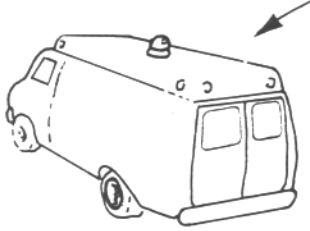
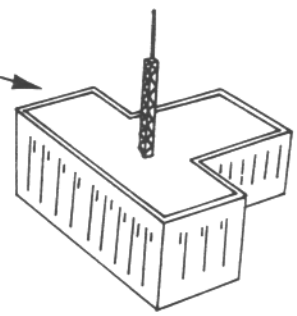
A Primer on Radio Communications



Or, How Do I Get From Here To There?



Last fall ***jems*** staff members had the opportunity to observe an amazing feat. In a lecture hall at the *Paramedics international* conference held in New Orleans, faculty member Harlan Felt turned the complicated language of radio communications into simple English. We asked Harlan to put his words onto paper and in this and the next three issues he presents a thorough but simple view of the subject. In this issue, Part 1 defines important terms. In future months Felt covers communication configurations, EMS field units, and hospital console/display units. Felt is the director of EMS at Foster G. McGaw Hospital of Loyola University in Maywood, Illinois and has been active in EMS since 1973. He has lectured and consulted extensively around the nation on communication systems and components.

Editors note — Man's desire to communicate with others over long distances has inspired great ingenuity over the ages. For example, the advent of smoke signals made possible the conveyance of information by one person to other persons several miles distant. Later, mirrors or other shiny articles were used to transmit coded reflections across a line-of-sight path during daylight hours. Still later, the miracle of telegraphy permitted messages (in the forms of dots and dashes) to travel across many miles with electric speed. The telephone released the technology of communications from the restrictions of line-of-sight, sunlight and Morse code. But it was the "wireless" that truly released mankind from the bonds of time, place and distance.

In 1906, Thomas K. Brown was delivering mail on horseback in Franklin County, Arkansas. About six miles from his home, Mr. Brown became violently ill. Unable to proceed, he was taken in by a farm family along his mail route. By next morning, Brown was well enough to ride his horse home. During the night, however, Brown's wife tried to assure her children that their father would arrive home soon. But she had no way of really knowing. Without a means of communicating with others along T.K. Brown's mail route, his wife spent a sleepless night wondering why her husband had not returned home.

A modern version of T.K. Brown's episode obviously would be much different. The local emergency ambulance service would be hailed by telephone. The EMTs would arrive in a self-propelled vehicle. And, from a farmyard in the rural reaches of Franklin County, the EMTs would be able to send their voices across the air to a hospital many miles away. Equally amazing, people at the hospital would be able to send ***their*** voices across the air to the EMTs. What's more, the voices flying through the air would travel through darkness, rain or snow. The voices would not be blown off course by winds. If a mountain stood between the EMTs and the hospital, the voices would be captured by a device on the mountain, they would be re-energized, and sent along their way to their original destination.

by Harlan Felt

"Ya mash this button and 'ya talk in here." For many, this basic instruction may be their only formal training in radio communications. There may be a few who are satisfied with such minimal information. But most will want to know more. They'll want to know ***how*** their voice can travel across the air to be received by a piece of equipment several miles away. They'll want to know why some radios can link them with some places but not others. They'll want to know why radios sometimes fail to function properly. In most cases, however, they'll be confronted by "technical mystique."

"Technical mystique" is both a language and a science. Technicians speak it with an air of authority. Non-technicians feel intimidated by

technical mystique. It is a language within their own native language, yet they understand very little of it. Intimidation retards asking of the simple question, "What do you mean?" Unchallenged, many of the technicians proceed undeterred along the pathway of technical mystique, never stopping to think that radio users may have a few unanswered questions.

In the interest of clearing the air — and cutting through the technical mystique — we present the following series on communications.

Part 1: Understanding The Language

The exchange of information is probably the most important aspect of our society and of the world. Without the ability to communicate, mankind would have no way to interact and to grow. The type of communications that we will deal with in this series of articles is Radio communications, and how this relates to emergency medical services. This article will provide a basic understanding of communications terminology and equipment designs.

