Agilent
GSM/EDGE Self-Guided Demonstration for the E4438C ESG Vector Signal Generator and PSA Series Spectrum Analyzers

Product Note

Striving to meet all your test needs

Agilent knows that the time you spend learning about test equipment is time you would rather spend working on your own product. This Self-guided Demo is part of an effort to shorten the learning curve for you, so that you can get back to doing what you do best. It is a quick way to learn about the key features of the TDMA personality. For detailed product features and TDMA specifications, see the Option 402 product overview. For detailed specifications on the base instrument, see the E4438C data sheet. All are listed in the back of this document.

Agilent Technologies

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Introduction

In watching hundreds of users work with our equipment, we observed that it is rare for a new user to read the manual before attempting to use the instrument. Most people prefer to "learn by doing". This demo was created for those people who just can't wait to get going. It takes the new user quickly through a series of common measurement setups for the ESG and PSA with enough detail to learn how they function, but without attempting to be exhaustive in its coverage. We start with a recommended instrument configuration, move through some background information on the GSM/EDGE, review the setup of the signal generator, and conclude with some common PSA measurements. Detailed keystrokes are provided. [ ] indicates hard keys on the front panel. { } indicate soft keys generated on the instrument display. Bold text indicates the feature name; underlined text indicates the desired selection.

Demo configuration

See table 1 for a list of options that are required for the ESG and PSA for the GSM/EDGE demo.

Product type	*Model number*	*Required options*
ESG Vector Signal Generator	E4438C	001 or 002 – Baseband generator 402 – TDMA personalities
PSA Spectrum Analyzer	E4440A/E4443A/ E4445A	B7J – Digital demodulation hardware 202 – GSM with EDGE measurement personality

Table 1. Required demo equipment

Connect the RF output of the ESG to the 50 Ω RF input of the PSA series spectrum analyzer with a RF cable, see figure 1. *For multi-slot measurements, the PSA will need an external trigger signal from the ESG.* Connect the "EVENT 1" output on the rear panel of the ESG to the "TRIGGER IN" input on the rear panel of the PSA with a 50 Ω BNC connector cable. Connect the 10 MHz OUT from the ESG to EXT REF IN on the PSA.

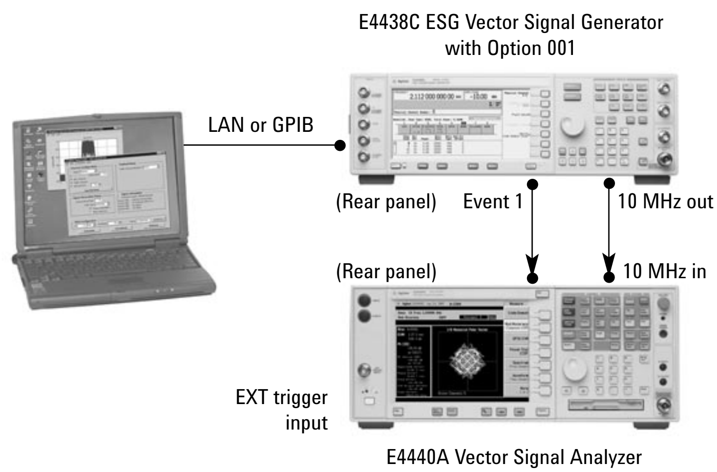

Figure 1. Demo set-up

Background information

The Global System for Mobile Communications (GSM) digital cellular standard is a time division multiple access (TDMA) channel access scheme that uses GMSK (Gaussian minimum shift keying) modulation.

Each GSM frequency channel is shared by up to 8 mobiles. Since there are a maximum of eight users per frequency, there are eight timeslots (TS) per GSM frame. Therefore, each mobile uses the channel for one timeslot and then waits for its turn to come round again in the next frame. The mobile transmitter turns on only during its active timeslot. The requirement to transmit in a single timeslot and stay idle during the remaining seven timeslots results in very tight demands on the switching on and off of the RF power. If a mobile station does not perform according to the specifications, it will disturb other mobile stations in adjacent timeslots and on adjacent channels.

EDGE (Enhanced Data Rates for GSM Evolution) is an enhancement to the GSM standard, that uses $3\pi/8$ 8PSK (phase shift keying) modulation. This improvement to the GSM standard promises to deliver wireless services such as multimedia and other broadband applications.

Since many essential EDGE transmitter measurements are similar to GSM measurements, the greater part of this guide addresses GSM measurements. The last part concentrates on the EDGE measurements, particularly where they are different from GSM.

GPRS (General Packet Radio Service) and EGPRS (Enhanced General Packet Radio Service) are other enhancements to the GSM standard. GPRS and EGPRS operate in a packet switched network, whereas GSM and EDGE are part of a circuit switched network. In GPRS or EGPRS, a user can utilize up to 8 timeslots for transmission and reception of data. GPRS uses GMSK modulation and has the same spectral characteristics as GSM. EGPRS uses GMSK or $3\pi/8$ 8PSK modulation, and has spectral characteristics similar to GSM or EDGE.

	GSM	*EDGE*
Modulation	GMSK	$3\pi/8$ 8PSK
Bits/symbol	1	3
Data bits per burst	114	342
Symbol rate	270.833 kHz	270.833 kHz
Filter	0.3 Gaussian	Linearized Gaussian

Table 2. Representative specifications for GSM and EDGE signal formats

Explore the GSM menu structure

GSM signal configuration

The purpose of this section is to explore the GSM feature set, as well as the various parameters that can be adjusted.

ESG instructions	*Keystrokes*
Select GSM mode (see figure 2)	[Preset] [Mode] {Real Time TDMA} {GSM}

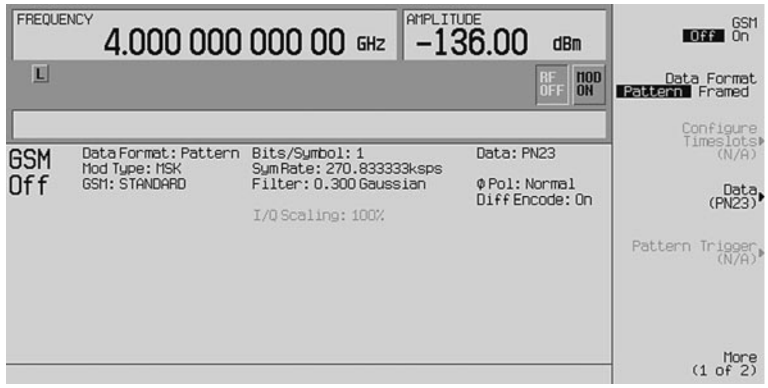

Figure 2. GSM main menu page 1

The default **Data Format** for GSM is **Pattern**, see figure 2. This setting creates a continuous GMSK modulated data stream. This data is not bursted or framed. Notice that the default data type is a PN23 (Pseudorandom Noise of period 2^{23}-1 bits). This **Data** pattern can be varied from: **(PN9, PN11, PN15, PN20, PN23 or a fixed sequence of data),** or the user can choose to supply his own data. The keys that are in grey indicate that the functionality is currently not available. The keys that are in black indicate that those features are available and can be modified. These will change depending on the operating mode. If the **Data** pattern is a PN sequence, then the **Pattern Trigger** key is (N/A). However, if the data pattern is changed to any other pattern, then the following functions illustrated in figure 3 are available for **Pattern Trigger**.

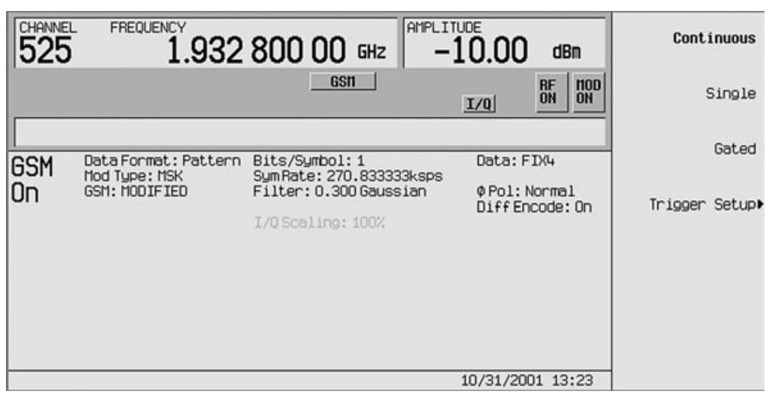

Figure 3. GSM pattern trigger menu

The ESG may also be used to trigger other equipment with the **Sync Out** feature (see figure 4a). The only selection available for **Data Format Pattern** mode is **Begin Pattern**. This outputs a 1-bit synchronization signal to the EVENT 1 rear panel connector.

