

# Pager Testing with a Specially Equipped Signal Generator

Matthew W. Bellis

This paper reviews current trends in the paging industry, describes typical pager designs, presents the test requirements of modern pagers, and discusses the contribution to pager testing of the HP 8648A signal generator with Option 1EP, the pager signaling option.

**T**oday there are over 88 million subscribers of paging services throughout the world. By the year 2000, the number of subscribers is expected to grow to over 140 million. To meet this demand, pager manufacturers will need to produce over 30 million pagers per year. This makes pagers one of the leading RF devices in production today.

The design and testing of pagers from concept to production requires sophisticated test equipment. In addition to the typical RF measurements, a paging signal is required to test the finished product. This article will review modern paging formats, typical pager designs, and methods for testing pagers.

## Paging Review

A paging network (see **Figure 1**) begins at the connection to the public switched network or telephone lines. The caller can initiate a page through voice mail or a paging operator, or can leave a message by entering touchtones from a telephone. Pages are assembled in the paging terminal and sent to the network controller, where they are combined into batches based on their final destination. Billing and management are also controlled at this point.

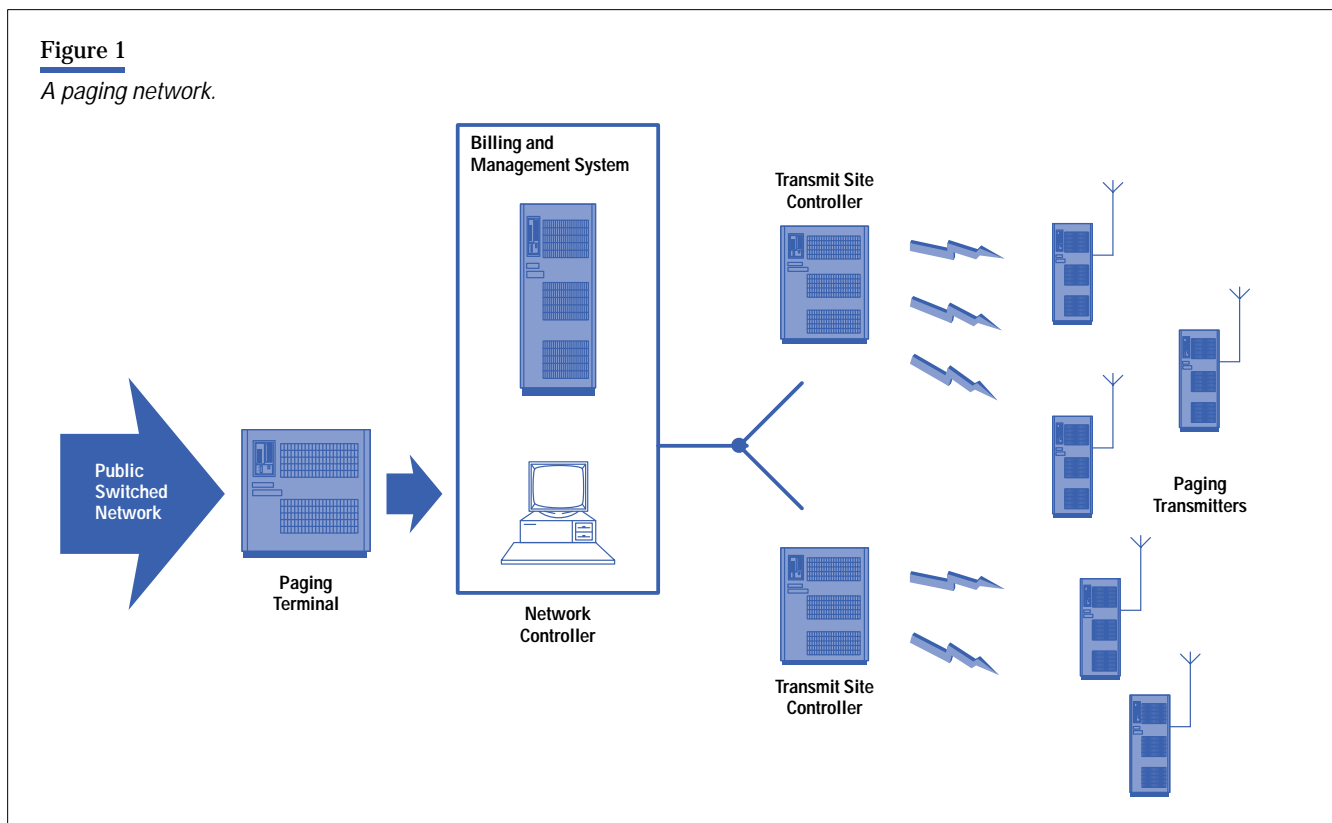
Many paging companies cover more than just one geographical area. For example, the company may serve an entire state or even country. The network controller specifies the site controllers for which the batched messages are intended and sends them out. Each site, covering a particular geographical location, can contain one or more paging transmitters. Once the site controller receives the batch of pages, it uplinks them to the paging transmitters, which