All radio communications within the U.S. are regulated by the Federal Communications Commission (FCC). The utilization of all radio frequencies and equipment are determined by rules and regulations issued by the FCC and all radio users must adhere to them. These rules determine who is eligible to license a transmitter as well as the specific frequencies and equipment configurations allowed for use. The section of FCC rules pertaining to EMS can be found in FCC Part 90 — Private Land Mobile Radio Services, and specifically subpart C, Special Emergency Radio Service. Copies of this are available by contacting The Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402 and asking for the current pricing and form numbers for FCC Part 90.

Many of the people involved with EMS may not understand the multitude of terms and phrases used by communications personnel. The following information should provide the reader with some insight into the sometimes strange but fascinating world of radio communications.

DEFINITIONS

This section contains many technical terms and their definitions:

Base Station — A grouping of radio equipment consisting of at least a transmitter and a receiver, placed at a fixed location.

Channel — For EMS radio systems this refers to a pair of radio frequencies, one for transmit and one for receive.

Console — A group of equipment used to control a base station(s). These are typically mounted in or on a desk.

Control Point — Any place from which a base station's functions may be controlled.

CTCSS — (Continuous Tone Coded Squelch System) — A system where radio receivers are equipped with tone sensitive circuits that only allow the receiver signals to be heard at the console when the proper tone has been received. That tone must be continuously sent for continuous receiver audio to be heard. CTCSS may be referred to by various trade names such as Private Line -PL (Motorola), Channel Guard -CG (General Electric), or Quiet Channel (RCA).

Decibel — db — A unit of measurement that is used for comparisons of signal strength and/or equipment performance.

Digital Dial — A type of tone controlling system using multidigit numbers entered by using a telephone — like dial.

DTMF — (Dual Tone MultiFrequency) — A tone signaling system similar to the telephone companies' "Touch-Tone" that is typically used to control equipment.

Duplex — The ability to transmit and receive simultaneously (like a telephone). This uses two different frequencies, one for transmit and one for receive.

Duplex/Multiplex — The ability to transmit and receive simultaneously with the concurrent transmission of both voice and EKG information.

Duty Cycle or Battery Life — This is typically the length of time that the radio transmitter can be kept keyed (transmitting). The longer the time specified the better.

ERP (Effective Radiated Power) — The power of the transmitter supplied to the antenna multiplied by the relative gain of the antenna. This is used when referring to the total output power of a base station in relation to the area it needs to cover.

Frequency — A numeric value indicating the measurement of complete cycles per units of time.

Half Duplex — The use of two different frequencies, one for transmit and one for receive, in a non-simultaneous mode.

Hertz — A unit of frequency equal to one cycle per second. The term is combined with metric prefixes to denote multiple units, such as megahertz (MHz — 1,000,000 Hz).

Microwave — A communications link that can cover many miles in a straight line of sight mode utilizing multiple channels (typically used to replace expensive dedicated leased telephone lines). The frequencies used are above 890 MHz.

Mobile Relay Station — A base station established for the automatic retransmission of base-received mobile radio signals back out on the receiving frequency of the mobiles.

Mobile Repeater — see Vehicular Repeater.

Multiplex — The simultaneous transmission of two or more sources over the same transmitting frequency. This is typically the EKG and the paramedic's voice.

Mute — This means to set the audio level from a radio speaker to a lower preset level. This is typically used in base consoles to allow the listener to faintly hear radio activity on other frequencies while monitoring their primary use frequency.

Ni-Cads — These are nickel cadmium rechargeable batteries used to power the portable and/or field radios. Generally the longer time a radio can operate between recharges the better.

Paging — A one-way transmission to receiving — only equipment typically using tone activation.

RTSS — Radio Telephone Switched System. This is a radio system that utilizes a multifrequency base station that interconnects to the dial of standard telephone network.

Selectivity — A measurement of the radio receiver's ability to reject (i.e. not hear) a signal on an adjacent frequency. This is referred to in negative numbers (i.e. -85 dB is better than -65 dB.).

Sensitivity — A measurement of the radio receiver's ability to receive a signal. The smaller the number the better (i.e. 0.5 uV is better than 0.7 uV.)

SERS — Special Emergency Radio Service. A specific group of radio frequencies designated by the FCC.

Simplex — The ability to transmit or receive in one direction at a time. This typically uses one radio frequency in the VHF high or low range.

Sinad — This is used as a comparative baseline measurement of a radio receiver's performance.

Squelch — This is a knob on the radio that shuts out all sound from the speaker until a signal is received.