ESG instructions	*Keystrokes*
View second page of GSM menu structure (figure 4)	{More (1 of 2)}

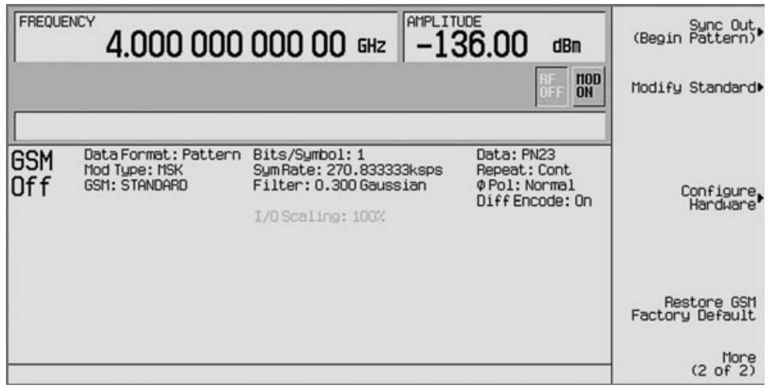

Figure 4a. GSM page 2 of 2 menu

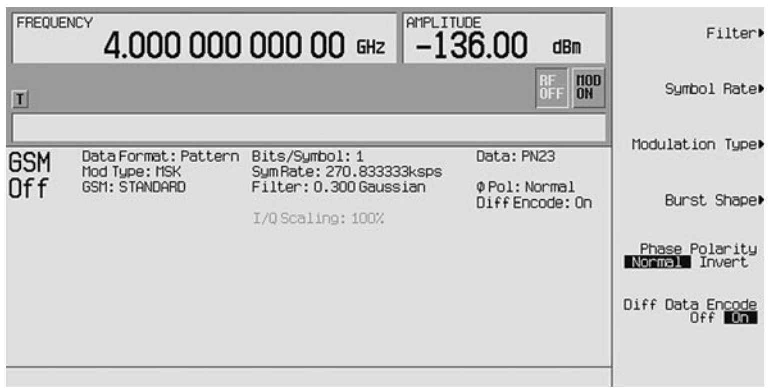

Figure 4b. Modify standard submenu

The **Modify Standard** soft key, see figure 4a, allows the user to change various parameters such as filtering, symbol rate, modulation type, phase polarity, and differential data encoding (figure 4b).

ESG instructions:	*Keystrokes*
Go back to GSM main menu	{More (2 of 2)}
Choose framed GSM data format	{Data Format Framed}
Configure frequency channels	[Frequency] {More 1 of 2} {Freq channels} {Channel band} {GSM/EDGE bands} {PCS base} {Channel number} [525] {Enter} {Freq Channels On}
Turn on GSM modulation	[Mode setup] {GSM On}
Set the amplitude to –10 dBm	[Amplitude] [-10] {dBm} [Return]
Turn on RF output	[RF On]

When the **Data Format Framed** is selected, the data in each timeslot is framed, and all 8 timeslots are part of a TDMA frame. Each timeslot is also bursted.

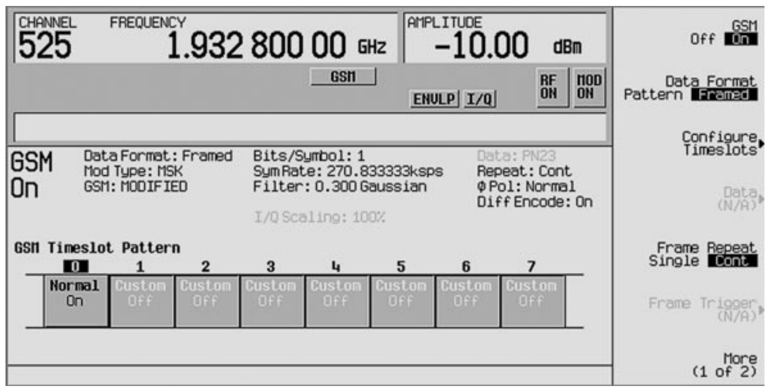

Figure 5. GSM main menu page 1

Using Frequency Division Multiple Access (FDMA), information is divided into the uplink and downlink. Within each band the channel numbering scheme is the same. However, the frequency range for uplink and downlink are different. Each band is divided into 200 kHz channels called Absolute Radio Frequency Channel Numbers (ARFCN). Notice that the ARFCN channel number 525 is displayed on the user interface (UI).

In the **More (1 of 2)** menu, the **Sync Out** feature is located. This outputs a 1-bit synchronization signal to the EVENT 1 rear panel connector. Various parameters are available for **Data Format Framed** mode **Sync Out** such as:

- **Begin Frame**
- **Begin Timeslot** (select which time slot)
- **All Timeslots** (sends out 1-bit for each time slot)

Notice that parameters such as **Configure Timeslots** and **Frame Trigger**, are listed on the right side of the UI (figure 5). The **Frame Trigger** soft key offers the following choices to trigger single or continuous TDMA Frames:

- **Trigger Key** (hard key on the front panel)
- **Bus** (via SCPI commands)
- **Ext** (allows delay bits to be set)

The **Modify Standard** soft key, located on page 2 of the menu structure, has the same selections as the **Data Format Pattern** mode, but in addition the **Burst Shape** of the timeslots can be configured. These parameters affect all of the 8 timeslots.

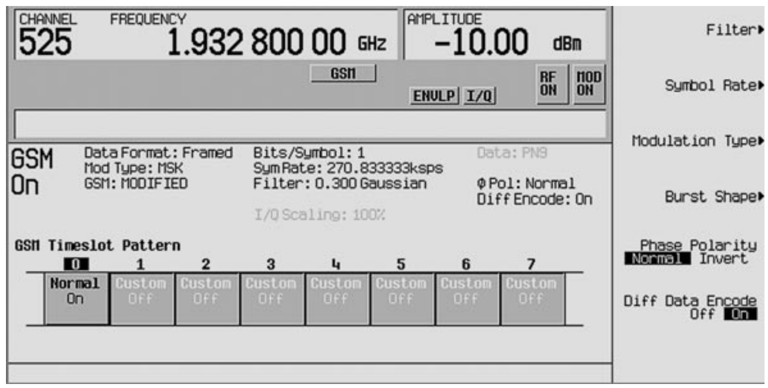

Figure 6. GSM modify standard submenu

The ESG offers all timeslot bursts as specified by the GSM standard.

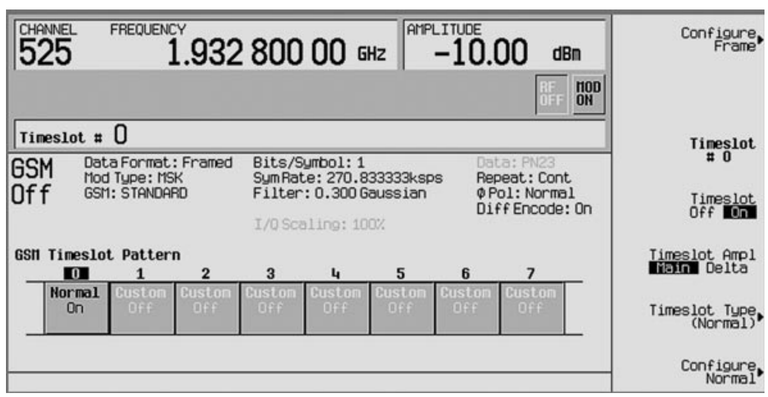

Figure 7. GSM configure timeslot menu

The **Timeslot Type** soft key selects the type of timeslot for each of the 8 timeslots. The **Configure** soft key allows the user to set various parameters in each of the timeslots, such as user data, training sequence, etc... The TDMA frame can be a combination of any of the time slot types.

Normal (**Normal** soft key) see figure 8

A *normal burst* is the most common burst in the GSM system and is transmitted in one timeslot either from the base station or the mobile station. This burst type configures the timeslot as a traffic channel, which carries either user data or signaling data. The GSM network organizes TCH channels in 26 frame multiframes. Frames 0 through 11 are TCH channels where the payload is either user data or signaling information, frame 12 is the slow associated control channel, and frame 25 is an idle channel. However, the ESG doesn't implement the SAACH channel. The SACCH is responsible for supervision and control messages, such as power control and timing information. The S field (stealing flag) is reserved to indicate a FACCH (fast associated control channel). This channel transmits handover information.

A different payload can be selected for each timeslot when in **Data Framed** mode For **Normal**, **Sync** and **Access** timeslots, pressing the **E** softkey from within the **Configure** menu reveals a menu of choices for internal **Data Generation (PN9, PN11**, **PN15, PN20, PN23** or a fixed sequence of data) or the user can choose to supply his own data. The number of data bits in the **E** field depends on the timeslot type chosen. For **Custom** timeslots: The same choices as above are automatically displayed when the **Configure Custom** softkey is pressed.

For a normal GSM burst, when **Multiframe Channel** is selected as the payload type, TCH/FS, CS-1, DL/UL MCS-1 are available packet types in the payload field.

In the GSM multiframe, CS-1 and DL/UL MCS-1 packets are transmitted in a 52 frame multiframe channel, see figure 9. Frames 25 and 51 are RF blanked. All the timeslots in frames 12 and 38 are all active. The timeslots within these frames are set as follows: T1 (tail bits field 1) = 0s, S1 (stealing bits field 1) = 0s, TS (training sequence or midamble) = same as the configured timeslot, S2 = 0s, T2 = 0s, G =1s.

If TCH/FS is selected as the payload, frame 12 is RF blanked. All the timeslots in frame 25 are all active. The timeslots within these frames are set as follows: T1 (tail bits field 1) = 0s, S1 (stealing bits field 1) = 0s, TS (training sequence or midamble)=same as the configured timeslot, S2 = 0s, T2 = 0s, G = 1s.

Please see the *TDMA Product Overview*, literature number 5988-4431EN, for more details.