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**Figure 1**

*A paging network.*



then transmit the batch of pages at the same time on the same frequency using a simulcast technique. Simulcast means that two or more transmitters are used to transmit identical information at the same time. This allows the system to provide seamless coverage on a single frequency.

Many different types of paging formats are currently in use. The most common and only worldwide standard at this time is POCSAG (Post Office Code Standardization Advisory Group), also known as RPC1. The digital formats currently under development are FLEX (a Motorola trademark), ERMES (European Radio Message System), and FLEX-TD (RCR-43). FLEX is receiving worldwide attention and has been implemented in North America, China, Indonesia, Singapore, and Thailand. ERMES is intended mainly for use in Europe. Japan has developed its own paging format, FLEX-TD, which is based on FLEX.

**Table I** shows a comparison of some of the main characteristics of current paging formats. A bit more detail regarding the protocol of each format is given in the following paragraphs. Probably the most important reason for the creation of the newer digital formats is the ability to send more information, faster, to more people.

#### POCSAG

POCSAG, Post Office Code Standardization Advisory Group, is a digital paging scheme that was developed by British Telecom to provide a standard signaling format for the United Kingdom. POCSAG is the most common paging format in use today.

POCSAG is an asynchronous paging scheme with a preamble (see **Figure 2**). Paging base stations transmit pages simultaneously within a service area. Messages are sent in batches and each pager address is located in a specific frame within a batch. Within the assigned frame, the pager will look for a message. Messages can exceed one frame, in which case the

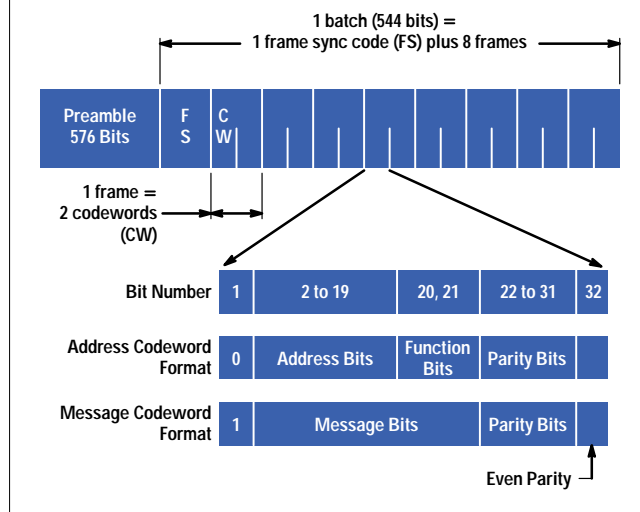
**Table I**

*Characteristics of Current Paging Formats*

Protocol	Data Rate (bits/s, forward/reverse)	Channel (kHz, forward/reverse)	Modulation	Timing	Applications
POCSAG	2400	25	2-FSK	Asynchronous	One-way
FLEX	6400	25	2- or 4-FSK	Synchronous	One-way
ReFLEX-25	6400/9600	25/12.5	2- or 4-FSK	Synchronous	Two-way
ReFLEX-50	6400/9600	50/12.5	2- or 4-FSK	Synchronous	Two-way
InFLEXion	6400/9600	50/12.5	2- or 4-FSK	Synchronous	Two-way and voice messaging
FLEX-TD	6400	25	2- or 4-FSK	Synchronous	One-way, Japanese version of FLEX
ERMES	6250		4-FSK	Synchronous	One-way, European standard
pACT				Synchronous	Two-way

**Figure 2**

*POCSAG paging format.*



message is continued in the following frame. Either five numeric or 2.8 alpha characters can be sent in a message codeword. This means that for a numeric pager to receive a caller's 10-digit phone number, two message codewords must be sent following the pager's address codeword.

The pager, after detecting the preamble and synchronizing to the frame sync word, turns off its receiver circuits until the proper frame appears—this increases the life of the pager battery. POCSAG pagers support tone, numeric, and alphanumeric messages. Voice is not supported.

POCSAG uses frequency-shift keying (FSK), a simple form of digital modulation. FSK offers good noise immunity and is inexpensive to generate. However, FSK is not suitable for high-data-rate transmission.

