation After Measurement]
```
Buffer=getVectorData("Vgate")
V_gate=storeAt(Vgate,I,1,at(Buffer,2,1))
Buffer=getVectorData("Igate")
I_gate=storeAt(Igate,I,1,at(Buffer,2,1))
I_gate@LowVg=storeAt(Igate,I,1,at(Buffer,1,1))
Val=at(Buffer,1,1)
Val=Val/Lg/Wg*1E-12
I_gate@LowVgPerArea=storeAt(I_gate@LowVgPerArea,I,1,Val)
```

```
  Buffer=getVectorData("IgatePerArea")
  I_gatePerArea=storeAt(I_gatePerArea,I,1,at(Buffer,1,1))
  I=I+1
```

[Test Output: X-Y Graph]
  X axis: Gate voltage V_gate (LINEAR)
  Y1 axis: Gate current I_gate (LOG)
  Y2 axis: Gate current at pulse base voltage I_gate@LowVg (LOG)

[Test Output: List Display]
  Gate voltage V_gate
  Gate current I_gate
  Gate current at pulse base voltage I_gate@LowVg
  Gate current per Gate unit area I_gatePerArea
  I_gate@LowVg per Gate unit area I_gate@LowVgPerArea

9.2 BVgb: MOS capacitor Gate-Substrate breakdown voltage (A.01.20)

[Description]
Measures the gate current vs gate voltage characteristics and extracts the breakdown voltage between gate and substrate (BVgb) of MOS capacitor.

[Device Under Test]
MOS capacitor

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Ig@BVgb: Gate current to decide the breakdown
Gate: SMU connected to Gate, primary sweep voltage output
VgStart: Sweep start voltage for Gate
VgStop: Sweep stop voltage for Gate
VgStep: Sweep step voltage for Gate
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time
GateMinRng: Minimum rabge for the gate current measurement

[Measurement Parameters]
Gate current Igate
For the all terminals, the SMU current compliance is set to Ig@BVgb*1.1.

[User Function]
Gate current per Gate unit area Igate_Area=Igate/Lg/Wg

[Analysis Function]
BVgb=@L1X (X intercept of Line1)

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Gate current Igate (LOG)
Y2 axis: Gate current per Gate unit area Igate_Area (LOG)

[Parameters Display Area]
Gate-Substrate breakdown voltage BVgb

[Auto Analysis]
Line1: Vertical line through Y1 data at Igate=Ig@BVgb

9.3 Cgb-Freq[2] Log: Cgb-f characteristics, 2 terminals (A.01.20)

[Description]
Measures MOS capacitor's characteristics of gate-to-substrate capacitance (Cgb, linear) vs frequency (f, log). The measurement frequency is 10 points per decade.

[Device Under Test]
MOS capacitor, 2 terminals
Connect CMU High and CMU Low to the substrate and gate respectively.

[Required Modules and Accessories]
Agilent B1520A MFCMU 1 unit

[Device Parameters]
Polarity: Nch (CMU forces the specified value) or Pch (CMU forces the negative specified value)
Lg: Gate length
Wg: Gate width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time
FreqStart: Sweep start frequency, LOG sweep
NoOfDecade: Number of decades for data collection
OscLevel: Measurement signal level
Gate: CMU connected to Gate terminal
Vgs: Voltage for Gate terminal, constant voltage

[Extended Test Parameters]
G_Min: Minimum transconductance value for graph
G_Max: Maximum transconductance value for graph
Cp_Min: Minimum capacitance value for graph
Cp_Max: Maximum capacitance value for graph

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
Circular constant PI=3.141592653589
Frequency Frequency=Freq
Dissipation factor D=G/(2*PI*Freq*Cp)
Parallel resistance Rp=1/G
Series capacitance Cs=(1+D^2)*Cp
Reactance X=-1/(2*PI*Freq*Cs)
Series resistance Rs=D*abs(X)
Impedance Z=sqrt(Rs^2+X^2)
Phase Theta=atan(X/Rs)

[X-Y Plot]
X axis: Frequency Freq (LOG)
Y1 axis: Gate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[List Display]

Frequency Freq
Gate capacitance (parallel capacitance) Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta
Substrate voltage Vsubs

[Test Output: X-Y Graph]
X axis: Frequency list FreqList (LOG)
Y1 axis: Gate capacitance (parallel capacitance) list CpList (LINEAR)
Y2 axis: Conductance list GList (LINEAR)

[Test Output: List Display]
Frequency FreqList
Gate capacitance (parallel capacitance) CpList
Conductance GList
Series capacitance CsList
Series resistance RsList
Parallel resistance RpList
Dissipation factor DList
Reactance XList
Impedance ZList
Phase ThetaList
Substrate voltage VsubsList

9.4 Cgb-Vg 2Freq: MOS capacitor Cgb-Vg characteristics, 2-frequency method (A.01.11)

[Description]
Measures the Gate-Substrate capacitance (Cgb) by using two-frequency method, and plots the Cgb-Vg characteristics.
DC bias output is performed from -VgbStart to -VgbStop in -VgbStep steps.
The Cgb value is given by the following formula. Then C1 and C2 are capacitance, D1 and C2 are dissipation factor measured at the frequency (f1 and f2).

Cgb = [f1^2*C1*(1+D1^2)-f2^2*C2*(1+D2^2)]/[f2^2-f1^2]

[Device Under Test]
MOS capacitor
Connect Gate to the CMU Low, and Substrate to the CMU High.

[Device Parameters]
Polarity: Nch (CMU forces the specified value) or Pch (CMU forces the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ1: Measurement frequency #1
FREQ2: Measurement frequency #2
OscLevel: Measurement signal level
Gate: CMU connected between Gate and channel (CV sweep measurement)
VgbStart: DC bias start voltage
VgbStop: DC bias stop voltage
VgbStep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Dissipation factor D

[User Function]
Vgb=-Vsubs

[Display Setup: X-Y Graph]
X axis: Gate voltage Vgb (LINEAR)
Y1 axis: Gate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Dissipation factor D (LINEAR)

[Display Setup: List Display]
Measurement frequency Freq
Gate voltage Vgb
Gate capacitance (parallel capacitance) Cp
Dissipation factor D

[Test Output: X-Y Graph]
X axis: Gate voltage VGB (LINEAR)
Y1 axis: Gate capacitance (parallel capacitance) Cgb (LINEAR)
Y2 axis: Gate capacitance (parallel capacitance) Cp_FREQ1 (LINEAR)
Y3 axis: Gate capacitance (parallel capacitance) Cp_FREQ2 (LINEAR)

[Test Output: List Display]
Gate voltage VGB
Gate capacitance (parallel capacitance) Cgb
Gate capacitance (parallel capacitance) Cp_FREQ1
Gate capacitance (parallel capacitance) Cp_FREQ2
Dissipation factor D_FREQ1
Dissipation factor D_FREQ2

9.5 Cgb-Vg[2]: MOS capacitor Cgb-Vg characteristics (A.01.11)

[Description]
Measures the Gate-Substrate capacitance (Cgb), and plots the Cgb-Vg characteristics.
DC bias output is performed from -VgbStart to -VgbStop in -VgbStep steps.