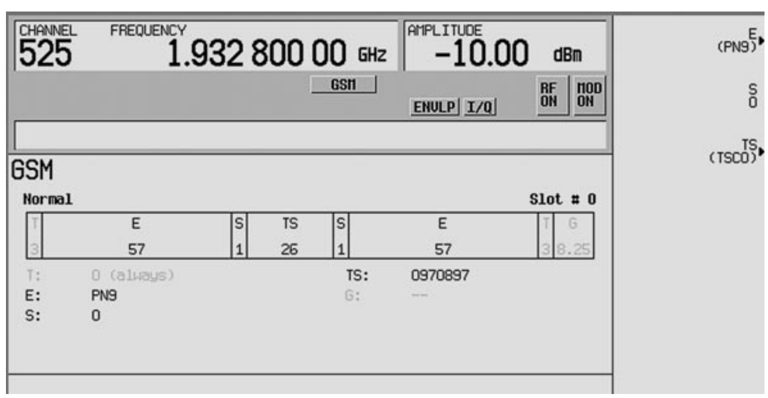

Figure 8. GSM configure one timeslot

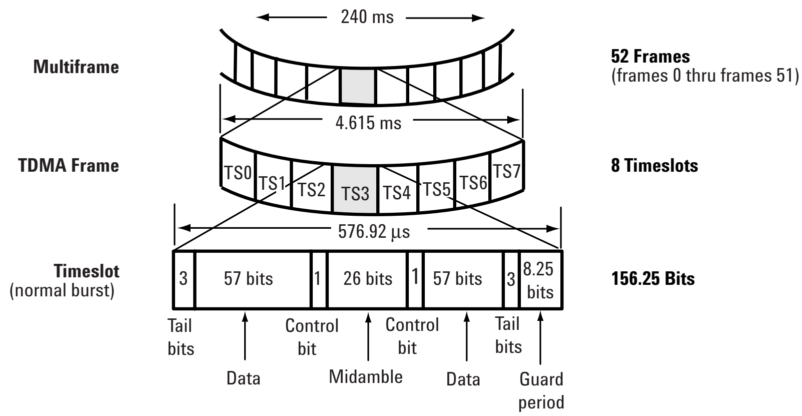

Figure 9. GSM burst with packets mapped onto a PDTCH

Frequency correction (**FCorr** soft key)

Timing is a critical need in a GSM system. The base station has to provide the means for a mobile station to synchronize with the master frequency of the system. To achieve synchronization the base station transmits a frequency correction burst, during certain known intervals. This frequency correction burst is a fixed sequence of zeros for the duration of one timeslot.

In a GSM network, frequency correction bursts occur every 10 frames (Frame 0, Frame 10, Frame 20 etc. of a BCH signaling data multiframe , and always occur in timeslot 0 (the base station always generates the BCH on timeslot 0). To maximize the flexibility of the ESG, however, any timeslot may be set to the frequency correction type.

If a timeslot is selected as a frequency correction burst, the ESG repeats the frequency correction burst in every frame, not every 10 frames (as defined by standard).

Synchronization (**Sync** soft key)

The base station sends signals on the BCH, which contain some system parameters, such as those which enable the mobile to synchronize to the BS. The mobile, however, needs a defined training sequence before it can demodulate and decode this information. The base station tells the mobile which training sequence to use with the synchronization burst. The synchronization burst has an extended midamble (or training sequence) with a fixed sequence in order to give the mobile the “key” it needs to decode the system parameters. Like frequency correction channels, synchronization channels occur every 10 frames (Frame 1, Frame 11, Frame 21 etc. of a signaling data multiframe, and the bursts always occur in timeslot 0. To maximize the flexibility of the ESG, however, any timeslot may be set to the synchronization type.

The synchronization burst will be repeated every frame, not every 10 frames (as called out by the standard), if the built-in data generator is used. To repeat every 10 frames, a long data sequence could be generated and loaded directly into the signal generator’s pattern RAM .

Random Access (**Access** softkey)

Mobiles use a random access burst when trying to gain initial access to the system. This burst type is shorter than a normal burst, and is used by the base station to measure the time delay a mobile's burst is experiencing.

Dummy (**Dummy** softkey)

In the GSM system, the base station must transmit something in each timeslot of the base channel. Even if these timeslots are not allocated to communication with any mobiles, the base station has to transmit dummy bursts, specially defined for this purpose, in the idle timeslots of the base channel.

Custom (**Custom** softkey)

The custom timeslot is provided for users' flexibility, but it is not a standard GSM timeslot type. A custom timeslot is configured using an internally-generated data pattern, a downloaded sequence of bits stored in a user file, or by supplying external data.

GSM measurements

GSM spectrum

If you have completed the ESG setup instruction on pages 5, 6, and 7, measurements can be made. The first measurement that will be made will be to view the spectrum.

PSA instructions:	*Keystrokes*
Enter GSM w/EDGE mode in the analyzer	[Preset] [Mode] {GSM (w/EDGE)}
Verify setup for GSM PCS band. The default device setting is for BTS.	[Mode Setup] {Radio} {Band} {PCS 1900}
Set center frequency to absolute RF channel number (ARFCN) 525 (1.9328 GHz)	[FREQUENCY] {ARFCN} [525] [Enter]
Turn on the external reference	[System] {Reference} {Freq Ref EXT}}

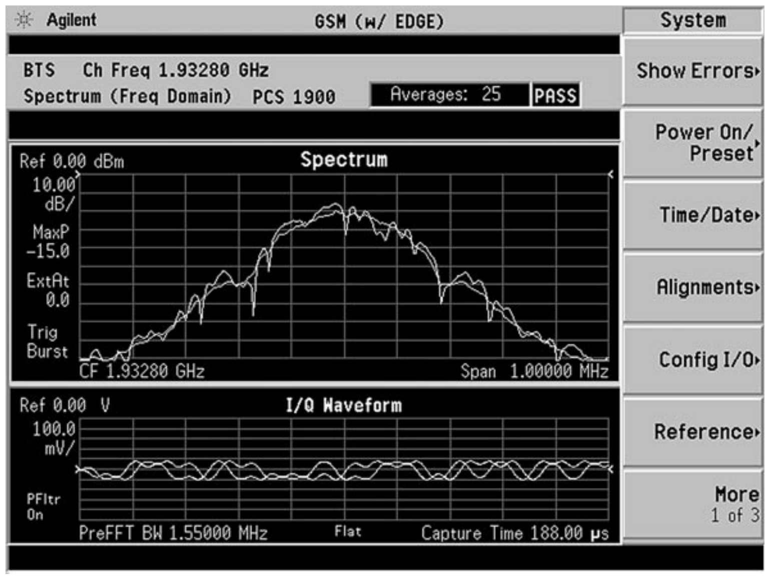

Figure 10. GSM spectrum and I/Q waveforms

Transmit power

Carrier power is the measure of in-channel power for GSM systems. Mobiles and base stations must transmit enough power with sufficient modulation accuracy to maintain a call of acceptable quality without the power leaking into other frequency channels or timeslots. GSM systems use dynamic power control to ensure that each link is maintained with minimum power. This gives two fundamental benefits: overall system interference is kept to a minimum and, in the case of mobile stations, battery life is maximized.

In this section, measure the mean transmitter carrier power and view the signal with the high dynamic range of the PSA series.

PSA instructions:	*Keystrokes*
Measure transmit power (figure 10)	[MEASURE] {Transmit Pwr}
Move the threshold level to –40 dB Notice the horizontal, white level bar move down	[Meas Setup] {Threshold Lvl} [-40] [Enter]

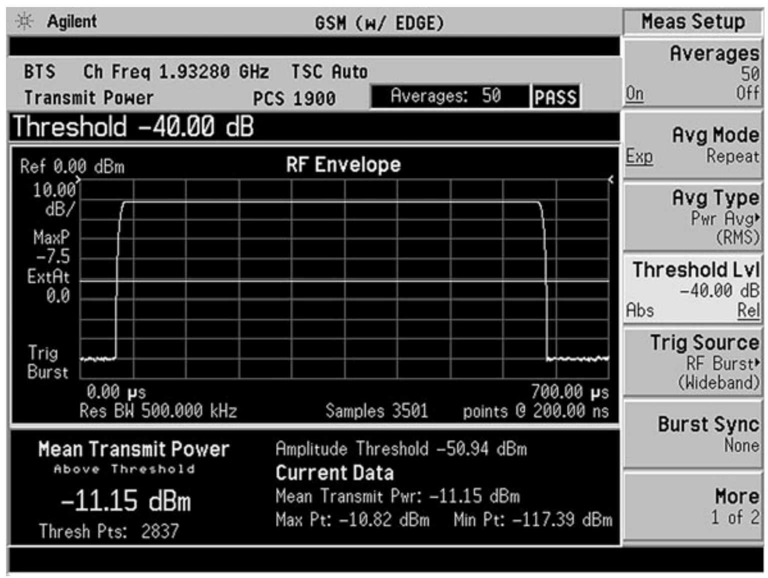

Figure 11. Transmit power measurement

GMSK power versus time

GSM is a TDMA multiplexing scheme with eight time slots, or bursts, per frequency channel. If the burst does not occur at exactly the right time, or if the burst is irregular, then adjacent channels can experience interference. Because of this, the industry standards specify a tight mask for the fit of the TDMA burst. For easy pass/fail testing the PSA displays the burst for a given time slot on the screen under the mask specified by GSM 05.05 standards.

In this section, measure power versus time for the GSM signal, then view only the rising and falling portions of the burst.