Talk In — Typically describes the communications range (distance) from a mobile or portable to a base station.

Talk Out — Typically describes the communications range (distance) from a base station to a mobile or portable radio.

Transceiver — A combination of transmitting and receiving equipment typically in one housing.

UHF — The radio frequencies in the 460 MHz range.

Vehicular Repeater — A mobile unit capable of automatically retransmitting on the mobile frequencies a signal typically received from a portable or a base station.

VHF High — The frequencies in the 150 MHz range.

VHF Low — The frequencies in the 30-50 MHz range.

Watt — This is a unit of measurement of a transmitter's power output.

FREQUENCY RANGES

Now let's take a look at some of the frequency ranges available in EMS.

In the VHF LOW BAND range there are a number of frequencies assigned for two-way usage and for paging. These are normally operated in a simplex mode.

In the VHF HIGH BAND range there are a number of frequencies assigned for two-way usage and also for paging. These are normally operated in a simplex mode.

When we use the UHF BAND the frequencies used are very specifically designated as follows:

Frequency (MHz)	
458.025	Portable to vehicular repeater
458.075	Portable to vehicular repeater
458.125	Portable to vehicular repeater
458.175	Portable to vehicular repeater

Frequency base/mobile	Frequency mobile	Channel name
462.950	467.950	up to local usage
462.975	467.975	up to local usage
463.000	468.000	MED 1 per the FCC
463.025	468.025	MED 2 per the FCC
463.050	468.050	MED 3 per the FCC
463.075	468.075	MED 4 per the FCC
463.100	468.100	MED 5 per the FCC
463.125	468.125	MED 6 per the FCC
463.150	468.150	MED 7 per the FCC
463.175	468.175	MED 8 per the FCC

These frequencies are utilized in either half duplex, duplex or multiplex modes.

Modes of Operation

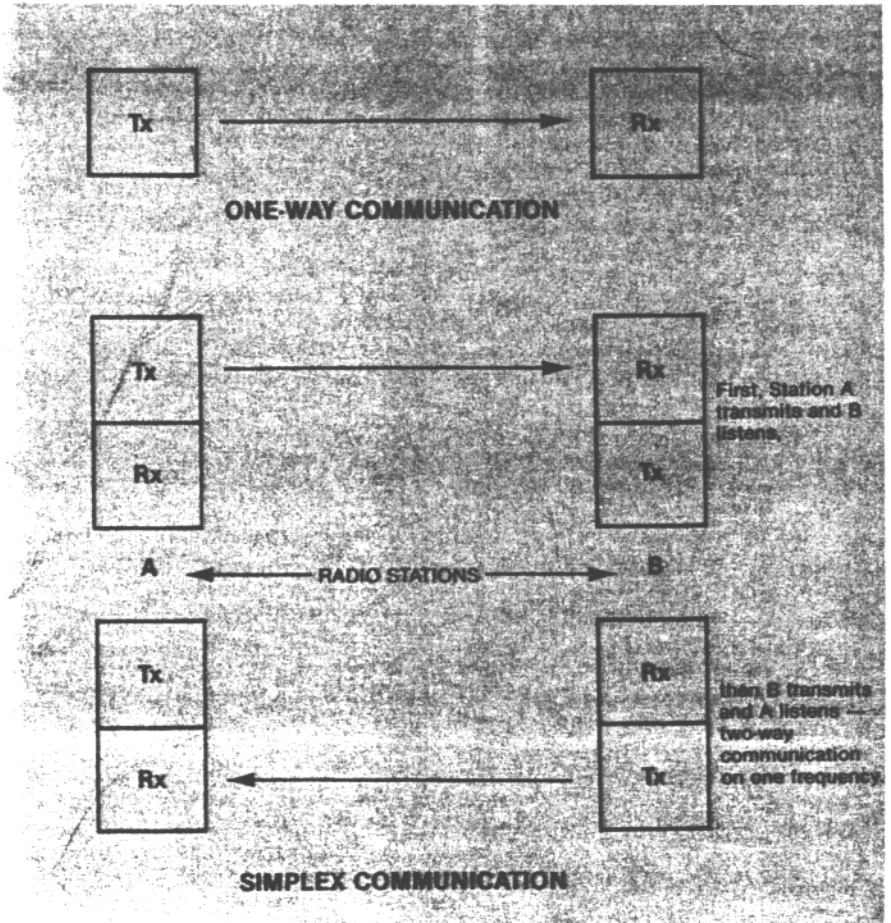
We have referred to a number of different modes of radio operation. Now let's see what each looks like.

