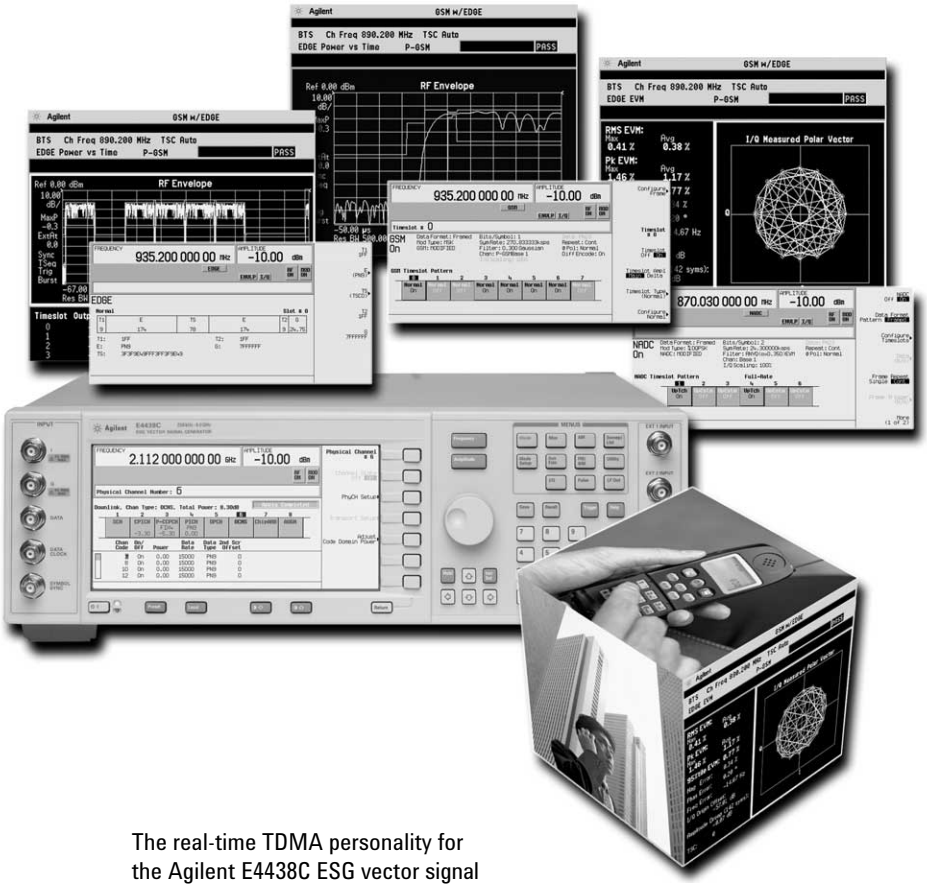
Agilent
Real-time TDMA Personality for the E4438C ESG Vector Signal Generator

Option 402
Technical Overview



The real-time TDMA personality for the Agilent E4438C ESG vector signal generator provides a broad collection of TDMA test signals at one low price. The TDMA suite includes the following:

- **Mixed GSM and EDGE**
- **GSM and GPRS**
- **EDGE and EGPRS**
- **NADC**
- **PDC**
- **PHS**
- **TETRA**
- **DECT**

This combination offers a viable test solution for the existing 2G and evolving 2.5G mobile radio networks – from the component to the system level.

The real-time TDMA personality provides all framing and bursting of the data. These signals are automatically set up according to the standard, and most of the parameters are easily modified.

Agilent Technologies

Introduction

The real-time TDMA personality for the ESG offers several common TDMA formats to provide a powerful development test suite for 2G and 2.5G mobile radios, base stations, and their components. The flexible signal creation personality includes GSM, EDGE, NADC, PDC, PHS, DECT, and TETRA.

The E4438C ESG contains a number of similarly-named setups under the arb waveform generator's "custom" menu that are included with the purchase of the baseband generator. We will refer to these as arbitrary waveform playback personalities. However, these are not equivalent to the real-time TDMA personality (Option 402). The pre-defined setups available under the arb custom menu (i.e. the arbitrary waveform playback personalities) are modulation only. They do not include framing, bursting, or channel coding, but they do include the ability to generate multiple carriers.