PSA instructions:	
Activate power versus time measurement	[MEASURE] {GMSK Pwr vs Time}
Zoom in on RF envelope (figure 11)	[AMPLITUDE] {Ref Value} [-10] {dBm} {Scale/Div} [0.2] {dB}

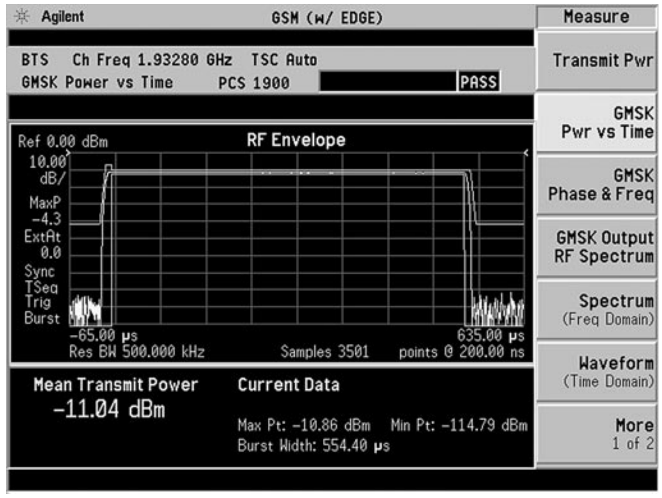

Figure 12. GSM power versus time measurement

PSA instructions:	*Keystrokes*
View the shape of the rising and falling parts of the burst (figure 13)	[Trace/View] {Rise & Fall}
Expand the rising edge display You can toggle between the three display sections by pressing the [Next Window] key.	[Zoom]
Zoom in on the trace	[AMPLITUDE] {Ref Value} [-8.5] {dBm} {Scale/Div} [1] {dB}

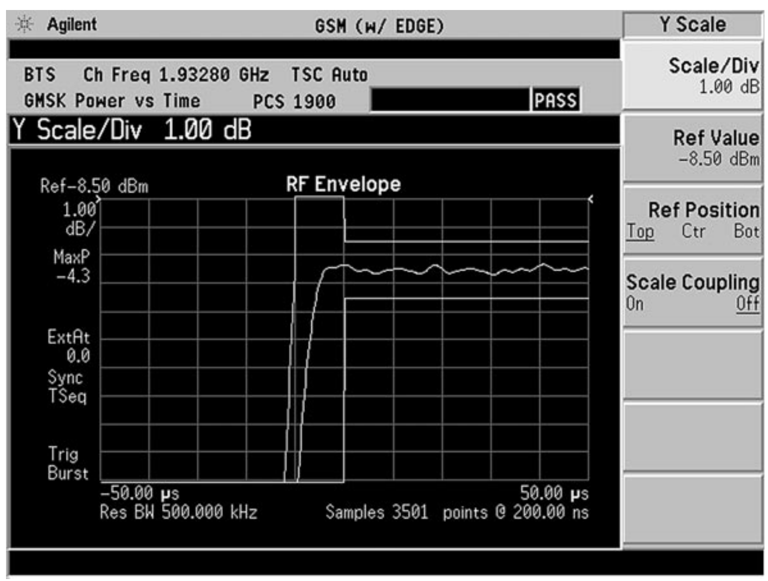

Figure 13. GSM power versus time measurement rising edge of burst

PSA instructions:	*Keystrokes*
Turn on averaging and display maximum and minimum averaged traces (figure 14) Observe the different typed of averaging available under the {Avg Type} menu.	[Meas Setup] {Avg Bursts On} {Avg Type} {Max & Min}
Deactivate averaging and view full display	{Avg Bursts Off}

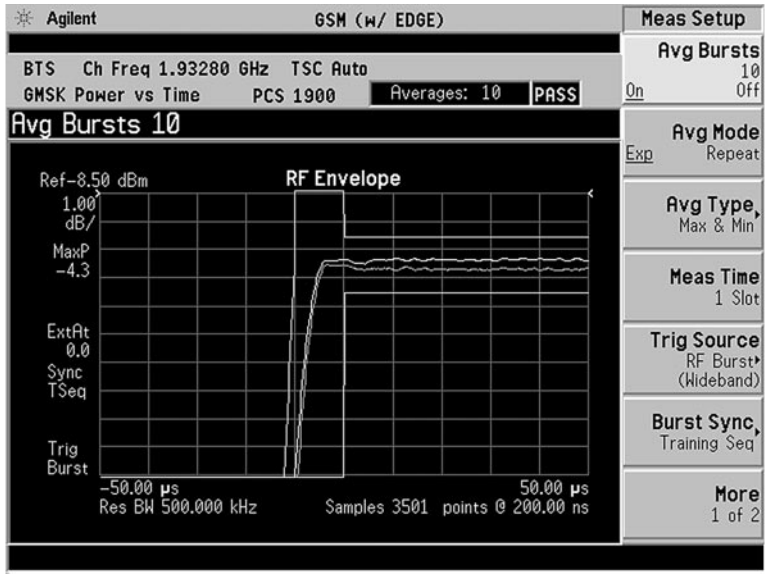

Figure 14. Rising edge of GSM burst with averaging on

Next we'll change the shape of the burst on the ESG source.

ESG instructions:	*Keystrokes*
Increase the rise time of the GSM burst to 6 bits (figure 15)	More (1 of 2)} {Modify Standard*} {Burst Shape} {Rise Time} [6] {bits}

Notice the different parameters that can be varied such as filtering, symbol rate, modulation type, burst shape, phase polarity, and differential data encoding.

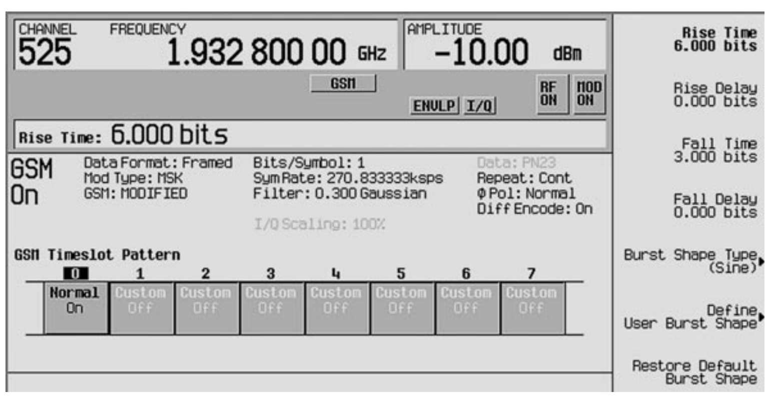

Figure 15. Modified burst shape

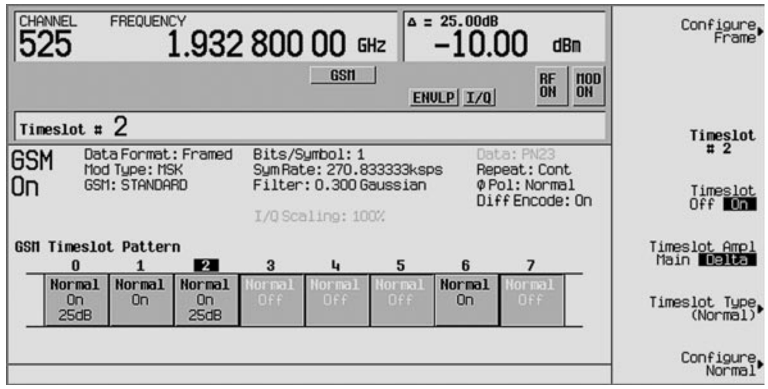

Figure 17. GSM alternate timeslot setting

PSA instructions:	*Keystrokes*
Enable the external trigger (should still be connected to rear panel)	[Meas Setup] {Trig Source} {Ext Rear}
Switch to multi-slot view in the power versus time measurement	[Trace/View] {Multi-Slot}
View the entire frame (8 slots) (figure 18)	[Meas Setup] {Meas Time} [8] [Enter]

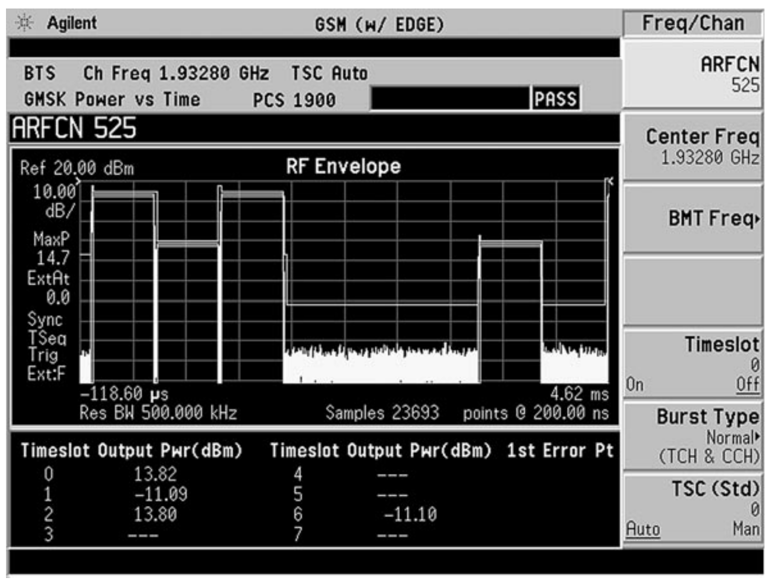

Figure 18. Multi-slot power versus time

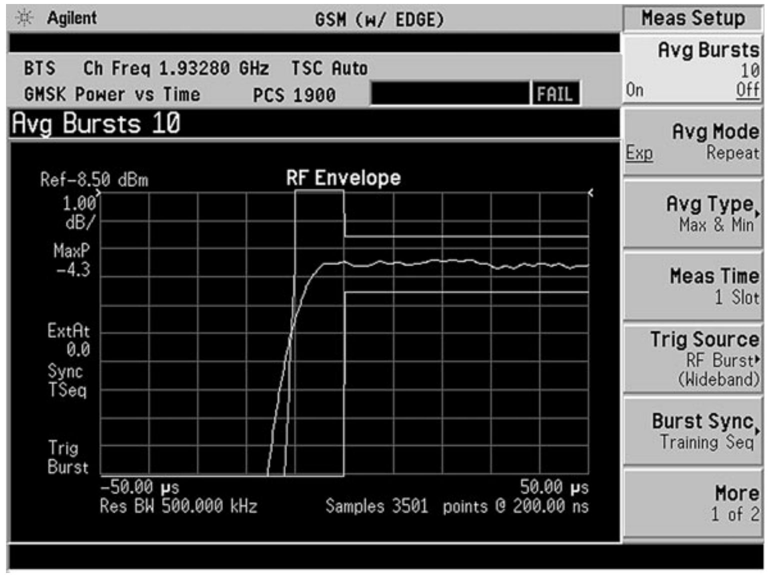

Figure 16. Modified GSM burst failing transmit spectral mask measurement

The PSA is also able to measure power versus time for multiple slots. Multi-slot views give information about the entire GSM frame. This is especially useful for examining slots that transmit at different power levels within a single frame.

