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note

GSM Testing using the 2026 family Signal Generators with Option 116

by David Owen

Option 116 is available on the IFR 2026 family to allow it to generate GSM spectrum signals. The 2026 is ideal for performing tests on GSM multi-carrier amplifiers and GSM receivers.

What is Option 116?

The IFR 2026 Multisource Generator family is an effective method of supplying multiple calibrated signals to a device under test. The generator contains two or three high performance, high power, low intermodulation signal generators in one enclosure with calibrated outputs being supplied at individual outputs or at a combined output. The combiner output is fully specified for intermodulation effects, few additional unintended signals are generated in the combining process.

Option 116 adds the capability of emulating a GSM carrier to the 2026 family.

Each of the signal generators retains its comprehensive analog modulation capability.

GSM Modulation

The GSM air interface is defined in terms of an FM signal but is specified in terms of phase accuracy. As shown in Figure 1 the digital data is passed through a Gaussian filter and is then frequency modulated on to the carrier. The Gaussian filter for GSM has a Bt (bandwidth-time) product of 0.3. Since the data rate is 270.8333 kHz (13 MHz/48) the 3 dB filter bandwidth is 81.25 kHz (270.8333 x 0.3).

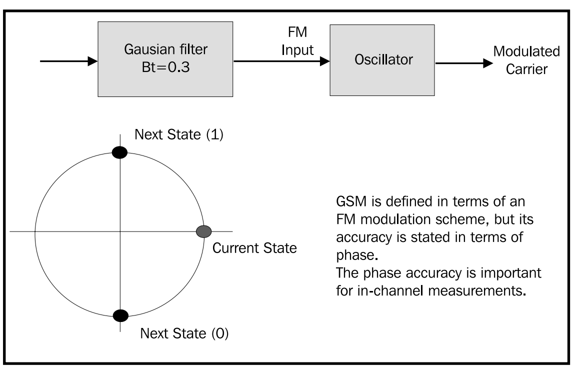

Figure 1 - GSM Modulation

The accuracy of the GSM signal is not specified in terms of frequency deviation, it is specified in terms of phase accuracy. Looking at the IQ diagram, and ignoring the effect of the filter, the phase of the carrier is rotated ±90° for each '1' or '0' (advance or retard). The accuracy is related to the accuracy of this ±90° rotation. The accuracy is defined in terms of the accumulated phase shift that should be present. So if, for instance, four 1's are transmitted the rotation should be 360° but the allowed phase error is still a fixed number of degrees.

If GSM is generated by an FM technique very good accuracy (in terms of FM deviation) is needed if long strings of 1's or 0's are transmitted since the phase error accumulates. In practice the transmitted signals are designed to avoid these long repetitive strings since it would cause the output spectrum to have a defined structure and make the demodulation process more difficult. Even so GSM signals are usually generated with IQ modulators rather than FM techniques.

In comparison DECT and Bluetooth signals do not specify modulation accuracy in terms of phase despite having a generically similar modulation scheme. These modulation schemes are generated with FM.

It is important to have good phase accuracy when generating in-channel signals for GSM receiver testing if data recovery is needed from signals having a repetitive data structure. However, when testing amplifiers, or the selectivity characteristics of receivers, it is unimportant. This makes it possible for 2026 to test GSM devices without an IQ modulator, saving the expense of an IQ signal generator.

Generating GSM Carriers with Option 116

Figure 2 shows how Option 116 allows the generation of GSM spectrum from 2026 family signal generators.

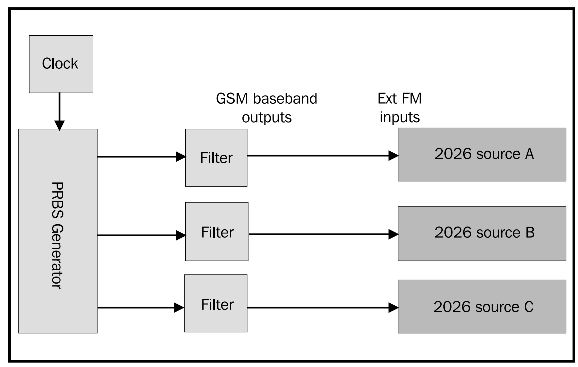

Figure 2 - Generating GSM with Option 116 on 2026

A PRBS generator provides a data source with a (2^{15} -1) pseudorandom sequence (PRBS). The clock for the PRBS generator is provided by a 13 MHz reference source (locked to the 2026 frequency standard) which is divided by a factor of 48. Three outputs are tapped off the PRBS sequence generator, each at a different phase of the sequence. This ensures the three outputs are not correlated.

