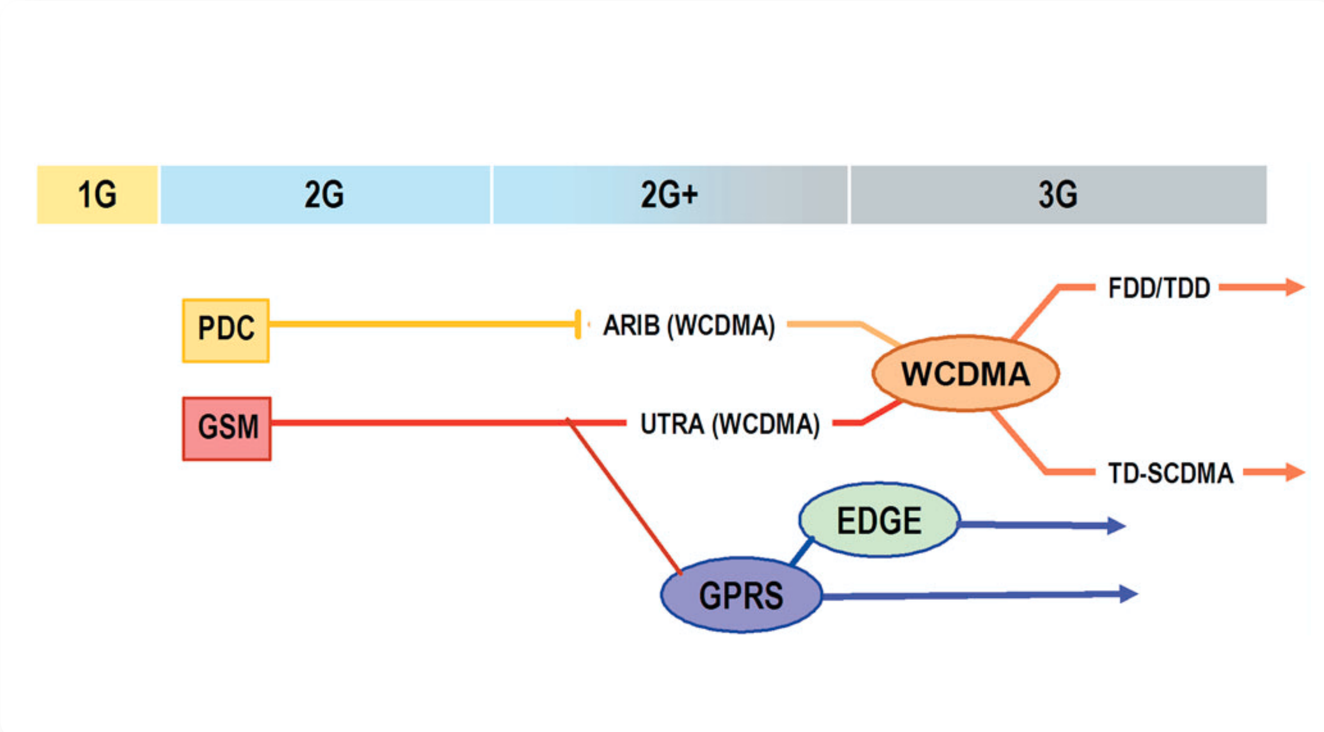
EDGE Wireless Networks



▶ **Figure 1.** *Evolution of GSM, GPRS, and EDGE Cellular Technologies.*

Cellular networks continue to grow at a rapid pace around the world. In many parts of the world, network operators are now putting, or have put, EDGE (Enhanced Data rates for Global Evolution) networks into commercial service, as part of the evolution towards third generation (3G) networks.

This technical brief will introduce the reader to GPRS and EDGE wireless networks and provide some understanding and insight to the air interface to enable base station maintenance personnel to effectively maintain them. We begin with a review of the migration to EDGE, followed by a description of the air interface and key RF parameters.

We will then describe some of the testing challenges in EDGE and state-of-the-art test tools to ensure that a wireless network meets important QoS goals. The term EDGE is used in this technical brief to refer to a GSM/GPRS wireless network that has been upgraded with EDGE capability and is referred to as Enhanced GPRS (EGPRS).

Tektronix
Enabling Innovation

A major driver for mobile devices today is access to the Internet and Web-based applications. Customer demand for data services is driving the wireless service providers to upgrade their networks to be able to accommodate these new services. The Internet is a packet switched network. Internet traffic is characterized as “bursty” traffic, as data is transmitted in bursts, rather than the continuous stream used by voice. GSM (Global System for Mobile communication) on the other hand is a circuit switched network and not well suited for Internet traffic. GPRS and EDGE provide the advances in technology to upgrade GSM networks or build EDGE networks and provide for these new data services.

Cell phone users have come to depend on high quality cellular service to conduct business and stay in contact. It is essential for wireless service providers to engineer and maintain their cellular network to ensure high Quality of Service. Dropped calls, non-availability, and slow data rates can lead to reduced revenue and customer dissatisfaction, which in turn leads to fewer customers. Retention of existing customers and attracting new customers are important business goals for wireless service providers.

Migration of GSM to EDGE

Before the 1980s, the mobile radio communication industry was limited to the armed services, commercial and public organizations using private systems and marine and aircraft communication. The general public’s first introduction to mobile telephones was portable telephones limited to the range of a single base station covering a small geography.

First Generation (1G)

Technical innovations such as automatic switching and reductions in hardware costs, size and weight led to the first generation (1G) of mobile communications systems in the early 1980s. These were based on analog cellular technology. These have been mainly based on two systems: the American AMPS (Advanced Mobile Phone Service/System) and the Scandinavian NMT system (Nordic Mobile Telephone). The transmission quality of these 1G systems left much to be desired and the incompatible systems made cooperation nearly impossible.

Second generation (2G)

Second generation systems began to appear in the late 1980s.

