

# Agilent PN 8648A-2

## Servicing and Repairing Pagers using the Agilent 8648A Option 1EP

Product Note



### Introduction

There are over 60 million subscribers of paging services throughout the world. By the year 2000, the number of subscribers is expected to grow to over 140 million. Pagers are extremely reliable devices. However, LCD replacement, recrystallization, and refurbishment of pagers ensure that companies that repair and service pagers can expect a continual flow of business.

*This product note covers three topics:*

- Paging theory overview
- Paging tests
- Recommended test equipment

The examination of these topics extends beyond testing and provides a general overview of paging. The goal of this paper is to assist you in repairing pagers.



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## Paging Overview

### Network Structure

A paging network connects the public to switched network or telephone lines. Callers access voice mail, a paging operator, or enter a message via the keypad of a touch-tone phone. Pages are assembled in the paging terminal and sent to the network controller where they are combined into batches based on their final destination. The network controller specifies which site controllers receive the batched messages and sends them out. Each site, covering a particular geographical location, contains one or more paging transmitters. Once a site controller receives a batch of pages, it uplinks them to the paging transmitters. Each paging transmitter then transmits the batch of pages at the same time and on the same frequency. Simultaneous broadcasting of identical information from two or more transmitters at the same time allows the system to provide seamless coverage.

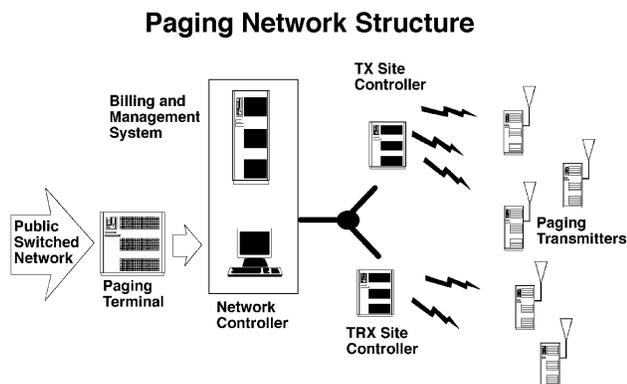


Figure 1. A Paging Network

### Types of Pager Services

Paging services come in several forms: tone-only, tone-voice, numeric, and alphanumeric.

The simplest type of paging service emits a tone when the subscriber is paged. This service is most useful when the subscriber only needs to call one place, such as his/her home or office. Tone-only service is the least expensive signaling option.

Tone-voice allows the subscriber to receive a voice message without calling a central location. Initially, tone-voice pagers could not store voice messages; therefore, a message could be missed if the subscriber was in a noisy environment when the page was received or was out of range of the transmitter. Newer systems are now available in some locations, where the pager can actually record messages up to 10 seconds long and play them back later.

Numeric pagers are the most popular on the market today. Callers dial the phone number assigned to the pager, then enter a numeric message using a touch-tone phone.

An alphanumeric pager requires the caller to have access to an alphanumeric terminal, or a message center, that can send alphanumeric messages to the pager. This type of service is the most expensive; however, it is valuable if the pager subscriber requires immediate information.

## Pager Formats

There are many different types of paging formats in use today. By far the most popular are the new digital formats which offer tone, numeric, or alphanumeric messaging, and in some cases voice messaging. Digital formats offer significant advantages over analog systems, including increased subscriber capacity, addressing flexibility, messaging capability, faster signaling speeds, and improved battery life.

The most common digital format is POCSAG (the most popular worldwide standard, also known as RPC1). The newer digital formats are FLEX (a Motorola trademark), FLEX-TD (a variation of the FLEX standard found in Japan), and ERMES (European Radio Message System).

The following table compares four digital paging formats: POCSAG, FLEX, FLEX-TD, and ERMES.

**Table 1. Digital Paging Format Comparison**

	POCSAG	FLEX, FLEX-TD	ERMES
Subscriber channel capacity	Two million	Up to one billion	Up to one billion
Data rates (bps)	512, 1200, 2400	1600, 3200, 6400	6250
Modulation type	2 level FSK	2 level FSK (at 1600 or 3200), 4 level FSK (at 3200 or 6400)	4 level FSK
Timing	Synchronous with preamble	Synchronous	Synchronous
Battery saving option	Yes	Yes	Yes

The Agilent Technologies 8648A with Option 1EP, the pager signaling option, provides the signaling required to meet POCSAG, FLEX and FLEX-TD protocols. The addition of Option 1E5, the high-stability timebase, enables the 8648A to meet the stringent requirements imposed on FLEX and FLEX-TD signals.