The real-time and arbitrary waveform playback personalities are intended to serve completely different test needs. Combined, they provide a comprehensive set of test signals for component and receiver test in development and manufacturing. The key differences between waveform playback and real-time signal generation capabilities for GSM/EDGE are highlighted in Table 1.

Introduction

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GSM/EDGE signal creation

Feature	GSM/EDGE Option 602 waveform playback	GSM/EDGE (Option 402) real-time signal generation
Primary application	Component test	Receiver test and ASIC baseband verification
Framing and coding	None	Framing for all data types. Data encoding for TCH/FS, CS-1, MCS-1, MCS-5, MCS-9, and E-TCH/43.2NT payloads.
Burst types supported	None	GSM, EDGE, mixed GSM and EDGE, sync, Fcorr, access, dummy, and custom
Bursting provided	No	Yes
Number of carriers	100	1

Table 1. Waveform playback and real-time signal generation feature comparison for GSM/EDGE.

Real-time signal generation mode

In real-time signal generation mode, the ESG baseband generator produces test signals almost instantly, without the precomputation time required for waveform builds.

Real-time test signals are primarily intended for mobile and base station receiver tests in the research and development environment. All the TDMA signals have framing applied to them.

GSM/EDGE signal creation features full channel coding and mixed GSM and EDGE timeslot capabilities which make standards based measurements such as sensitivity and adjacent channel selectivity tests possible. With these test signals, the user can perform Bit Error Rate (BER), Block Error Rate (BLER), and Frame Error Rate (FER) measurements.

Additionally, power ramping between timeslots can be disabled to simulate the multislot operation of a GPRS or EGPRS mobile station.

GSM/EDGE Overview

Figure 1 illustrates a GSM burst as defined in the GSM standard. Figure 2 has the details of the bit sequence for each field in the GSM burst. *Note:* the ESG's user interface refers to the GSM burst as the Normal burst.

- All GSM burst types supported in Option 402
  - GSM
  - EDGE
  - Fcorr
  - Sync
  - Access
  - Dummy
  - Custom
- Data framing for all burst types
- Use customized FIR filters or select from predefined filters such as Gaussian, Nyquist, and root Nyquist, and more.
- Channel coded data for TCH/FS payloads
- Channel coded data for PDTCH packets:
  - CS-1, CS-4, UL/DL MCS-1, UL/DL MCS-5, UL/DL MCS-9, and E-TCH/F43.2NT

All the GPRS and EGPRS packets listed above that require channel coding are encoded according to the 3GPP TS 05.03, V8.9.0, 2000-11 (release 1999): "Digital cellular telecommunications system (Phase 2+); Channel coding 1999" standard.

T (tail bits) 3 bits	E (encrypted) field (payload or user data) 57 bits	S (stealing bit) 1 bit	TS (training sequence)	E (encrypted) field (payload or user data) 57 bits	S (stealing bit) 1 bit	T (tail bits) 3 bits	G (guard bits) 8.25 bits

Figure 1. GSM burst description of each field and bit length

0	Non-channel coded data • PN sequence • user file • predefined patterned Channel coded data available: • TCH/FS • CS-1 • CS-4 • MCS-1 uplink and downlink	1 or 0	Any one of 7 predefined GSM training sequences or user defined.	1 or 0	Non-channel coded data • PN sequence • user file • predefined patterned Channel coded data available: • TCH/FS • CS-1 • CS-4 • MCS-1 uplink and downlink	0	0

Figure 2. Contents of the GSM burst shown in Figure 1

Certain fields are coupled in the GSM burst. This means when the data pattern is selected for one of the fields, it applies to the other field as well.

- Coupled fields:
  - Tail bits field
  - Stealing bits field
  - Encrypted field

GPRS/EGPRS Coding with GMSK modulation

Figures 3 through 4 show the details of the E field of the GSM traffic bursts. The fields are shown before channel coding. For details of the channel coding applied see 3GPP TS 5.03, V8.9.0, 2000-11 (release 1999).