GSM

The first digital cellular system was GSM. GSM became popular very quickly, because it provided improved speech quality and a uniform international standard. A single telephone number and mobile phone could be used around the world. The standardization work started by the CCITT and continued by ETSI, led to the GSM standard in 1991. GSM has continued to evolve and add additional features and capabilities. GSM is now used in over 160 countries with over 350 million subscribers worldwide. GSM was estimated to represent 63% of the overall cellular market at the end of 2001.

Interim step to 3G, 2.5G

In order to accommodate the growing demand for Internet applications, it was found that the circuit switched infra-structure or core network needed to migrate to a packet switched infra-structure.

GPRS

With initial release in 1997, General Radio Packet Service (GPRS) was specified to create a sound foundation for packet switching in GSM networks. GPRS offers higher data rates for mobile users. It installs a packet switched network on top of the existing circuit switched network of GSM, without altering the radio interface. Higher data rates could be offered to users by dynamically allocating multiple channels. GPRS is the first step in enhancing the GSM core network in preparation for UMTS (Universal Mobile Telecommunications Services). GPRS also introduces important QoS features.

EDGE

EDGE (Enhanced Data rates for Global Evolution) was standardized in 1999 and is an enhancement to the radio interface; employing 8-PSK (Phase Shift Keying) modulation (GSM and GPRS use GMSK/ Gaussian Minimum Shift Keying). EDGE employs Link Quality Control procedures that are used to select the optimal channel-coding scheme based upon the quality of the radio link in order to provide the maximum data rate. In practice, EDGE is deployed in conjunction with GPRS and is also referred to as EGPRS (Enhanced General Packet Radio Service).

Third Generation (3G)

In an effort to coordinate worldwide migration to 3G mobile networks, the ITU (International Telecommunications Union) evaluated and accepted 17 different proposals as IMT-2000 (International Mobile Telecommunication 2000) standards in 1999. The most important IMT-2000 proposals were UMTS (Universal Mobile Telecommunication System)/W-CDMA (Wide band Code Division Multiple Access), cdma2000 (as the IS-95 successor), and TD-SCDMA. TD-SCDMA (Time Division - Synchronous CDMA) is a 3G specification that is being considered in China. The ITU defines a 3G network as one that provides improved system capacity and spectrum efficiency compared to 2G systems.

W-CDMA

W-CDMA defines the air interface access of the UMTS network. Unlike GSM and GPRS, which uses time division multiple access and frequency division multiple access, W-CDMA allows all users to transmit at the same time and to share the same RF carrier. Further, W-CDMA uses a wider bandwidth (5 MHz) as compared to CDMA IS-95 systems (1.25 MHz). The access technology, W-CDMA, is termed UTRA (UMTS Terrestrial Radio Access). Early W-CDMA specifications and field trials, such as ARIB in Japan (Association for Radio Industry and Business) and the Universal Mobile Telephone System (UMTS) in Europe, have been harmonized under the supervision of the Third Generation Partnership Project (3GPP). The 3GPP is made up of worldwide standards bodies from around the world. While W-CDMA is powerful and fast, it is also expensive to deploy. This expense has encouraged adoption of EDGE in rural areas and as a competitive alternative in some parts of the world.

The Basics of EDGE

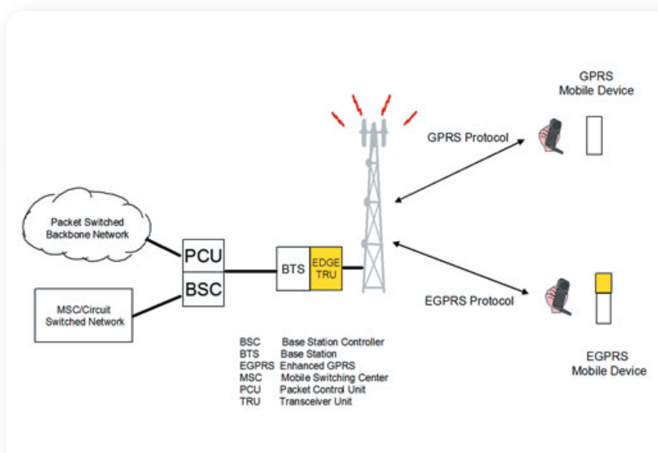
This section will review the technology and concepts of GPRS and EDGE from the air access interface perspective. In this technical brief, the terms BTS (Base Transceiver Station) and BSS (Base Station System) will be used interchangeably with base station.

Overview – The RF interface

From an air interface perspective, GSM and GPRS have the same RF interface. As mentioned earlier, the key difference in the migration from GSM to GPRS is in the core network.

GSM is based upon a circuit switched network. GPRS introduces packet-switched data network into GSM core networks. The packet-switched network is essential to support the data services required for Internet based applications. Internet data packet traffic may be based upon the IP (Internet Protocol) or the older X.25 protocol. Both protocols provide network addressing and the handling of data streams into smaller data packets. The GPRS air interface will dynamically allocate timeslots (resources) for voice and packet data channels.

EDGE introduces a new method to increase the data rate over the GSM/GPRS air interface. EDGE brings a new modulation technique and new channel coding that can be used to transmit both packet-switched and circuit-switched voice and data services (Figure 2). EDGE can be viewed as an “add on” to GPRS and the combination of EDGE and GPRS is referred to as EGPRS (Enhanced GPRS). GPRS and EGPRS also use different protocols on the base station side of the network. In this technical brief, we will continue to use the term EDGE to refer to an EGRPS enabled wireless network.

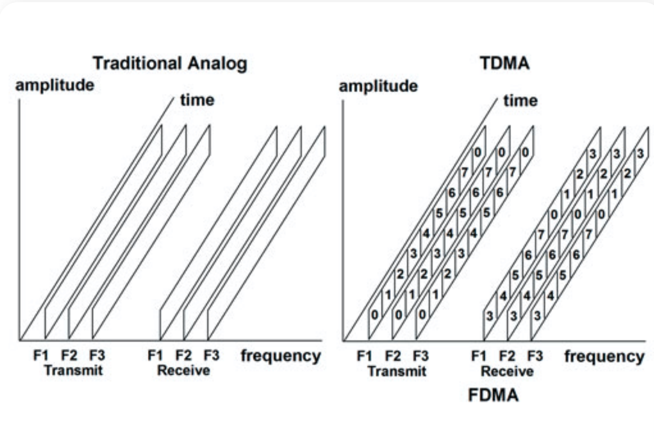


▶ **Figure 2.** EDGE incremental add-on to GPRS system.