[Device Under Test]
MOS capacitor
Connect Gate to the CMU Low, and Substrate to the CMU High.

[Device Parameters]
Polarity: Nch (CMU forces the specified value) or Pch (CMU forces the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
Gate: CMU connected between Gate and channel (CV sweep measurement)
VgbStart: DC bias start voltage
VgbStop: DC bias stop voltage
VgbStep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
Vgate=-Vsubs
CpPerArea=Cp/Lg/Wg
CpPerWg=Cp/Wg

[X-Y Graph]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Gate capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[List Display]
Gate voltage Vgate
Gate capacitance (parallel capacitance) Cp

Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta
Gate-Substrate capacitance per Gate unit area CpPerArea
Gate-Substrate capacitance per Gate unit width CpPerWg

9.6 Cj-Freq Log: Cj-f characteristics, junction device (A.01.20)

[Description]
Measures the junction capacitance (Cj, linear) vs frequency (f, log) characteristics of a junction device. The measurement frequency is 10 points per decade.

[Device Under Test]
Junction device (diode), 2 terminals
Connect CMU High and CMU Low to the anode and cathode respectively.

[Required Modules and Accessories]
Agilent B1520A MFCMU 1 unit

[Device Parameters]
L: Junction length
W: Junction width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time
FreqStart: Sweep start frequency, LOG sweep
NoOfDecade: Number of decades for data collection
OscLevel: Measurement signal level
Anode: CMU connected between Anode and Cathode
Vanode: Voltage applied on Anode

[Extended Test Parameters]
G_Min: Minimum transconductance value for graph
G_Max: Maximum transconductance value for graph
Cp_Min: Minimum capacitance value for graph
Cp_Max: Maximum capacitance value for graph

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
Circular constant PI=3.141592653589
Frequency Frequency=Freq
Dissipation factor D=G/(2*PI*Freq*Cp)
Parallel resistance Rp=1/G
Series capacitance Cs=(1+D^2)*Cp
Reactance X=-1/(2*PI*Freq*Cs)
Series resistance Rs=D*abs(X)
Impedance Z=sqrt(Rs^2+X^2)
Phase Theta=atan(X/Rs)

[X-Y Plot]
X axis: Frequency Freq (LOG)
Y1 axis: Junction capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[List Display]
Frequency Freq

Anode voltage Vanode
Junction capacitance (parallel capacitance) Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta

[Test Output: X-Y Graph]
X axis: Frequency list FreqList (LOG)
Y1 axis: Gate capacitance (parallel capacitance) list CpList (LINEAR)
Y2 axis: Conductance list GList (LINEAR)

[Test Output: List Display]
Frequency FreqList
Anode voltage VaList
Gate capacitance (parallel capacitance) CpList
Conductance GList
Series capacitance CsList
Series resistance RsList
Parallel resistance RpList
Dissipation factor DList
Reactance XList
Impedance ZList
Phase ThetaList

9.7 Cj-V: Junction capacitance Cj-V characteristics (A.01.11)

[Description]
Measures the junction capacitance (Cj), and plots the Cj-V characteristics.

[Device Under Test]
Junction device, diode

[Device Parameters]
L: Junction length
W: Junction width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
Anode: CMU connected between Anode and Cathode (CV sweep measurement)
VacStart: DC bias start voltage
VacStop: DC bias stop voltage
VacStep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
Vgate=-Vsubs
CpPerArea=Cp/L/W
CpPerWg=Cp/W

[X-Y Graph]
X axis: Anode voltage Vanode (LINEAR)
Y1 axis: Junction capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[List Display]
Anode voltage Vanode
Junction capacitance (parallel capacitance) Cp
Conductance G
Series capacitance Cs
Series resistance Rs

Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta
Junction capacitance per unit area CpPerArea
Junction capacitance per unit width CpPerWg

9.8 *Diode BVAndCj-V ASU : Diode junction capacitance and breakdown voltage measurement using ASUs (A.01.20)*

[Description]
Measures the reverse bias junction capacitance and breakdown voltage by using one MFCMU and two sets of the HRSMU/ASU.

[Device Under Test]
Diode

[Required Modules and Accessories]
One MFCMU module and two sets of HRSMU/ASU are required.
ASU#1 connections: Output: anode, SMU: HRSMU, AUX: MFCMU High
ASU#2 connections: Output: cathode, SMU: HRSMU, AUX: MFCMU Low
Connection wire must be connected between the CMU Return terminals of ASUs.
Setting of ASU I/O Path, ASU tab, Configuration window: AUX

[Device Parameters]
L: Diode length
W: Diode width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time

[Test Parameters: for Junction Capacitance Measurements]
AnodeAC: CMU connected to Anode terminal
FREQ: Measurement frequency
OscLevel: Measurement signal level
VBiasStart: DC bias start voltage
VBiasStop: DC bias stop voltage
VBiasStep: DC bias step voltage

[Test Parameters: for Breakdown Voltage Measurements]
AnodeDC: SMU connected to Anode terminal, primary sweep voltage output
VanodeStart: Sweep start voltage for Anode terminal
VanodeStop: Sweep stop voltage for Anode terminal
VanodeStep: Sweep step voltage for Anode terminal
Ianode@BV: Anode current to decide the breakdown
CathodeDC: SMU connected to Cathode terminal, constant voltage output

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time
AnodeMinRng: Minimum range for the anode current measurement

[Junction Capacitance Measurements: Measurement Parameters]
Parallel capacitance Cp
Conductance G

[Junction Capacitance Measurements: X-Y Plot]
X axis: Anode voltage (LINEAR)
Y1 axis: Junction capacitance Cp (LINEAR)

Y2 axis: Conductance G (LINEAR)

[Junction Capacitance Measurements: List Display]
Impedance Z
Phase Theta
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Capacitance per junction unit area Cp_S

[Junction Capacitance Measurements: Parameters Display Area]
Zero bias capacitance value Cj0

[Breakdown Voltage Measurements: Measurement Parameters]
Anode current
For the anode terminal, the SMU current compliance is set to Ianode@BD*1.1.

[Breakdown Voltage Measurements: User Function]
Anode current per junction unit area Ianode_S

[Breakdown Voltage Measurements: X-Y Plot]
X axis: Anode voltage (LINEAR)
Y1 axis: Anode current (LOG)

[Breakdown Voltage Measurements: Parameters Display Area]
Junction breakdown voltage BV
Zero bias capacitance value Cj0

9.9 *Diode BVAndCj-V SCUU: Diode junction capacitance and breakdown voltage measurement using SCUU (A.01.20)*

[Description]
Measures the reverse bias junction capacitance and breakdown voltage by using one MFCMU, two SMUs, and a set of SCUU/GSWU.