One Way

One-way is typically used for paging. The equipment required is a transmitter, a receiver to monitor (listen to) the frequency before transmitting, and the paging receiver. All these operate on the same frequency.

Simplex

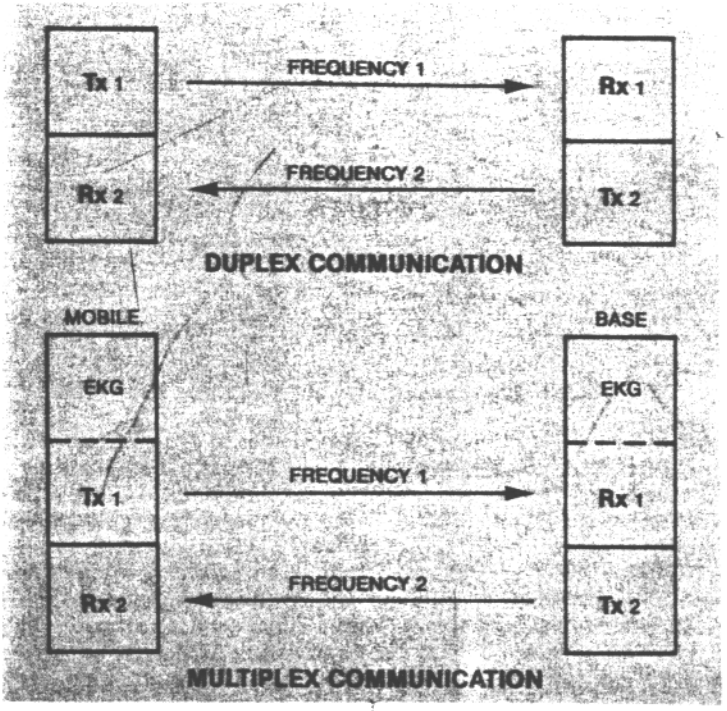
Simplex requires a transmitter (Tx) and a receiver (Rx) at each end of the communications path, both operating on the same frequency. Only one end may operate at a time as shown above.



Duplex
Duplex uses two frequencies, as shown, allowing for both ends to communicate simultaneously (like the telephone). The advantage to this mode is that either end could interrupt the other or break in during an EKG transmission, etc. Implementting a system using this mode can be complex and expensive.

Half Duplex uses the same frequency configuration as Duplex but does not allow for the simultaneous and/or interrupt capability.

Multiplex
Multiplex operates in the same fashion as Duplex with the additional capability, as shown, of typically transmitting the EKG and the paramedic's voice at the same time from the field unit. A radio system utilizing this mode will typically be complex and the most expensive.