Another advantage to EDGE is that it can be deployed by operators without W-CDMA RF spectrum licenses. EDGE is attractive in that it allows 3G coverage and performance in the existing 2G spectrum. EDGE provides an interim step in an overall strategy to deploy 3G technology. EDGE also provides a low cost alternative to W-CDMA, given the slow acceptance of the higher data rate services offered by W-CDMA. Both GPRS and EDGE provide the capability for the mobile device to maintain a continuous connection to the Internet. This aspect means that the mobile connection is "always on" and this must be accommodated by the RF air interface.

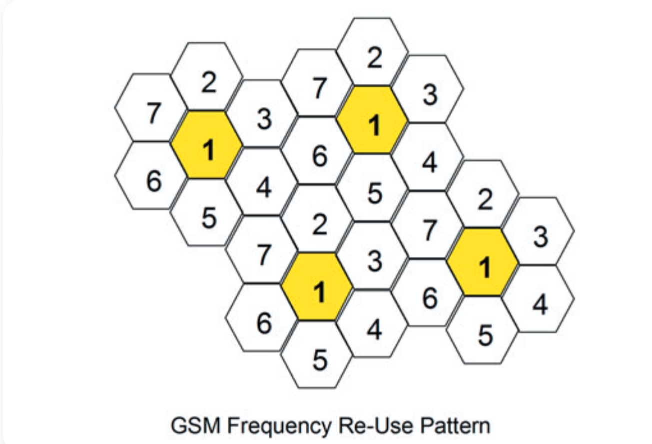
Frequency Reuse

Similar to GSM, GPRS uses an air interface scheme between the BTS and the cellular devices based upon a combination of FDMA (Frequency Division Multiple Access) and TDMA (Time Division Multiple Access) as shown in Figure 3.



▶ **Figure 3.** Comparison of TDMA and FDMA

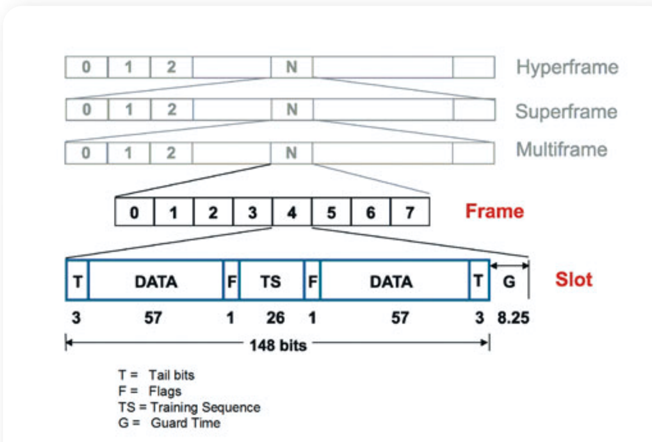
GSM/GPRS/EDGE systems in Europe operate in 900 and 1800 MHz bands and in systems in the United States operate in the 800 MHz (cellular) and 1900 MHz Personal Communications Services (PCS) bands. In engineering the coverage and placement for cell base stations, GSM/GPRS/EDGE cells use a 7-cell frequency reuse pattern for proper cellular coverage (Figure 4). The allocated bandwidth of 25 MHz is divided into 124 carrier frequencies spaced 200 kHz apart. One or more carrier frequencies are assigned to each base station. A different set of frequencies is used in each of the adjoining cells to minimize cell-to-cell interference. Within each cell, complete duplex pairs of frequencies are used to transmit to and receive from the mobile devices in the cell area.



▶ **Figure 4.** GSM, GPRS, and EDGE frequency reuse pattern.

Time slots, Bursts and Frames

For GSM, GPRS, and EDGE, TMDA divides the time of each physical RF radio transmission into 8 time slots or bursts of information. Eight time slots make up a frame, which forms the basic TDMA unit, and is in turn further multiplexed to form multiframe, superframe and hyperframe patterns (Figure 5). A time slot is 577 µsec long and is filled with 148 bits of data and 8.25 bits of guard space. The total length of a slot is 156.25 bits. Of the 156.25 bits, 114 bits may be dedicated to data. The data bits carry the voice and data information as well as the controlling and signaling information. The guard period of just over 30 µsec allows for the ramp down time of the current RF burst and ramp up for the next time slot burst.

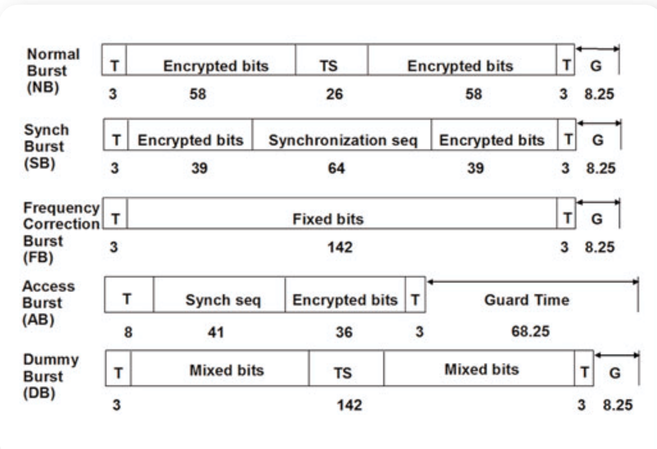


▶ **Figure 5.** Timeslot structure of GSM/GPRS/EDGE TDMA frames.

The training sequence (TS) has special significance. It serves two purposes, first to synchronize mobiles and base stations and second to provide an equalization function.

