Pulsed Measurements on GSM Amplifier SMD ICs with Vector Network Analyzer ZVR

Application Note 1EZ42_1E

Subject to change

19 May 1998, Olaf Ostwald

Products:

ZVR

ZVC

ZVRE

ZVCE

ZVRL

ROHDE&SCHWARZ

1 Measurement Task

A typical task during final inspection after fabrication of components for GSM (Global System for Mobile communications) applications is the measurement of the electrical characteristics of **power amplifier integrated circuits** (ICs). The device under test (DUT) is an integrated two-stage amplifier according to the functional block diagram as shown in Fig 1.

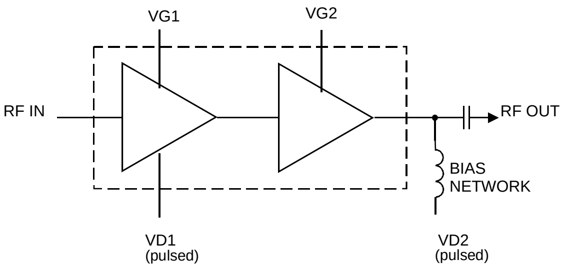

Fig 1: Functional block diagram of two-stage GSM amplifier DUT

The power amplifier has an SMD (surface mounted device) package and is therefore tested in a custom-specific test-fixture. A special requirement for testing a GSM component is to measure the electrical characteristics of the DUT, eg gain of a power amplifier, under **pulsed conditions**. The test should be similar to the real operating conditions in a mobile telephone and should yield additional insight into the dynamic behavior of the DUT during a GSM pulse.

For final inspection after production the amplifier under test is measured in a specially designed test-fixture (see Fig 3 on next page). The DUT is supplied with constant gate voltages VG1 and VG2 and **pulsed** drain voltages VD1 and VD2. While VG1, VG2 and VD1 are fed to the amplifier directly via supply pins of the device, due to the internal structure of the chip the drain voltage VD2 for the output stage of the amplifier must be supplied via a bias network to the output pin of the amplifier. Pulse width of drain voltages is 577 µs with a puls duty cycle of 12.5%. Common ground and heatsink are on the backside of the IC.

As one important part of the necessary overall specification measurements of the DUT, which have to be performed in the test shop of the manufacturer, the **available gain** of the DUT has to be measured with pulsed drain voltages. For that the following test set-up is used (Fig 2).

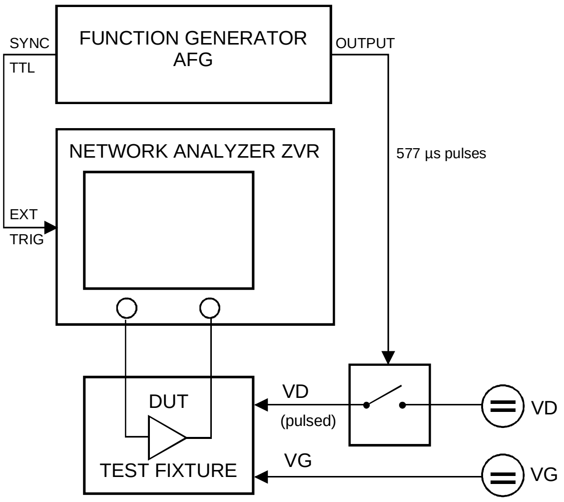

Fig 2: Test set-up for pulsed gain measurements

The test set-up mainly consists of

- Power Supply (eg NGT25),
- Function Generator (eg AFG),
- Vector Network Analyzer ZVR,
- and a custom specific test fixture (see Fig 3 on next page).

Drain and gate voltages for the DUT are supplied by a power supply. While the gate voltage is directly connected to the DUT, drain voltage is fed to a FET switch, which is triggered by a pulse signal. Function Generator AFG is used to generate these 577-µs-pulses similar to GSM pulses. The pulsed output signal of the Function Generator controls the drain voltages via the FET-switch (eg enhancement type N-channel MOS-FET BUK45G). Through this it is achieved, that the power amplifier under test is only supplied with drain voltage during the time of the GSM pulse and its characteristics can be measured under realistic conditions.

Additionally the TTL SYNC output signal of the Function Generator is fed to the EXT TRIGGER input of ZVR to synchronize the measurement points to the GSM pulses.