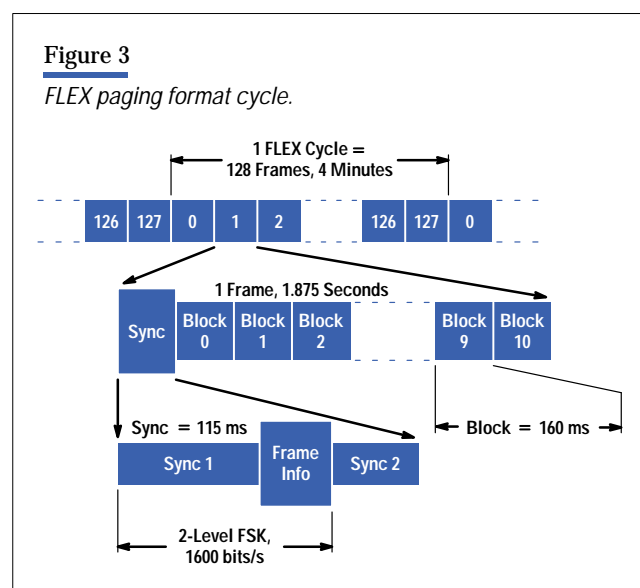
**Table II** shows typical specifications for a POCSAG pager. These specifications are warranted by the manufacturer and many are verified during production of the pager. Several of these specifications are indirectly verified or are verified by design.

Code Format	POCSAG
Channel Spacing	25 kHz
Frequency Deviation	± 4.5 kHz
Paging Sensitivity	5 µV/m for 1200 bits/s
Spurious and Image Rejection	60 dBc
EIA Selectivity	65 dB at ± 25 kHz
Frequency Stability	± 0.002% of reference
Power Consumption	3.75 mA (0.383 mA standby) for 1200 bits/s
Battery Life	> 2100 hours (1200 bits/s)

#### FLEX Family

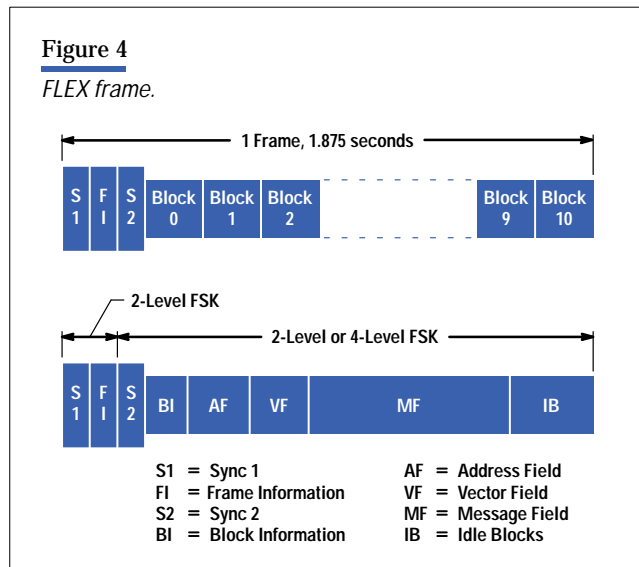
In many areas there is growing demand for increased capacity because existing systems are reaching their maximum capacity. There is also a demand for more sophisticated messaging capability. To meet this demand, Motorola introduced the FLEX family of paging protocols. The FLEX family consists of an enhanced one-way paging protocol, FLEX, and three two-way paging protocols, ReFLEX-25, ReFLEX-50, and InFLEXion. In addition to two-way messaging, InFLEXion also supports voice messaging.

FLEX is a synchronous protocol that assigns pagers to frames (see **Figure 3**). These frames occur at a rate of 128 every four minutes. One FLEX cycle equals 128 frames. There are 15 FLEX cycles per hour. Each pager is assigned to look at a particular frame (or frames) within a FLEX cycle. Upon power-on, the pager synchronizes with the FLEX network. During synchronization, network timing information is passed to the pager. The synchronization information is used to determine the pager's assigned frames. Thereafter, the pager will only turn on its receiver circuitry during the assigned frames.



This feature of FLEX results in improved pager battery life since it eliminates the need for preamble detection. The frame assignment for a pager is configured in the pager or determined from information within the paging signal.

Each frame (**Figure 4**) is 1.875 seconds long and consists of a sync field and 11 blocks. The sync information takes up 115 ms and is composed of three parts: sync 1, frame information, and sync 2. The first two parts are always transmitted at 1600 bits/s using 2-level FSK. Sync 1 provides timing information and an indication of the speed of the rest of the frame. The frame information word contains the frame number (0 to 127), the cycle number (0 to 14), and other information. Sync 2 provides synchronization at the frame's block speed so the remainder of the frame can be properly decoded.