Since the training sequence is a precisely known bit sequence, the mobile device uses this sequence to adjust active equalization to better recover the training sequence. The same adjustment allows better recovery of the other data bits in the burst.

A GSM/GPRS/EDGE system uses five types of time slots, or bursts, as shown in Figure 6. A Normal Burst is used to carry information on the traffic and control channels and contains 116 bits of encrypted data (including 2 flag bits). A Sync Burst is used for time synchronization of a mobile device. It has a longer training sequence and information that includes the TDMA frame number and base station identity code.



▶ **Figure 6.** Time slot or burst types.

A Frequency Correction Burst is used for frequency synchronization of a mobile device. It is equivalent to an unmodulated carrier shifted in frequency. An Access Burst is a special burst that overcomes the problem of initiating a call from a mobile device at an unknown distance from the base station. This burst has a much longer guard time of 68.25 bits duration, approximately 252 ms. This means that the mobile device burst can arrive 252 ms late and still not interfere with other mobile transmissions in the next timeslot. This additional round trip time is equivalent round trip time is equivalent to a one-way distance of 33.2 km, making the maximum cell radius 33.2 km. The Access Burst is also used during hand-off.

A Dummy Burst is a burst that is transmitted over a channel when the channel is not in use. This is important in the BCCH channels, which are “always on”. All of the time slots of the BCCH frame must either be filled with traffic channels or filled with Dummy bursts. Idle channels (no signal) are not permitted in the BCCH channel.

A mobile physical channel within a cell site is defined by the combination of the frequency of the RF carrier and the timeslot number within a frame. On top of the physical channels, a series of logical channels are defined to perform a variety of functions, e.g., signaling, broadcast of general system information, synchronization, channel assignment, paging, etc. We will discuss these more later.

The channel allocation in GPRS and EDGE is different from the original GSM. GPRS/EDGE allows a single mobile station to transmit on multiple time slots of the same TDMA frame. This results in a very flexible channel allocation process; one to eight timeslots in the TDMA frame may be assigned to one mobile user. Additionally, the uplink and downlink timeslots are allocated separately, which allows for more efficient asymmetric data traffic, such as Web surfing. In GPRS/EDGE, the channels are only allocated when data packets are sent or received, and they are released after the transmission. With bursty data traffic, this more efficiently uses resources and permits multiple users to share one physical channel.

TDMA frames are combined to form three types of multi-frames. Traffic channels (TCH) use a 26-frame multiframe structure for traffic and associated control channels. Control channels (BCCH, etc.) use a 51-frame multiframe structure for broadcast and common control logical channels. Packet data channels use a 52-frame multiframe structure for packet data traffic and control channels.

Logical Channels in GPRS/EDGE

On top of the physical channels, a series of logical channels are defined for GPRS/EDGE. As with conventional GSM, they can be divided into two categories: traffic channels and control/signaling channels (Table 1).

Table 1. Selected Important Logical Channels in GSM/GPRS/EDGE

Group	Channel	Function
Traffic	TCH	Speech Channel or Circuit Switched Data Channel
	PDTCH	Packet Data Traffic Channel
Control/Signaling	FCCH	Frequency Correction Channel
	SCH	Synchronization Channel
	BCCH	Broadcast Control Channel
	PBCCH	Packet BCCH
Common Control	CCCH	Common Control Channel
	PCCH	Packet CCCH

The Broadcast Control Channel (BCCH) is an important logical channel, which provides general information about the local base station to the mobile devices. All mobile devices will first synchronize with the BCCH. Timeslot 0 of the frames containing the BCCH is reserved for the BCCH logical channel. The BCCH also indicates whether or not packet switched traffic is supported. If packet switched traffic is supported and if the Packet Broadcast Control Channel (PBCCH) exists, then the BCCH broadcasts the position of the packet data channel (PDCH) carrying the PBCCH. The Mobile Assisted Hand Off (MAHO) also monitors the BCCH power and is one of the reasons BCCH is "always on".

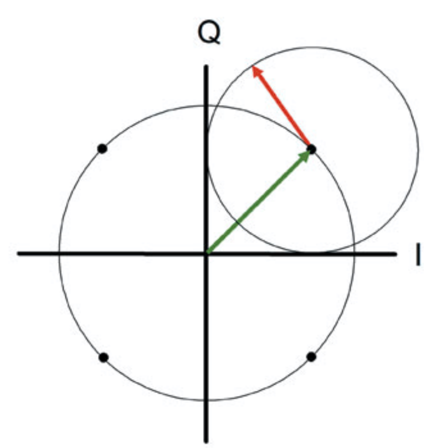
The Packet Broadcast Control Channel (PBCCH) is a unidirectional point-to–multipoint signaling channel from the base station to the mobile devices. It is used by the base station to broadcast specific information about the organization of the GPRS radio network to all GPRS devices within that cell base station. The PBCCH also reproduces the information transmitted on the BCCH to allow circuit switched operation, so that a GSM/GPRS/EDGE mobile device does not need to listen to the BCCH.

The Packet Common Control Channel (PCCH) is a bidirectional point-to-multipoint signaling channel that transports signaling information for network access management, such as allocation of radio resources and paging.

The coordination between circuit switched and packet switched logical channels is important. If the PCCCH is not available in a cell, a mobile device can use the common control channel (CCCH) of GSM to initiate the packet transfer. If the PBCCH is not available, the mobile device will listen to the BCCH to get informed about the radio network.

