An Automated DC Parameter Measurement System for Power Modules and Smart Power ICs Using the HP 4142B Modular DC Source/Monitor

Application Note 1216-2

1. Introduction

The HP 4142B Modular DC Source/Monitor with one HP 41422A High Current Unit (HCU) and one HP 41423A High Voltage Unit (HVU) can source/measure up to 10A/1000V. This can be easily extended to 20A/2000V by using two HCUs and two HVUs.

Another unique feature of the HP 4142B is its ability to control external relays. The External Relay Control function was designed so you could programmatically change the connections between the measurement units and the test device's terminals. In addition, the 16-bit control signal can be used as control signal sources for smart power ICs.

These all combine to create an economical and highly automated 20A/2000V dc parametric system for power devices, power modules, and smart power ICs.

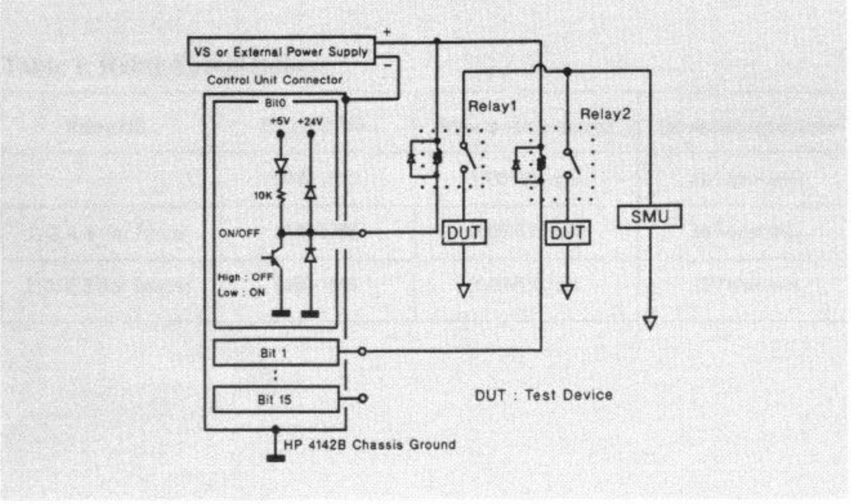

Figure 1. Example of the External Relay Control

2. External Relay Control Function

In addition to controlling the Module Selector (HP 16087A or HP 16088B Option 300) the HP 4142B Control Unit can output a 16-bit digital TTL level signal. This added capability is extremely useful for controlling external relays under program control. Figure 1 is an illustration of this capability.

The relay's coil should be connected between the appropriate Control Unit pin and an external power supply or VS of HP 41424A Voltage Source/Voltage Monitor Unit (VS/VMU). A coil suppression diode should be connected across the relay coil. The relay's contacts should be connected between the device and measurement unit which is best suited for your application. With the HP 4142B you can choose from the HPSMU, MPSMU, HCU, VS/VMU and GNDU. Please refer to the HP 4142B data sheet for module specifications.

The 16-bit TTL level digital signal can also be used as input signals for smart power ICs. Even simple digital patterns can be generated.

As an added degree of flexibility, you can use the 16-bit digital signal directly from the Control Unit or from the HP 16087A Module Selector. A special cable interconnects the Control Unit and Module Selector. See figure 2 for more information.

The Control Unit connector's pin assignment is depicted in figure 3. Pins 9 through 13 and 22 through 25 are dedicated to the Module Selector.

3. Application Examples

The following sections describe how to programmatically evaluate bipolar power transistors and power modules up to 20A/2000V using the HP 4142B, External Relay Control function, and HP 16087A Module Selector. A useful example of how to control smart power ICs is also described.

4. Automatic Power Device Measurements to 20A/2000V

The HP 4142B can support a maximum of two HPSMUs (HP 41420A Source Monitor Unit), two HCUs (HP 41422A High Current Unit), or two HVUs (HP 41423A High Voltage Unit) at the same time. In addition, multiple HP 4142B mainframes can be used together.

In this example, the first HP 4142B mainframe contains two HCUs and the second two HVUs. This combination will allow you to perform automatic measurement up to 20A/2000V.