Multi-slot measurements will be performed now.

ESG instructions:	*Keystroke*
Reset rise time back to default value	{Restore default burst shape} [Mode Setup]
Turn on timeslot 1	{Configure Timeslots} {Timeslot #} [1] {Enter} {Timeslot Type} {Normal All} {Timeslot On}
Turn on timeslot 2	{Configure Timeslots} {Timeslot #} [1] {Enter} {Timeslot On}
Turn on timeslot 6	{Configure Timeslots} {Timeslot #} [6] {Enter} {Timeslot On}
Adjust the alternate timeslot amplitude	[Amplitude] {More (1 of 2)} {Alternate Amplitude} {Alt Ampl Delta} [25] {dB} {Alt Amp Trigger} (Int) {Alt Ampl On}
Turn alternate amplitude on for timeslots 0 and 2	[Mode Setup] {Configure Timeslot} {Timeslot} [0] {Enter} {Timeslot Ampl Delta} {Configure Timeslot} {Timeslot} [2] {Enter} {Timeslot Ampl Delta}

GMSK phase and frequency

Phase and frequency error are the measures of modulation quality for GSM systems. Since GSM systems use relative phase to transmit information, phase and frequency accuracy are critical to the system's performance. In a real system, phase error will reduce the ability of a receiver to correctly demodulate.

Demodulation and signal analysis is complicated by the challenge of synchronizing to the actual GSM signal. The Agilent PSA series has multiple trigger and synchronization options to make measurements simple. In this section, a one-button measurement captures the phase and frequency error information.

PSA instructions:	*Keystrokes*
Measure GMSK phase and frequency error	[MEASURE] {GMSK Phase & Freq}
Enable the external trigger	[Meas Setup] {Trig Source} {Ext Rear}
The two vertical, white bars in the RF Envelope plot of the lower, left part of the display indicate which timeslot is being measured.	
Make the measurements on timeslot 1 (figure 19)	[FREQUENCY] {Timeslot On} [1] [Enter]
View the polar vector diagram (figures 20 and 22)	[Trace/View] {I/Q Measured}
View the demodulated I and Q bits (figure 23)	{Data Bits}

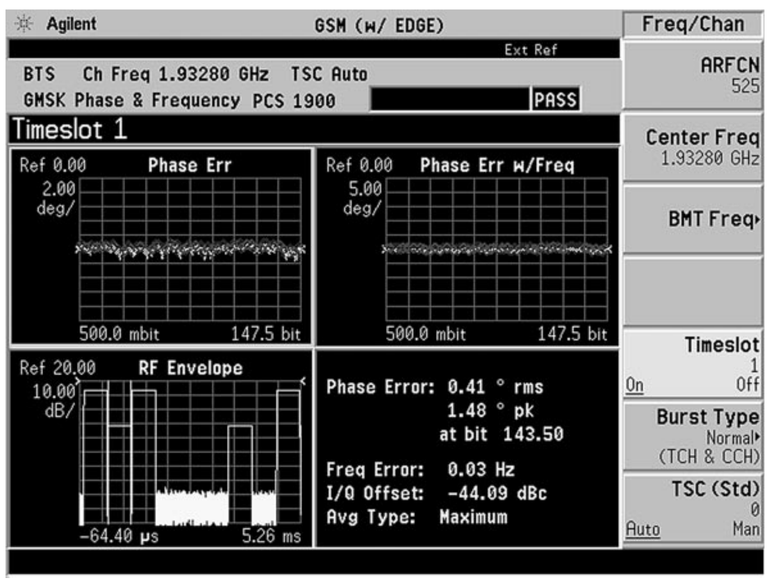

Figure 19. Phase and frequency error

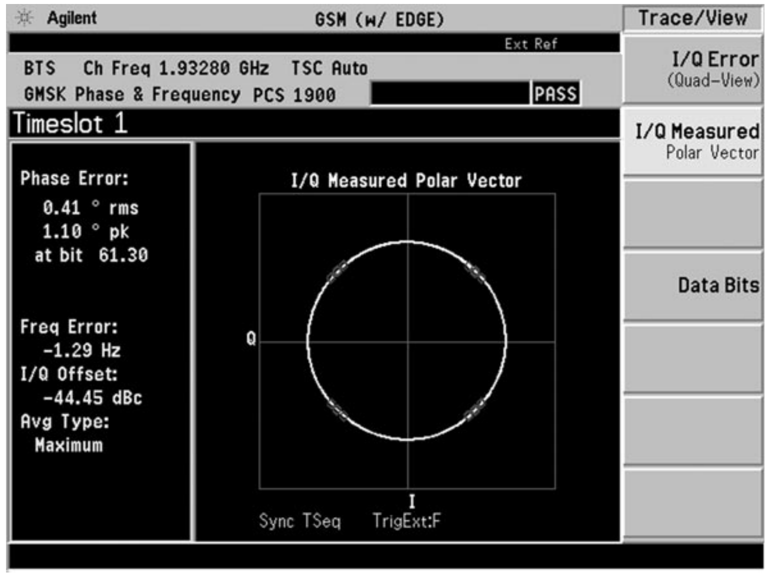

Figure 20. I/Q polar vector plot

ESG instructions	*Keystrokes*
Add I/Q impairments to the GSM Signal	[I/Q] {I/Q Adjustments} {I/Q Gain Balance} [3] {dB}
Turn on I/Q impairment	{I/Q Adjustments On}

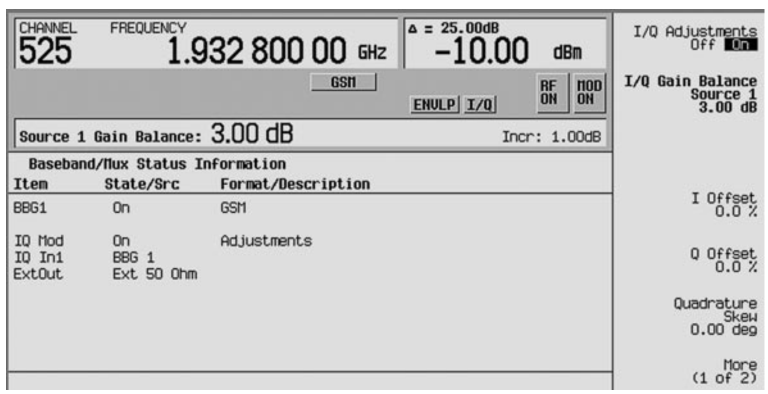

Figure 21. Added I/Q impairments to the GSM signal

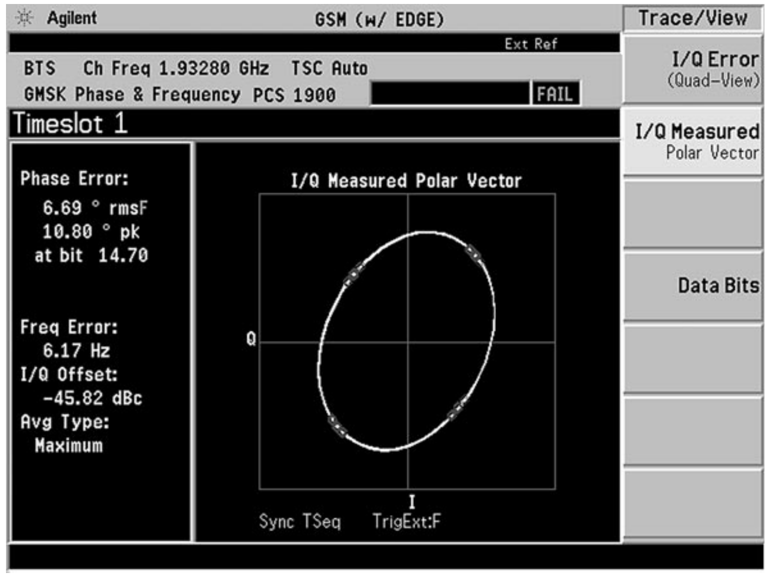

Figure 22. I/Q polar vector plot of impaired GSM signal

ESG instructions	*Keystrokes*
Turn on I/Q impairment	{I/Q Adjustments Off}

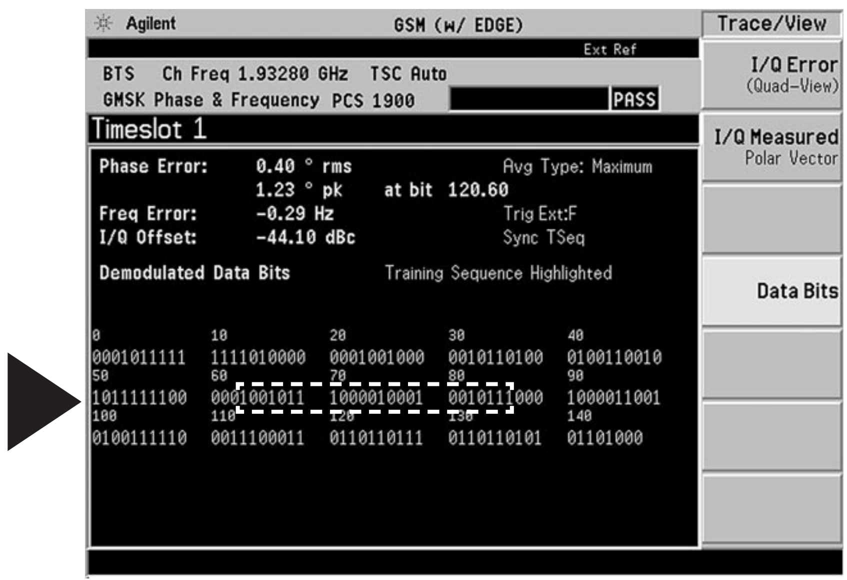

Figure 23. I and Q demodulated bits

Notice that the TS (training sequence or midamble) is highlighted, see figure 23 and 24. The other bits are the other fields of the timeslot. The only portion of the timeslot that is not demodulated is the guard field. The data is only demodulated to the symbol level, thus for any of the payload data that is channel encoded, will not be decoded to bit level.