[Device Under Test]
Diode

[Required Modules and Accessories]
One MFCMU module, two SMU modules, and a set of SCUU/GSWU are required.
SCUU connections: Output1: anode, Output2: cathode
Connection wire must be connected between the GSWU and the DUT interface High/Low guard lines for the capacitance measurements.

[Device Parameters]
L: Diode length
W: Diode width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time

[Test Parameters: for Junction Capacitance Measurements]
AnodeAC: CMU connected to Anode terminal
FREQ: Measurement frequency
OscLevel: Measurement signal level
VBiasStart: DC bias start voltage
VBiasStop: DC bias stop voltage
VBiasStep: DC bias step voltage

[Test Parameters: for Breakdown Voltage Measurements]
AnodeDC: SMU connected to Anode terminal, primary sweep voltage output
VanodeStart: Sweep start voltage for Anode terminal
VanodeStop: Sweep stop voltage for Anode terminal
VanodeStep: Sweep step voltage for Anode terminal
Ianode@BV: Anode current at breakdown
CathodeDC: SMU connected to Cathode terminal, constant voltage output

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time
AnodeMinRng: Minimum range for the anode current measurement

[Junction Capacitance Measurements: Measurement Parameters]
Parallel capacitance Cp
Conductance G

[Junction Capacitance Measurements: X-Y Plot]
X axis: Anode voltage (LINEAR)
Y1 axis: Junction capacitance Cp (LINEAR)
Y2 axis: Conductance G (LINEAR)

[Junction Capacitance Measurements: List Display]
Impedance Z
Phase Theta
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp
Dissipation factor D
Reactance X
Capacitance per junction unit area Cp_S

[Junction Capacitance Measurements: Parameters Display Area]
Zero bias capacitance value Cj0

[Breakdown Voltage Measurements: Measurement Parameters]
Anode current
For the anode terminal, the SMU current compliance is set to Ianode@BD*1.1.

[Breakdown Voltage Measurements: User Function]
Anode current per junction unit area Ianode_S

[Breakdown Voltage Measurements: X-Y Plot]
X axis: Anode voltage (LINEAR)
Y1 axis: Anode current (LOG)

[Breakdown Voltage Measurements: Parameters Display Area]
Junction breakdown voltage BV
Zero bias capacitance value Cj0

9.10 Ig-Vg Iforce: MOS capacitor Ig-Vg characteristics, current sweep (A.01.20)

[Description]
Measures gate current vs gate voltage (Ig-Vg) characteristics of MOS capacitor gate insulator.

[Device Under Test]
MOS capacitor

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep current output
IgStart: Sweep start current for Gate terminal
IgStop: Sweep stop current for Gate terminal
VgLimit: Gate voltage compliance
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time
SubsMinRng: Minimum range for the substrate current measurement

[Measurement Parameters]
Gate voltage Vgate
Substrate current Isubs

[User Function]
IgatePerArea: Gate current per unit gate area IgatePerArea=Igate/Lg/Wg
IsubsPerArea: Substrate current per unit gate area IsubsPerArea=Isubs/Lg/Wg

[X-Y Plot]
X axis: Gate current Igate (LOG)
Y1 axis: Gate voltage Vgate (LINEAR)

9.11 Ig-Vg Vforce: MOS capacitor Ig-Vg characteristics, voltage sweep (A.01.20)

[Description]
Measures gate current vs gate voltage (Ig-Vg) characteristics of MOS capacitor gate insulator.

[Device Under Test]
MOS capacitor

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
IgLimit: Gate current compliance
Subs: SMU connected to Substrate, constant voltage output
Vsubs: Substrate voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time
GateMinRng: Minimum range for the gate current measurement
SubsMinRng: Minimum range for the substrate current measurement

[Measurement Parameters]
Gate current Igate
Substrate current Isubs

[User Function]
IgatePerArea: Gate current per unit gate area IgatePerArea=Igate/Lg/Wg
IsubsPerArea: Substrate current per unit gate area IsubsPerArea=Isubs/Lg/Wg

[X-Y Plot]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Gate current Igate (LOG)

[List Display]
Gate voltage Vgate
Gate current Igate
Substrate current Isubs

9.12 Interconnect CouplingCap: Interconnection capacitance (A.01.11)

[Application]
Measures the interconnection capacitance, and plots the C-V characteristics.

[Device Under Test]
Capacitor generated between two interconnections in the same layer

[Device Parameters]
L: Metal length
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
MetalA: CMU connected between MetalA and MetalB (CV sweep measurement)
Vstart: DC bias start voltage
Vstop: DC bias stop voltage
Vstep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)
CsPerLength=Cs/L
CpPerLength=Cp/L

[X-Y Graph]
X axis: DC bias VmetalA (LINEAR)
Y1 axis: Interconnection capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Dissipation factor D (LINEAR)
Y3 axis: Conductance G (LINEAR)

[List Display]
Measurement frequency Freq
DC bias VmetalA
Interconnection capacitance (parallel capacitance) Cp
Conductance G
Series capacitance Cs
Series resistance Rs

Parallel resistance Rp
Dissipation factor D
Reactance X
Impedance Z
Phase Theta
Cs per unit length CpPerLength
Cp per unit length CpPerLength

9.13 Interconnect OverlapCap: Layer to layer film capacitance (A.01.11)

[Application]
Measures the capacitance of the film between two interconnection layers, and plots the C-V characteristics.

[Device Under Test]
Film capacitor generated between two interconnection layers

[Device Parameters]
L: Metal length
W: Metal width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
FREQ: Measurement frequency
OscLevel: Measurement signal level
MetalA: CMU connected between MetalA and MetalB (CV sweep measurement)
Vstart: DC bias start voltage
Vstop: DC bias stop voltage
Vstep: DC bias step voltage

[Extended Test Parameters]
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Parallel capacitance Cp
Conductance G

[User Function]
PI=3.141592653589
D=G/(2*PI*FREQ*Cp)
Rp=1/G
Cs=(1+D^2)*Cp
X=-1/(2*PI*FREQ*Cs)
Rs=D*abs(X)
Z=sqrt(Rs^2+X^2)
Theta=atan(X/Rs)

[X-Y Graph]
X axis: DC bias VmetalA (LINEAR)
Y1 axis: Film capacitance (parallel capacitance) Cp (LINEAR)
Y2 axis: Dissipation factor D (LINEAR)
Y3 axis: Conductance G (LINEAR)

[List Display]
Measurement frequency Freq
DC bias VmetalA
Film capacitance (parallel capacitance) Cp
Conductance G
Series capacitance Cs
Series resistance Rs
Parallel resistance Rp

Dissipation factor D
Reactance X
Impedance Z
Phase Theta

9.14 Junction BV: Junction device breakdown voltage (A.01.20)

[Description]
Measures the junction device reverse bias characteristics, and extracts the breakdown voltage.