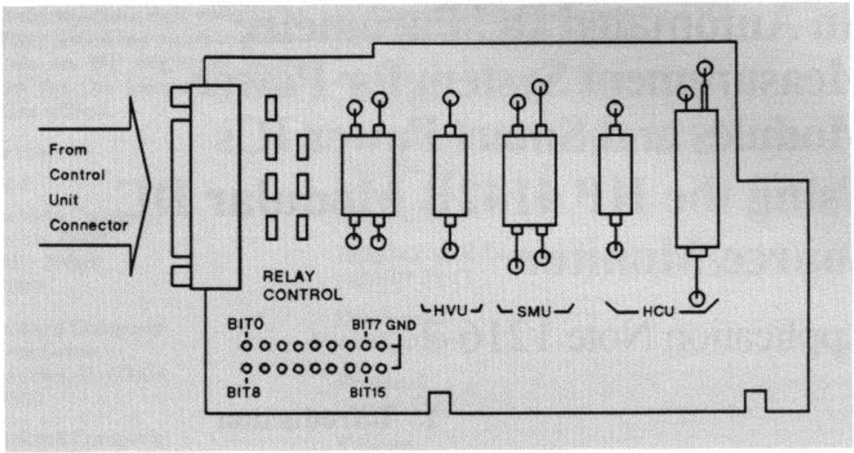

Figure 2. Module Selector Board (HP parts NO: 16087-66501)

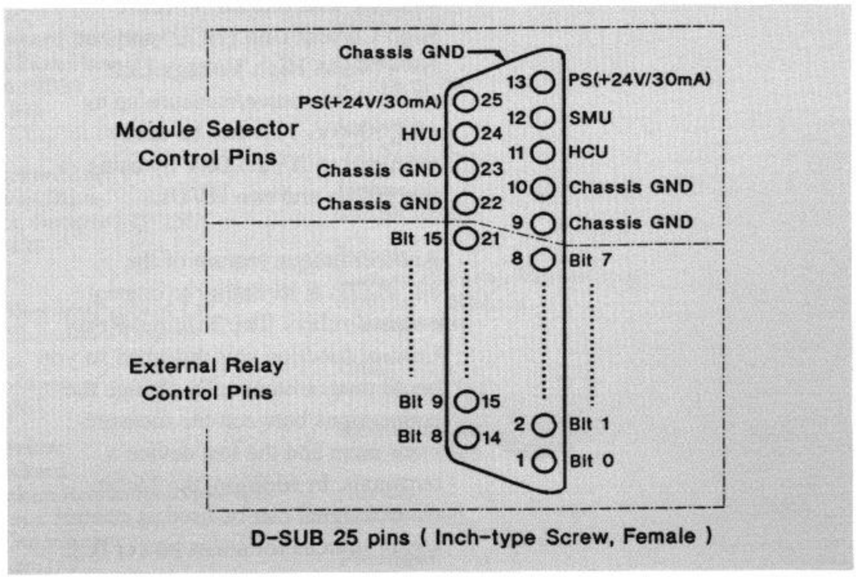

Figure 3. Control Unit Connector Pin Assignment

4-1. Measurement Configuration

Figures 4 and 5 illustrate the HP 4142B and module configuration for measurements to 20A/2000V. The components outside the dotted line are standard HP 4142B measurement modules. A VS/VMU is used to drive the external relays and it is necessary to short the common terminals of the GNDUs.

Table 1 lists the relays and their specifications used in this example. Figure 6 shows the Module Selector wiring. The digital control signals for the external relays are provided from the Module Selector. Refer to Appendix A for more details on wiring the Module Selector to the test device.