RF Modulation Method– GSM/GPRS

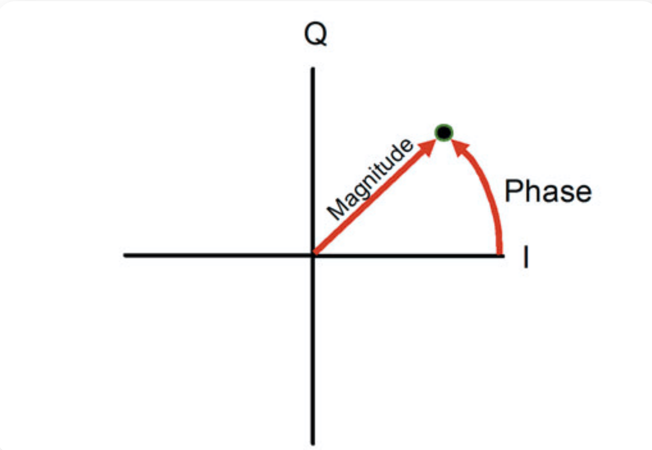
GSM and GPRS use a modulation method called GMSK (Gaussian Minimum Shift Keying) to encode the data stream information onto the RF signal. GSM and GPRS are designed to use a phase modulation method that transmits only one bit per phase shift. Positive shifts are encoded as a 1 and negative shifts are encoded as a 0. This design provides a very robust signal and benefits the reliability of the transmission in several ways. First, the amplitude of the signal never needs to change. Since the phase never changes 180 degrees, the vector path is never through the center of the I/Q diagram, and avoids a large amplitude change. This makes the transmitter and receiver much easier to design, less expensive and more robust. In addition, this modulation method has a high immunity to errors, as can be seen in Figure 7. The error vector can be quite large before there is a possibility of one bit being confused with another. The design tradeoff for this robust transmission method is a relatively low data transmission rate, which is more suited for voice communications only.



▶ **Figure 7.** GSM and GPRS GMSK Modulation Diagram

I/Q diagram

An I/Q diagram is useful to visualize the constellation of the digital modulation process (Figure 8). An I/Q diagram shows the real (I) and imaginary (Q) components of the transmitted signal. This represents the magnitude (amplitude) and phase of each symbol state on the modulation constellation.

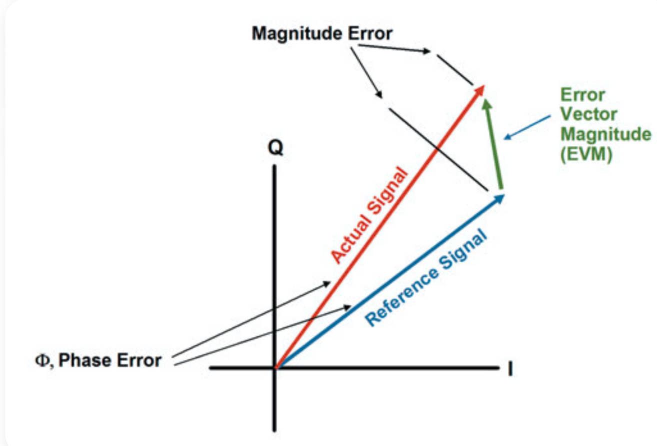


▶ **Figure 8.** I/Q diagram.

Digital modulation is often accomplished by phase and/or amplitude shifting. The phase and/or amplitude shifts can represent digital bits or symbols, encoded in the phase shifts.

Error Vector Magnitude (EVM) and Signal Quality

The transmitted signal from the base station is a GMSK modulation or the more complex 8-PSK modulation method. The symbols represented by the modulated signal need to be demodulated and decoded within discrete decision points in the constellation in order to be error free. Increasing degradation of a received RF signal, due to impairments such as interference or noise, may spread the points out until errors begin to occur. At the base station transmitter, modulation accuracy of the transmitter or distortion along the RF path may also cause the points to spread. EVM (Error Vector Magnitude) is a measurement which evaluates the signal quality. EVM is computed from the vector difference between the actual received signal and a calculated, ideal reference signal (Figure 9). The GPRS/EDGE standards specify the EVM tolerances.

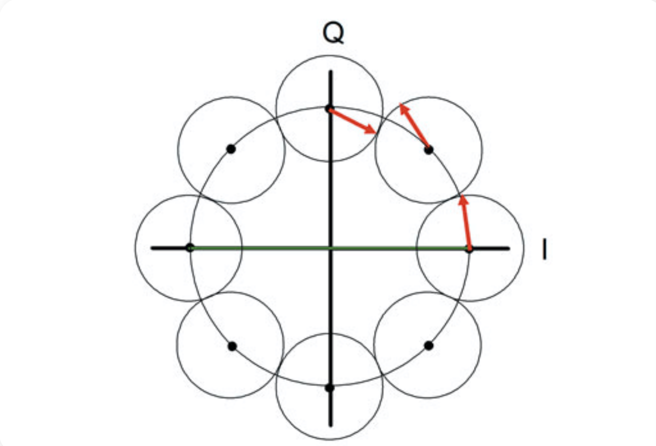


▶ **Figure 9.** EVM measurement concept.

Modulation Method - EDGE

To achieve higher bit rates per timeslot than GSM or GPRS, the modulation method in EDGE is modified to add 8 PSK (Phase Shift Keying). EDGE is specified to reuse the channel structure, channel width, channel coding and the existing mechanisms and functionality of GPRS. This makes it possible to integrate EDGE channels into an existing frequency plan and to assign new EDGE channels in the same way as GSM/GPRS channels.

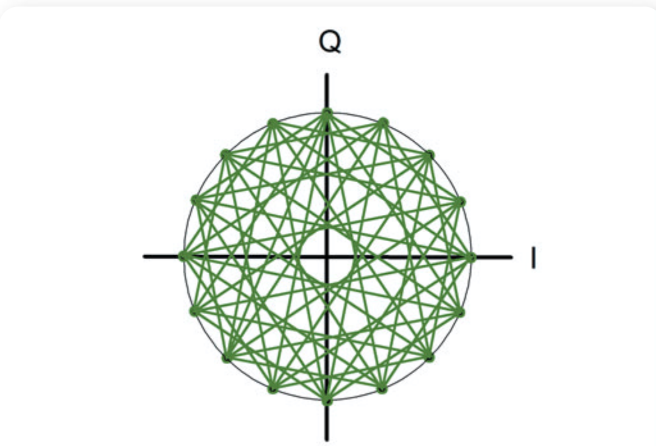
8-PSK allows 8 different phase shifts, which allow assignment of 3 bit data patterns to each of the 8 phase shifts (Figure 10). The data transmission rate has increased three times, however the transmission reliability has been reduced in several ways. First, the maximum permissible error vector has been reduced by half. Second, the effects of a decoding error are worse. Where GSM/GPRS signals would lose one bit if a single decoding error was made, 8-PSK signals would lose three bits for every decoding error. Lastly, the signal amplitude is no longer a constant. Rather than staying at constant amplitude, the modulated signal now needs to be able to reach any phase position from any starting point. This means that 8-PSK signals have large amplitude change, which stresses RF amplifiers and causes further distortion. Consequently, much more attention must be paid to distortion, signal quality, and interference. A design method for 8-PSK that reduces the large amplitude changes is 3–/8 rotation (see sidebar on page 8).