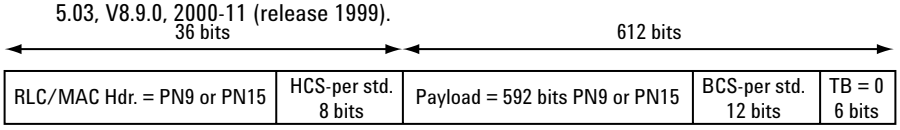

Figure 3. UL MCS-1 packet in the E field of a GSM burst

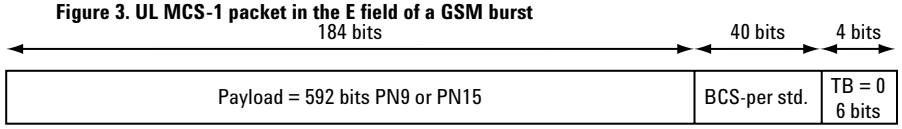

Figure 4. CS-1 packet in the E field of a GSM burst

The PN sequence encoded across the RLC/MAC header is independent of the PN sequence contained in the payload field.

GPRS and EGPRS test signals are also configurable as part of the GSM and EDGE signal creation. All GPRS and EGPRS packets are mapped across 4 GSM or EDGE bursts. Figure 5 shows an example of how this mapping is performed.

These interleaving bursts occur across multiple frames. The packet data is transmitted in a given timeslot over four frames.

For MCS-1, after channel coding is performed, 12 stealing bits (as defined by the standard) are prepended to the beginning of the packet.

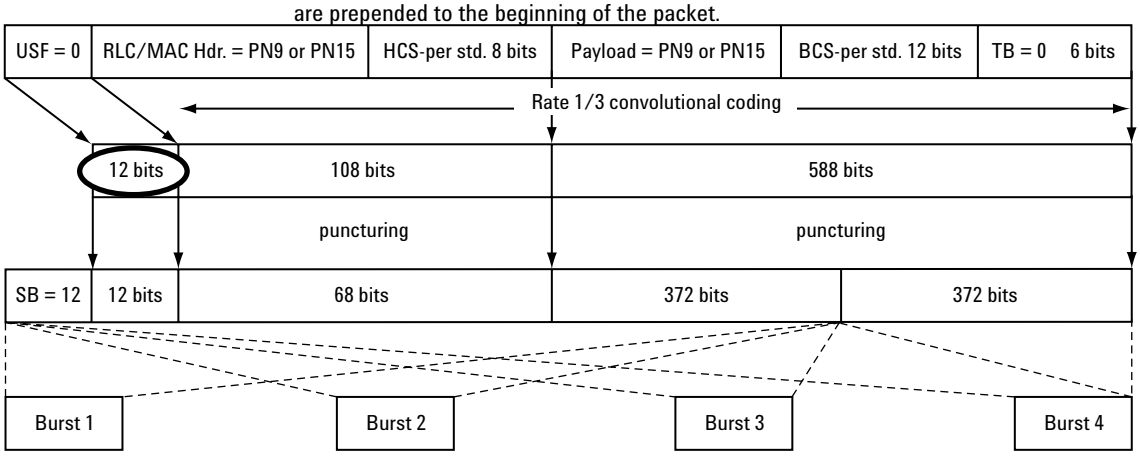

Figure 5. DL MCS-1 packet in the E field of a GSM burst

EDGE/EGPRS Coding with 8PSK modulation

EDGE burst

Figure 6 illustrates an EDGE burst as defined in the GSM standard. Figure 7 has the details of the bit sequence for each field in the EDGE burst.

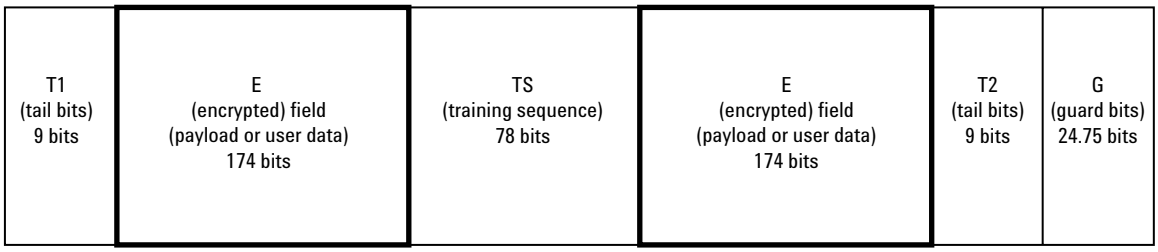

Figure 6. EDGE burst

User definable	Non-channel coded data • PN sequence • user file • predefined patterned Channel coded data available: • MCS-5 uplink and downlink • MCS-9 uplink and downlink	Any one of 7 predefined GSM training sequences or user defined.	Non-channel coded data • PN sequence • user file • predefined patterned Channel coded data available: • MCS-5 uplink and downlink • MCS-9 uplink and downlink	User definable	User definable