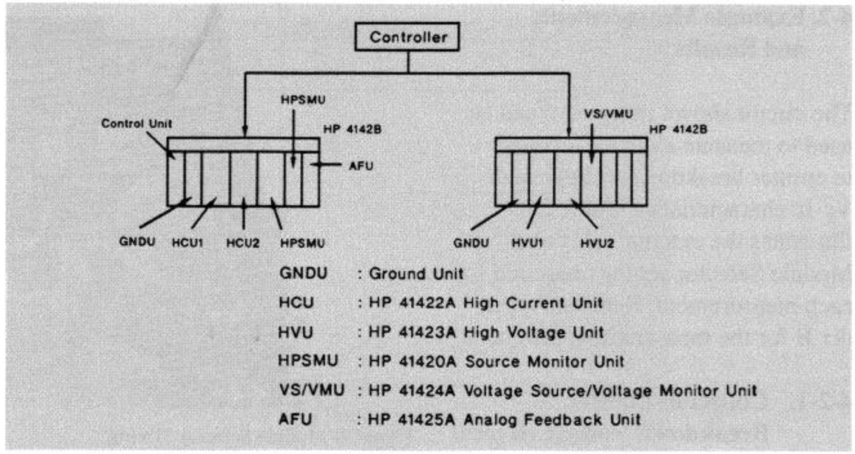

Figure 4. 20A/2000V Example Configuration

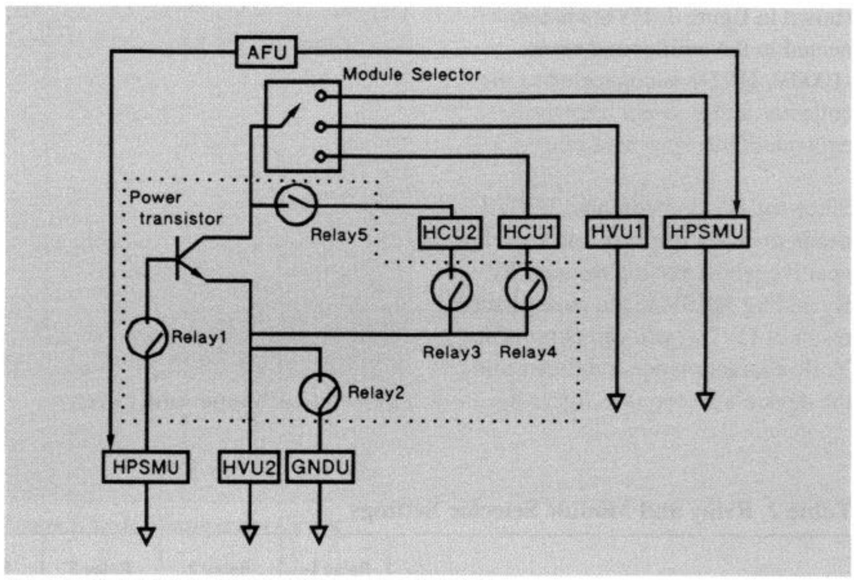

Figure 5. 20A/2000V Equivalent Measurement Circuit

Table 1. Relay Specifications

Relay NO.	HP parts NO.	Withstanding voltage.	Insulation resistance	Voltage (Coil rating)	Current (Coil rating)
1	0490-1613	1500VDC min.	10^{11} ohm min.	18.0VDC	13.6mA
2, 3, 4, 5 (for Force)	0490-1763	5000VDC min.	10^{11} ohm min.	24.0VDC	15.0mA
2, 3, 4, 5 (for Sence)	0490-1698	3500VDC min.	10^{13} ohm min.	24.0VDC	15.0mA

4-2. Example Measurements and Results

The circuit shown in figure 5 can be used to measure a device's collector to emitter breakdown voltage and Vc-Ic characteristics. Table 2 illustrates the external relay and Module Selector settings required for each measurement. Refer to Appendix B for the measurement program.

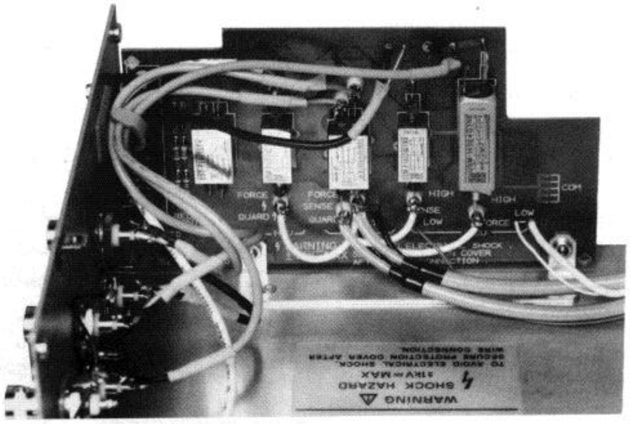

Figure 6. Module Selector Wiring

4-2-1. Collector-Emitter Breakdown Voltage (Bvceo)

The Bvceo measurement circuit is shown in figure 7. HVU2 is connected to the emitter and set to -1000V. HVU1 is connected to the collector and is swept over the equivalent measurement range.

Since the HVU is unipolar, HVU1 needs to be set negative and switched positive while passing through 0V. By adding 1000V to the measurement result of HVU1, you can obtain the Vc-Ic characteristics and determine the device's Bvceo (see figure 8).

