Agilent
PSA Series Spectrum Analyzers
E4406A Vector Signal Analyzer
GSM with EDGE Measurement Personality

Technical Overview with Self-Guided Demonstration
Option 202

The PSA Series of high-performance spectrum analyzers and E4406A vector signal analyzer (VSA) offer the GSM with EDGE measurement personality to help you measure radio systems quickly, easily, and accurately in the lab or on the manufacturing line.

Agilent Technologies

Evaluate Your Designs Quickly and Thoroughly in R&D and Manufacturing

The Global System for Mobile Communications (GSM) digital cellular standard is a time division multiple access (TDMA) multiplexing scheme that uses Gaussian minimum shift keying (GMSK) modulation. Making GSM measurements and meeting standards requirements presents unique challenges. Enhanced Data Rates for GSM Evolution (EDGE), which is also TDMA but uses 3π/8 8PSK (phase shift keying) modulation, is an enhancement to GSM that promises to deliver true third-generation (3G) wireless services such as multimedia and other broadband applications.

The Agilent PSA Series offers high performance spectrum analysis up to 50 GHz with powerful one-button measurements, a versatile feature set, and a leading-edge combination of flexibility, speed, accuracy and dynamic range. Expand the PSA to include GSM and EDGE digital signal analysis capability with the GSM with EDGE measurement personality (Option 202).

For many manufacturing needs, the E4406A VSA, a vector signal analyzer, is an affordable platform that also offers the GSM with EDGE personality.

This technical overview includes

- measurement details
- demonstrations
- PSA Series key specifications for GSM with EDGE measurements
- ordering information
- related literature

All demonstrations utilize the PSA Series and the E4438C ESG vector signal generator; however, they can also be performed with the E4406A VSA. Keystrokes surrounded by [ ] indicate hard keys located on the front panel, while key names surrounded by { } indicate soft keys located on the right edge of the display.

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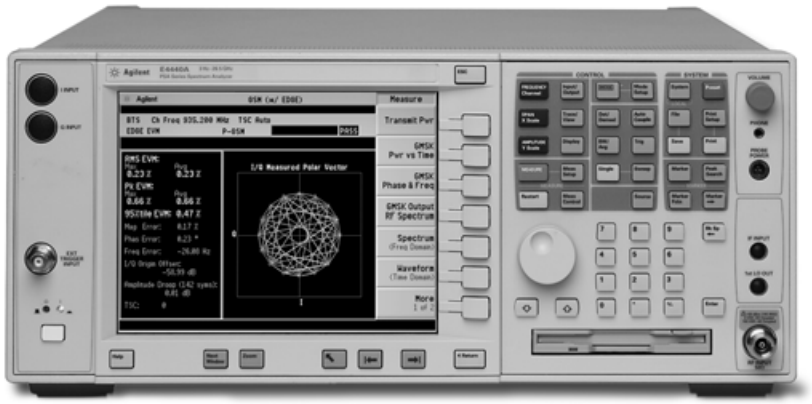
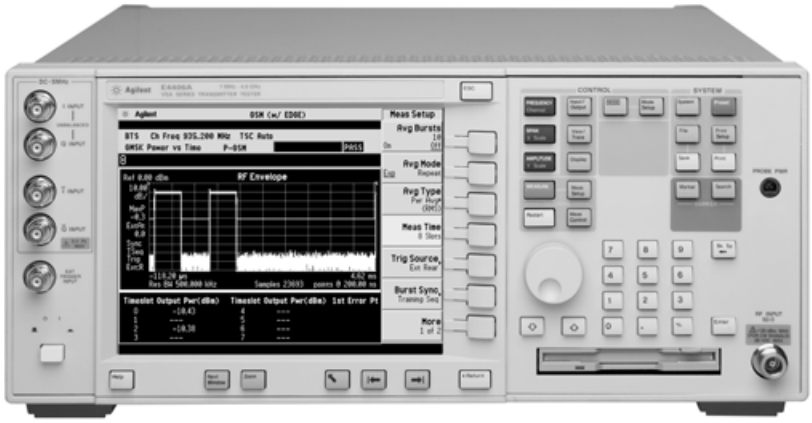


PSA Series spectrum analyzer



E4406A vector signal analyzer

Demonstration preparation

The following options are required for the ESG and the PSA Series.

Product type	Model number	Required options
ESG vector signal generator	E4438C	001 or 002 – baseband generator 402 – TDMA personalities
PSA Series spectrum analyzer	E4440A/E4443A/E4445A/ E4446A/E4448A	B7J – Digital demodulation hardware 202 – GSM with EDGE measurement personality

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. The PSA Series with this optional measurement personality can make complex GSM and EDGE measurements easy.