[Device Under Test]
Junction device, diode

[Device Parameters]
L: Junction length
W: Junction width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Ianode@BV: Anode current to decide the breakdown
Anode: SMU connected to Anode terminal, primary sweep voltage output
VanodeStart: Sweep start voltage for Anode terminal
VanodeStop: Sweep stop voltage for Anode terminal
VanodeStep: Sweep step voltage for Anode terminal
Cathode: SMU connected to Cathode terminal, constant voltage output

[Extended Test Parameters]
Vcathode: Cathode voltage
HoldTime: Hold time
DelayTime: Delay time
AnodeMinRng: Minimum range for the anode current meausrement

[Measurement Parameters]
Anode current Ianode
Cathode current Icathode

[User Function]
IanodePerArea=Ianode/L/W
IcathodePerArea=Icathode/L/W

[Analysis Function]
BV=@L1X (X intercept of Line1)

[X-Y Plot]
X axis: Anode voltage Vanode (LINEAR)
Y1 axis: Anode current Ianode (LINEAR)
Y2 axis: Anode current Ianode (LOG)
Y3 axis: Cathode current Icathode (LINEAR)
Y4 axis: Cathode current Icathode (LOG)

[List Display]
Anode voltage Vanode
Anode current Ianode
Anode current per unit area IanodePerArea
Cathode current Icathode
Cathode current per unit area IcathodePerArea

[Parameters Display Area]

Junction breakdown voltage BV

[Auto Analysis]
Line1: Vertical line through Y1 data at Ianode=Ianode@BV

9.15 Junction DcParam: Junction device DC parameters (Is,N,Rs) (A.01.20)

[Description]
Measures the forward bias anode voltage vs anode current characteristics, and extracts the slope minimum value (N_Min), the reverse direction saturation current minimum value (IsMin, IsMin2), and the series resistance (Rs).

[Device Under Test]
Junction device, diode

[Device Parameters]
L: Junction length
W: Junction width
Temp: Temperature
Imax: Current compliance

[Test Parameters]
IntegTime: Integration time
Anode: SMU connected to Anode terminal, primary sweep voltage output
VanodeStart: Sweep start voltage for Anode terminal
VanodeStop: Sweep stop voltage for Anode terminal
VanodeStep: Sweep step voltage for Anode terminal
Cathode: SMU connected to Cathode terminal, constant voltage output

[Extended Test Parameters]
Vcathode: Cathode voltage
HoldTime: Hold time
DelayTime: Delay time
AnodeMinRng: Minimum range for the anode current measurement

[Measurement Parameters]
Anode current Ianode
Cathode current Icathode

[User Function]
IanodePerArea=Ianode/L/W
IcathodePerArea=Icathode/L/W
Vt=k*(Temp+273.15)/q
N=1/Vt/(diff(log(Ianode),Vanode))
N_Min=min(N)
Slope=diff(lgt(Ianode),Vanode)
Is=lgt(Ianode)-Slope*Vanode
IsMin=min(Is)
SmplNum=abs((VanodeStop-VanodeStart)/VanodeStep)+1
I_Rs=at(Ianode,SmplNum,1)
deltaV_Rs=VanodeStop-N_Min*Vt*log(I_Rs/IsMin)
Rs=deltaV_Rs/I_Rs

[Analysis Function]
IsMin2=@L1Y (Y intercept of Line1)

[X-Y Plot]
X axis: Anode voltage Vanode (LINEAR)
Y1 axis: Anode current Ianode (LOG)

Y2 axis: Anode current Ianode (LINEAR)
Y3 axis: Slope N (LINEAR)

[Parameters Display Area]
Slope minimum value N_Min
Reverse direction saturation current minimum value IsMin
Reverse direction saturation current minimum value IsMin2
Series resistance Rs

[Auto Analysis]
Line1: Tangent line through Y1 data at Slope=max(Slope)

9.16 Junction IV Fwd: Diode forward bias characteristics (A.01.20)

[Description]
Measures the forward bias anode voltage vs anode current characteristics.

[Device Under Test]
Junction device, diode

[Device Parameters]
L: Junction length
W: Junction width
Temp: Temperature
Imax: Current compliance

[Test Parameters]
IntegTime: Integration time
Anode: SMU connected to Anode terminal, primary sweep voltage output
VanodeStart: Sweep start voltage for Anode terminal
VanodeStop: Sweep stop voltage for Anode terminal
VanodeStep: Sweep step voltage for Anode terminal
Cathode: SMU connected to Cathode terminal, constant voltage output

[Extended Test Parameters]
Vcathode: Cathode voltage
HoldTime: Hold time
DelayTime: Delay time
AnodeMinRng: Minimum range for the anode current measurement

[Measurement Parameters]
Anode current Ianode
Cathode current Icathode

[User Function]
IanodePerArea=Ianode/L/W
IcathodePerArea=Icathode/L/W

[X-Y Plot]
X axis: Anode voltage Vanode (LINEAR)
Y1 axis: Anode current Ianode (LINEAR)
Y2 axis: Anode current Ianode (LOG)

9.17 Junction IV Rev: Diode reverse bias characteristics (A.01.20)

[Description]
Measures the reverse bias anode voltage vs anode current characteristics.

[Device Under Test]
Junction device, diode

[Device Parameters]
L: Junction length
W: Junction width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Anode: SMU connected to Anode terminal, primary sweep voltage output
VanodeStart: Sweep start voltage for Anode terminal
VanodeStop: Sweep stop voltage for Anode terminal
VanodeStep: Sweep step voltage for Anode terminal
IanodeLimit: Anode current compliance
Cathode: SMU connected to Cathode terminal, constant voltage output

[Extended Test Parameters]
Vcathode: Cathode voltage
HoldTime: Hold time
DelayTime: Delay time
AnodeMinRng: Minimum range for the anode current measurement

[Measurement Parameters]
Anode current Ianode
Cathode current Icathode

[User Function]
IanodePerArea=Ianode/L/W
IcathodePerArea=Icathode/L/W

[X-Y Plot]
X axis: Anode voltage Vanode (LINEAR)
Y1 axis: Anode current Ianode (LOG)
Y2 axis: Cathode current Icathode (LOG)

9.18 Rdiff-I kelvin: Diffusion resistor R-I characteristics, Kelvin connection (A.01.11)

[Description]
Measures the resistance vs current characteristics (R-I characteristic).

[Device Under Test]
Diffusion resistor, 3 terminals
Connect the Port1 and VM1 modules to a terminal, the Port2 and VM2 modules to the other terminal.