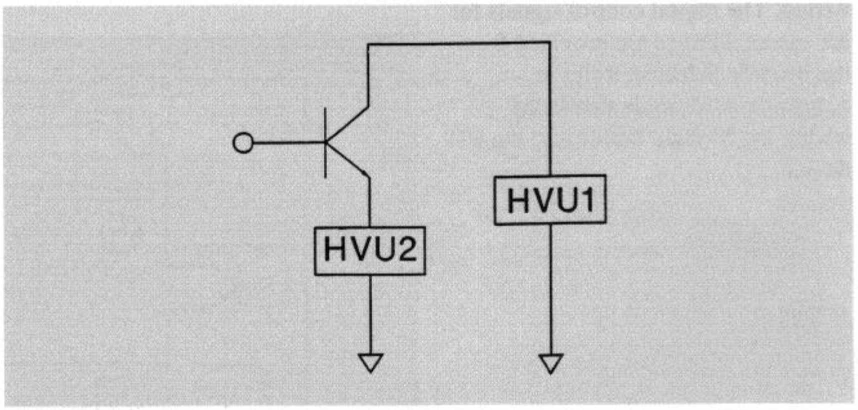

Figure 7. Bvceo Measurement Circuit

Table 2. Relay and Module Selector Settings

	Relay 1	Relay 2	Relay 3	Relay 4	Relay 5	Module Selector
Collector-emitter breakdown voltage (Bvceo)	OFF	OFF	OFF	OFF	OFF	HVU-ON
Vc-Ic Characteristics	ON	ON	ON	ON	ON	HCU-ON

Note 1) Relays 2-5 are dual relays, Force and Sense lines.
Note 2) The direction of the reed relay must be considered.
Note 3) A series resistor must be used to prevent exceeding the 18.0V relay coil rating.

The HVU has a 10mA maximum current compliance.

4-2-2. Vc-Ic Characteristics

The Vc-Ic measurement circuit is shown in figure 9. The HCUs are connected in parallel between the collector and emitter. A 2 channel pulsed sweep mode is used to synchronize the HCUs and minimize thermal generation affects. Each HCU is sweep from 0A to 10A, the combined current is therefore 0A to 20A.

The Vc-Ic measurement result is shown in figure 10.