Begin by connecting the ESG's 50 Ω RF output to the PSA's 50 Ω RF input with a 50 Ω RF cable. Turn on the power in both instruments. *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.

Instructions	Keystrokes
On the ESG:	
Choose GSM 900 frequency band.	[Preset] [Frequency] {More} {Freq Channels} {Channel Band} {GSM/Edge Bands} {P-GSM Base} {Freq Channels On}
Select GSM mode and data format.	{Mode} {Real Time TDMA} {GSM} {Data Format Framed}
Turn on GSM modulation.	{GSM On}
Set the amplitude to –10 dBm.	[Amplitude] [-10] {dBm}
Turn on RF output.	[RF On]
On the PSA:	
Perform factory preset. (Skip this step for E4406A VSA.)	[System] {Power On/Preset} {Preset Type} {Factory}
Enter the GSM with EDGE mode in the analyzer.	[Preset] [Mode] {GSM (w/EDGE)}
Verify setup for GSM 900 band.	[Mode Setup] {Radio} {Band} {P-GSM}
Set center frequency to absolute RF channel number (ARFCN[1]) 1 (935.2 MHz).	[FREQUENCY] {ARFCN} [1] [Enter]

1. Absolute radio frequency channel number

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, industry standards specify a tight mask for the fit of the TDMA burst.

Easily measure the RF envelope of a GSM/EDGE burst, and receive pass/fail result based on the GSM/EDGE standard. This measurement provides a visual display of power versus time, helping you see transient characteristics at the edges of a burst or power control throughout the burst.

This measurement also allows you to focus on the rise and fall time of the burst or the whole burst, and provides an on-screen mask to help you visually determine where any violations may occur.

You control the following unique GSM/EDGE power versus time measurement parameters:

- measurement time (defaults to 1 slot)
- power control level
- burst search threshold
- number of bursts to average over
- RBW filter width and shape
- average mode and type

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

Instructions	Keystrokes
On the PSA:	
Activate power versus time measurement.	[MEASURE] {GMSK Pwr vs Time}
Zoom in on RF envelope (Figure 1).	[AMPLITUDE] {Ref Value} [–10] {dBm} {Scale/Div} [0.2] {dB}
View the shape of the rising and falling parts of the burst (Figure 2).	[Trace/View] {Rise & Fall}
Expand the rising edge display. You can toggle between the three display sections by pressing the [Next Window] key.	[Next Window] until the upper left part of the display is highlighted in green, [Zoom]
Zoom in on the trace.	[AMPLITUDE] {Ref Value} [–8.5] {dBm} {Scale/Div} [0.5] {dB}
Turn on averaging and display maximum and minimum averaged traces (Figure 3). Observe the different types 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} [Zoom]