[Device Parameters]
Polarity: Ntype (SMUs force the specified value) or Ptype (SMUs force the negative specified value).
L: Resistor length
W: Resistor width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to resistor, primary sweep current output
I1Start: Primary sweep start current
I1Stop: Primary sweep stop current
I1Step: Primary sweep step current
V1Limit: Port1 voltage compliance
Subs: SMU connected to substrate, secondary sweep voltage output
VsubsStart: Secondary sweep start voltage
VsubsStop: Secondary sweep stop voltage
VsubsStep: Secondary sweep step voltage
IsubsLimit: Subs current compliance
Port2: SMU connected to resistor, constant voltage output
VM1: SMU connected to resistor, constant current output
VM2: SMU connected to resistor, constant current output

[Extended Test Parameters]
V2: Port2 output voltage
IM1: VM1 output current
IM2: VM2 output current
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Port1 measurement voltage V1
VM1 measurement voltage Vm1
VM2 measurement voltage Vm2

[User Function]
Voltage between terminals DeltaV=Vm1-Vm2
Resistance R=DeltaV/I1
Sheet resistance Rsheet=R*W/L

[X-Y Graph]
X axis: Port1 output current I1 (LINEAR)
Y1 axis: Resistance R (LINEAR)
Y2 axis: Voltage between terminals DeltaV (LINEAR)

[List Display]
  Port1 output current I1
  Port1 measurement voltage V1
  Subs output voltage Vsubs
  Voltage between terminals DeltaV
  Resistance R
  Sheet resistance Rsheet

9.19 Rdiff-I: Diffusion resistor R-I characteristics (A.01.11)

[Description]
Measures the resistance vs current characteristics (R-I characteristic).

[Device Under Test]
Diffusion resistor, 3 terminals

[Device Parameters]
Polarity: Ntype (SMUs force the specified value) or Ptype (SMUs force the negative specified value).
L: Resistor length
W: Resistor width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to resistor, primary sweep current output
I1Start: Primary sweep start current
I1Stop: Primary sweep stop current
I1Step: Primary sweep step current
V1Limit: Port1 voltage compliance
Subs: SMU connected to substrate, secondary sweep voltage output
VsubsStart: Secondary sweep start voltage
VsubsStop: Secondary sweep stop voltage
VsubsStep: Secondary sweep step voltage
IsubsLimit: Subs current compliance
Port2: SMU connected to resistor, constant voltage output

[Extended Test Parameters]
V2: Port2 output voltage
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Port1 measurement voltage V1

[User Function]
Resistance R=V1/I1
Sheet resistance Rsheet=R*W/L

[X-Y Graph]
X axis: Port1 output current I1 (LINEAR)
Y1 axis: Port1 measurement voltage V1 (LINEAR)
Y2 axis: Resistance R (LINEAR)

[List Display]
Port1 output current I1
Port1 measurement voltage V1
Resistance R
Sheet resistance Rsheet

9.20 Rdiff-V kelvin: Diffusion resistor R-V characteristics, Kelvin connection (A.01.20)

[Description]
Measures the resistance vs voltage characteristics (R-V characteristic).

[Device Under Test]
Diffusion resistor, 3 terminals
Connect the Port1 and VM1 modules to a terminal, the Port2 and VM2 modules to the other terminal.

[Device Parameters]
Polarity: Ntype (SMUs force the specified value) or Ptype (SMUs force the negative specified value).
L: Resistor length
W: Resistor width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to resistor, primary sweep voltage output
V1Start: Primary sweep start voltage
V1Stop: Primary sweep stop voltage
V1Step: Primary sweep step voltage
I1Limit: Port1 current compliance
Subs: SMU connected to substrate, secondary sweep voltage output
VsubsStart: Secondary sweep start voltage
VsubsStop: Secondary sweep stop voltage
VsubsStep: Secondary sweep step voltage
IsubsLimit: Subs current compliance
Port2: SMU connected to resistor, constant voltage output
VM1: SMU connected to resistor, constant current output
VM2: SMU connected to resistor, constant current output

[Extended Test Parameters]
V2: Port2 output voltage
IM1: VM1 output current
IM2: VM2 output current
HoldTime: Hold time
DelayTime: Delay time
Port1MinRng: Minimum range for the port1 current measurement

[Measurement Parameters]
Port1 measurement current I1
VM1 measurement voltage Vm1
VM2 measurement voltage Vm2

[User Function]
Voltage between terminals DeltaV=Vm1-Vm2
Resistance R=DeltaV/I1
Sheet resistance Rsheet=R*W/L

[X-Y Graph]
X axis: Port1 output voltage V1 (LINEAR)
Y1 axis: Port1 measurement current I1 (LINEAR)

Y2 axis: Resistance R (LINEAR)

[List Display]
Port1 output voltage V1
Voltage between terminals DeltaV
Port1 measurement current I1
Resistance R
Sheet resistance Rsheet

9.21 Rdiff-V: Diffusion resistor R-V characteristics (A.01.20)

[Description]
Measures the resistance vs voltage characteristics (R-V characteristic).

[Device Under Test]
Diffusion resistor, 3 terminals

[Device Parameters]
Polarity: Ntype (SMUs force the specified value) or Ptype (SMUs force the negative specified value).
L: Resistor length
W: Resistor width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to resistor, primary sweep voltage output
V1Start: Primary sweep start voltage
V1Stop: Primary sweep stop voltage
V1Step: Primary sweep step voltage
I1Limit: Port1 current compliance
Subs: SMU connected to substrate, secondary sweep voltage output
VsubsStart: Secondary sweep start voltage
VsubsStop: Secondary sweep stop voltage
VsubsStep: Secondary sweep step voltage
IsubsLimit: Subs current compliance
Port2: SMU connected to resistor, constant voltage output

[Extended Test Parameters]
V2: Port2 output voltage
HoldTime: Hold time
DelayTime: Delay time
Port1MinRng: Minimum range for the port1 current measurement

[Measurement Parameters]
Port1 measurement current I1

[User Function]
Resistance R=V1/I1
Sheet resistance Rsheet=R*W/L

[X-Y Graph]
X axis: Port1 output voltage V1 (LINEAR)
Y1 axis: Resistance R (LINEAR)
Y2 axis: Port1 measurement current I1 (LINEAR)

[List Display]
Port1 output voltage V1
Port1 measurement current I1
Resistance R
Sheet resistance Rsheet

9.22 R-I DVM: Low resistance measurement using 3458A, current force (A.01.20)

[Description]
Measures the low resistance of a 2-terminal device. SMU forces current and DVM (3458A) measures voltage between terminals. Resistance is calculated from the output value of a current and measured value of a voltage between terminals. For the purpose of excluding thermoelectric power, this test is designed to measure resistance again by switching the direction of voltage and to get the average value of resistance as a test result.