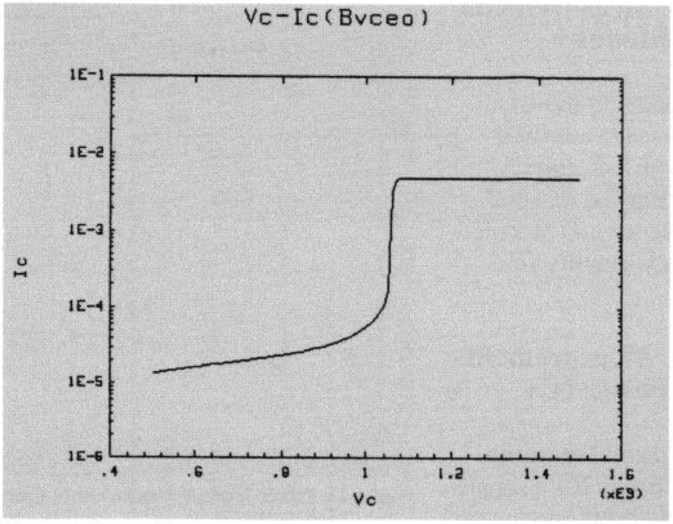

Figure 8. Bvceo Measurement Result

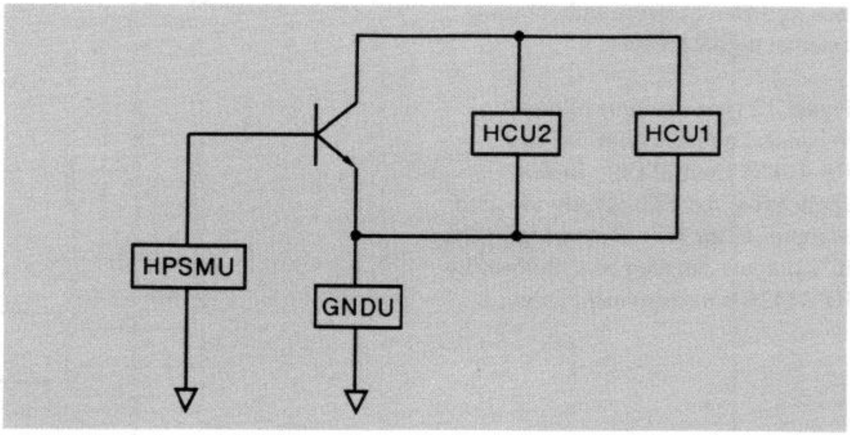

Figure 9. Vc-Ic Measurement Circuit

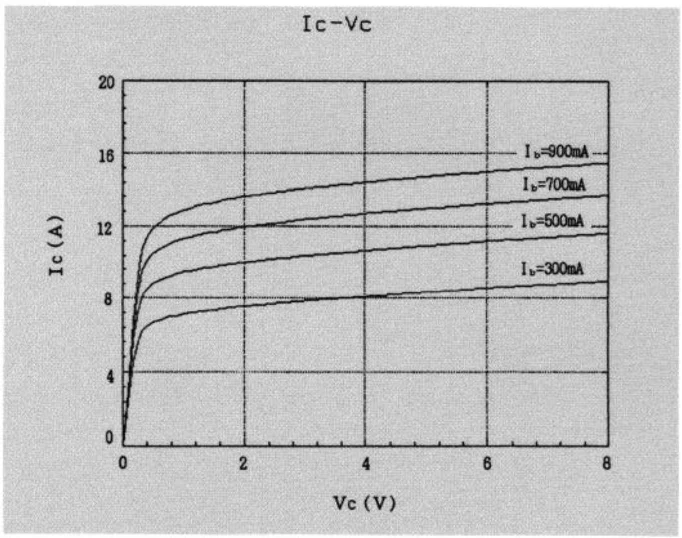

Figure 10. Vc-Ic Measurement Circuit

5. Automatic Measurements on Power Modules

The measurement circuit shown in figure 11 can be used to automate your power MOSFET modules measurements. Using the External Relay Control function and Module Selector can greatly simplify your measurements.

6. Automatic Measurements on Smart Power ICs

The HP 4142B Control Unit makes controlling smart power ICs a simple task by programmatically varying the input signals in order to get the device into its different states without using external digital sources.

Figure 12 is an example of how to connect a motor driver IC and HP 4142B Control Unit. In this application, the TTL outputs are used as inputs to the IC's control logic. The IC's outputs can then be monitored by HP 4142B's measurement units.