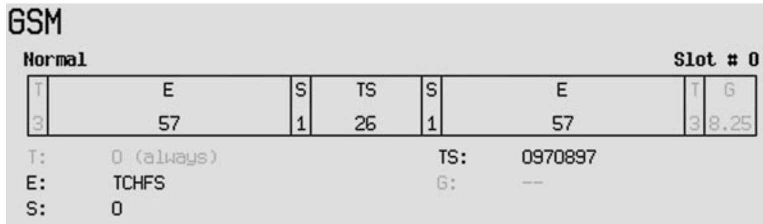

Figure 24. Portion of GSM Configure Normal Timeslot Menu

GMSK output RF spectrum

The modulation process in a transmitter causes the continuous wave (CW) carrier to spread spectrally. This is referred to as "spectrum due to modulation and wideband noise." Defects in the transmit chain may cause the spectrum to spread excessively, resulting in interference with other frequency bands. Measuring the spectrum due to modulation can be thought of as making an adjacent channel power (ACP) measurement where several adjacent channels are considered.

GSM transmitters ramp RF power rapidly. The transmitted RF carrier power versus time measurement is used to ensure that this process happens at the correct times and at the correct rate. If RF power is ramped too quickly, undesirable spectral components will arise in the transmitted signal. This upsets the "spectrum due to switching" which again results in interference with other frequency bands.

Spectrum due to modulation and spectrum due to switching measurements are usually grouped together and known as the output RF spectrum (ORFS). The GSM 3GPP specifications have particular restrictions on ORFS for a series of frequencies. Verification of compliance with the 3GPP specification requires up to 80 dB of dynamic range. The PSA series has more than enough dynamic range to accomplish this, and a complete ORFS measurement (modulation and switching) can be performed in 3 seconds[1]. Another great feature of the PSA series' ORFS measurement is its ability to represent the spectrum due to modulation data in either a traditional table format or a spectrum trace with a mask. Both the table and the mask use a pass/fail indicator to signify compliance with the GSM specification.

This exercise explores the ORFS measurement using the PSA

PSA instructions:	*Keystrokes*
Make measurements on timeslot 0	[FREQUENCY] {Timeslot Off} [Enter]
Activate the ORFS measurement (figure 25) The default setting measures spectrum due to modulation at multiple offsets. This measurement takes about one second to complete.	[MEASURE] {GMSK Output RF Spectrum} [Meas Setup] {Ofs Freq List} {Standard}
Examine spectrum due to modulation at a single offset (250 kHz) (figure 26)	[Meas Setup] {Meas Method} {Single Offset}
Now measure the spectrum due to switching	{Meas Type} {Switching}
Go back to multi-offset measurement Observe that this measurement is completed in about 2 seconds.	{Meas Method} {Multi-Offset}
Restore the default measurement	{More} {Restore Meas Defaults} [Return]
View ORFS with mask (figure 27) This measurement takes several seconds to complete	{Mod Method Sweep}

1. Remote operation with SCPI commands.

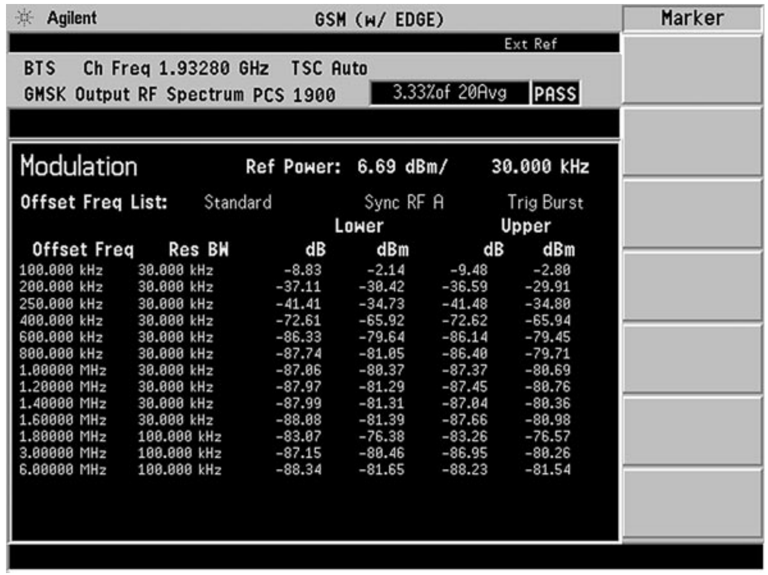

Figure 25. ORFS spectrum due to modulation

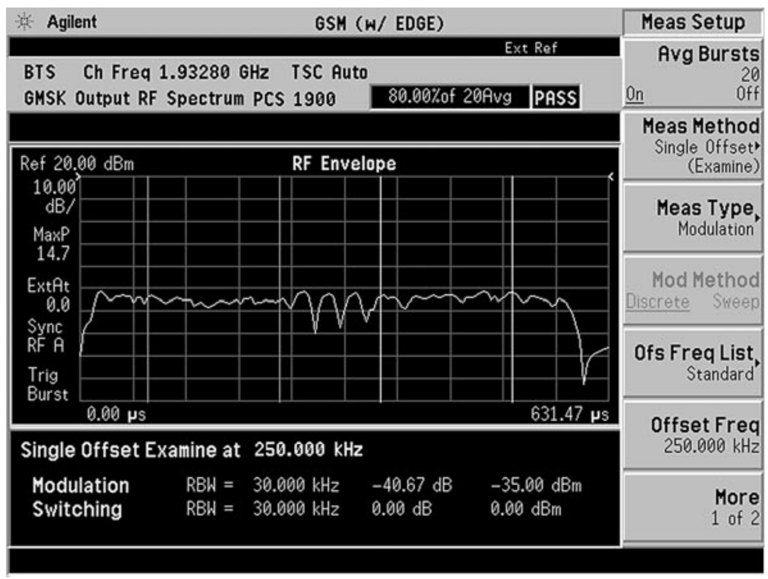

Figure 26. ORFS spectrum due to modulation at 250 kHz

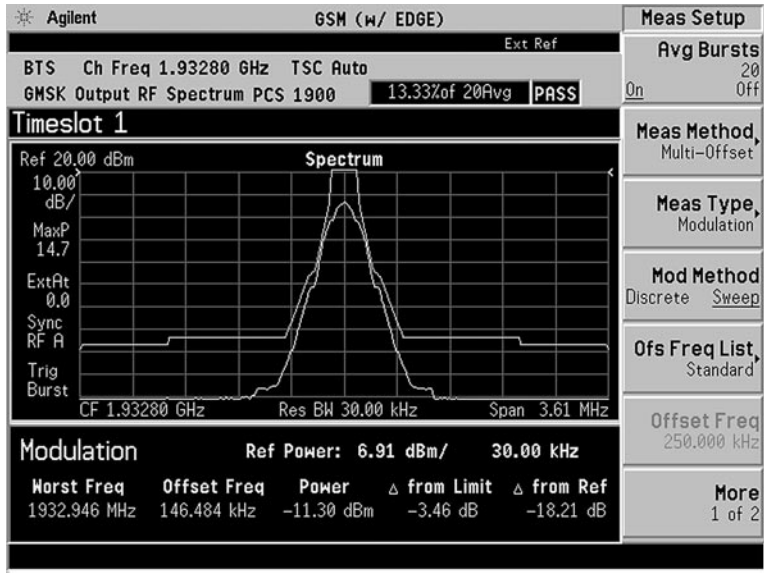

Figure 27. ORFS with mask GMSK Tx band spurious

Tx band spurious is a measurement that identifies undesirable energy in wrong parts of the Tx band. This measurement reveals little more than the switching due to modulation and wideband noise measurement; however, it is a swept measurement with no time gating.

Make this one-button measurement. Sufficient power is required at the input for optimum dynamic range, and the PSA will automatically set the attenuation level whenever the measurement is restarted ([Restart] key).