The three outputs are then each put through a Gaussian filter with the correct bandwidth to emulate a GSM signal. Each Gaussian filter is implemented as an 8 pole RC filter. The filtered outputs are then made available on three BNC connectors, typically located on the rear panel of the 2026.

To use the signals they have to be connected to the external FM input of the 2026, typically located on the front panel (the position is only different if the 2026 has the rear panel output, Option 4, fitted). The FM system is set to external with the modulation ALC selected and the FM deviation set to 67.7 kHz. The deviation value is the symbol rate (270.8333 kHz) divided by 4 so that the peak signal causes a nominal phase change of 90° over one period of the GSM clock (270.833 kHz).

The resulting RF spectrum is shown in Figure 3, and is identical to the spectrum generated by an IQ modulator based solution.

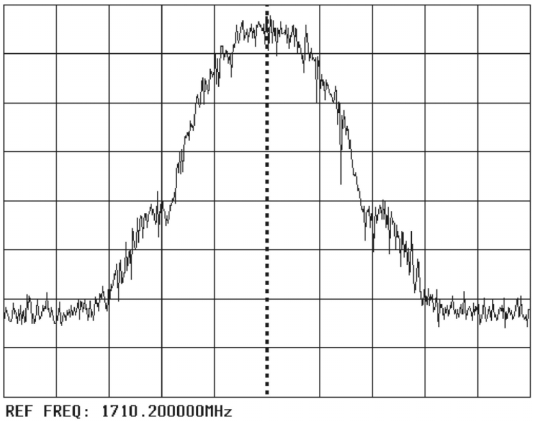

Figure 3 - GSM spectrum from 2026 with Option 116

Multi-Carrier Power Amplifiers

The 2026 can be used to test the new generation of multi-carrier amplifiers being deployed in GSM base stations. A conventional base station uses separate amplifiers for each physical RF channel. The outputs from these amplifiers are combined in a complex combining network, typically using cavity combiners,

Cavity combiners are used to reduce the insertion loss between the amplifier and the base station antenna, but they are frequency selective devices which impose limits on the usage of the RF spectrum. If a base station's frequency plan needs changing it requires the combiner system to be reconfigured, which can be time consuming and cause lead time problems on the components.

The industry is moving towards base stations using multi-carrier power amplifiers that combine the RF signals at low power levels, where losses are a less serious cost issue, and then amplifies the array of GSM signals in a single amplifier. The amplifier clearly needs higher overall power than the individual power amplifiers of a conventional base station, but eliminates a number of complex devices in the base station output system.

In addition to needing a higher power capability the amplifier needs to be very linear in order to avoid generating intermodulation products and additive noise. The high performance required by the base station requires the use of amplifiers that have complex linearisation circuits to improve their performance. The linearisation circuits need to be extensively tested to ensure that they achieve the performance levels specified in the GSM standards since the performance is effected by many design and manufacturing elements.

Testing with Option 116

Option 116 on 2026 is an ideal way of generating the test signals to stimulate the multi-carrier amplifier under test. A single 2026 can provide three GSM carriers, either on its individual outputs or on its combiner output. Each of the carriers has different modulation data applied, so the instantaneous RF envelope behaves in exactly the way the base station is used under real life traffic conditions.

An added advantage is that the noise performance of a 2026 used in this way is typically better than that of ARB-Vector based signal generators generating the same signal.

To understand why this is the case you need to simply consider how the drive signals for a GSM signal generator are derived as shown in Figure 4. An IQ modulator is usually driven from the output of a DSP (or ARB) which is converted to an analog form using a D-A converter. The D-A converter will have a certain amount of quantisation noise due to its finite resolution. This appears as white noise at the D-A output. Typically a filter to eliminate aliasing components will follow the converter and this frequency shapes the noise. The exact bandwidth of the filter is dependent on the sampling rate of the converter.