Figure 1. GSM power versus time measurement

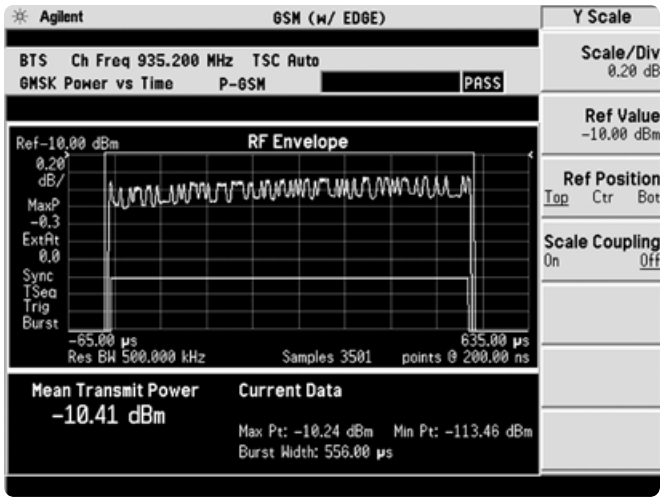


Figure 2. Rising and falling edges of GSM burst

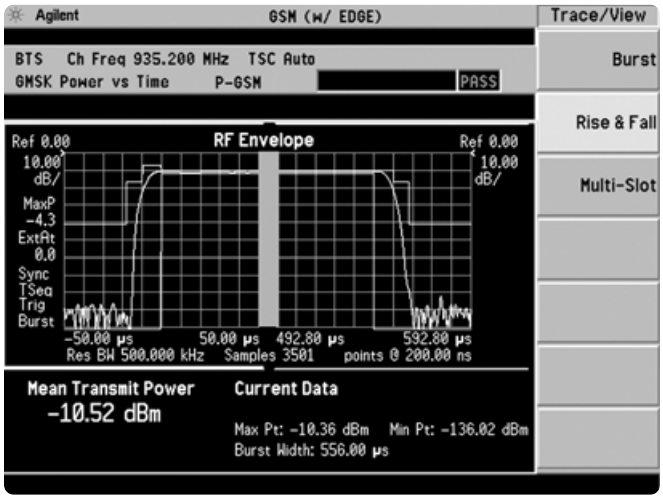
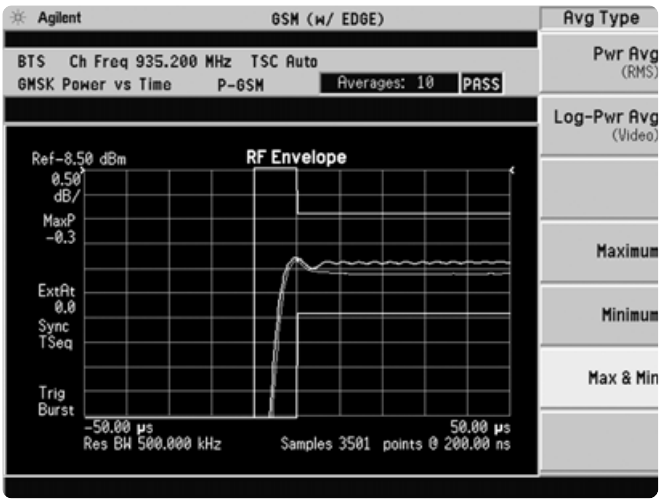


Figure 3.
Rising edge with averaging

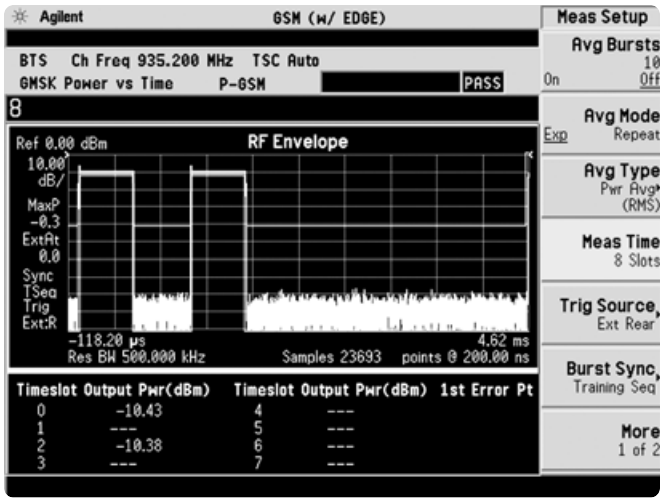


The PSA is also able to measure power versus time for multiple slots at the same time. Multi-slot views give information about the entire GSM frame. This is especially useful for examining slots that transmit at different power levels within a single frame.

Now experiment with the multi-slot capabilities of the PSA.

Instructions	Keystrokes
On the ESG:	
Add another timeslot.	[Mode] {Real Time TDMA} {GSM} {Configure Timeslots} {Timeslot #} [2] {Enter} {Timeslot Type} {Normal All} {Timeslot On}
On the PSA:	
Enable the external trigger.	[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 4).	[Meas Setup] {Meas Time} [8] [Enter]

Figure 4.
Multi-slot power versus time



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, poor phase error will reduce the ability of a receiver to correctly demodulate.

Demodulation and signal analysis required by industry standards is further complicated by the challenges of triggering and synchronizing to the actual GSM signal. The Agilent PSA Series has multiple trigger and synchronization options to make measurements simple.

Diagnose and correct modulation errors with displays of phase error versus time and demodulated bits.

GSM phase and frequency parameters:

- burst averaging
- average mode
- mean or max averaging

In this section, a one-button measurement captures the phase and frequency error information.

Instructions	Keystrokes
On the PSA:	
Measure GMSK phase and frequency error.	[MEASURE] {GMSK Phase & Freq}
Enable the external trigger. The two vertical, white bars in the RF Envelope plot in the lower, left part of the display indicate which timeslot is being measured.	[Meas Setup] {Trig Source} {Ext Rear}
Make the measurements on timeslot 2 (Figure 5). Notice the bars in the lower, left display move to timeslot 2.	[FREQUENCY] {Timeslot On} [2] {Enter}
View the polar vector diagram (Figure 6).	[Trace/View] {I/Q Measured}
View the demodulated I and Q bits (Figure 7).	{Data Bits}