[Device Under Test]
Resistor element, 2 terminals

[Required Modules and Accessories]
Agilent 3458A digital multimeter 1 unit
GPIB cable

[Required Test Definition]
Measure Diff-V

[Device Parameters]
L: Resistor length
W: Resistor width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to resistor, current output
I1: Applied current
V1Limit: Port1 voltage compliance
Port2: SMU connected to resistor, constant voltage output
GPIB_Adr: GPIB address of DVM

[Extended Test Parameters]
V2: Port2 output voltage
HoldTime: Hold time
DelayTime: Delay time
PortMinRng: Minimum range for port current measurement

[Measurement Parameters]
[Measurement Parameters for first measurement (Vpos)]
Vport1: Port1 voltage

[Measurement Parameters for second measurement (Vneg)]
Vport2: Port2 voltage

[X-Y Plot]
[X-Y Plot for first measurement (Vpos)]
X axis: Applied current Iport1 (LINEAR)
Y1 axis: Measured voltage Vport1 (LINEAR)

[X-Y Plot for second measurement (Vneg)]
X axis: Applied current Iport2 (LINEAR)
Y1 axis: Measured voltage Vport2 (LINEAR)

[List Display]
[X-Y Plot for first measurement (Vpos)]
Applied current Iport1
Measured voltage Vport1

[X-Y Plot for second measurement (Vneg)]
Applied current Iport2
Measured voltage Vport2

[Test Output: X-Y Graph]
X axis: Applied current IsmuList (LINEAR)
Y1 axis: DVM measurement result voltage VdvmList (LINEAR)
Y2 axis: Measured voltage VsmuList (LINEAR)
Y3 axis: Resistance value (LINEAR)

[Test Output: List Display]
IsmuList: Applied current
VsmuList: Measured voltage
VdvmList: DVM measured voltage
RList: Resistance value

[Test Output: Parameters]
Rav: Average resistance value of 2 measurements

9.23 R-I kelvin: Resistor R-I characteristics, Kelvin connection (A.01.11)

[Description]
Measures the resistance vs current characteristics (R-I characteristic).

[Device Under Test]
Resistor, 2 terminals
Connect the Port1 and VM1 modules to a terminal, the Port2 and VM2 modules to the other terminal.

[Device Parameters]
L: Resistor length
W: Resistor width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to resistor, primary sweep current output
I1Start: Sweep start current
I1Stop: Sweep stop current
I1Step: Sweep step current
V1Limit: Port1 voltage compliance
Port2: SMU connected to resistor, constant voltage output
VM1: SMU connected to resistor, constant current output
VM2: SMU connected to resistor, constant current output

[Extended Test Parameters]
V2: Port2 output voltage
IM1: VM1 output current
IM2: VM2 output current
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Port1 measurement voltage V1
VM1 measurement voltage Vm1
VM2 measurement voltage Vm2

[User Function]
Voltage between terminals DeltaV=Vm1-Vm2
Resistance R=DeltaV/I1
Sheet resistance Rsheet=R*W/L

[X-Y Graph]
X axis: Port1 output current I1 (LINEAR)
Y1 axis: Resistance R (LINEAR)
Y2 axis: Voltage between terminals DeltaV (LINEAR)

[List Display]
Port1 output current I1
Port1 measurement voltage V1
Resistance R
Voltage between terminals DeltaV

9.24 R-I: Resistor R-I characteristics (A.01.11)

[Description]
Measures the resistance vs current characteristics (R-I characteristic).

[Device Under Test]
Resistor, 2 terminals

[Device Parameters]
L: Resistor length
W: Resistor width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to resistor, primary sweep current output
I1Start: Sweep start current
I1Stop: Sweep stop current
I1Step: Sweep step current
V1Limit: Port1 voltage compliance
Port2: SMU connected to resistor, constant voltage output

[Extended Test Parameters]
V2: Port2 output voltage
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
Port1 measurement voltage V1

[User Function]
Resistance R=V1/I1
Sheet resistance Rsheet=R*W/L

[X-Y Graph]
X axis: Port1 output current I1 (LINEAR)
Y1 axis: Port1 measurement voltage V1 (LINEAR)
Y2 axis: Resistance R (LINEAR)

[List Display]
Port1 output current I1
Port1 measurement voltage V1
Resistance R
Sheet resistance Rsheet

9.25 R-V DVM: Low resistance measurement using 3458A, voltage force (A.01.20)

[Description]
Measures the low resistance of a 2-terminal device. SMU forces voltage and measures current, and DVM (3458A) measures voltage between terminals. Resistance is calculated from the measured value of a current and that of a voltage between terminals. For the purpose of excluding thermoelectric power, this test is designed to measure resistance again by switching the direction of voltage and to get the average value of resistance as a test result.

[Device Under Test]
Resistor element, 2 terminals

[Required Modules and Accessories]
Agilent 3458A digital multimeter 1 unit
GPIB cable

[Required Test Definition]
Measure Diff-V

[Device Parameters]
L: Resistor length
W: Resistor width
Temp: Temperature (deg)

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to resistor, voltage output
V1: Applied voltage
I1Limit: Port1 current compliance
Port2: SMU connected to resistor, constant voltage output
GPIB-Adr: GPIB address of DVM

[Extended Test Parameters]
V2: Output voltage
HoldTime: Hold time
DelayTime: Delay time
PortMinRng: Minimum range for port current measurement

[Measurement Parameters]
[Measurement Parameters for first measurement (Vpos)]
Iport2: Measured current

[Measurement Parameters for second measurement (Vneg)]
Iport1: Measured current

[X-Y Plot]
[X-Y Plot for first measurement (Vpos)]
X axis: Applied voltage on Port1 Vport1 (LINEAR)
Y1 axis: Measured current Iport2 (LINEAR)

[X-Y Plot for second measurement (Vneg)]
X axis: Applied voltage on Port2 Vport2 (LINEAR)

Y1 axis: Measured current Iport1 (LINEAR)

[List Display]
[X-Y Plot for first measurement (Vpos)]
Applied voltage Vport1
Measured current Iport2

[X-Y Plot for second measurement (Vneg)]
Applied voltage Vport2
Measured current Iport1

[Test Output: X-Y Graph]
X axis: Applied voltage VsmuList (LINEAR)
Y1 axis: DVM measurement result voltage VdvmList (LINEAR)
Y2 axis: Measured current IsmuList (LINEAR)
Y3 axis: Resistance value RList (LINEAR)

[Test Output: List Display]
VdvmList: DVM measured voltage
IsmuList: Measured current
RList: Resistance value

[Test Output: Parameters]
Rav: Average resistance value of 2 measurements

9.26 R-V kelvin: Resistor R-V characteristics, Kelvin connection (A.01.20)

[Description]
Measures the resistance vs voltage characteristics (R-V characteristic).

[Device Under Test]
Resistor, 2 terminals
Connect the Port1 and VM1 modules to a terminal, the Port2 and VM2 modules to the other terminal.