▶ **Figure 10.** 8-PSK modulation diagram.

3—/8 Phase Shift

In order to avoid large amplitude change in the modulated signal for 8-PSK modulation, a method was devised, which rotates the I/Q axis 1.5 data points, or 3—/8 radians between every phase shift (Figure 11).



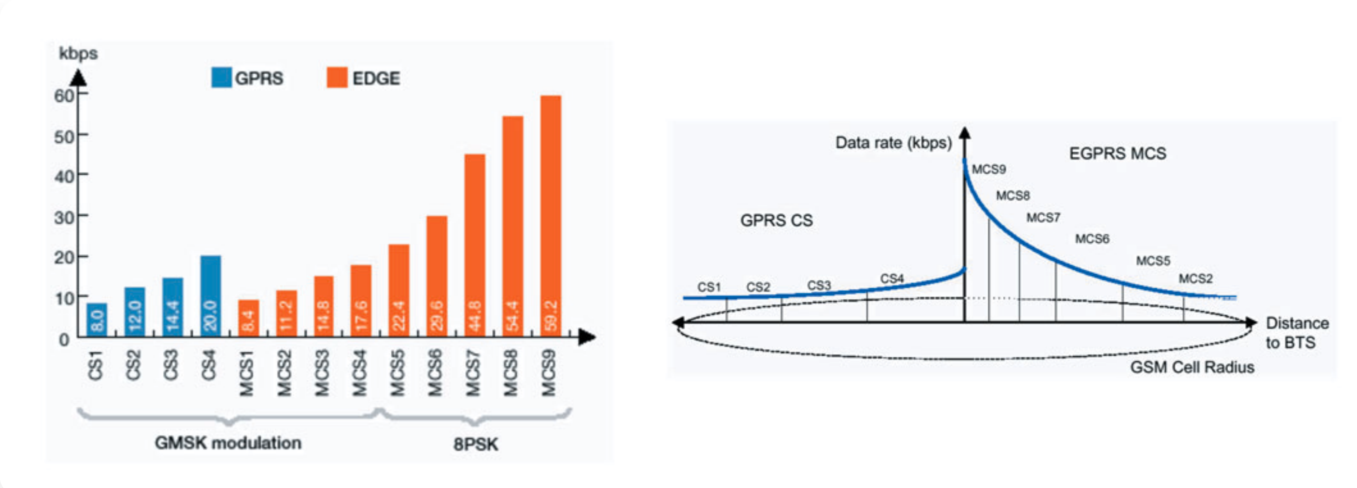
▶ **Figure 11.** 8-PSK modulation with 3_/8 phase shift.

Note in Figure 11 that the power does not go to zero. This lessens the stress on the RF amplifier. The rotation does not affect the maximum EVM (Error Vector Magnitude) allowable, however. Each transition still only has 8 possible destinations, so the max allowable EVM is still as shown in Figure 9.

Coding Schemes

The distance from the cell base station transmission antennae to the mobile device greatly affects the strength of the received signal, makes interference much more likely, and increases the potential for data errors to occur. The farther the mobile device is away from the cell tower and the stronger the interference, the lower the achievable data rate. A set of coding schemes has been devised; each with different amounts of error-correcting coding that is optimized for different radio environments. GPRS uses four different coding schemes, designated CS1 through CS4. EDGE has nine new modulation coding schemes, designated MCS1 through MCS9. The slower four, MCS1 to MCS4, use GMSK modulation and the faster five, use 8-PSK modulation (Figure 12).

The coding schemes have built in error correction, which increase their robustness. In Table 2, the column labeled “code rate” shows the amount of protection, or error correction, applied to the signal. Consider first MCS-1, which uses GMSK modulation and has the slowest data rate. It has a code rate of 0.53, which means that the error correction encoding slows the transmission down to 53% of the un-encoded rate. Another way of thinking of this is that 47% of the bits sent are error protection bits. Consider now MCS-5 and the modulation changes to 8-PSK, allowing 3 bits to be sent for every phase change. In addition, the code rate changes to 0.37, which means that 63% of the data sent is error correction bits. Lastly, consider MCS-9, the fastest data rate, zero error correction bits, and the least robust transmission rate (8-PSK). We need a very clean signal to achieve the data rate of 59.2 kbps.



▶ **Figure 12.** Comparison of distance from BTS, coding scheme, modulation type and data rate.

Table 2. EDGE/EGPRS Data Rates and Coding Schemes (adapted from 3GPP spec. TS 05.01, Nov 2001).

Coding Scheme	Code Rate	Modulation	Data Rate (kbps)
MCS-9	1.0		59.2
MCS-8	0.92		54.4
MCS-7	0.76	8PSK	44.8
MCS-6	0.49		29.6
MCS-5	0.37		22.4
MCS-4	1.0		17.6
MCS-3	0.85	GMSK	14.8
MCS-2	0.66		11.2
MCS-1	0.53		8.8

Dynamic Radio Environment

GSM and GPRS mobile devices monitor and measure the radio environment by analyzing the radio link for carrier strength and bit error rate. The addition of EDGE now increases the data rates as well as increasing the suscepti-bility for errors by decreasing the margins for error. Therefore, the radio link analysis must occur even more quickly, in order for the system to be able to react quickly to changes in the radio environment. EDGE uses a combination of link adaptation and incremental redundancy to significantly improve this performance.