Figure 5. Phase and frequency error

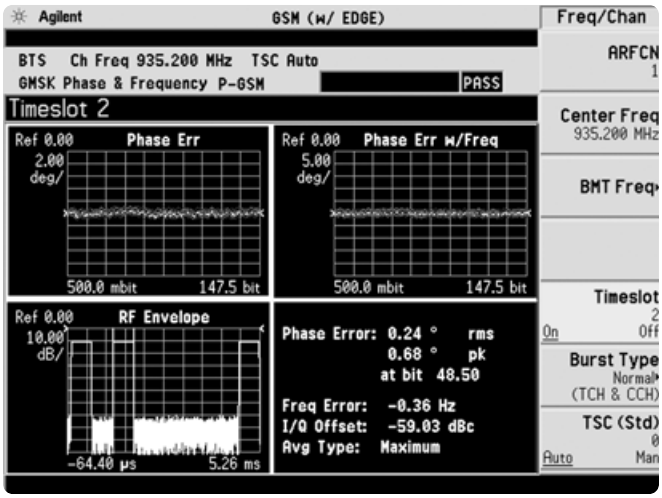


Figure 6.
I/Q polar vector plot

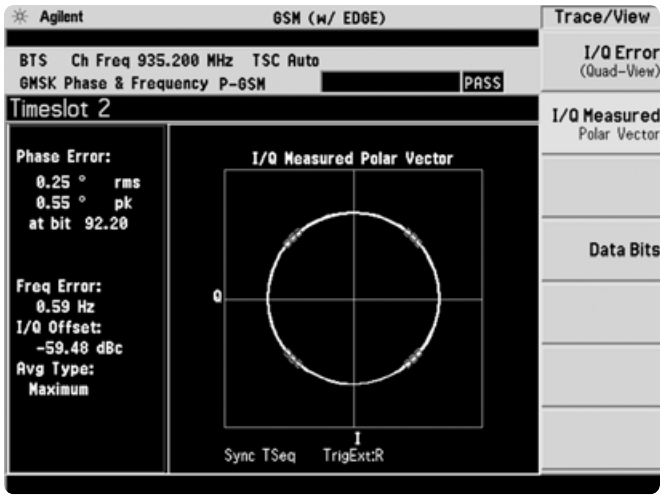
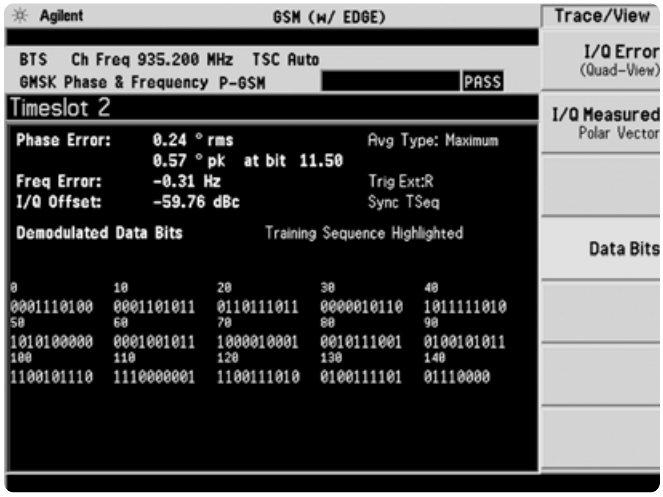


Figure 7.
I and Q
demodulated bits



GMSK output RF spectrum (ORFS)

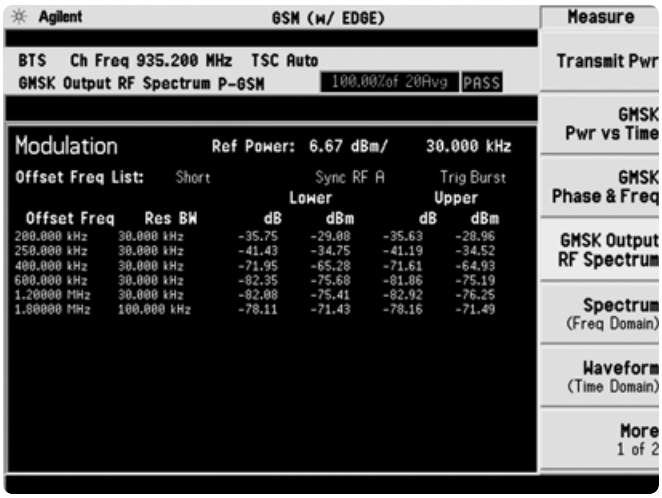
The modulation process in a transmitter causes the continuous wave (CW) carrier to spread spectrally. This is referred to as "spectrum due to modulation and wideband noise." Defects in the transmit chain may cause the spectrum to spread excessively, resulting in interference with other frequency bands. 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 happens fast enough. However, 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.