[Device Parameters]
L: Resistor length
W: Resistor width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to resistor, primary sweep voltage output
V1Start: Sweep start voltage
V1Stop: Sweep stop voltage
V1Step: Sweep step voltage
I1Limit: Port1 current compliance
Port2: SMU connected to resistor, constant voltage output
VM1: SMU connected to resistor, constant current output
VM2: SMU connected to resistor, constant current output

[Extended Test Parameters]
V2: Port2 output voltage
IM1: VM1 output current
IM2: VM2 output current
HoldTime: Hold time
DelayTime: Delay time
Port1MinRng: Minimum range for the port1 current measurement

[Measurement Parameters]
Port1 measurement current I1
VM1 measurement voltage Vm1
VM2 measurement voltage Vm2

[User Function]
Voltage between terminals DeltaV=Vm1-Vm2
Resistance R=DeltaV/I1
Sheet resistance Rsheet=R*W/L

[X-Y Graph]
X axis: Port1 output voltage V1 (LINEAR)
Y1 axis: Resistance R (LINEAR)
Y2 axis: Port1 measurement current I1 (LINEAR)

[List Display]
Port1 output voltage V1
Voltage between terminals DeltaV
Port1 measurement current I1
Resistance R
Sheet resistance Rsheet

9.27 R-V: Resistor R-V characteristics (A.01.20)

[Description]
Measures the resistance vs voltage characteristics (R-V characteristic).

[Device Under Test]
Resistor, 2 terminals

[Device Parameters]
L: Resistor length
W: Resistor width
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to resistor, primary sweep voltage output
V1Start: Sweep start voltage
V1Stop: Sweep stop voltage
V1Step: Sweep step voltage
I1Limit: Port1 current compliance
Port2: SMU connected to resistor, constant voltage output

[Extended Test Parameters]
V2: Port2 output voltage
HoldTime: Hold time
DelayTime: Delay time
Port1MinRng: Minimum range for the port1 current measurement

[Measurement Parameters]
Port1 measurement current I1

[User Function]
Resistance R=V1/I1
Sheet resistance Rsheet=R*W/L

[X-Y Graph]
X axis: Port1 output voltage V1 (LINEAR)
Y1 axis: Resistance R (LINEAR)
Y2 axis: Port1 measurement current I1 (LINEAR)

[List Display]
Port1 output voltage V1
Port1 measurement current I1
Resistance R
Sheet resistance Rsheet

9.28 VanDerPauw Square: Van Der Pauw pattern sheet resistance (A.01.11)

[Description]
Measures the sheet resistance of the Van Der Pauw pattern, and plots the sheet resistance vs input current characteristics.

[Device Under Test]
Van Der Pauw pattern, 4 terminals

[Device Parameters]
Temp: Temperature

[Test Parameters]
IntegTime: Integration time
Port1: SMU connected to pattern, primary sweep current output
I1Start: Sweep start current
I1Stop: Sweep stop current
I1Step: Sweep step current
V1Limit: Port1 voltage compliance
Port2: SMU connected to pattern, constant voltage output
VM1: SMU connected to pattern, constant current output
VM2: SMU connected to pattern, constant current output

[Extended Test Parameters]
V2: Port2 output voltage
IM1: VM1 output current
IM2: VM2 output current
HoldTime: Hold time
DelayTime: Delay time

[Measurement Parameters]
VM1 measurement voltage Vm1
VM2 measurement voltage Vm2

[User Function]
Voltage between terminals DeltaV=Vm1-Vm2
Sheet resistance Rsheet=(3.141592/log(2))*(DeltaV/I1)

[X-Y Graph]
X axis: Port1 output current I1 (LINEAR)
Y1 axis: Voltage between terminals DeltaV (LINEAR)
Y2 axis: Sheet resistance Rsheet (LINEAR)

[List Display]
Port1 output current I1
Voltage between terminals DeltaV
Sheet resistance Rsheet

10 TFT

1. TFT Id-Vd: TFT Id-Vd characteristics (A.01.20)
2. TFT Id-Vg: TFT Id-Vg characteristics (A.01.20)

10.1 TFT Id-Vd: TFT Id-Vd characteristics (A.01.20)

[Description]
Measures the drain current vs drain voltage characteristic of TFT.

[Device Under Test]
Thin Film Transistor, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Drain: SMU connected to Drain terminal, primary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
Gate: SMU connected to Gate terminal, secondary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
IgLimit: Gate current compliance
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
gds: Output conductance gds=diff(Idrain,Vdrain)
Rds: Output resistance Rds=1/gds

[X-Y Graph]
X axis: Drain voltage Vdrain (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)

[List Display]
Drain voltage Vdrain
Gate voltage Vgate
Drain current Idrain
Output conductance gds
Output resistance Rds

10.2 TFT Id-Vg: TFT Id-Vg characteristics (A.01.20)

[Description]
Measures the drain current vs gate voltage characteristics of TFT.

[Device Under Test]
Thin Film Transistor, 3 terminals

[Device Parameters]
Polarity: Nch (SMUs force the specified value) or Pch (SMUs force the negative specified value).
Lg: Gate length
Wg: Gate width
Temp: Temperature
IdMax: Drain current compliance

[Test Parameters]
IntegTime: Integration time
Gate: SMU connected to Gate terminal, primary sweep voltage output
VgStart: Sweep start voltage for Gate terminal
VgStop: Sweep stop voltage for Gate terminal
VgStep: Sweep step voltage for Gate terminal
IgLimit: Gate current compliance
Drain: SMU connected to Drain terminal, secondary sweep voltage output
VdStart: Sweep start voltage for Drain terminal
VdStop: Sweep stop voltage for Drain terminal
VdStep: Sweep step voltage for Drain terminal
Source: SMU connected to Source terminal, constant voltage output

[Extended Test Parameters]
Vs: Source voltage
HoldTime: Hold time
DelayTime: Delay time
DrainMinRng: Minimum range for the drain current measurement

[Measurement Parameters]
Drain current Idrain

[User Function]
IdrainPerWg: Drain current per unit gate width IdrainPerWg=Idrain/Wg
gm: Transconductance gm=diff(Idrain,Vgate)
gmPerWg: Transconductance per unit gate width gmPerWg=diff(IdrainPerWg,Vgate)

[X-Y Graph]
X axis: Gate voltage Vgate (LINEAR)
Y1 axis: Drain current Idrain (LINEAR)
Y2 axis: Drain current Idrain (LOG)
Y3 axis: Transconductance gm (LINEAR)

[List Display]
Gate voltage Vgate
Drain voltage Vdrain
Drain current Idrain
Transconductance gm
Drain current per unit gate width IdrainPerWg

Transconductance per unit gate width gmPerWg

11 Utility

1. ForcePG1: PG Output1 (A.01.20)
2. ForcePG2: PG Output2 (A.01.20)
3. ForcePG2P: PG Output1/Output2 (A.01.20)
4. ForcePG12: PG Output1/Output2 (A.01.20)
5. ForcePG: PG OutputX (A.01.20)
6. ForcePGC: PG Output1 Continuous Output (A.01.20)
7. Measure Diff-V: Voltage measurement by 3458A (A.01.20)
8. ResetPG: PG reset (A.01.20)
9. Subsite move: Probing next subsite (A.02.00)

11.1 ForcePG1: PG Output1 (A.01.20)

[Description]
Sets the Output1 of the Agilent 81110A Pulse Generator, and triggers it.