The information that is transmitted within a FLEX frame is shown in **Figure 4**. The fields are not constrained by block boundaries. The fields that are transmitted in a frame are a block information field, an address field, a vector field, a message field, and idle blocks.

The block information field is typically one word long and contains information that indicates where in the frame the address and vector fields start, frame information from the system as discussed above, and the number of priority addresses placed at the beginning of the address field. Priority addresses are assigned to pagers with an urgent priority.

The system collapse value is also contained in the block information field. The collapse concept enables service providers to better manage their paging networks. The pager's assigned frame is represented by a seven-bit word (any number from zero to 127 can be represented by a seven-bit binary word). The system collapse value, or collapse cycle, instructs pagers to mask one or more of the address bits. For example, if the collapse cycle is set to three, the pager will mask all but the three least-significant bits of its assigned frame and the current frame being transmitted. When the collapse cycle is three, the pager will monitor one out of eight frames instead of one out of 128 frames. Thus, the 128-frame cycle ( $2^7$ ) is collapsed to an eight-frame cycle ( $2^3$ ). In addition to the system collapse cycle, the pager has a default collapse cycle. During operation, the collapse cycle in effect will be the lesser of the system collapse cycle and the pager collapse cycle.

The address field contains addresses of the pagers that are being paged during this frame time. The vector field has a one-to-one relationship with the address field, so the pager knows where to look for the vector. The vector points to the start word of the message and indicates the length of the message, again so the pager knows where its message occurs. The vector field also indicates the type of message. FLEX supports several types of messages (see **Table III**). The type of

**Table III**

*Common FLEX Message Types*

Vector Type	Description
Numeric Vector	The received message should be displayed as a number.
Numeric Vector with Format (Special)	Special formatting should be applied to the message. For example, the parentheses and dashes normally displayed in a telephone number are added by the pager and not sent over the channel. This saves one message word.
Alphanumeric Vector	The received message should be displayed as alphanumeric.
Hex/Binary Vector	Starting with the third word in the message field, each four-bit field represents one of sixteen combinations. This vector type is selected when transmitting Chinese characters. Several four-bit fields are combined to represent a character.
Numeric Vector with Message Number	In addition to receiving a message, a number is assigned to the transmitted message. This number can be used by the pager (or subscriber) to identify missed messages.

message indicates how the bits within the message field should be grouped and decoded to recover the information being transmitted.

The message field follows the vector field. Any unused blocks in a frame are filled with bits representing idle: alternating 1s and 0s at 1600 bits/s. At higher speeds, the symbols, adjusted for the speed and modulation format, must represent that same pattern.

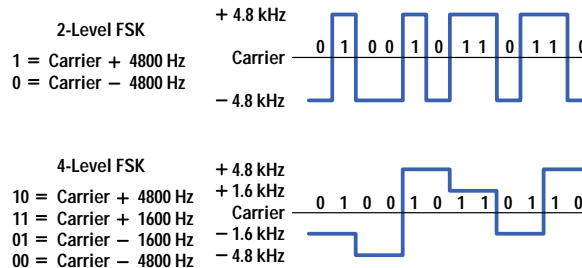
The FLEX protocol can be transmitted at three different speeds: 1600, 3200, or 6400 bits per second. FLEX pagers can operate at any of the three speeds. FLEX pagers automatically decode the correct signaling speed based on information from the paging signal (located in the sync word).

FLEX uses two-level and four-level FSK to achieve the various data rates. **Figure 5** indicates the frequency deviations and bit assignments. Four-level FSK, a more complex modulation format, enables FLEX to operate at higher data rates.

Some typical test specifications are listed in **Table IV**. Many of these specifications are verified during production of the pagers or are verified by design.

**Figure 5**

*Two-level and four-level frequency-shift keying (FSK) in the FLEX protocol.*



**Table IV**

*Typical Specifications for a FLEX Pager*

Code Format	FLEX
Channel Spacing	25 kHz
Frequency Deviation	$\pm 4.8$ kHz
Paging Sensitivity	20 $\mu$ V/m for 6400 bits/s
Spurious and Image Rejection	50 dBc
EIA Selectivity	55 dB at $\pm 15$ kHz
Frequency Stability	$\pm 0.02$ ppm of reference
Battery Life	> 10,000 hours (6400 bits/s)

### Typical Pager Design

The top-level block diagram of a pager is fairly simple (see **Figure 6**). Pagers have receiving circuitry, digital decoding circuitry, and the devices that alert the subscriber and display a message.