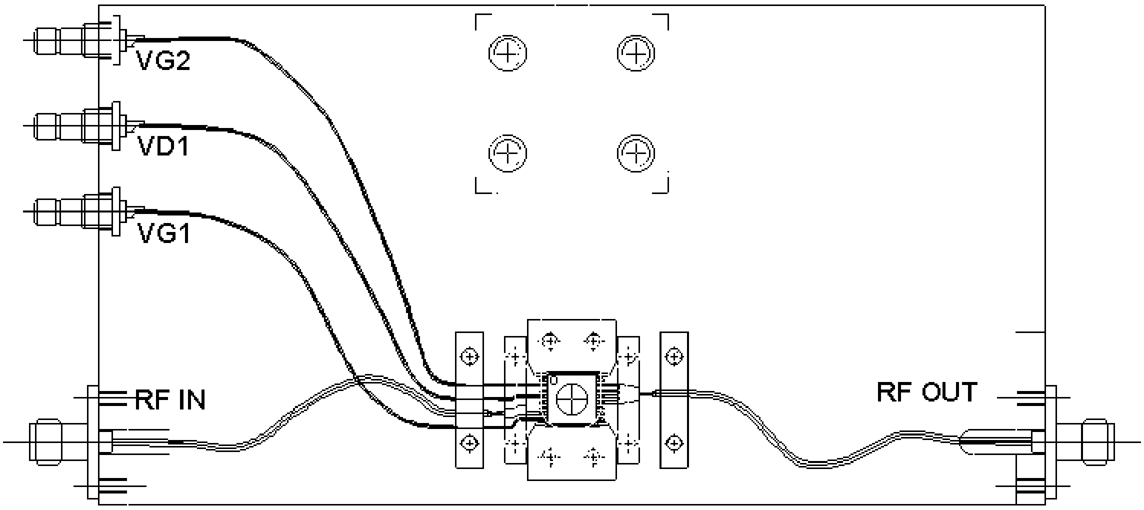

Fig 3: Test fixture for GSM amplifier SMD ICs

2 Instrument Settings

The instrument settings for the measurements are chosen as follows:

Power Supply NGT25

- VG = -1.7 V
- VD = 3.2 V

Function Generator AFG

- Waveform PULSE CONT
- PER = 4.616 ms
- N = 1
- WIDTH = 577 µs
- H-LEV = 6 V
- L-LEV = 0 V

Vector Network Analyzer ZVR

- PRESET
- MEAS S21
- FORMAT MAGNITUDE
- CENTER 900 MHz
- SPAN 100 MHz
- SWEEP DEF TRIGGER Menu
    - EXTERNAL
    - TRIGGER DELAY 100 µs
    - POINT TRIGGER
    - NEGATIVE SLOPE (side menu)

Vector Network Analyzer ZVR is swept over the frequency range 850 MHz to 950 MHz. For a defined instant of measurement during the GSM pulse an external triggering via the SYNC TTL-signal of the Function Generator is used. The trigger signal activates a single measurement point (POINT TRIGGER) during measurement sweep.

The achieved **sweep rate** is determined by the product of GSM pulse period (4.616 ms) and the chosen number of points for ZVR sweep (eg 401) and is approx. 1.9 s for this example.

The period of **time for data acquisition** at each frequency point depends upon the chosen IF bandwidth. This corresponds to the respective number of taps of the internal digital IF filter. Since the ZVR's internal IF signal is sampled with a period of 5.12 µs the data acquisition time can be calculated as the product of number of taps and the given sampling period. For the 10-kHz-IF bandwidth for instance 26 samples are evaluated and therefore the data acquisition time is approx. 133 µs. The corresponding time for other IF bandwidths are given in Table 1 on the next page.

The data acquisition time howerver is only a single product of number of samples and sampling period if only **normalized measurements** (eg TRANS NORM) are performed. Then the internal change-over switch within the test set is in a fixed position and not switched. Consequently only one port, PORT1 or PORT2, is continuously driving.

On the other hand, if a **two-port system error correction** is active, always measurements with PORT1 and alternately PORT2 as drive ports are performed. At each frequency then first PORT1 is driving and after that the drive signal is switched over to PORT2. This enables a high accuracy and nearly no delay for the display of the measurement results. The measurement time however is significantly greater due to a doubled data acquisition and an additional transient period of the receiver. This has to settle twice, as measurements for both cases are necessary, PORT1 and PORT2 driving.