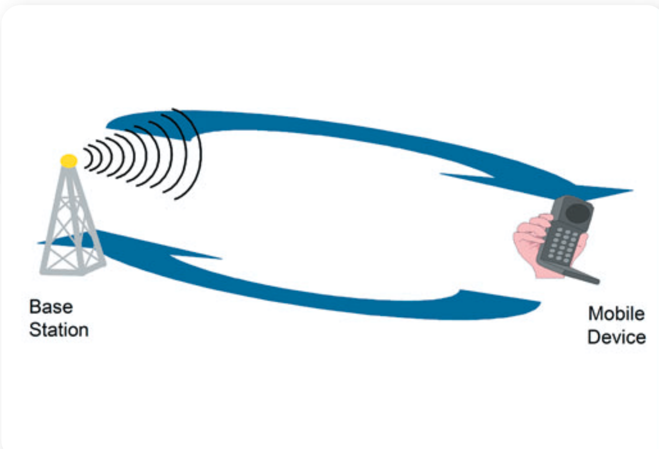
Link adaptation uses the radio link quality, measured either by the mobile device downlink or by the base station uplink, to select the most suitable modulation coding scheme to use for transmission of the next sequence of data frames or packets. As the radio link quality varies, the base station communicates to the mobile device which coding scheme to use for transmission of the next sequence of data.

In addition to the link adaptation, a process that does not use the radio link quality information is incremental redundancy. For a particular coding scheme, very little error protection is initially used. When information is received incorrectly, additional coding is transmitted until the information is successfully decoded. The additional coding is then removed.

RF Power Control

RF power levels are a critical part of the optimal operation of the cellular system. As an option, the base station can utilize downlink RF power control. In addition to the static RF power that is designed for the base station, the base station may support for each modulation method up to 15 steps of power control levels with a step size of 2 dB ± 1.5 dB, in addition the actual absolute output power.

The mobile device monitors the received power of the RF downlink signal transmitted by the base station. The mobile device communicates the power information back via the uplink. RF power control is used to minimize the transmit power required by the mobile device of the base station, while ensuring the quality of the radio links. By minimizing the transmit power levels, interference among co-channel users can be reduced. For circuit-switched services, the base station controls the power level to be used by the mobile device. For packet services (GPRS/EDGE), the mobile device controls the process, since the packet data transmission is not constant.



▶ **Figure 13.** Power Control

The mobile device computes the power to be used on each of the uplink data channels. This is dependent upon the power control parameters set by the network and is a function of the maximum power allowed in the cell, the mobile device power class, and the received signal strength. The uplink Access Bursts are the exception, which transmit at maximum power.

Hand offs

When a user moves from the coverage area defining one cell into that of another, the system must provide the capability for that user to remain connected, even while breaking the connection with one base station and establishing another connection with another base station. This operation is called a hand off. In GSM/GPRS/EDGE cellular systems, this is a hard hand off, where the air link connection between the mobile device and the current serving base station are momentarily severed before reconnecting with a new base station.

In a Mobile Assisted Hand Off (MAHO), the mobile device participates but does not control the hand off. A decision process is used to determine when the hand off should occur, based on factors such as the received power level and signal quality. Once predetermined threshold values have been exceeded, indicating that the edge of cell coverage has been reached, the mobile switching center decides which base station to hand off to. Throughout this process, the mobile device measures the receive power levels from base stations (the BCCH channel is “always on”) on the neighbor list and reports this to the network.

Measurement Issues and Challenges

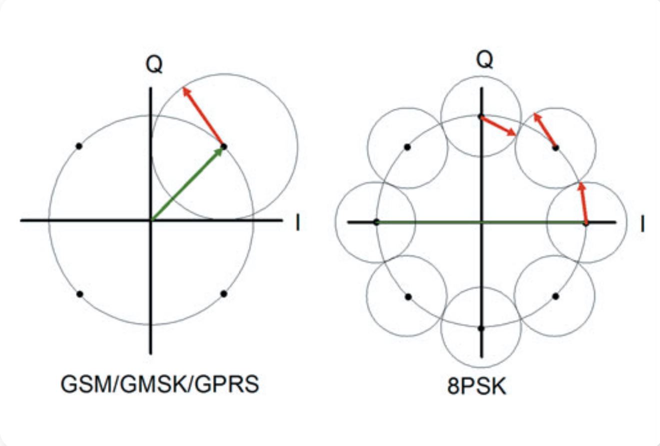
The challenge of the network operations manager is to deliver high Quality of Service (QoS) consistently and cost effectively. QoS, as experienced by the mobile device user, is evaluated on the basis of parameters such as dropped calls, blocked calls, lack of signal, and slow data throughput.

In the case of EDGE, the main risk is not that the call will be dropped. Instead, as the signal quality declines, the user is moved to slower and slower data rates. Frustration on the part of the mobile user will increase and their interest in the service will decrease. The higher the received signal quality, the higher the data rate can be. Of great importance, then, is measuring and analyzing the signal quality. This requires evaluation of signal quality by measuring the EVM (Error Vector Magnitude) routinely and keeping it at the best possible level. This is very important in EDGE systems.

Error Vector Magnitude (EVM) and Signal Quality

As described before, EVM (Error Vector Magnitude) is a useful measure of distortion in phase modulated signal such as GMSK and 8-PSK signals.

By design, GSM using GMSK modulation has a very robust signal and has a high immunity to phase errors. GMSK has a large error vector margin and if an error does occur, then only 1 bit per phase error is lost. Due to the robustness of GSM, there is less need to test. The trade-off for robustness is a low data rate that is suited to voice only communications.



▶ **Figure 14.** Comparison of EVM margin in GMSK and 8-PSK.