Figure 7. Contents of an EDGE burst listed in figure 6

The E fields are coupled in the EDGE burst. This means when the data pattern is selected for one of the E fields, it applies to the other E field as well. Eight stealing bits (as defined by standard) are prepended to the beginning of MCS-5 and MCS-9 packets, after channel coding is performed. Figures 8 through 11 show the details of the E field of the EDGE bursts. The fields are shown before channel coding. For details of the channel coding applied see 3GPP TS 5.03, V8.9.0, 2000-11 (release 1999).

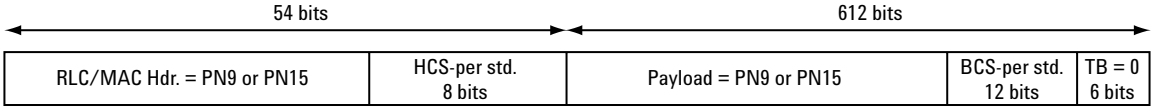

Figure 8. UL MCS-5 packet in E field of an EDGE burst

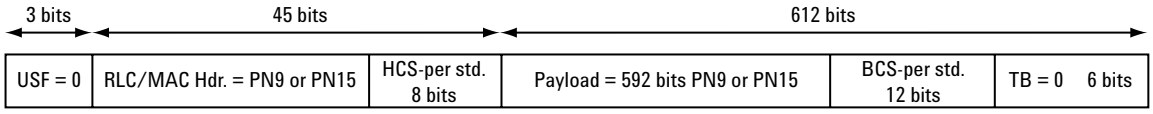

Figure 9. DL MCS-5 packet in E field of an EDGE burst

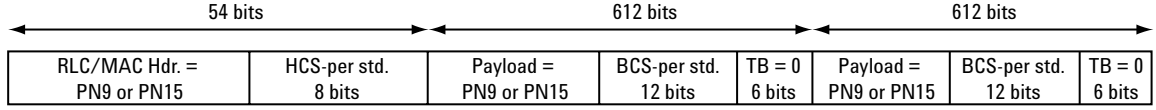

Figure 10. UL MCS-9 packet in an E field of an EDGE burst

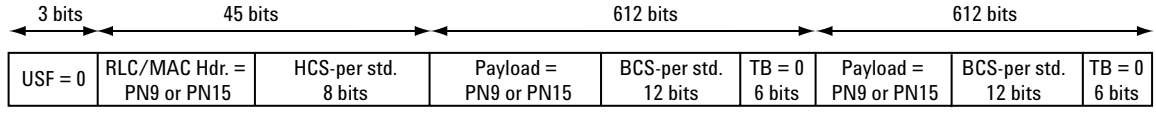

Figure 11. DL MCS-9 packet in an E field of an EDGE burst

GPRS/EGPRS Multiframe configuration

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Multiframe channel description

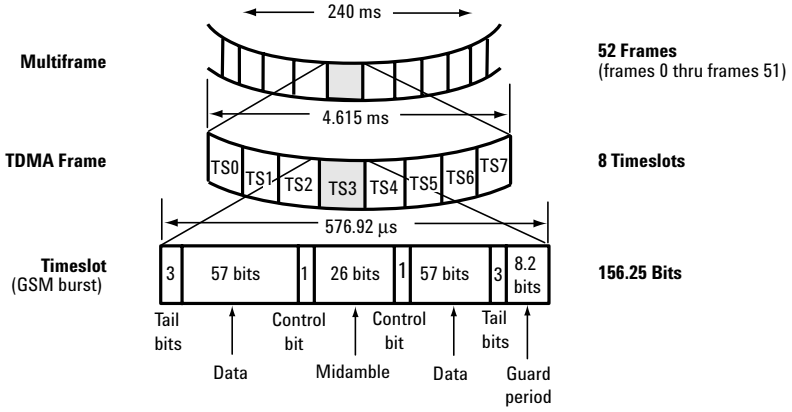

Figure 12. Illustration of GPRS packet and how it is mapped onto a 52 multiframe packet data traffic channel (PDTCH)