The **data acquisition times** for a single port driving are given in Table 1.

IF BW	Data acquisition time
1 Hz	860 ms
3 Hz	300 ms
10 Hz	85 ms
30 Hz	29 ms
100 Hz	7.8 ms
300 Hz	2.8 ms
1 kHz	970 µs
3 kHz	430 µs
10 kHz	133 µs
FULL (26 kHz)	41 µs

Table 1: Data acquisition time
(single port driving)

The **moment of measurement** during the GSM pulse can be simply altered by varying the TRIGGER DELAY. Through this the gain of the DUT can be controlled even as a function of time during the GSM pulse.

3 Calibration

To eliminate parasitics and frequency dependent attenuations and reflections of the test setup it is advisable to perform a calibration, thus achieving accurate measurement results. For in-fixture calibration the **patented calibration technique TNA** (Through-Network-Attenuator) is especially suitable. An advantage of TNA calibration technique as compared to other calibration methods is that calibration standards may be partially unknown. For instance, the N-standard must only show a large reflection, but the reflection coefficient may be unequal to 1 and may be arbitraryly frequency dependent and unknown. The attenuation of the A-standard is arbitrary too, apart from not being zero.

TNA-calibration is peformed in three steps, for each of it the DUT is replaced by a calibration standard:

1) T-standard (Through): It produces a through-connection between input and output port of the test-fixture. T-standard must be well-matched. Its electrical length must only be known, if precise phase measurements are required. R&S is able to deliver appropriate custom-specific T-standards with a well-known electrical length.

2) N-standard (Network): Thanks to the mathematical algorithm used for system error correction no requirements at all are necessary for the N-standard besides it reflection symmetry. Therefore, for this calibration step it is fully sufficient to let the test fixture simply open.

3) A-standard (Attenuator): The final standard must be well-matched and needs to produce attenuation. The attenuation however may be arbitrary and must not be known. As for the T-standard, also the A-standard can be custom-specifically produced by R&S.

4 Verification

After applying a TNA-calibration the expectable measurement accuracy can be simply estimated through a verification measurement. For that a fully metallized substrate is utilized as a **short-circuit** and put into the test-fixture instead of the DUT. As a short-circuit was not used during calibration, it serves as a fully independent standard. Consequently the attained measurement results yield much more information than a simple repeatability test.