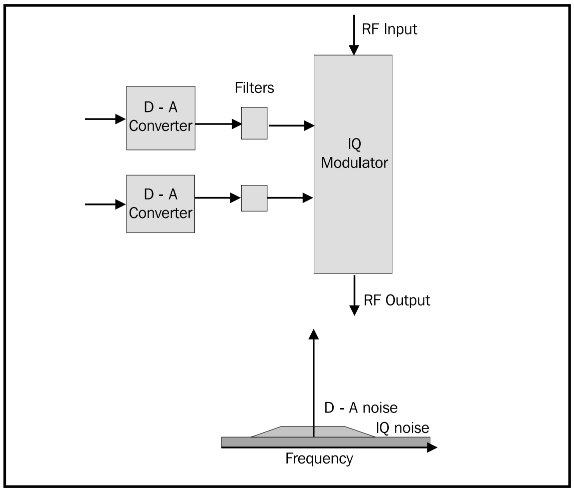

Figure 4 - Noise limitations on GSM signals

The output from the filter drives the IQ modulator. The modulator is a complex component that typically has to be designed to exhibit good linearity and phase accuracy, and as a result tends to introduce additional noise.

When the output spectrum is plotted the two major contributors of noise are the D-A noise and the IQ modulator noise, both of which have white noise characteristics.

By comparison generating GSM signals with an FM system results in a quite different situation. The first difference is that the source is not a D-A converter - the signal is a digital data signal filtered by an analog Gaussian filter network- so there is no quantisation noise. The second difference is that the signal is applied to an oscillator as FM - and white additive noise in an FM system results in a noise profile which declines at 6 dB per octave as the offset frequency is increased. Consequently the noise (and spurious) introduced by the data source declines until it reaches the limits of the RF processing system in the signal generator. The net result is a noise performance that is hard for a conventional IQ signal generator to emulate.

For 2026 the noise can be measured in accordance to methods described in the GSM standards. In order to improve the ease with which these measurements are made the ETSI standard specifies a slightly unusual method of measurement. With the modulation turned on the GSM carrier power is measured with a 30 kHz resolution bandwidth spectrum analyzer filter. Since the actual spectrum of the GSM signal is wider than 30 kHz the "measured" power is in fact approximately 6 dB less than the actual power (the exact difference is dependent on the spectrum analyzer). The noise at higher offset is then measured relative to this "measured" power, but in a 100 kHz resolution bandwidth. When the measurement is performed in this way the ratio of the noise at 6 MHz offset to "carrier power" is typically -75 dB for a +10 dBm output.

Testing GSM Receivers

The 2026 with Option 116 can also be used for testing GSM receivers. Using a radio test set GSM output into the rear external RF input of a 2026, a signal can be produced on the combined output which consists of the radio test set signal (to hold the receiver in a conversation) and one or two large amplitude signals testing the large signal response of the receiver input. Using the test set as the in-channel signal, the receiver can be tested for co-channel interference, receiver intermodulation, and receiver selectivity and blocking.

For the intermodulation testing the GSM specification specifies that one of the added signals is modulated and the other is a CW signal, resulting in a third order intermodulation product which carries GSM like modulation. Option 116 allows this test to be performed.

The frequency and level coupling functions of the 2026 make testing the receiver much simpler than using separate signal generators and the calibration of the test system is more accurate and consistent.

Option 116 Specifications

Option 116 is available on all 2026 signal generators.

BASEBAND SOURCE

Data rate
270.833333 kHz (13 MHz/48).

Data rate accuracy
As 10 MHz frequency standard.

Filter
Gaussian filter approximated by eight-pole RC network.

Number of outputs
3

Data pattern
(2^{15} -1) PRBS sequence.
The outputs are separated in time to ensure that they are not correlated.

ACCURACY

FM deviation
Typically better than 2% when used as described.

SPECTRAL CHARACTERISTIC

Wideband noise
For an output of +10 dBm on the individual output typically -75 dBc measured in a 100 kHz bandwidth relative to the modulated signal measured in a 30 kHz bandwidth at 6 MHz offset, in accordance with ETSI-defined measurement methods on wideband noise.

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