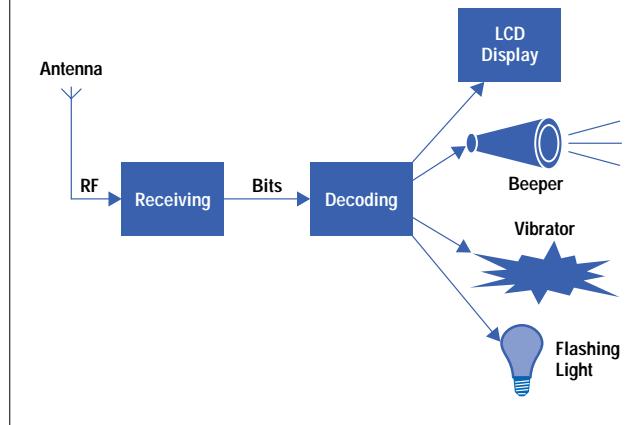
The receiving section demodulates the data from the RF carrier and passes the data to the decoding section. The decoder then looks at the data and decides whether the information being received is for the subscriber. If so, that information is displayed on the pager and the subscriber is alerted by the selected means: beep, vibration, or flashing light.

Throughout the design process, testing of each section of the pager is required. In addition, designs must be able to withstand reasonable manufacturing tolerances and still meet specifications. During production, testing is done primarily to ensure functional operation and compliance with sensitivity specifications.

Most pager receivers are double-downconversion superheterodyne receivers, as shown in **Figure 7**. A loop antenna is used to couple the incoming RF. The coupling is primarily magnetic. The incoming RF signal is filtered to remove unwanted out-of-band signals. Two IF filters are employed, but the second IF filter often determines the selectivity of the receiver. After the second IF filter, an FM detector extracts the FSK signal. An analog-to-digital converter (ADC) is used to convert the analog waveform to a series of digital words that are processed to recover the information. Often, the RF antenna, the preselector, the first mixer, and the first local oscillator (LO) contain variable components that must be adjusted during production. Components used after the first mixer are generally fixed (e.g., ceramic filters, demodulators) and do not require adjustment. Most manufacturing testing is done because of the adjustable components that are in the pager receiver section.

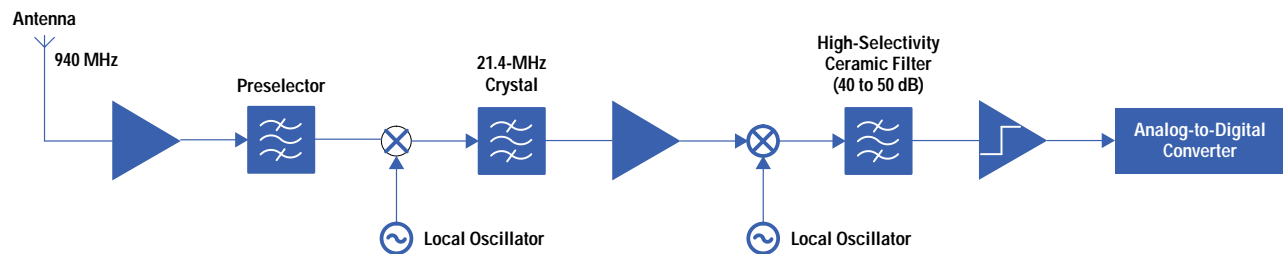
**Figure 6**

*Top-level block diagram of a pager.*



**Figure 7**

*Double-downconversion superheterodyne pager receiver.*



This type of design produces highly sensitive pagers whose specifications can be maintained during high-volume production. However, high levels of integration are difficult to achieve with the above design. Recently, receiver architectures using image-reject mixers and direct downconversion have been introduced with performance equal to double-downconversion receivers. Because these designs use fewer filters, oscillators, and mixers, higher levels of integration are more easily achieved.

#### Pager Testing with the HP 8648A Signal Generator

The HP 8648A Option 1EP synthesized signal generator incorporates the necessary protocol to test POCSAG, FLEX, and FLEX-TD pagers. In addition, the HP 8648A includes an arbitrary message that can be used to create user-defined POCSAG bursts or FLEX and FLEX-TD frames or cycles. The use of the arbitrary message allows sophisticated users access to all of the features supported by POCSAG, FLEX, and FLEX-TD.