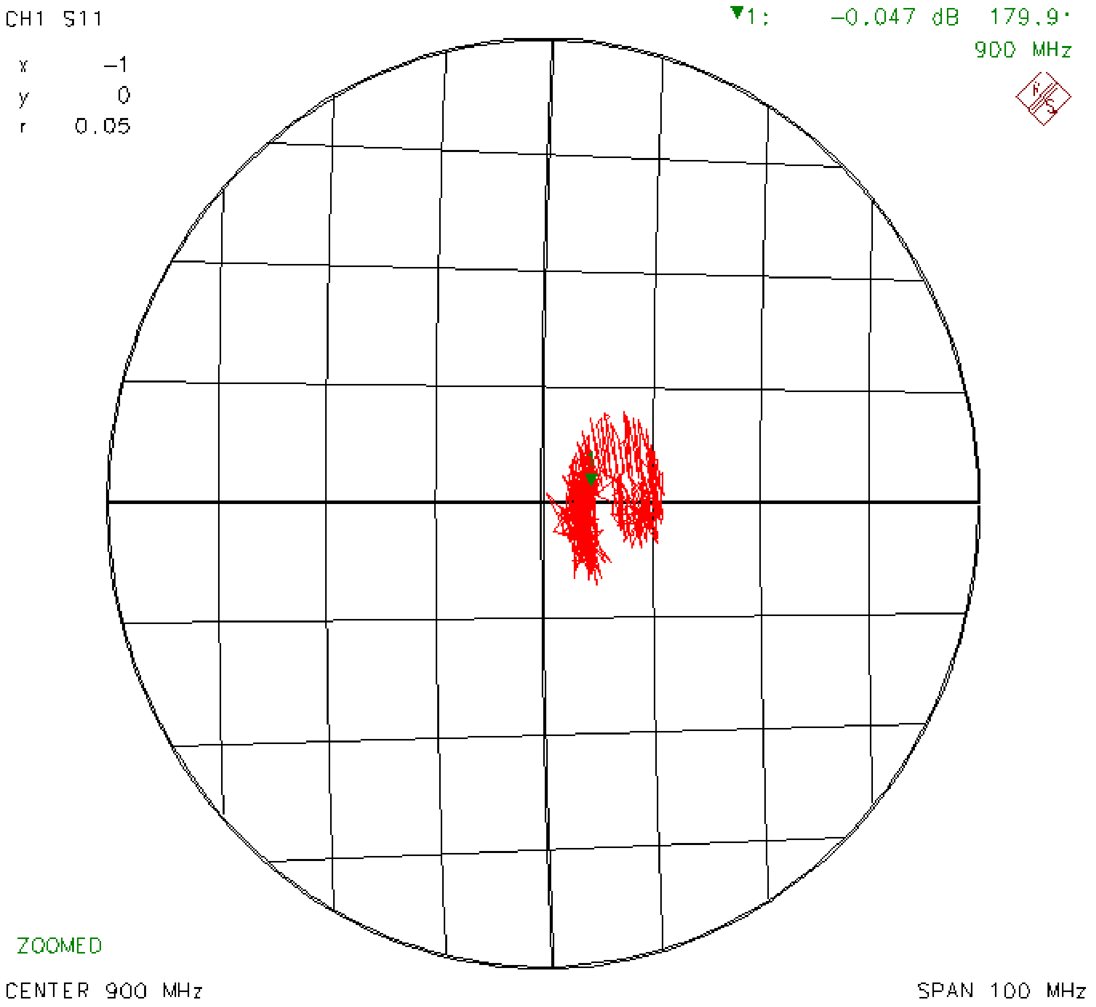

Fig 4: Verification with a short circuit after TNA calibration within the test-fixture. Zoomed Smith diagram with reflection coefficient -1 (ideal short) in the center and a radius of 5%. Offset Electrical Length Port 1 was -11.8 mm. Maximum deviations from ideal short are less than 0.12 dB and 0.6° resp.

The achieved results of verification measurements with a short circuit are shown in a zoomed Smith diagram (see Fig 4). The center of the diagram represents the locus of an ideal short circuit. The radius of the diagram is 5%. The solid horizontal line is the real axis, the solid vertical line is a part ot the unit-circle representing the outer edge of an unzoomed Smith-diagram. As can be seen, the magnitude of measured reflection coefficient is slightly less than 1. The minimum value of measured reflection coefficient of the short circuit in the measured frequency range from 850 MHz to 950 MHz is about 98.6% corresponding to a return loss of approximately **0.12 dB**. The observed maximum phase deviation related to the ideal value of 180° is less than **0.6°**.

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Rohde & Schwarz
19 May 1998

5 Further Application Notes

[1] O. Ostwald: 3-Port Measurements with Vector Network Analyzer ZVR, Appl. Note 1EZ26_1E.

[2] H.-G. Krekels: Automatic Calibration of Vector Network Analyzer ZVR, Appl. Note 1EZ30_1E.

[3] O. Ostwald: 4-Port Measurements with Vector Network Analyzer ZVR, Appl. Note 1EZ25_1E.

[4] T. Bednorz: Measurement Uncertainties for Vector Network Analysis, Appl. Note 1EZ29_1E.

[5] P. Kraus: Measurements on Frequency-Converting DUTs using Vector Network Analyzer ZVR, Appl. Note 1EZ32_1E.

[6] J. Ganzert: Accessing Measurement Data and Controlling the Vector Network Analyzer via DDE, Appl. Note 1EZ33_1E.

[7] J. Ganzert: File Transfer between Analyzers FSE or ZVR and PC using MS-DOS Interlink, Appl. Note 1EZ34_1E.

[8] O. Ostwald: Group and Phase Delay Measurements with Vector Network Analyzer ZVR, Appl. Note 1EZ35_1E.

[9] O. Ostwald: Multiport Measurements using Vector Network Analyzer, Appl. Note 1EZ37_1E.

[10] O. Ostwald: Frequently Asked Questions about Vector Network Analyzer ZVR, Appl. Note 1EZ38_3E.