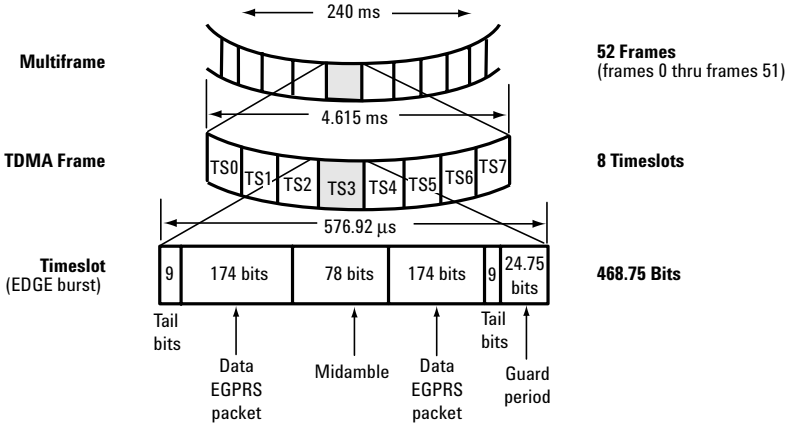

Figure 13. Illustration of an EGPRS packet and how it is mapped onto a 52 multiframe packet data traffic channel (PDTCH)

GSM timeslots containing multiframe packets (CS-1, CS-4, or MCS-1) are mapped into a 52 multiframe packet data channel (PDTCH). In this multiframe mode, the E field (payload) in the chosen timeslot is continuous across multiple frames; that is, the PN sequence is not truncated. However, following the standard, the chosen time slot is RF blanked during frames 25 and 51. Also, during frames 12 and 38, the tail bits, control bits, and payload bits of the chosen slot are set to zero, while the guard bits are set to 1. The midamble bits are unchanged.

EDGE timeslots containing EGPRS packets (MCS-5 or MCS-9) are also mapped into a 52 multiframe packet data channel (PDTCH). In this multiframe mode, the E field (payload) in the chosen timeslot is continuous across multiple frames; that is, the PN sequence is not truncated. Again, following the standard, the chosen time slot is RF blanked during frames 25 and 51. During frames 12 and 38, the tail bits, control bits and guard bits are set to 1, the payload bits of the chosen slot are set to zero, while the midamble bits remain unchanged.

A maximum of 4 timeslots can be configured for multiframe packets.

Receiver tests

GSM/EDGE/GPRS/EGPRS receiver testing
Channel coding for the test signals enables receiver BER/FER/BLER/RBER testing, baseband ASIC verification, and functional testing of the receiver's decoding algorithms.

An optional GSM/EDGE base station receiver tester, Option 300, is available for the ESG. The GSM/EDGE base station receiver test performs BER/FER/RBER/BLER and sensitivity tests on fully coded GSM/EDGE signals. The ESG with the TDMA personality creates the test signal that is sent to the receiver portion of the BTS under test. The BTS under test then loops this signal back to the transmitter section of the BTS . This test signal from the BTS transmitter is then sent to a receiver, such as the E4440A or E4406A, at RF where it is down converted to a 321.4 MHz IF. This 321.4 MHz signal is then sent to the ESG to perform the final downconversion, demodulation, decoding, and BER tests.

Real-time TDMA personality specifications [1, 2, 3]