#### Pager Tests

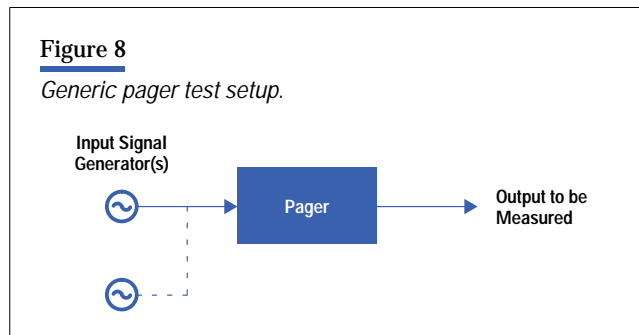
A variety of testing is done during the design and production of pagers. The following list, although not exhaustive, covers much of the testing:

- Preselector alignment
- Oscillator tuning



- Sensitivity
- Adjacent channel selectivity
- Functional.

The first four tests are primarily RF tests. Functional testing of the pager is a system-level test. All testing is done with the same basic test setup (see **Figure 8**). A pager is placed in some type of RF isolation, one or more inputs signals are applied, and the parameter of interest is measured.



**Preselector Alignment.** Many pager designs use adjustable components in the preselector section of the receiver. The receiver of a popular POCSAG pager, for example, has one tunable capacitor (2 pF to 10 pF) and three tunable inductors (two 3-turn and one 17-turn). These components are adjusted during testing. For example, if the pager is designed to operate at 929.1125 MHz with a 25-kHz channel width, the components in the preselector will be adjusted to filter out frequencies outside of this channel.

For this test, a signal generator outputs a paging signal (for example, a four-level FSK signal for a FLEX pager) at the channel frequency (for example, 929.1125 MHz). The adjustable components—the variable capacitor and inductors—are adjusted to maximize the received signal strength after the amplifier. Many pager designs have a test point where a voltage level that is proportional to the received signal strength can be measured. For these designs a voltmeter can be used to verify that the preselector has been properly aligned.

Often during design a spectrum analyzer is used to ensure that the spectrum of the signal is properly passed. The received signal strength can be viewed directly on the spectrum analyzer by adjusting the center frequency of the spectrum analyzer to the desired channel (for example, 929.1125 MHz) and setting the span to at least the channel width (for example, 25 kHz). The spectrum analyzer also displays any asymmetry in the preselector filter shape. The amplitude levels of the FSK sidelobes should be of equal height. Sidelobes that are of unequal height indicate that the preselector filter shape needs to be adjusted.

**Oscillator Tuning.** After adjusting the preselector to the appropriate channel, the local oscillator (LO) needs to be adjusted to downconvert the RF signal to the correct intermediate frequency (IF). Many pager designs incorporate a variable inductor into the oscillator design. A simple method of tuning is to connect a frequency counter at the IF output of the first mixer and adjust the oscillator value until the counter reads the proper IF frequency. The signal generator must provide a sine wave at the required channel frequency (for example, 929.1125 MHz).

This is an inexpensive solution. However, the counter requires a filter to remove unwanted mixing products and generally requires a preamplifier to raise the signal level to the detection threshold. For designs that use a fixed IF filter, the measurement can be made at the IF filter output. This eliminates the need for an external filter at the counter input. A spectrum analyzer can be used instead of a frequency counter. The spectrum analyzer is frequency selective and has greater sensitivity. This eliminates the need for an external filter and a preamplifier.

Some manufacturers use laser trimming to adjust the LO frequency. In laser trimming, a YAG laser is aimed at a laser trimmable component (usually a capacitor). The capacitor is generally a multilayer ceramic capacitor. The energy from the YAG laser removes metal and ceramic material from the capacitor. The removal of material changes the value of the capacitor and thus changes the LO frequency.

Laser trimming systems require an automated system that shuts off the laser at the proper time. In an automated system, an input signal is applied and the LO is tuned while the received signal strength at the first IF is monitored. When the received signal strength reaches the specified level, the YAG laser is shut down.

**Sensitivity.** Once the pager has been properly aligned and tuned, the sensitivity of the pager can be measured. Perhaps the most important specification for a pager is the receiver sensitivity. The receiver sensitivity determines the ability of the pager to receive low-level signals properly. A pager with poor sensitivity will not detect messages reliably, resulting in unhappy customers.

Sensitivity specifications are usually in microvolts per meter ( $\mu\text{V/m}$ ). A sensitivity measurement must be made with a calibrated, known field strength. To achieve this, the pager is placed in an RF isolation enclosure, typically a TEM cell,\* screen room, or isolation chamber. A signal generator is attached to the enclosure. The field strength generated inside the enclosure should be uniform. Bit error rate (BER) is usually the performance measure for receivers of digitally modulated signals. The sensitivity of a pager is formally defined as the minimum signal level that produces a specified BER. In practice, however, less cumbersome measurements are often substituted for BER.