This exercise explores the ORFS measurement using the PSA.

Instructions	Keystrokes
On the ESG:	
Return to a single timeslot signal.	{Timeslot #} [2] {Enter} {Timeslot Off}
On the PSA:	
Set analyzer to make measurements on default timeslot.	[FREQUENCY] {Timeslot Off}
Activate the ORFS measurement (Figure 8). The default setting measures spectrum due to modulation at multiple offsets. This measurement takes about one second to complete.	[MEASURE] {GMSK Output RF Spectrum}
Examine spectrum due to modulation at a single offset (250 kHz) (Figure 9).	[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 10). This measurement takes several seconds to complete.	{Mod Method Sweep}

Figure 8. ORFS spectrum due to modulation



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 (Third-Generation Partnership Project) specifications have particular restrictions on ORFS for a series of frequencies. Verification of compliance with the 3GPP 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's 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 3GPP specification.

GSM/EDGE output RF spectrum parameters:

- burst averaging
- multi or single offset
- discrete or swept frequencies
- short, standard, or custom frequency offsets
- fast averaging
- RBWs at various offsets

Figure 9.
ORFS spectrum due to modulation and switching at 250 kHz

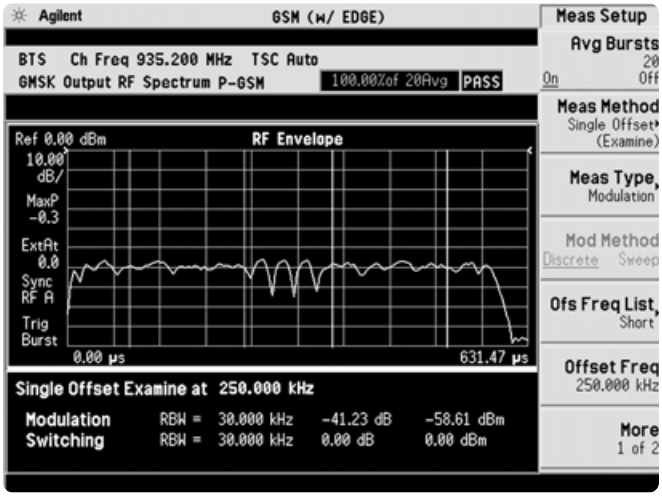
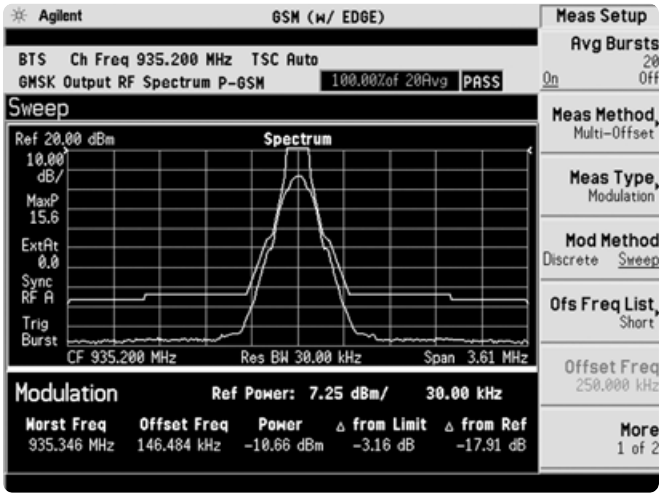


Figure 10.
ORFS with mask



1. Remote operation with SCPI commands.

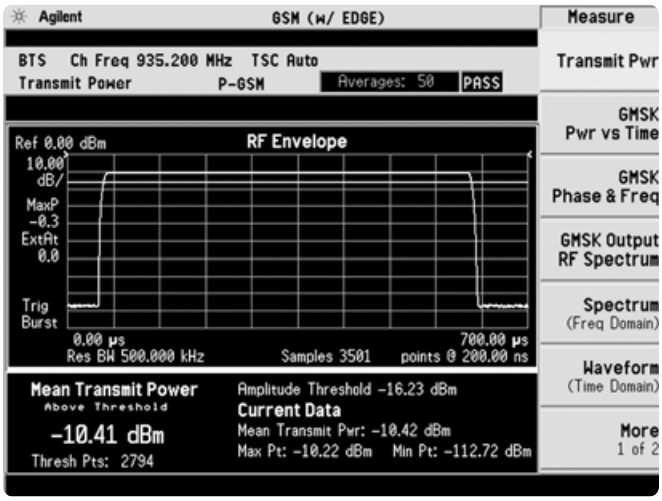
Transmit power

Carrier power is the measure of in-channel power for GSM systems. Mobile devices 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 high dynamic range.