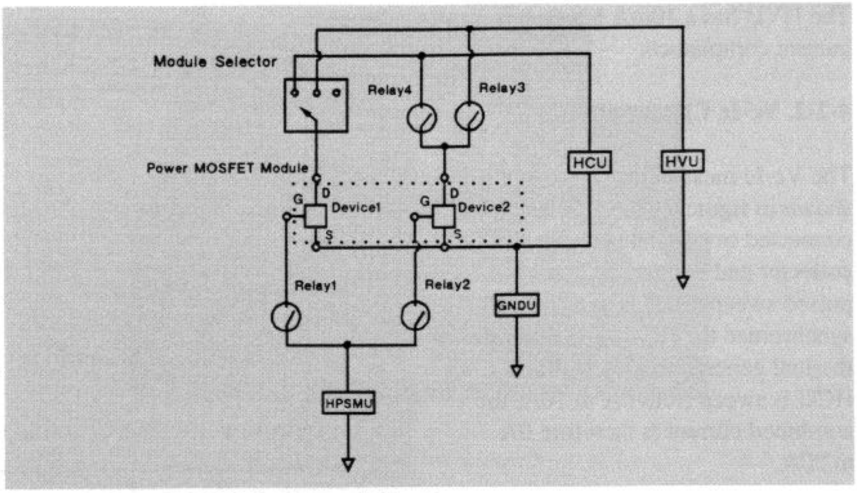

Figure 11. Power Module Measurement Circuit

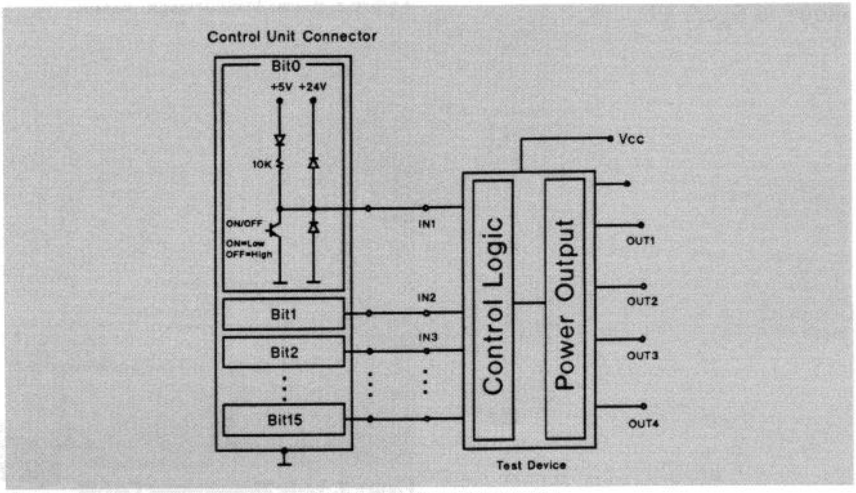

Figure 12. Connecting the Control Unit and Motor Driver IC

Appendix A

In order to obtain maximum measurement performance and safety, care must be taken in wiring the Module Selector to the Test Device:

1. To decrease the chance of oscillation, minimize the cable length between Module Selector and test device. The HCU also used a special twisted pair wiring scheme to minimize inductance.

2. Be sure to use the INTLK terminal and HVU ON/OFF STATUS terminal as shown in figure 13 to reduce the risk of electric shock.