The 9-of-10 method is a common technique for measuring sensitivity. In this method, the signal generator output is set to the sensitivity of the pager. Ten pages are sent. To pass, at least nine of the ten pages should be received. When using a TEM cell, the pager should be oriented to achieve the maximum sensitivity reading. Other techniques involve varying the orientation of the pager with respect to the incoming paging signal.

A second technique, known as the 3/20 method, is more involved. In the 3/20 method, the pager is placed inside a TEM cell. The measurement begins with the pager placed in the upright position inside the TEM cell. A total of eight measurements are made, with the pager rotated 45 degrees for each measurement. The sensitivity of the pager, in  $\mu\text{V/m}$ , is recorded at each orientation.

To obtain the pager sensitivity at each orientation, three consecutive pages are sent. If the pager responds to all three, the output power is reduced by 1 dB and three more pages are sent. The output power is gradually reduced to the lowest level that triggers a response on each of the three successive pages. The output field strength is recorded as  $E_{3p}$ .

The output power is then further reduced by 1 dB, and twenty pages are sent. If three successive pages are received, the output power is reduced by 1 dB. If no pages are received, the output power is increased by 1 dB. Otherwise, the output power remains the same. The output field strength is recorded as  $E_{20p}$ .

The pager sensitivity at each orientation is the average of  $E_{3p}$  and  $E_{20p}$ :

$$E_n = \frac{E_{3p} + E_{20p}}{2},$$

where  $n = 1, 2, \dots, 8$  identifies the orientation. The overall pager sensitivity is calculated as:

$$E_{\text{sens}} = \sqrt{\frac{8}{\sum_{n=1}^8 1/E_n^2}}.$$

\* A TEM cell provides electromagnetic isolation. Radiation propagating within the cell is largely confined to the transverse electromagnetic (TEM) mode.

Adjacent Channel Selectivity. Most pager designs have tight requirements, on the order of 65 dB, for adjacent channel selectivity. The adjacent channel selectivity of a pager receiver is a measure of the receiver's ability to receive a modulated input signal on its assigned channel frequency in the presence of a second modulated signal in the adjacent channel ( $\pm 25$  kHz). Again, the standard performance measure is BER. Two signal generators are needed to measure adjacent channel selectivity accurately. One signal generator provides the in-channel paging signal, while the second provides the interfering signal. The level of the paging signal is generally set to a level above the pager's sensitivity (usually 3 dB) and the level of the interfering signal is increased until the specified BER is achieved (usually the same BER specified for the sensitivity test). The level difference between the two signals is then recorded as the adjacent channel selectivity.

In practice, BER measurements are generally not done. The following test method is often used. For a pager receiver that has been tuned to receive 929.1125 MHz, the signal generator carrier frequency is set to 929.1125 MHz. The output of the signal generator is set to produce a paging signal. The amplitude of the signal generator is set to 3 dB above the sensitivity of the pager. The frequency of the interfering signal generator is set to an adjacent channel, 929.1375 MHz. The interfering signal is FSK modulated with the proper deviation. The strength of the interfering signal is set below the adjacent channel selectivity specification and is increased until the (modified) sensitivity of the pager (under the current conditions) is reached. The difference between the paging signal level and the interfering signal level is the adjacent channel selectivity.

The phase noise performance of the interfering signal can greatly affect the measurement. The following equation is used to determine the acceptable level of phase noise:

$$\text{Signal Generator Single-Sideband Phase Noise} < \\ - (\text{Adjacent Channel Selectivity}) - (\text{Noise/Hz}) \\ - \text{Margin.}$$

For a specification of 65 dB, a channel width of 25 kHz, and a margin of 10 dB, the single-sideband phase noise at the channel offset of 25 kHz must be less than or equal to  $-65 \text{ dB} - 10\log(25 \text{ kHz}/1 \text{ Hz}) - 10 \text{ dB} = -119 \text{ dBc/Hz}$ .

The HP 8648A signal generator's phase noise at a 20-kHz offset for a 1-GHz carrier is  $-116 \text{ dBc/Hz}$ . The HP 8657A/B signal generator's phase noise at 20-kHz offset for a 1-GHz carrier is approximately  $-130 \text{ dBc/Hz}$ . For adjacent channel selectivity measurements on pagers, the HP 8657A/B provides a better phase noise margin. However, the HP 8648A provides a cleaner solution for generating an FSK signal.