## Pager Tests

Detailed service and repair procedures are available from most pager manufacturers. Many recommend similar tests. The following common tests will be reviewed in this product note:

- Sensitivity measurements
- Oscillator tuning

Other tests include antenna alignment, backend alignment, and gain measurements.

To test a pager receiver without interference, the pager must be in an RF isolation enclosure. Shielding the pager from any external RF signals ensures that the pager is responding only to the test signal.

The following test equipment will be used:

Test Equipment	Description	Use
8648A	Synthesized signal generator	Generates paging signal
Option 1EP	Pager signaling option	Supplies paging protocol
Option 1E5	High stability timebase	Ensures that the signal meets manufacturer's specifications
Option K17	TEM cell with test fixture	RF isolation and probing
8590L	RF spectrum analyzer	Measure IF signal

### Sensitivity Measurements

Perhaps the most important specification for a pager is the receiver sensitivity. The receiver sensitivity determines the ability of the pager to properly receive low-level signals. A pager with poor sensitivity will not reliably detect messages and will result in unhappy customers!

Pager sensitivity specifications are usually in microvolts per meter (mV/m) or dB microvolts per meter (dBmV/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 power from the signal generator is radiated into the enclosure and generates a uniform field strength. When using the Agilent 8648A with option 1EP, the output power will need to be converted to field strength using the following formulas:<sup>1</sup>

$$E(\text{volts/meter}) = \text{SQRT} ( P(\text{watts}) \times \Omega(\text{ohms}) )/d(\text{meters})$$

$$E(\mu\text{V/m}) = E(\text{V/m}) \times 10^6(\mu\text{V/V})$$

$$E(\text{dB}\mu\text{V/m}) = 20 \log ( E (\mu\text{V/m})/1\mu\text{V/m} )$$

Where:

- P = power output from the signal generator
- Ω = impedance of the RF isolation enclosure
- d = distance from upper wall to septum of TEM cell

An optional TEM cell is available with the 8648A (Option K17) which provides RF isolation.



**RF isolation of pager for sensitivity measurement**

### Operating the Pager Encoder, Option 1EP:

1. Before entering the pager encoder menu, set the correct carrier frequency and FM deviation for the pager under test.
2. Enter the pager encoder menu by pressing the [FM] (ENCODER) key for a second time. The screen should display FORMAT in the upper left corner.
3. To select a parameter, use the [PREV] and [NEXT] keys.
4. To move between settings for each parameter rotate the AMPLITUDE/ENCODER knob until the desired setting is displayed. Any alphanumeric entry must be terminated by pressing the ENTER key.
5. When all parameter settings have been selected, press the [INCR SET] (START/STOP) key to initiate a page.
6. To exit the pager encoder menu, press the [FM] (ENCODER) key again.

The following table converts the output power from the signal generator to the field strength inside Option K17, the TEM cell. The impedance of the TEM cell is 50 ohms and the distance, d, is 7.5 cm. In addition, there is 0.2 dB of loss between the output of the signal generator and the TEM cell.

**Table 2. Power to Field Strength Conversion**

Signal Generator Power (dBm)	Option K17 TEM Cell Field Strength (μV/m)	Option K17 TEM Cell Field Strength (dBμV/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

1. Myron L. Crawford, "Generation of Standard EM fields using TEM transmission cells," IEEE Transactions on Electromagnetic Compatibility, November 1974.