With the higher speed EDGE transmissions using 8-PSK, the error vector margin is reduced and therefore the probability of errors occurring is greatly increased. Note that both the phase and amplitude of the 8-PSK signal are changing. This means that 8-PSK signals have large amplitude changes, which stress RF amplifiers and cause further distortion. If a symbol decoding error does occur in 8-PSK, then there are 3 bit errors that result. 8-PSK has tighter EVM specifications and EVM measurements become more critical. Consequently, in order to maintain the faster data rates for mobile users, much more attention must be paid to distortion, signal quality, and interference.

In-the-field measurements of base station transmitted RF signals and other possibly interfering RF signals, provide much of the basic information needed to evaluate Quality of Service. To ensure that the GSM/GRPS/EDGE system is running within specification, it is necessary to measure and evaluate the RF transmitted signal and the parameters that we have discussed.

A summary of key field maintenance measurements and the base station transmitter parameters being measured to ensure the ongoing Quality of Service of a cellular system are described in Table 3.

Table 3. Field maintenance measurements summary.

Group	Channel	Function
RF Output Power	BCCH Channel Power and Traffic Channel Power - Time Slot Aware	Indicator of health of base station & power budget. Time slot leveling is important for optimum performance.
RF Output Power	Power versus Time	Indicator of amplifier issues, modulation problems, co-channel interference, or timing issues.
RF Power Interference	Spectrogram, Signal Strength, Noise Floor	Analysis of intermittent interfering RF signals.
RF Frequency	Frequency and Error	Finding transmitter faults and mis-configurations.
RF Frequency	Occupied Bandwidth	Excessive bandwidth contributes to noise in other RF carriers, lowering system call capacity.
Signal Quality	EVM (Error Vector Magnitude)	Degradation in quality contributes to lower data rates, dropped calls and lower system capacity.
Signal Quality	Phase Error	Indicates phase instability of received signal.
Signal Quality	Origin Offset	Indicator of faulty modulators in the radio unit.
Signal Quality	C/I	In-Service measurement indicating co-channel or off-channel interference.

Overview of the NetTek

▶ **Figure 15.** The Tektronix NetTek®

The Tektronix NetTek YBT250, option EM1, field transmitter and interference tester is optimized to provide the right set of tests for field maintenance technicians and RF engineers to maintain and troubleshoot GSM/GPRS/EDGE base stations. A series of basic Pass/Fail tests summarizes BTS performance and pinpoints problems. In addition, in-depth tests are a great help for those more difficult problems. Measurements can be made by either connecting the analyzer directly to the base station or by making over-the-air (OTA) measurements. OTA measurements evaluate received signals for unwanted interference, as well perform first level performance "wellness" checks.

The Tektronix NetTek YBT250, option IN1 Interference Analyst is a superb tool for identifying and locating sources of interference. A detailed analysis and application study can be found in Tektronix application notes, "Hunting for Sources of Interference in Mobile Networks", publication number 2GW-14759-0, and "Fundamentals of Interference in Mobile Networks", publication number 2GW-14758-0.

In addition to the RF and demodulation testing, the Tektronix NetTek YBA250 BTS Antenna and Transmission Line Analyzer provides the tools necessary for fast identification and easy location of base station antenna and transmission line trouble.

The package is designed to be rugged, modular and easy-to-use. It is purpose built specifically for the base station technician and field RF engineers. Traditional, larger, dedicated test instrumentation is too costly, heavy and complicated to use in practical applications in the field. The Tektronix NetTek is a comprehensive one "toolbox" approach needed for RF transmitter maintenance, with specific measurements for W-CDMA/UMTS, CDMA, GSM, TDMA, and analog systems.

Conclusion

In the field measurements of the base station transmitted RF signal and the surrounding environment provide key information to evaluate QoS. Traditionally, these tests have been performed either by complex compliance testers, which can be difficult to use, or very simple testers, such as area testers, which can spot some problems, but are not so useful when it is time to fix the problems. A better, more cost effective alternative would be a test set designed for field conditions with just the right set of tools, or measurements, to get the job done quickly. This tester would combine measurements normally acquired from several discrete, conventional instruments into a "Tool Box" containing the commonly used measurements for GSM/GPRS/EDGE base stations. The Tektronix NetTek provides this capability.

In this technical brief, we have reviewed GPRS and EDGE wireless networks and the air interface of GPRS/EDGE base stations. We looked at the evolving cellular technologies from an RF perspective. We then described some of the testing challenges and finished with a consideration of ideal field maintenance test tools for GSM/GPRS/EDGE base station technicians.

Appendix

3GPP	Third-Generation Partnership Project
8-PSK	Eight – Phase Shift Keying
AMPS	Advanced Mobile Phone Service
ARIB	Association for Radio Industry and Business (Japan)
BCCH	Broadcast Control Channel
BSS	Base Station Subsystem
BTS	Base Transceiver Station
CCCH	Common Control Channel
CCITT	Committee Consultative International Telephone and Telegraph
EDGE	Enhanced Data rates for Global Evolution
EGPRS	Enhanced General Packet Radio Service
EMI	Electro-Magnetic Interference
ETSI	European Telecommunications Standardization Institute
EVM	Error Vector Magnitude
FCCH	Frequency Correction Channel
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
GMSK	Gaussian Minimum Shift Keying
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
IMT-2000	International Mobile Telecommunication 2000
IS	Interim Standard
ITU	International Telecommunications Union
MAHO	Mobile Assisted Hand Off
NADC	North America Digital Cellular
NMT	Nordic Mobile Telephone
PCS	Personal Communications Service
PDC	Personal Digital Cellular (Japan)
PDTCH	Packet Data Traffic Channel
OTA	Over-The-Air
PBCCH	Packet Broadcast Control Channel
PCCH	Packet Common Control Channel
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
SCH	Synchronization Channel
TCH	Traffic Channel
TIA	Telecommunications Industry Association
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TS-CDMA	Time Synchronous Code Division Multiple Access
UMTS	Universal Mobile Telephone System (Europe)
UTRA	UMTS Terrestrial Radio Access
W-CDMA	Wideband Code Division Multiple Access

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