	NADC		PDC		PHS		TETRA[4]		DECT	GSM, DCS, PCS		EDGE
Error vector magnitude [5, 6] [% rms]												
Low EVM mode	0.9 (0.6)		0.9 (0.7)		0.8 (0.5)		0.8 (0.5)					1.2 (0.6)
Low ACP mode	(1.1)		(0.9)		(0.6)		(1.0)					
Global phase error [5]												
rms	N/A		N/A		N/A		N/A		N/A	0.6 (0.3)		N/A
pk										1.9 (1.0)		
Deviation accuracy [5] [kHz, rms]	N/A		N/A		N/A		N/A		2.5 (1.1)	N/A		N/A
Channel spacing [kHz]	30		25		300		25		1728	200		200
Adjacent channel power [5] [ACP]	Cont.	Burst	Cont.	Burst	Cont.	Burst	Cont.	Burst	N/A	Cont.	Burst	N/A
(Low ACP mode, dBc)												
at adjacent channel [7]	(-35)	(-34)	–	–	–	–	(-70)	(-64)		(-37)	(-37)	
at 1st alternate channel [7]	(-80)	(-79)	(-74)	(-74)	(-83)	(-79)	(-81)	(-80)		(-71)	(-71)	
at 2nd alternate channel [7]	(-84)	(-84)	–	–	(-85)	(-82)	(-82)	(-82)		(-87)	(-84)	
at 3rd alternate channel [7]	(-86)	(-85)	(-82)	(-82)	–	–	(-84)	(-84)		(-88)	(-85)	
Support burst types	Custom up/down TCH		Custom up/down TCH up Vox		Custom TCH, sync		Custom up control 1 & 2, up normal, down normal,		Custom dummy B 1 & 2, traffic B, low capacity	Custom, GSM Fcorr, sync, dummy, access		
Scramble capability					Yes		Yes					

Table 2. Specifications for theTDMA personalities

1. This level of performance can be attained using the external I/Q inputs, provided the quality of the baseband signal meets or exceeds that of the ESG baseband generator.
2. Specifications apply at power levels ≤ +4 dBm [≤ +5 dBm for Option 506, and ≤ +8 dBm for Option UNB] with default scale factor of I/Q outputs.
3. Parentheses denote typical performance.
4. ACP for TETRA is measured over a 25 kHz band width, with an 18 kHz root raised cosine filter. Low ACP mode is valid at power levels ≤ –1 dBm [≤ 1 dBm for Option 506 and ≤ +4 dBm for Option UNB].
5. Specifications apply for the symbol rates, filter, filter factors [α or BbT] and default scaling factor specified for each standard, and at power levels ≤ +7 dBm [≤ +10 dBm for Option UNB].
6. Valid after executing I/Q calibration and maintained within +/- 5 °C of the calibration temperature.
7. The "channel spacing" determines the offset size of the adjacent and alternate channels: Adjacent channel offset = 1 x channel spacing, 1st alternate channel = 2 x channel spacing, 2nd alternate channel = 3 x channel spacing, etc.

GSM/EDGE key features

GSM/EDGE real-time signal generation

Framing	
Framed	0 to 7 timeslots in the TDMA frame
Non-framed (pattern)	Non-framed, non bursted continuous data (payload E field only transmitted)
Data source for payload GSM/EDGE single framed data for GSM burst	
Single frame	PN9, PN11, PN15, PN20, PN23
GSM and EDGE (payload field)	Fixed pattern 4 bits, 4 1s and 4 0s, 8 1s and 8 0s, 16 1s and 16 0s, 32 1s and 32 0s, 64 1s and 62 0s, user file from stored memory External (serial data from external DATA input)
Data source for payload GSM/EDGE multiframe data	
	Multiframe (GSM/EDGE E field) (Multiframe = 52 frames for GPRS/EGPRS; frames 12 and 25 are RF blanked: for details of multiframe contents see page 8.) (Multiframe = 26 frames for GSM TCH/FS) Includes channel coding (see GSM 05.03 version 8.6.0 Rel. 1999 Channel Coding): PN9 or PN15 CS-1 CS-4 TCH/FS DL MCS-1 UL MCS-1 Uncoded DL MCS-9 UL MCS-9 DL MCS-5 UL MCS-5 E-TCH/F43.2 A maximum of 4 timeslots can be turned on for EGPRS multiframe coded data.
Data source for patterned (non-framed and non-bursted data)	
	PN9, PN11, PN15, PN20, PN23 Fixed pattern 4 bits, 4 1s & 4 0s, 8 1s & 8 0s, 16 1s and 16 0s 32 1s and 32 0s, and 64 1s and 62 0s User file from memory
Burst types (for framed data)	
	Mixed GSM and EDGE GSM Custom Fcorr Sync Dummy Access EDGE EDGE-custom

GSM/EDGE key features

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Frequency channels (pre-set channel bands) for framed or non-framed data

P-GSM base/mobile
- Channels: 1 to 124 (935.2 MHz to 959.8 MHz)