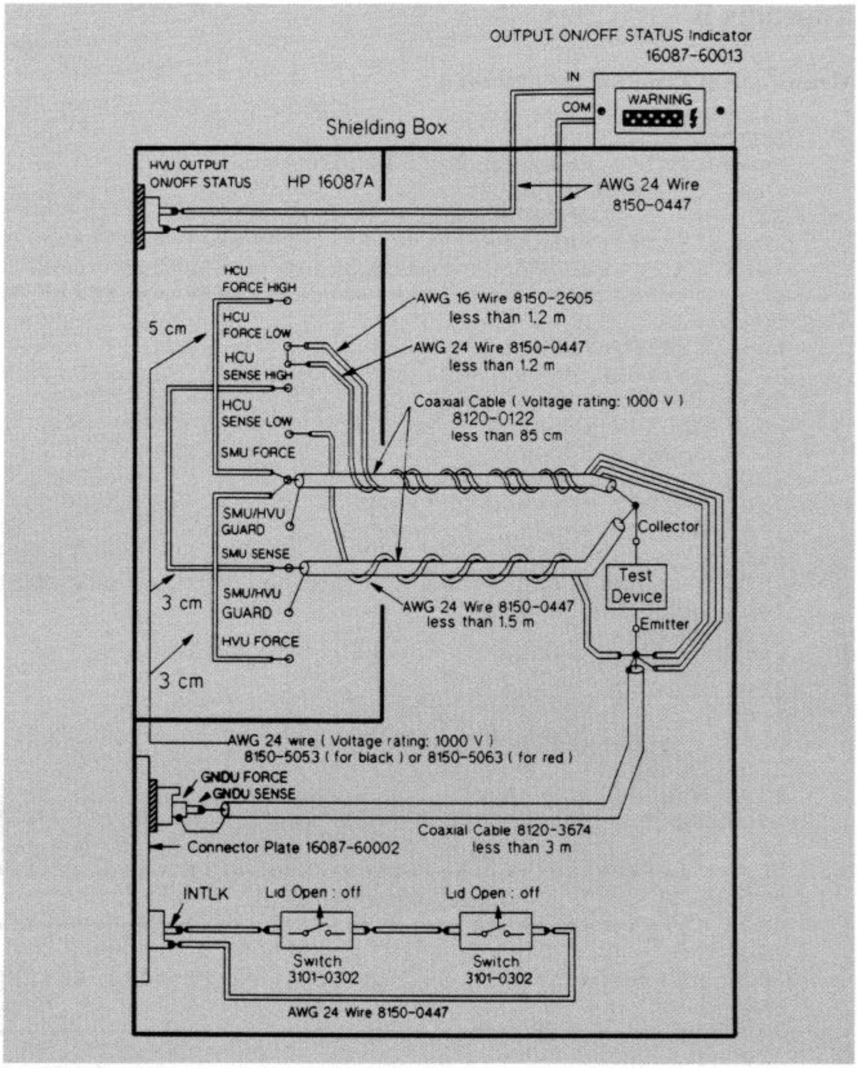

Figure A. Connecting the Module Selector and Test Device

Appendix B

Measurement Program for Section 4

```
Appendix B.
Measurement Program for Section 4

10   !     LOADSUB ALL FROM "GRAPHICS"
20   !***********************************************
30   !     2000V/20A measurememt using two HP 4142Bs
40   !***********************************************
50   !
60   OPTION BASE 1
70   INTEGER Hpsmu,Smu1,Hcu1,Hcu2,Hvu1,Hvu2,Vs
80   !
90   ASSIGN @Hp4142_1 TO 723
100  ASSIGN @Hp4142_2 TO 724
110  !
120  OUTPUT @Hp4142_1;"*RST"
130  OUTPUT @Hp4142_2;"*RST"
140  !
150  !---HP 4142B frame_1 ( Including Control Unit )------
160  Hcu1=2
170  Hcu2=4
180  Hpsmu=6
190  Smu1=7
200  !
210  !---HP 4142B frame_2------
220  Hvu1=2
230  Hvu2=4
240  Vs=5
250  !
260  !*********************************************
270  !           Bvceo Measurement
280  !*********************************************
290  !
300  DIM Vc_no1(101),Ic_no1(101),Vc_f1(101),A$(2)[15]
310  !
320  !-------Parameter settings-------------------
330  !
340  Vc_start_1=0           ! Vc_start=0V
350  Vc_stop_1=1000         ! Vc_stop=1000V
360  Vc_no_step_1=101       ! Vc_no_step=101
370  Iccomp=-5.E-3          ! Ic_comp=-5mA
380  Bv1=-500               ! Bv1=-500V
390  V_relay=20             ! Drive_relay_voltage=20V
400  !
410  Vc_step_1=(Vc_stop_1-Vc_start_1)/(Vc_no_step_1-1)
420  !
430  FOR Var1=1 TO Vc_no_step_1
440    Vc_no1(Var1)=Vc_start_1+(Var1-1)*Vc_step_1
450  NEXT Var1
460  !
470  !-------Bvceo measurement--------------------
480  !
490  OUTPUT @Hp4142_2;"CN";Hvu1,Hvu2,Vs
500  OUTPUT @Hp4142_2;"DV";Vs,0,V_relay
510  OUTPUT @Hp4142_1;"ERC";1,2
520  OUTPUT @Hp4142_2;"POL";Hvu2,1
```

```
530  OUTPUT @Hp4142_2;"FMT";5
540  !
550  OUTPUT @Hp4142_2;"DV";Hvu2,0,Bv1,Iccomp*1.2
560  FOR Var1=1 TO Vc_no_step_1
570    OUTPUT @Hp4142_2;"DV";Hvu1,0,Vc_no1(Var1),
   Iccomp
580    OUTPUT @Hp4142_2;"MM";1,Hvu1
590    OUTPUT @Hp4142_2;"XE"
600    ENTER @Hp4142_2 USING "#,3A,12D,X";
       A$(1),Ic_no1(Var1)
610  NEXT Var1
620  !
630  OUTPUT @Hp4142_2;"CL"
640  !
650  !-------Calculating actual Vc-----------------
660  !
670  FOR Var1=1 TO Vc_no_step_1
680    Vc_f1(Var1)=Vc_no1(Var1)-Bv1
690  NEXT Var1
700  !
710  !-------Graphics-------------------------------
720  !
730  CLEAR SCREEN
740  Loggraph(400,1600,1.E-6,1.E-1,"Vc (V)","Ic (A)","Vc-Ic(Bvceo)",1,0)
750  !
760  FOR Var1=1 TO 101
770    PLOT Vc_f1(Var1),LGT(ABS(Ic_no1(Var1)))
780  NEXT Var1
790  !
800  PRINT "**Press RETURN to perform Vc-Ic measurement**"
810  PAUSE
820  !
830  !*********************************************
840  !            Vc - Ic Measurement
850  !*********************************************
860  !
870  DIM  Vc(101),Ic(5,101),Ic_1(5,101),Ic_2(5,101),A1$(5,101)[3],A2$(5,
)[3]
880  INTEGER Vc_no_step,Ib_no_step
890  !
900  !-------Parameter settings-------------------
910  !
920  Vc_start=0          ! Vc_start=0V