Instructions	Keystrokes
On the PSA:	
Measure transmit power (Figure 11).	[MEASURE] {Transmit Pwr}
Move the threshold level to –40 dB. Notice the horizontal, white level bar move down.	[Meas Setup] {Threshold Lvl} [–40] {dB}

Figure 11. Transmit power measurement



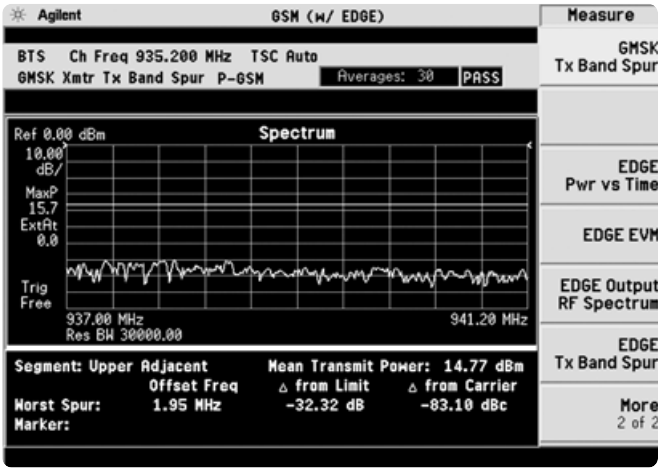
GMSK transmitter band spurious

Transmitter band spurious is a measurement that identifies undesirable energy in wrong parts of the transmitter 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 on the PSA. 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).

Instructions	Keystrokes
On the ESG:	
Increase the GSM signal amplitude.	[Amplitude] [15] {dBm}
On the PSA:	
Measure transmitter band spurious emissions (Figure 12).	[MEASURE] {More} {GMSK Tx Band Spur}

Figure 12. GMSK transmitter band spurious



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EDGE measurements

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, if not exactly, 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 is phase error. For EDGE, the modulation quality metric is error vector magnitude (EVM).

EDGE EVM settings:

- droop compensation on/off
- extreme limits on/off
- averaging amount, type

This measurement lets you easily analyze the EVM of an EDGE radio with a constellation diagram and a tabular list of measurement results. This display helps diagnose modulation or amplification distortions that lead to bit errors in the receiver. Agilent's unique algorithm provides a zero-ISI (inter-symbol interface) constellation that maintains the same pinpoint accuracy and methods for diagnosis as the traditional Nyquist-filtered systems.

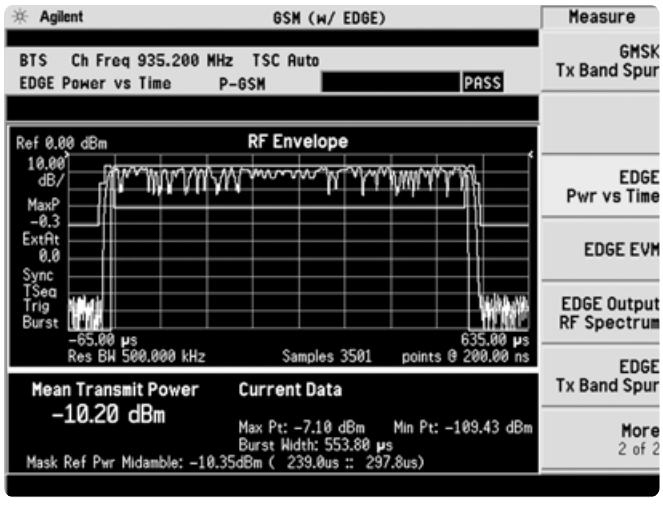
This exercise explores some of the EDGE measurements with emphasis on the EVM measurement.

Table 1. Representative specifications for GSM and EDGE signal formats

	GSM	EDGE
Modulation	GMSK	3π/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

Instructions	Keystrokes
On the ESG:	
Choose GSM 900 frequency band.	[Preset] [Frequency] {More} {Freq Channels} {Channel Band} {GSM/Edge Bands} {P-GSM Base} {Freq Channels On}
Select EDGE mode and data format.	{Mode} {Real Time TDMA} {EDGE} {Data Format Framed}
Turn on EDGE modulation.	{EDGE On}
Set the amplitude to –10 dBm.	[Amplitude] [–10] {dBm}
Turn on RF output.	[RF On]
On the PSA:	
Make the EDGE power versus time measurement (Figure 13). 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 14).[1]	[MEASURE] {More} {EDGE EVM}
View error and EVM plots.	[Trace/View] {I/Q Error}
Examine the demodulated data bits (Figure 15).	{Data Bits}

Figure 13. EDGE power versus time



1. Though the EDGE signal has considerable inter-symbol-interference (ISI), Agilent's proprietary ISI compensation algorithm provides both a clear constellation diagram and accurate EVM measurements.