[11] A. Gleißner: Internal Data Transfer between Windows 3.1 / Excel and Vector Network Analyzer ZVR, Appl. Note 1EZ39_1E.

[12] A. Gleißner: Power Calibration of Vector Network Analyzer ZVR, Appl. Note 1EZ41_2E

[13] O. Ostwald: Pulsed Measurements on GSM Amplifier SMD ICs with Vector Analyzer ZVR, Appl. Note 1EZ42_1E.

[14] O. Ostwald: Zeitbereichsmessungen mit dem Netzwerkanalysator ZVR, Appl. Note 1EZ44_1D.

6 Ordering Information

Order designation	Type	Frequency range	Order No.
Vector Network Analyzers (test sets included) *			
3-channel, unidirectional, 50 Ω, passive	ZVRL	9 kHz to 4 GHz	1043.0009.41
3-channel, bidirectional, 50 Ω, passive	ZVRE	9 kHz to 4 GHz	1043.0009.51
3-channel, bidirectional, 50 Ω, active	ZVRE	300 kHz to 4 GHz	1043.0009.52
4-channel, bidirectional, 50 Ω, passive	ZVR	9 kHz to 4 GHz	1043.0009.61
4-channel, bidirectional, 50 Ω, active	ZVR	300 kHz to 4 GHz	1043.0009.62
3-channel, bidirectional, 50 Ω, active	ZVCE	20 kHz to 8 GHz	1106.9020.50
4-channel, bidirectional, 50 Ω, active	ZVC	20 kHz to 8 GHz	1106.9020.60
Alternative Test Sets *			
75 Ω SWR Bridge for ZVRL (instead of 50 Ω) ¹⁾			
75 Ω, passive	ZVR-A71	9 kHz to 4 GHz	1043.7690.18
75 Ω SWR Bridge Pairs for ZVRE and ZVR (instead of 50 Ω) ¹⁾			
75 Ω, passive	ZVR-A75	9 kHz to 4 GHz	1043.7755.28
75 Ω, active	ZVR-A76	300 kHz to 4 GHz	1043.7755.29
Options			
AutoKal	ZVR-B1	0 to 8 GHz	1044.0625.02
Time Domain	ZVR-B2	same as analyzer	1044.1009.02
Mixer Measurements ²⁾	ZVR-B4	same as analyzer	1044.1215.02
Reference Channel Ports	ZVR-B6	same as analyzer	1044.1415.02
Power Calibration ³⁾	ZVR-B7	same as analyzer	1044.1544.02
3-Port Adapter	ZVR-B8	0 to 4 GHz	1086.0000.02
Virtual Embedding Networks ⁴⁾	ZVR-K9	same as analyzer	1106.8830.02
4-Port Adapter (2xSPDT)	ZVR-B14	0 to 4 GHz	1106.7510.02
4-Port Adapter (SP3T)	ZVR-B14	0 to 4 GHz	1106.7510.03
Controller (German) ⁵⁾	ZVR-B15	-	1044.0290.02
Controller (English) ⁵⁾	ZVR-B15	-	1044.0290.03
Ethernet BNC for ZVR-B15	FSE-B16	-	1073.5973.02
Ethernet AUI for ZVR-B15	FSE-B16	-	1073.5973.03
IEC/IEEE-Bus Interface for ZVR-B15	FSE-B17	-	1066.4017.02
Generator Step Attenuator PORT 1	ZVR-B21	same as analyzer	1044.0025.11
Generator Step Attenuator PORT 2 ⁶⁾	ZVR-B22	same as analyzer	1044.0025.21
Receiver Step Attenuator PORT 1	ZVR-B23	same as analyzer	1044.0025.12
Receiver Step Attenuator PORT 2	ZVR-B24	same as analyzer	1044.0025.22
External Measurements, 50 Ω ⁷⁾	ZVR-B25	10 Hz to 4 GHz (ZVR/E/L) 20 kHz to 8 GHz (ZVC/E)	1044.0460.02

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1) To be ordered together with the analyzer.
2) Harmonics measurements included.
3) Power meter and sensor required.
4) Only for ZVR or ZVC with ZVR-B15.
5) DOS, Windows 3.11, keyboard and mouse included.
6) For ZVR or ZVC only.
7) Step attenuators required.

*** Note:**
Active test sets, in contrast to passive test sets, comprise internal bias networks, eg to supply DUTs.