930  Vc_stop=10          ! Vc_stop=10V
940  Vc_no_step=101      ! Vc_no_step=101
950  Ic_comp=10          ! Ic_comp=10A
960  Ib_start=3.E-1      ! Ib_start=300mA
970  Ib_step=2.E-1       ! Ib_step=200mA
980  Ib_no_step=4        ! Ib_no_step=4
990  P_width=1.E-4       ! Pulse_width=100us
1000 !
1010 Vc_step=(Vc_stop-Vc_start)/(Vc_no_step-1)
1020 !
1030 FOR Var1=1 TO Vc_no_step
1040   Vc(Var1)=Vc_start+(Var1-1)*Vc_step
```

```
1050 NEXT Var1
1060 !
1070 !-------Measurement ( Vc - Ic )--------------
1080 !
1090 OUTPUT @Hp4142_1;"CN";Hcu1,Hcu2,Hpsmu
1100 OUTPUT @Hp4142_2;"CN";Vs
1110 OUTPUT @Hp4142_2;"DV";Vs,0,V_relay
1120 OUTPUT @Hp4142_1;"ERC";1,3
1130 OUTPUT @Hp4142_1;"ERC";2,31
1140 OUTPUT @Hp4142_1;"FL";0,Hpsmu
1150 !
1160 FOR Var2=1 TO Ib_no_step
1170   Ib=Ib_start+Ib_step*(Var2-1)
1180   OUTPUT @Hp4142_1;"DI";Hpsmu,0,Ib,10
1190   FOR Var1=1 TO Vc_no_step
1200     OUTPUT @Hp4142_1;"PDM";Hcu1
1210     OUTPUT @Hp4142_1;"PDV";Hcu1,0,0,
    Vc(Var1),Ic_comp
1220     OUTPUT @Hp4142_1;"PV";Hcu2,0,0,
    Vc(Var1),Ic_comp
1230     OUTPUT @Hp4142_1;"PT";.02,P_width,2.E-2
1240     OUTPUT @Hp4142_1;"MM";7,Hcu1
1250     OUTPUT @Hp4142_1;"XE"
1260     ENTER @Hp4142_1 USING "#,3A,12D,X";
       A1$(Var2,Var1),Ic_1(Var2,Var1)
1270   NEXT Var1
1280 NEXT Var2
1290 !
1300 FOR Var2=1 TO Ib_no_step
1310   Ib=Ib_start+Ib_step*(Var2-1)
1320   OUTPUT @Hp4142_1;"DI";Hpsmu,0,Ib,10
1330   FOR Var1=1 TO Vc_no_step
1340     OUTPUT @Hp4142_1;"PDM";Hcu1
1350     OUTPUT @Hp4142_1;"PDV";Hcu1,0,0,Vc(Var1),
         Ic_comp
1360     OUTPUT @Hp4142_1;"PV";Hcu2,0,0,Vc(Var1),
         Ic_comp
1370     OUTPUT @Hp4142_1;"PT";.02,P_width,2.E-2
1380     OUTPUT @Hp4142_1;"MM";7,Hcu2
1390     OUTPUT @Hp4142_1;"XE"
1400     ENTER @Hp4142_1 USING "#,3A,12D,X";
         A2$(Var2,Var1),
         Ic_2(Var2,Var1)
1410   NEXT Var1
1420 NEXT Var2
1430 OUTPUT @Hp4142_1;"CL";Hcu1,Hcu2,Hpsmu
1440 OUTPUT @Hp4142_2;"CL";Vs
1450 !
1460 !-------Calculating  Ic ------------------------
1470 !
1480 FOR Var2=1 TO Ib_no_step
1490   FOR Var1=1 TO Vc_no_step
1500     Ic(Var2,Var1)=Ic_1(Var2,Var1)
    +Ic_2(Var2,Var1)
1510   NEXT Var1
```

```
1520 NEXT Var2
1530 !
1540 !-------Graphics-------------------------------
1550 !
1560 CLEAR SCREEN
1570 Lingraph(0,10,0,20,"Vc(V)","Ic(A)","Ic-Vc",1)
1580 !
1590 FOR Var2=1 TO Ib_no_step
1600   FOR Var1=1 TO Vc_no_step
1610     PLOT Vc(Var1),Ic(Var2,Var1)
1620   NEXT Var1
1630   PENUP
1640   LABEL "Ib=";300+(Var2-1)*200;"mA "
1650 NEXT Var2
1660 !
1670 END
```

Description

60-240	Initialization.
320-450	Defines the Bvceo measurement parameters.
470-630	Measures Bvceo characteristics.
650-690	Calculates actual Vc values.
710-780	Displays measurement results.
900-1050	Defines parameters for Vc-Ic characteristics measurement.
1070-1440	Measures Vc-Ic characteristics.
1460-1520	Calculates Ic values.
1540-1650	Displays measurement results.

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