ESG instructions:	*Keystrokes*
Change frequency channel to 512	[Freq] {More (1 of 2)} [Freq Channels] {Channel number} [512] {Enter}
Increase the GSM signal amplitude	[Amplitude] [15] {dBm}

PSA instructions:	*Keystrokes*
Change frequency channel to **Bottom**	[Frequency] {BMT Freq} {Bottom}
Measure transmitter band spurious emissions (figure 30)	[MEASURE] {More} {GMSK Tx Band Spur}

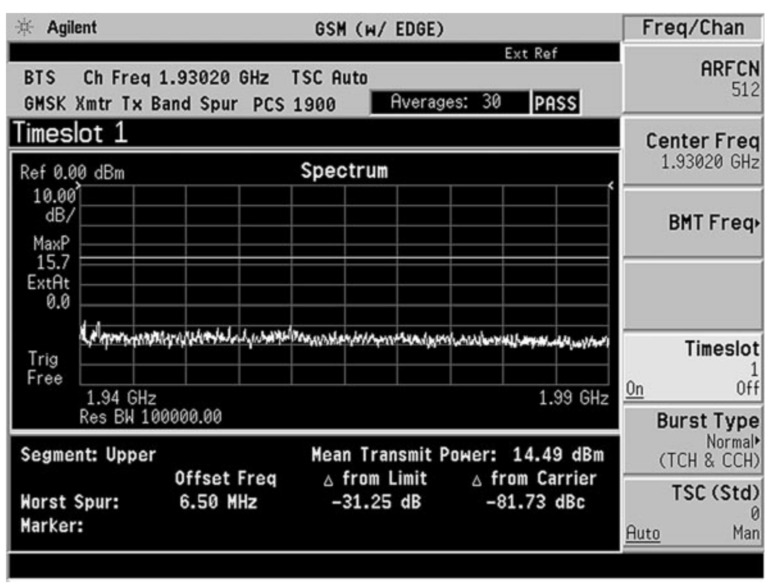

Figure 28. GMSK Tx band spurious

Explore the EDGE menu structure

EDGE signal configuration

EDGE has the same spectral characteristics as GSM, as well as the same symbol rate and frame structure (table 1). Therefore many of the EDGE measurements are almost, identical to the GSM measurements. The only measurement that is significantly different between the two signal formats is modulation accuracy. The critical metric for GSM modulation quality is phase error. For EDGE, the modulation quality metric is EVM (error vector magnitude).

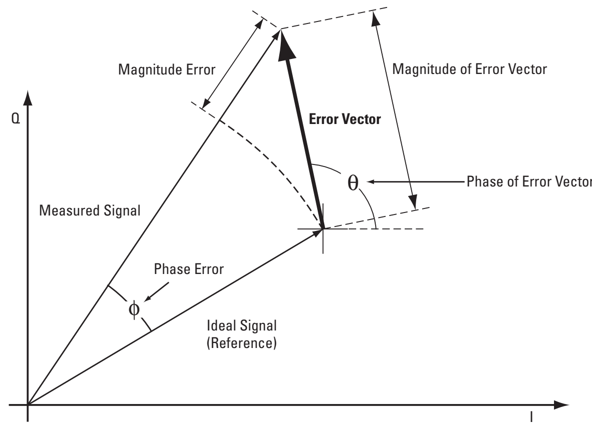

Figure 29. The error vector diagram

Figure 29 defines the error vector, a measure of the amplitude and phase differences between the ideal modulated signal and the actual modulated signal. The root-mean-square (rms) of the error vector is computed and expressed as a percentage of the square root of the mean power of the ideal signal. This is the error vector magnitude (EVM). EVM is a common modulation quality metric widely used in digital communications. Though the EDGE signal has considerable inter-symbol-interference or ISI, a proprietary ISI compensation algorithm PSA instructions provides both a clear constellation diagram and accurate EVM measurements.

This exercise explores some of the EDGE measurements with emphasis on the EVM measurement.

ESG instructions:	*Keystrokes*
Select EDGE mode	[Mode Setup] {GSM Off} [Mode] {Real Time TDMA} {EDGE}
Choose EDGE data format	{Data Format Framed}
Turn on EDGE modulation	{More} {EDGE On}
Set the amplitude to –2 dBm	[Amplitude] [-2] {dBm}

An EDGE burst is transmitted in one timeslot either from the base station or the mobile station. This burst type configures the timeslot as a traffic channel, which carries either user data or signaling data. The GSM network organizes TCH channels in 26 frame multi-frames. Frames 1 through 12 are TCH channels where the payload is either user data or signaling information, frame 13 is the slow associated control channel, and frame 26 is an idle channel. However, the ESG doesn’t implement this structure. Whatever timeslot is chosen, is repeated for every TDMA frame. The SACCH is responsible for supervision and control messages, such as power control and timing information. The S field (stealing flag) is reserved to indicate a FACCH (fast associated control channel). This channel transmits handover information.

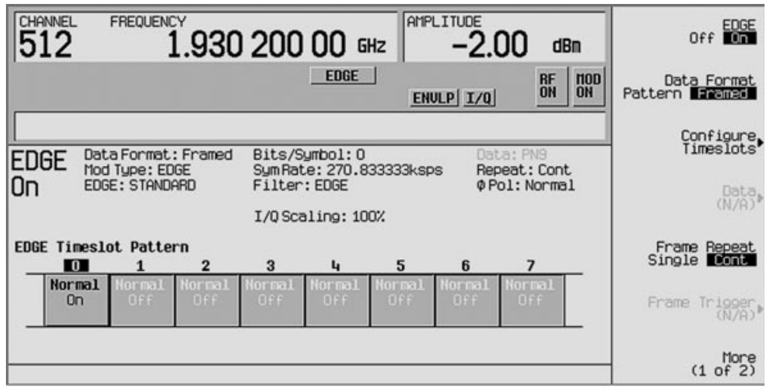

Figure 30. EDGE main menu page 1

A different payload can be selected for each timeslot when in **Data <u>Framed</u>** mode for **Normal**, **Sync** and **Access** timeslots, pressing the **E** softkey from within the **Configure** menu reveals a menu of choices (see figure 31) for internal data generation (PN9, PN11, PN15, PN20, PN23 or a fixed sequence of data) or the user can choose to supply his own data. The number of data bits in the **E** field depends on the timeslot type chosen.

In the EDGE multiframe, MCS-5, MCS-9, E-TCHS/F43.2 and UNCODED are the available payload fields.

MCS-5, MCS-9, and UNCODED packets are transmitted in a 52 frame multiframe channel, see TDMA Product Overview for details, literature number 5988-4431EN. Frames 25 and 51 are RF blanked. Frames 12 and 38 are all active. The timeslots within these frames are set as follows: T1 (tail bits field 1) = 1s, S1 (stealing bits field 1) = 0s TS (training sequence or midamble) = same as the configured timeslot, S2 = 0s, T2 = 1s, G =1s.

If E-TCH/F43.2 is selected as the payload, frame 12 is RF blanked. All the timeslots in frame 25 are all active. The timeslots within this frames is set as follows: T1 (tail bits field 1) = 1s, S1 (stealing bits field 1) = 0s, TS (training sequence or midamble) = same as the configured timeslot, S2 = 0s, T2 = 1s, G =1s.

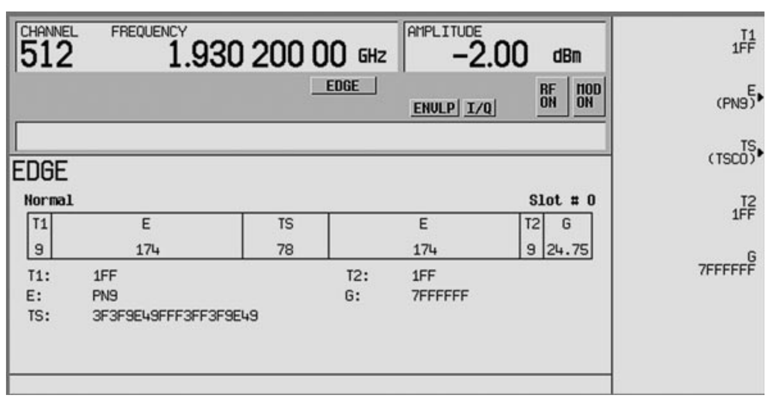

Figure 31. EDGE Normal Burst Configure Timeslot menu

EDGE measurements

EDGE power versus time, output RF spectrum and EVM

PSA instructions:	*Keystrokes*
Make the EDGE power versus time measurement (figure 32) Observe the greater amplitude variations within the burst compared to the GSM signal.	[MEASURE] {More} {EDGE Pwr vs Time}
Measure EDGE ORFS	[MEASURE] {More} {EDGE Output RF Spectrum}
Activate the EDGE EVM measurement (figure 33)	[MEASURE] {More} {EDGE EVM}
View error and EVM plots	[Trace/View] {I/Q Error}
Examine the demodulated data bits (figure 34)	{Data Bits}