E-GSM base/mobile
- Channels: 0 to 124 (935.2 MHz to 959.8 MHz)
- Channels: 975 to 1023 (925.2 to 934.8 MHz)

R-GSM base/mobile
- Channels: 0 to 124 (935.0 MHz to 959.8 MHz)
- Channels: 955 to 1023 (921.2 to 934.8 MHz)

DCS base/mobile
- Channels: 512 to 885 (1.8052 to 1.8798 GHz)

PCS base/mobile
- Channels: 512 to 885 (1.9302 to 1.989 GHz)

GSM 450 base/mobile
- Channels: 259 to 293 (460.60 to 467.4 MHz)

GSM 480 base/mobile
- Channels: 306 to 340 (485.80 to 489 MHz)

GSM 850 base/mobile
- Channels: 128 to 251 (869.2 to 893.80 MHz)

Clock

Reference clock: External 13 MHz clock input

External data (bit) clock
- Normal: Supply clock or pulse to DATA CLOCK INPUT
- Symbol: Data is clocked on rising and falling edge of symbol sync signal

Baseband generator data clock
- Internal
- External

User to supply data (bit) or symbol sync

I/Q scaling: 0 to 100%

Configure secondary frame

Secondary frame	On/off
Secondary frame trigger	Trigger key Bus Ext (external from pattern from trigger input (BNC))

Filter

Gaussian
root Nyquist
Nyquist
User FIR

Symbol rate: 1 sps to 50 Msps

Modulation type: PSK, FSK, QAM, user FSK

Power ramp control

Burst shape type	Sine, user-defined burst shape	
Ramp time	Rise time	0.032 to 999.008 bits
	Rise delay	0 to 18.125 bits
	Fall time	0.032 to 999.008 bits
	Fall delay	0 to 19 bits

Multislot power ramping: Disable power ramping between timeslots to simulate multislot operation

GSM/EDGE key features

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Slot attenuation	0 to 130 dB The maximum and minimum limits for the alternate timeslot power level are bounded by the upper and lower power levels of the ESG signal generator, given below: -136 dBm <= main RF level + delta <= +13 dBm (250 kHz to 1000 MHz) -136 dBm <= main RF level + delta <= +10 dBm (>1000 MHz to 3000 MHz) -136 dBm <= main RF level + delta <= +7 dBm (>3000 MHz to 4000 MHz)
Phase polarity	Normal or invert
Differential GSM data encoding	Off or on
Secondary frame trigger	Trigger key, bus, external (from external trigger input), trigger in polarity: Negative/positive
Trigger Trigger setup	Continuous, single, gated Trigger source: Trigger key, bus External source (pattern trigger input 1 or 2) Delay: 0-1048575 Continuous mode: Free run, trigger and run, reset and run

Arbitrary waveform playback mode

Using the TDMA arbitrary waveform playback personalities, it is possible to create multicarrier GSM,EDGE, NADC, PDC, PHS, TETRA, DECT, APCO25, CDPD, and PWT. The TDMA arbitrary waveform playback signals can be used as a test signal to properly stress components – including combiners, filters, and amplifiers. Signals generated in arbitrary waveform playback mode can be used for base station and mobile tests ranging from the component level to the system level; however, they are primarily intended for the component test industry.

In arbitrary waveform playback mode, the ESG baseband generator operates like a traditional arbitrary waveform generator. After the signal parameters have been configured, a sampled version of the baseband I/Q signal is stored in waveform RAM. These samples are then played back through a DAC and pass through a reconstruction filter before being supplied to the I/Q modulator. TDMA presets are available under the custom, arb waveform generator menu.

Because these signals are primarily intended for component test, channel coding, framing, and bursting are not implemented.

Key features:

- Select from pre-defined configurations
- Use your own FIR filters or select from predefined filters
- Baseband clipping; clip the peak power of signals before or after FIR filtering
- Generate CCDF plots

Multicarrier TDMA signals

Stress active components by generating multicarrier TDMA configurations to create up to 100 carriers.

Custom and pre-defined filters

Choose or create your unique filter. Choose from EDGE, Gaussian, or root Nyquist filters. Define your own FIR filter to meet specific (non-standard) test requirements.