Figure 14.
EDGE EVM measurement with polar vector plot

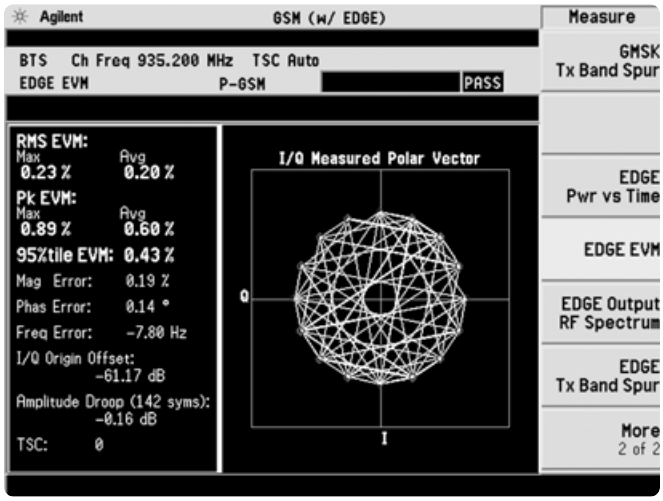
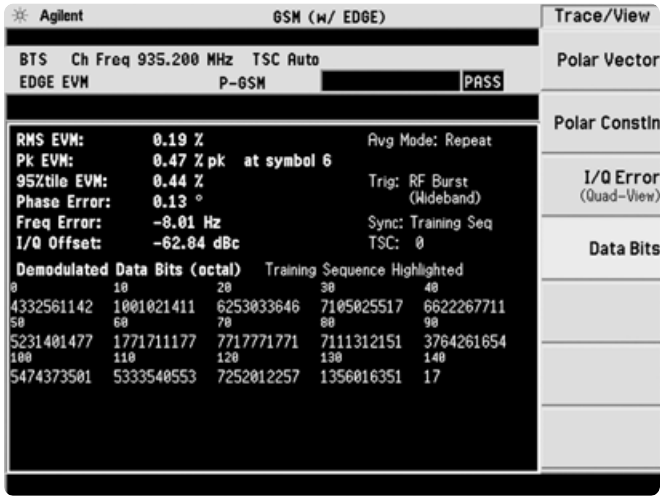


Figure 15.
EDGE demodulated data bits



PSA Series Key Specifications[1]

GSM with EDGE measurement personality

The following specifications apply to models E4443A/45A/40A only.
Models E4446A and E4448A have similar, but not warranted performance.

Power versus time measurement (GSM/EDGE)

Minimum carrier power at RF input	–40 dBm (nominal)
Absolute power accuracy for in-band signal (excluding mismatch error)	
Attenuation > 2 dB	–0.11 ±0.66 dB (-0.11 ±0.18 dB, typical)
Power ramp relative accuracy (referenced to mean transmitted power)	
RF input range = auto	
+6 dB to noise	±0.13 dB
Mixer Level ≤ –12 dBm	
0 to +6 dB	±0.13 dB
0 to noise	±0.08 dB
Mixer level ≤ –18 dBm	
+6 dB to noise	±0.08 dB
Measurement floor	–88 dBm + input attenuation (nominal)
Time resolution	200 ns
Burst to mask uncertainty	±0.2 bit (approximately ±0.7 µs)

Output RF spectrum measurement (GSM/EDGE)

Minimum carrier power at RF input	–20 dBm (nominal)	
ORFS relative RF power uncertainty		
Due to modulation		
Offsets ≤ 1.2 MHz	±0.15 dB	
Offsets ≥ 1.8 MHz	±0.25 dB	
Due to switching	±0.15 dB (nominal)	
ORFS absolute RF power accuracy		
Attenuation > 2 dB	±0.72 dB (±0.18 dB, typical)	
Dynamic range, spectrum due to modulation		
Offset frequency	**GSM/EDGE**	
100 kHz	67.3 dB	
200 kHz	74.5 dB	
250 kHz	76.9 dB	
	GSM	**EDGE**
400 kHz	81.5 dB	81.3 dB
600 kHz	85.6 dB	85.1 dB
1.2 MHz	91.0 dB	89.4 dB
1.8 MHz	90.3 dB	90.2 dB
6.0 MHz	94.0 dB	93.7 dB
Dynamic range, spectrum due to switching		
Offset frequency		
400 kHz	72.1 dB	
600 kHz	75.9 dB	
1.2 MHz	80.2 dB	
1.8 MHz	84.6 dB	