In the previous calculation, a 10-dB margin was used to determine the acceptable level of phase noise for a signal source. With a 10-dB margin, the single-sideband phase noise of the signal generator will add 0.4 dB of error to the adjacent channel selectivity measurement. The following table indicates the error contribution for other margins.

Margin (dB)	0	1	2	3	4	5	10
Error contribution (dB)	3	2.5	2.1	1.8	1.5	1.2	0.4

Functional Test. Functional test requires that an actual page be sent. To do this, the test signal must contain the proper protocol. Because of the need for pager testing, the HP 8648A option 1EP incorporates much of the protocol for the POCSAG, FLEX, and FLEX-TD paging formats.

In general, protocol is not tested at the system level. However, when the protocol affects the RF performance, the interaction of the protocol with the RF section should be tested and verified. The following tests verify this interaction:

- Receiving a message
- Reset
- Resynchronization
- Roaming

- Receiving a message.

During production, the functional test of a pager is simple: Does the pager respond? The requirements for production testing of POCSAG and FLEX pagers are generally few. The pager should respond to a message, all of the alert methods (sound, light, vibration) should work, and the entire display should work.

Sending a message sounds like a relatively simple task. However, messages can be formatted in numerous ways. Most manufacturers of pagers produce a variety of pagers for a variety of markets. To ensure that all needs are met, the HP 8648A option 1EP supports the following:

- POCSAG

- Numeric
- Alphanumeric
- Hex/Binary
- 14-Bit and 16-Bit Chinese Characters

- FLEX, FLEX-TD

- Numeric
- Numeric with Format (Special)
- Alphanumeric
- Hex/Binary (Used for Chinese Characters)
- Numeric with Message Numbering.

When testing FLEX pagers, synchronization must be provided by the test signal. In addition, after the test signal is removed, it is often desirable to reset the pager to remove the timing synchronization. The HP 8648A can be configured to reset the pager.

On occasion, the entire FLEX network may lose timing synchronization. When this happens, all of the pagers on the network must be resynchronized. A resynchronization signal is sent by the network to resynchronize the pagers. During design, the ability of the pager to do this should be tested.

The ability to support roaming is a major contribution of FLEX. The FLEX paging protocol defines two methods for roaming: simulcast system identification (SSID) and network identification (NID).

With SSID, a list of simulcast areas is programmed into the pager. When the pager encounters one of these areas, the pager is instructed when to look (which frame) and where to look (which channel) to receive pages. The SSID list contains codes that identify the simulcast areas. In addition, a channel scan list with the information required to find and identify each simulcast system is stored. For a pager to fully support SSID roaming, the pager must have the ability to change channels.

NID roaming is a superset of SSID roaming. NID is supported for subscribers that may roam across national and possibly global regions. In such large areas, storage of all SSID information is impractical.

Roaming is an important functional parameter to test because roaming connects a feature of the protocol to the RF control of the receiver. Although within the firmware implementation of the protocol the proper bits may be set, the functional aspect should be tested because the change in the RF channel should be verified.

## RF Isolation

RF isolation is needed when making any type of measurement on a pager. Without isolation, stray signals will be coupled into the pager by the antenna and even the printed circuit traces. Most specifications, however, are written in terms of field strengths. Therefore, when using an isolation chamber, the power levels of the test signals must be converted to field strengths:

$$E = \sqrt{P} \times R/d,$$

where E is the field strength in volts per meter, P is the power from the signal generator in watts, R is the output resistance of the signal generator, and d is the distance over which the power is radiated. In the more common units of dB above one microvolt per meter (dB $\mu$ V/m):

$$E_{\mu} = 20 \log(E \times 10^6),$$

where E $_{\mu}$  is the field strength in dB $\mu$ V/m.

The HP 8648A comes with an optional TEM cell that provides RF isolation and a calibrated field strength. For this TEM cell, the conversion from power level to field strength is shown in **Table V**.

**Table V**  
*HP 8648A TEM Cell Conversion Table*

Signal Generator Power (dBm)	TEM Cell Field Strength ( $\mu$ V/m)	TEM Cell Field Strength (dB $\mu$ V/m)
-120	2.91	9.29
-115	5.18	14.29
-110	9.21	19.29
-105	16.38	24.29
-100	29.14	29.29

## Conclusion

This article has reviewed the current trends in the paging industry, typical pager designs, and the test requirements of modern pagers. In addition, the contribution to pager testing of the HP 8648A signal generator with Option 1EP, the pager signaling option, was discussed.

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