Baseband clipping (not applicable to GMSK)

Reduce signal stress on power amplifiers. Clip the peak-to-average power of signals before or after baseband FIR filtering. Clipping the signal before filtering smooths any discontinuities in the resulting signal that can generate distortion. Optionally, the signal can be clipped after FIR filtering to simulate base stations that operate in this mode. Clipping may be applied individually to I and Q or to the composite I/Q vector.

CCDF curve display

Visually check the peak-to average ratio of the configured signal. View the power statistics of the TDMA waveforms produced by the ESG. Digital modulation must be on for this feature to work.

GSM/EDGE in the custom arbitrary waveform generator menu

Arbitrary waveform generator menu features

Setup select (GSM) setting: Non-framed, non bursting data

Mode type	MSK
Filter	0.300 gaussian
Data	Random
Symbol rate	270.833 ksps
Trig type	Continuous
Trig source	External
Polarity	Negative
Retrigger	On
Delay	Off

Note: Data is not framed, bursted, or encoded.

Setup select (EDGE) Automatically sets non-framed, non-bursted data

Mod type	EDGE 3π/8 8-PSK)
Filter	EDGE
Data	random
Symbol rate	270.833 ksps
Trig type	Continuous
Trig source	External
Polarity	Negative
Retrigger	On
Delay	Off

Note: Data is not framed, bursted, or encoded.

Data source for GSM and EDGE	Random
Multicarrier features	
Maximum	Up to 100 carriers
Multicarrier waveform statistics	Plot CCDF
Multicarrier phase	Fixed, random
Trigger	Continuous, single, gated Segment advance for ARB menu
Filter types for digital modulation	(change the GSM/EDGE settings from standard) Gaussian, root Nyquist, Nyquist, IS-95 and IS-2000, user-defined FIR, WCDMA, rectangle, APCO 25 C4FM
Modulation type	PSK, MSK, FSK, QAM
Phase polarity of IQ signals	Normal or invert

GSM/EDGE in the custom arbitrary waveform generator menu

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Sample clock	
	100 MHz maximum 1 Hz minimum
Symbol rate	1 sps to 32 Msps
Clock reference	External or internal
Reconstruction filter	40 MHz or through
Markers	
Total	4
Polarity	Negative or positive
Waveform sequence (built from waveform segments)	
	Set repetitions Toggle markers

Connectivity information

The E4438C ESG vector signal generator offers a wide array of I/O capabilities to simplify measurement setups.

Perform firmware upgrades, download waveforms to the instrument, or remotely control the instrument with SCPI commands using either 10BaseT LAN or IEEE-488 GPIB. LAN control requires the use of the K version or later of Agilent I/O libraries, downloadable from the Agilent web site: **www.agilent.com/find/iolib**

Recommended configuration[1]

E4438C Vector Signal Generator

Frequency option

503	250 kHz to 3 GHz frequency range
UNJ	Enhanced phase noise performance
602	Internal baseband generator with 64 MSa memory
005	6 GB internal hard drive (Option 001, 002, 601 or 602 required)
402	Real-time TDMA personality

Other configurations are available. For details regarding the E4438C ESG option structure, refer to the *Configuration Guide* in the Related Agilent literature section.

Ordering information

The real-time TDMA personality may be purchased as Option E4438C-402 with a new Agilent E4438C ESG vector signal generator. If you need assistance, your Agilent field sales engineer can help you configure your instrument properly. Contact information can be found at **www.agilent.com/find/connectivity**

Upgrade kits

If you currently own an E4438C ESG with the optional internal baseband generator and are interested in obtaining an upgrade kit only (license key), order: E4438CK-402.

Firmware updates

Firmware updates can be downloaded from **www.agilent.com/find/upgradeassistant**

1. All options should be ordered using E4438C-XXX, where the XXX represents the option number.

Related Agilent literature

Brochures

Agilent E4438C ESG Vector Signal Generator
Publication number 5988-3935EN

2G & 3G Solutions -Accelerating Progress
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

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

Other Agilent products

Wireless Communications Products
Publication number 5968-6174E

CDMA Solutions
Publication number 5966-3058E

Agilent E4440E Performance Spectrum Analyzer
Publication number 5980-1284E

See **www.agilent.com** for more information

References

3GPPTS 05.03, V8.90, 2000-11 (Release 1999)

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