Phase and frequency error measurement (GSM)

Carrier power range at RF input	+27 to –45 dBm (nominal)
Phase error	
RMS floor	0.5°
RMS measurement accuracy	± 0.5°
Frequency error accuracy	5 Hz +(transmitter frequency x frequency reference error)

EVM measurement (EDGE)

Carrier power range at RF Input	+24 to –45 dBm (nominal)
EVM	
Floor	0.5% (0.3% typical)
Accuracy EVM range 1% to 10%	±0.5%

1. For specifications on the E4406A VSA, please refer to the E4406A VSA data sheet, literature number 5968-3030E.

Ordering Information

PSA Series spectrum analyzer

E4443A	3 Hz to 6.7 GHz
E4445A	3 Hz to 13.2 GHz
E4440A	3 Hz to 26.5 GHz
E4446A	3 Hz to 44 GHz
E4448A	3 Hz to 50 GHz

Options

To add options to a product, use the following ordering scheme:

Model	E444xA (x = 0, 3, 5, 6 or 8)
Example options	E4440A-B7J
	E4448A-1DS

Digital demodulation hardware

E444xA-B7J	Digital demodulation hardware (required for digital demodulation measurement personalities)

Digital demodulation measurements

E444xA-BAF	W-CDMA measurement personality
E444xA-202	GSM w/ EDGE measurement personality
E444xA-B78	cdma2000 measurement personality
E444xA-204	1xEV-DO measurement personality
E444xA-BAC	cdmaOne measurement personality
E444xA-BAE	NADC, PCD measurement personality

General purpose measurements

E444xA-226	Phase noise measurement personality
E444xA-219	Noise figure measurement personality

Amplifiers

E444xA-1DS	100 kHz to 3 GHz built-in preamplifier

Inputs and outputs

E4440A-BAB	Replaces type "N" input connector with APC 3.5 connector

Connectivity software

E444xA-230	BenchLink Web Remote Control Software

Warranty and service

For warranty and service of 5 years, please order 60 months of R-51B (quantity = 60). Standard warranty is 36 months.

R-51B	Return-to-Agilent warranty and service plan

Calibration[1]

For 3 years, order 36 months of the appropriate calibration plan shown below. For 5 years, specify 60 months.

R-50C-001	Standard calibration
R-50C-002	Standards compliant calibration

E4406A vector signal analyzer

E4406A 7 MHz to 4 GHz

Options

To add options to a product, use the following ordering scheme:

Model	E4406A
Example options	E4406A-BAH

Digital demodulation measurements

E4406A-BAF	W-CDMA measurement personality
E4406A-B78	cdma2000 measurement personality
E4406A-202	EDGE with GSM measurement personality
E4406A-204	1xEV-DO measurement personality
E4406A-BAH	GSM measurement personality
E4406A-BAC	cdmaOne measurement personality
E4406A-BAE	NADC, PDC measurement personality
E4406A-HN1	IDEN measurement personality

Inputs and outputs

E4406A-B7C	I/Q inputs

Connectivity software

E444xA-230	BenchLink Web Remote Control Software

Warranty and service

For warranty and service of 5 years, please order 60 months of R-51B (quantity = 60). Standard warranty is 36 months.

R-51B	Return-to-Agilent warranty and service plan

Calibration[1]

For 3 years, order 36 months of the appropriate calibration plan shown below. For 5 years, specify 60 months.

R-50C-001	Standard calibration
R-50C-002	Standards compliant calibration

1. Options not available in all countries.

Product Literature

Selecting the Right Signal Analyzer for Your Needs, selection guide, literature number 5968-3413E

PSA Series literature

PSA Series, brochure, literature number 5980-1283E

PSA Series, data sheet, literature number 5980-1284E

E4406A VSA literature

E4406A VSA, brochure, literature number 5968–7618E

E4406A VSA, data sheet, literature number 5968–3030E

Application literature

Understanding GSM/EDGE Transmitter and Receiver Measurements for Base Stations and Components, application note, literature number 5968–2320E

Measuring EDGE Signals New and Modified Techniques and Requirements, application note, literature number 5980–2508E

For more information on the E4406A VSA or the PSA Series, please visit:

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