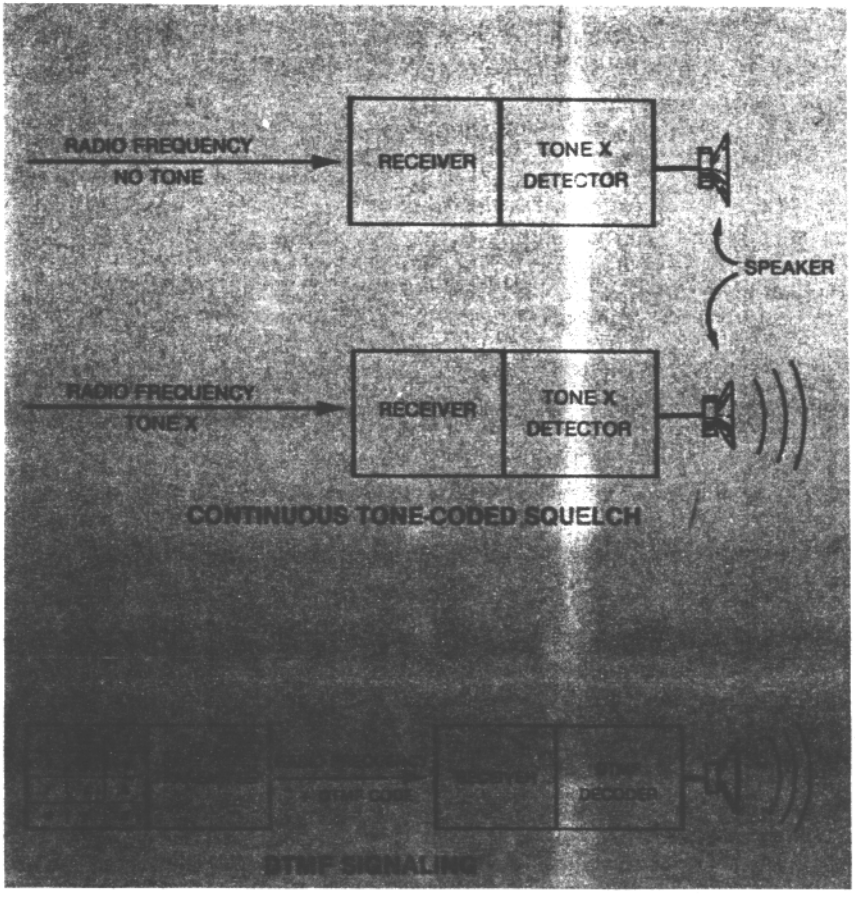


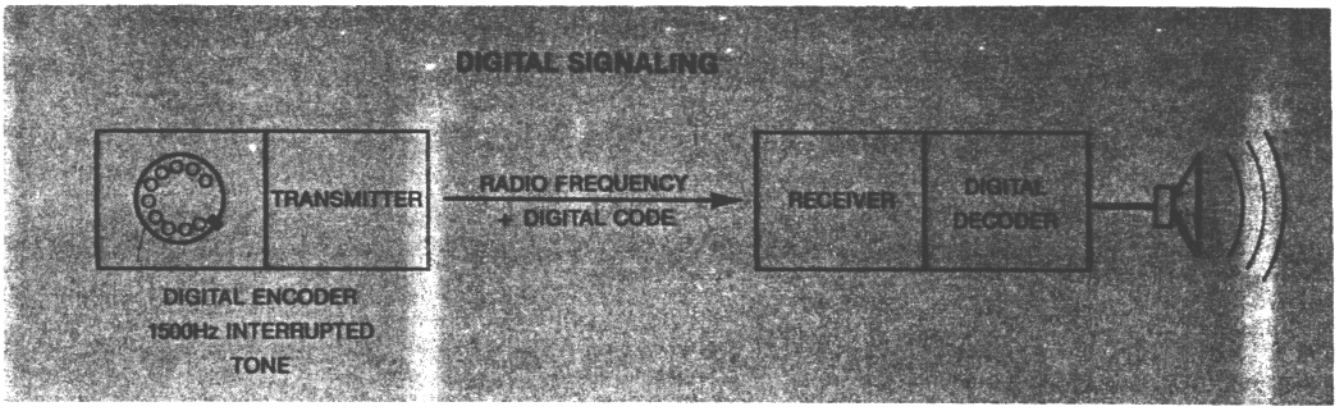
Tone Controlling or Signaling Methods

There are three types of signaling methods typically used in EMS systems and they are used as follows:

CTCSS
CTCSS requires that a radio receiver be equipped with circuitry that listens for and decodes a specific subaudible (too low to be heard) tone. If that tone is not continuously received then the voice message will not be heard from the radio speaker. While that tone is received, any communication on that frequency will be heard. The normal use for CTCSS is to "quiet" a radio's speaker until that radio receives a signal or message meant for that specific unit.

DTMF
DTMF is typically used to control base station functions. This could include frequency changes, specific base station access, telephone line interconnect such as in RTSS systems, etc. It operates just like the telephone company's "Touch Tone" telephones. It is easier and faster (and therefore safer) to use than Digital Dial.





Digital Dial

DIGITAL DIAL is another method of specifying the radio unit you want to reach. It also "quiets" the radio's speaker until the proper sequence of dial pulses are received. When the proper code is received, the message will be heard from the radio speaker. The radio will now hear all communications on that frequency until the digital dial decoder is reset to its "listen" mode (this is typically used for base stations and the reset would be done by hanging up the microphone or handset). Digital dial codes are usually seven numbers long and are slowly entered just like a telephone number. Because of this a safety hazard may exist when mobile unit drivers try to access base stations while driving. This is one reason why digital dial is typically used for base-to-base access.

We have now reviewed individual functions of radio communications — important terms, EMS frequency ranges, modes of radio operation, and signaling methods. Next month we'll see how these various elements are utilized in different kinds of communications systems. □