**Configuring the 8648A with 1EP for Making a Sensitivity Measurement:**

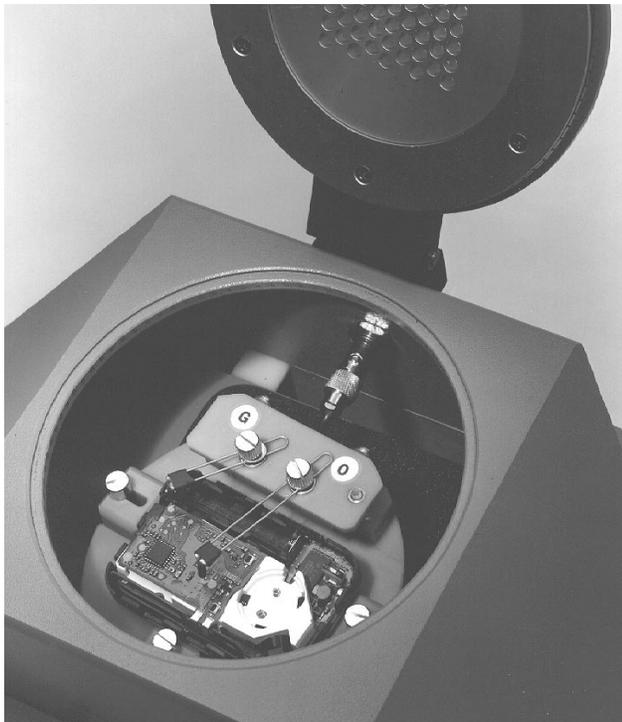
1. Place the pager inside the TEM cell.
2. The TEM cell has two type-N connector ports. Using a type-N cable, connect one port of the TEM cell to the signal generator. Make sure the other port is terminated with a 50 ohm load.
3. Press [FREQUENCY] on the 8648A and enter the paging frequency.
4. Press [FM] and enter the FM (FSK) deviation (4.5 kHz for POCSAG, 4.8 kHz for FLEX and FLEX-TD).
5. Press [AMPLITUDE] and enter an output power below the sensitivity of the pager (see Table 2).
6. Press [FM] a second time to enter the encoder menu. You should see FORMAT displayed in the upper left corner.
7. Rotate the AMPLITUDE/ENCODER knob to select the proper paging format.
8. Press the [NEXT] key to move to the DATA RATE parameter and enter the desired data rate.
9. Press the [NEXT] key to move to the PAGER TYPE parameter and select the desired pager type.
10. Press the [NEXT] key to move to the MESSAGE parameter and select a message.
11. Press the [NEXT] key to move to the MODE parameter and select continuous.
12. Press the [NEXT] key to move to the PAGER CODE parameter and use the alphanumeric keys to enter the pager code. Press [ENTER] when finished.
13. For FLEX pagers, press the [NEXT] key to move to the COLLAPSE CYCLE parameter. Adjust the COLLAPSE CYCLE value to 1. This ensures that the pager searches for a message every other frame.
14. Press the [START/STOP] button to begin paging.

15. Use the AMPLITUDE/ENCODER knob to increase the RF power until the pager responds. Record this value. With the RF power above the pager sensitivity threshold, lower the RF power until the pager fails to respond. Record this value. Most pagers will require that you acknowledge a received page before the pager stops beeping. Generally pressing any button on a pager will stop the alert signal. Because FLEX pagers can recognize duplicate pages, messages received by a FLEX pager will need to be deleted.

When making a sensitivity measurement, do not adjust the RF power of the signal generator too quickly. POCSAG, FLEX, and ERMES are synchronous paging formats. Adjusting the signal level too quickly will cause incorrect results. For POCSAG pagers operating at 1200 bps, the preamble and a single batch of pages takes about one second. Thus, the power level should be adjusted about 1 dB per second. For FLEX pagers the entire FLEX cycle can take as much as four minutes. Therefore, for FLEX pagers, the collapse cycle should be adjusted to one to ensure that the pager receiver circuitry is active for every other frame. With the collapse cycle adjusted to one, the power level should be adjusted about 1 dB every two seconds.



**Test Fixture with Pager**



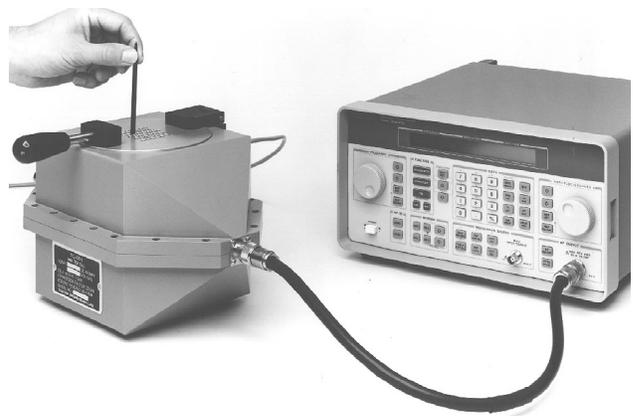
**Test Fixture and RF Isolation of Pager**

**Using the TEM Cell and the Test Fixture:**

1. Using the manufacturer's procedure, open the pager.
2. Place the pager in the test fixture.
3. Place the G probe on the pager ground point.
4. Place the O probe on the appropriate test point within the pager receiver section.
5. Close the TEM cell lid and tighten the handle to ensure maximum RF shielding.
6. Connect a 50 ohm load to one of the two ports on the TEM cell.