[Input Parameters]
Address: GPIB address of the Agilent 81110A Pulse Generator
Period1: Output1 pulse period [s]
Delay1: Output1 delay time [s]
Dcyc1: Output1 duty cycle [%]
Level1: Output1 pulse level [V]
Base1: Output1 base level [V]
TrigCount: Number of output pulses (1 to 65536)

11.2 ForcePG2: PG Output2 (A.01.20)

[Description]
Sets the Output2 of the Agilent 81110A Pulse Generator, and triggers it.

[Input Parameters]
Address: GPIB address of the Agilent 81110A Pulse Generator
Period2: Output2 pulse period [s]
Delay2: Output2 delay time [s]
Dcyc2: Output2 duty cycle [%]
Level2: Output2 pulse level [V]
Base2: Output2 base level [V]
TrigCount: Number of output pulses (1 to 65536)

11.3 ForcePG2P: PG Output1/Output2 (A.01.20)

[Description]
Sets Output1 and Output2 of Agilent 81110A Pulse Generator, and triggers it. Pulse leading/trailing edge transition time can be set.
Execute ResetPG to stop pulse output before the specified pulses are applied.

[Required Modules and Accessories]
Agilent 81110A Pulse Generator (2-output, PGU1 and PGU2)
GPIB cable

[Test Parameters]
Address: GPIB address of Agilent 81110A Pulse Generator
Period1: Pulse period [s] for port 1
Delay1: Pulse delay time [s] for port 1
Width1: Pulse width [s] for port 1
LeadTime1: Pulse leading edge transition time [s] for port 1
TrailTime1: Pulse trailing edge transition time [s] for port 1
Level1: Pulse High level [V] for port 1
Base1: Pulse Low level [V] for port 1
ExtImp1: Load impedance [ohm] for port 1
Period2: Pulse period [s] for port 2
Delay2: Pulse delay time [s] for port 2
Width2: Pulse width [s] for port 2
LeadTime2: Pulse leading edge transition time [s] for port 2
TrailTime2: Pulse trailing edge transition time [s] for port 2
Level2: Pulse High level [V] for port 2
Base2: Pulse Low level [V] for port 2
ExtImp2: Load impedance [ohm] for port 2
NoOfPulse12: Number of output pulses

11.4 ForcePG12: PG Output1/Output2 (A.01.20)

[Description]
Sets Output1 and Output2 of Agilent 81110A Pulse Generator, and triggers it. Pulse leading/trailing edge transition time can be set.
Execute ResetPG to stop pulse output before the specified pulses are applied.

[Required Modules and Accessories]
Agilent 81110A Pulse Generator (2-output, PGU1 and PGU2)
GPIB cable

[Test Parameters]
Address: GPIB address of the Agilent 81110A Pulse Generator
Period1: Output1 pulse period [s]
Delay1: Output1 delay time [s]
Dcyc1: Output1 duty cycle [%]
LeadTime1: Output1 pulse leading edge transition time [s]
TrailTime1: Output1 pulse trailing edge transition time [s]
Level1: Output1 pulse high level [V]
Base1: Output1 pulse low level [V]
ExtImp1: Output1 load impedance [ohm]
NoOfPulse12: Number of output pulses (1〜65536)。
Period2: Output2 pulse period [s]
Delay2: Output2 delay time [s]
Dcyc2: Output2 duty cycle [%]
LeadTime2: Output2 pulse leading edge transition time [s]
TrailTime2: Output2 pulse trailing edge transition time [s]
Level2: Output2 pulse high level [V]
Base2: Output2 pulse low level [V]
ExtImp2: Output2 load impedance [ohm]

11.5 ForcePG: PG OutputX (A.01.20)

[Description]
Sets Output1 or Output2 of Agilent 81110A Pulse Generator, and triggers it. Pulse leading/trailing edge transition time can be set.
Execute ResetPG to stop pulse output before the specified pulses are applied.

[Required Modules and Accessories]
Agilent 81110A Pulse Generator (2-output, PGU1 and PGU2)
GPIB cable

[Test Parameters]
Address: GPIB address of Agilent 81110A Pulse Generator
SelectPort: Pulse output port
Period: Pulse period [s]
Delay: Pulse delay time [s]
Width: Pulse width [s]
LeadTime: Pulse leading edge transition time [s]
TrailTime: Pulse trailing edge transition time [s]
Level: Pulse High level [V]
Base: Pulse Low level [V]
ExtImp: Load impedance [ohm]
NoOfPulse: Number of output pulses

11.6 ForcePGC: PG Output1 Continuous Output (A.01.20)

[Description]
Sets Output1 of Agilent 81110A Pulse Generator, and triggers continuous pulse output. Pulse leading/trailing edge transition time can be set.
Execute ResetPG to stop pulse output before the specified pulses are applied.

[Required Modules and Accessories]
Agilent 81110A Pulse Generator (2-output, PGU1 and PGU2)
GPIB cable

[Test Parameters]
Address: GPIB address of Agilent 81110A Pulse Generator
Period1: Pulse period [s]
Delay1: Pulse delay time [s]
Dcyc1: Duty cycle [%]
LeadTime1: Pulse leading edge transition time [s]
TrailTime1: Pulse trailing edge transition time [s]
Level1: Pulse High level [V]
Base1: Pulse Low level [V]
ExtImp1: Load impedance [ohm]

11.7 Measure Diff-V: Voltage measurement by 3458A (A.01.20)

[Description]
Performs voltage measurement between two terminals by using Agilent 3458A Digital Multimeter.
Measurement data is stored to DVM_Val variable.

[Required Modules and Accessories]
Agilent 3458A Digital Multimeter
GPIB cable

[Input Parameters]
Adrs: GPIB address of Agilent 3458A Digital Multimeter

[Test Output: Analaysis Parameters]
DVM_Val: Voltage measurement data [V]

11.8 ResetPG: PG reset (A.01.20)

[Description]
Resets Agilent 81110A Pulse Generator.

[Required Modules and Accessories]
Agilent 81110A Pulse Generator (2-output, PGU1 and PGU2)
GPIB cable

[Input Parameter]
GPIB address of Agilent 81110A Pulse Generator

11.9 Subsite move: Probing next subsite (A.02.00)

[Description]
Moves wafer prober chuck to the next subsite, reads device ID from the prober, and sets it to the Device ID of the test record.

[Supported Probers]
While this application test supports Cascade Microtech, SUSS MicroTec and Vector Semiconductor wafer prober drivers as standard basis, you may specify a command path name into the CustomProber entry field to operate with a non-standard wafer prober driver.

[Test Parameters]
ProberType: Type of wafer prober
CustomProber: Command path name for non-standard wafer probers

If CustomProber is not blank, ProberType field is ignored.