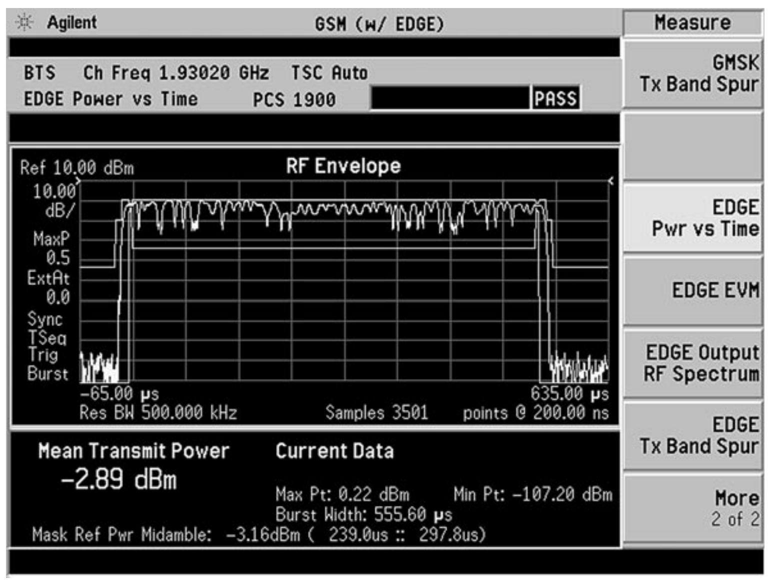

Figure 32. EDGE power versus time

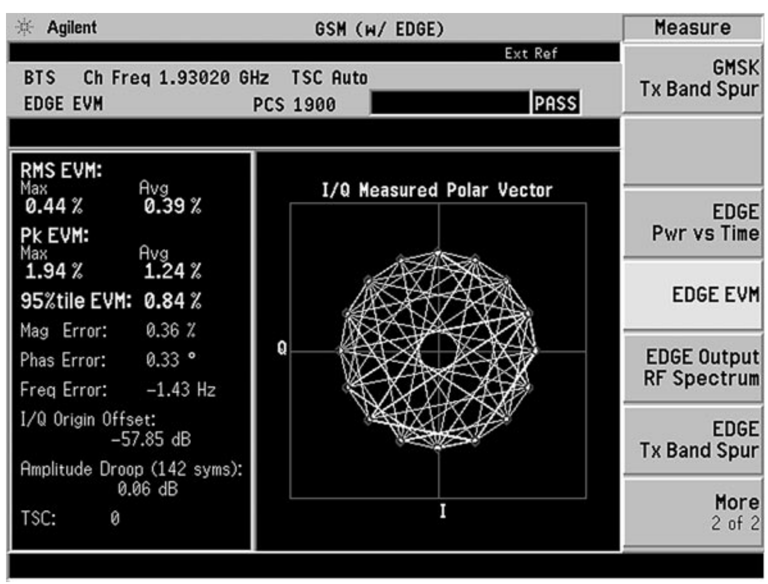

Figure 33. EDGE polar vector plot

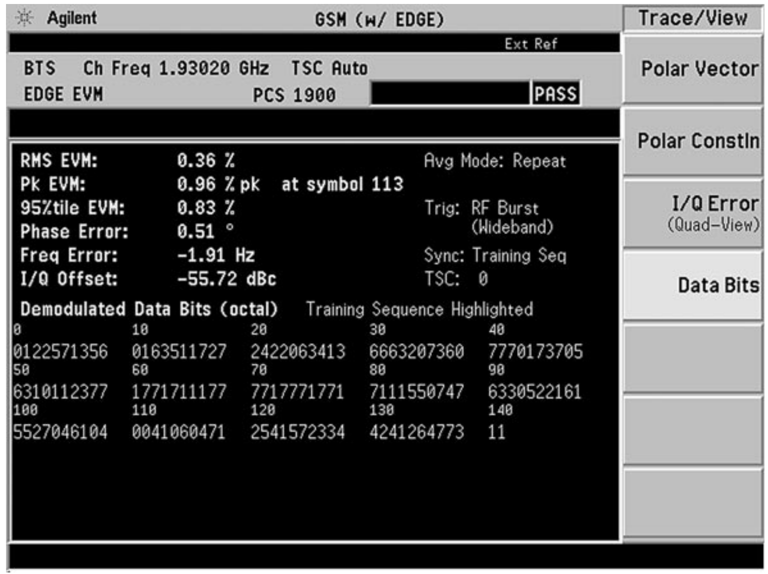

Figure 34. EDGE demodulated data bits

EDGE multicarrier waveform creation and spectrum view

The GSM and EDGE test signals created thus far are single carrier real-time GSM and EDGE test signals. The ESG can also create multicarrier GSM waveforms or multicarrier EDGE waveforms. These waveforms are non-framed and non-bursted GSM or EDGE test signals. The multicarrier waveform creation feature is included at no additional charge with the baseband generator.

ESG instructions:	*Keystrokes*
Create a multicarrier EDGE (3p/8 8-PSK) modulated waveform.	{EDGE Off}} [Mode] {Custom} {ARB Waveform Generator}
Turn on multicarrier feature	{Multicarrier On}
Create a multicarrier EDGE waveform	{Multicarrier Define} {Initialize Table} {Carrier Setup} {EDGE}
Create 4 EDGE modulated carriers	{# of carriers} [4] {Enter}
Space the EDGE modulated carriers 500 kHz apart (this is the GSM or EDGE channel spacing)	{Frequency Spacing} [500] {kHz} {Done}
Apply the multicarrier waveform	{Apply multicarrier}
Make the starting phase of the EDGE modulated carriers Random with respect to one another	{More (1 of 2)} {Carrier Phases Random}
Turn on the digital modulation	[Mode Setup] {Digital Modulation On}

Figure 35. Digital Modulation menu for creating a multicarrier EDGE modulated waveform

Notice the ARB EDGE setup automatically sets the filter to EDGE, and the symbol rate to 270.833 ksps as the standard requires.

The waveform can be clipped if desired. The following steps tell how custom waveform can be clipped.

ESG instructions:	*Keystrokes*
Select the waveform from the Dual ARB menu	[Mode] {Dual ARB} {Select Waveform} WFM1: AUTOGEN_WAVEFORM
Turn ARB on	{ARB On}
Now clip the waveform to 65%	{Waveform Segments} {Store} {Waveform Utilities} {Clipping} {|I+jQ|} {Clip To} [65] {%} {Apply to Waveform}

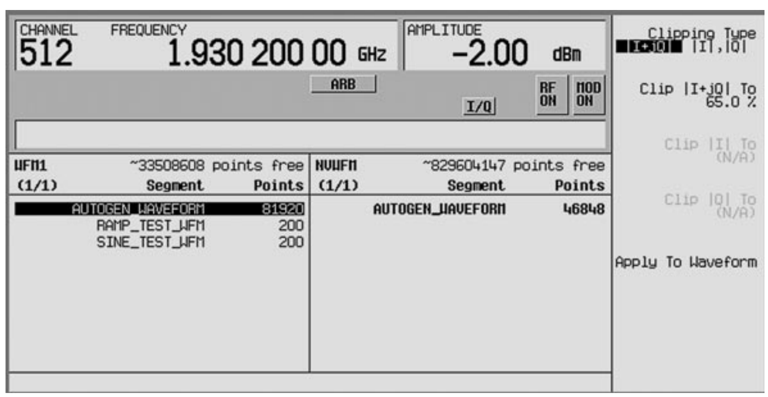

Figure 36. ARB waveform clipping menu

More details about waveform clipping can be found in the *Agilent ESG Vector Signal Generator Users Guide,* part number E4400-90503.

PSA instructions:	*Keystrokes*
Change the instrument settings to spectrum analysis mode	[Mode] {Spectrum Analysis}
Change the Frequency Channel to that of the PSA	{Center Frequency} [1.93020] {GHz}
Change the span	[Span] [5] {MHz}
Turn on averaging	[BW/Avg] {Average On}

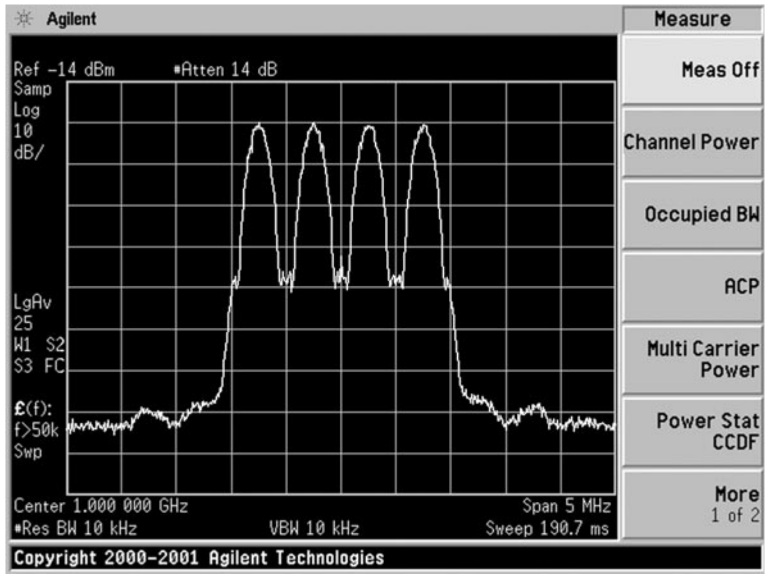

Figure 37. Spectrum of 4 EDGE modulated carriers spaced 500 kHz apart

Related Agilent literature

Brochures

Agilent E4438C ESG Vector Signal Generator
Publication number 5988-3935EN
Wireless 3G Solutions
Publication number 5968-5860

Data sheets

E4438C ESG Vector Signal Generator
Publication number 5988-4039EN

Configuration guides

E4438C ESG Vector Signal Generator
Publication number 5988-4085EN

Application notes

Digital Modulation in Communication Systems-An Introduction
Publication number 5965-7160E
Measuring Edge Signals – New and Modified Techniques and Measurement Requirements Application note 1361
Publication number 5980-2580EN
Testing and Troubleshooting Digital RF Communications Transmitter Designs - Application note 1313
Publication number 5968-3578E
Understanding GSM Transmitter and Receiver Measurements for Base Transceiver Stations and their Components - Application note 1312
Publication number 5968-2320E
Testing and Troubleshooting Digital RF Communications Receiver Designs
Publication number 5968-3579E
Characterizing Digitally Modulated Signals with CCDF Curves
Publication number 5968-6875E

Product overviews

Real-time TDMA Firmware Option for the E4438C ESG Vector Signal Generator – Option 402
Publication number 5988-4311EN

Other Agilent products

Wireless Communications Products
Publication number 5968-6174E
CDMA Solutions
Publication number 5966-3058E
Agilent E4406A Vector Signal Analyzer
Publication number 5968-7618E
Agilent E4440E Performance Spectrum Analyzer
Publication number 5980-1284E
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