**Configuring the 8648A for oscillator tuning:**

1. Connect the output of the 8648A to the TEM cell using a type-N cable.
2. Press [FREQUENCY] and enter the paging frequency. Do not turn on any modulation!
3. Press [AMPLITUDE] and enter the required output power (see the pager service note for the required level).
4. Press [RF ON/OFF] to turn on the output power.



**Pager Component Adjustment**

## Oscillator Tuning

For many manufacturers, oscillator tuning is part of the alignment procedure. The alignment procedure returns the pager to manufacturer specifications by tuning the oscillator, adjusting antenna components, and adjusting backend components. There are several reasons why a pager may require oscillator tuning:

1. Pagers that do not meet the specified sensitivity may need to have their local oscillator (LO) tuned.
2. Occasionally the LO of a pager drifts slightly off of the required frequency.
3. When a pager is recrystallized, the LO should be tuned.

All oscillator tuning methods require some component adjustment. Pager manufacturers provide service notes that identify the components that need to be adjusted during tuning and where these components are found. Please consult the appropriate service note for more specific details.

A simple method of tuning is to connect a frequency counter at the IF output of the mixer and adjust the oscillator value until the counter reads the proper IF frequency. The output of the signal generator must be a sine wave at the required channel frequency (for example, 929.1125 MHz).

This is an inexpensive tuning solution. However, the counter may require 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.

An oscilloscope can also be used to tune the oscillator. Filtering and a preamplifier may be needed when using an oscilloscope. The counter has better frequency accuracy; however, the waveform of the signal can be viewed on the oscilloscope.

A spectrum analyzer can be used instead of either a frequency counter or an oscilloscope. The spectrum analyzer is frequency selective and has greater sensitivity. This eliminates the need for an external filter and a preamplifier.

Some manufacturers have an IF test point where a voltage level may be measured instead of a frequency. For these pager designs, a digital multimeter (DMM) can be used to measure the voltage level. No external filters or preamplifiers are required.

## Recommended Test Equipment

For POCSAG pagers, most tests can be made with an 8648A with Options 1EP and K17, a frequency counter, and a DMM. In addition, a spectrum analyzer or an oscilloscope is often used.

For FLEX and FLEX-TD, the same test equipment may be used. However, when testing FLEX and FLEX-TD, a high stability timebase for the 8648A is required. FLEX and FLEX-TD both require that the FSK deviation of the output signal be within 60 Hz of the specified deviation. The high stability timebase option for the 8648A, Option 1E5, with an accuracy specification of 0.15 ppm, enables the 8648A to meet this requirement. In addition, an external reference may be used if the performance specifications of the reference signal are superior to those of the high stability timebase, Option 1E5.

<b>8648A</b>	Synthesized Signal Generator
Option 1EP	Pager Signaling Option (FLEX, FLEX-TD and POCSAG)
Option 1E5	High Stability Timebase (needed to meet FLEX requirements)
Option K17	TEM Cell for RF Isolation (includes test fixture)
<b>34401A</b>	Digital multimeter (used in pager tuning and alignment procedures)
<b>53181A<sup>2</sup></b>	RF Counter (used in pager tuning and alignment procedures)

### Alternate test equipment

<b>8590L</b>	RF Spectrum Analyzer (may be used in place of a frequency counter)
<b>54600 Series<sup>2</sup></b>	General Purpose Oscilloscope (may be used in place of a digital multimeter (DMM) and frequency counter)

## References

Information about specific pagers may be obtained from the pager manufacturers. The following is a partial list of pager manufacturers:

- Motorola, America's Parts Division, Paging Products Group
- NEC
- Uniden
- Panasonic

These companies provide excellent service documentation for their pagers.

2. A filter and preamplifier may be required.

## Agilent Technologies' Test and Measurement Support, Services, and Assistance

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