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MOBILE TELEPRINTERS

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Introduction

This paper sets out to outline some of the features and characteristics of mobile teleprinters and their applications in radio schemes. The subject if explained in depth is lengthy due to the many principles involved but an attempt has been made to give sufficient information without recourse to excessive detail.

Outline

The current practice in mobile radio communication systems is to convey intelligence by natural or on occasions by cryptic speech. It is unlikely that speech will ever be supplanted for emergency messages of short duration in which voice inflexions can impart a sense of urgency. However, for a number of reasons involving issues of channel occupancy, channel capacity related to bandwidth, attainable operational efficiency, and other aspects, the routine or lengthy message and that for which privacy is important, could best be handled by data communications techniques.

Channel occupancy in this sense means time of transmission which, for both speech and data, is easily measured. A radio channel designed to carry speech signals could be used to greater advantage for data communication providing it is not unduly noisy. This is considered in more detail in the following section.

Messages sent out in data form are in code so that the radio scheme needs encoding equipment at Control for message origination and decoding terminals for its reception. The receiving terminals for a mobile radio scheme would be vehicles fitted with compact teleprinters connected to the receiving portion of the combined transmitter/receiver.

Bandwidth Considerations

The bandwidth of a communication channel is the space it occupies in the relevant audio or radio frequency spectrum. The channel has upper and lower limits of frequency and its bandwidth is the difference between those limits. A signal passed over the channel must not spread in frequency beyond the channel bandwidth capability if distortion is not to result or interference be caused to the channels on either side. Radio transmission techniques during the conversion processing of the signal from audio to radio frequency, except in special cases, double or more than double the effective spread in frequency of the basic signal so that the radio channel must be that much wider.

Voice signals, allowing for the different pitches and enunciation of various speakers, spread in frequency from about 300 to 3500 Hz requiring a pre-requisite electrical bandwidth to transmit over line or radio. When a person speaks into a microphone the electrical voice signal has time intervals between individual sounds and these intervals are shortened during fast speech. However, the rate of speech, whether fast or slow, does not effectively alter the limits of the frequency spread and hence the overall bandwidth required. On the other hand, in data transmission, the rate of information and channel bandwidth are directly related. If the speech message is put into written form and for each alpha-numeric character a precise data code is allocated, it is a very simple matter in principle, if not in application, to transmit in data all that can be said by an extremely fast talker - at say 200 words per minute - in half the time and within a very much narrower bandwidth. The reduction in bandwidth, much

prized in congested communication bands, is the important feature since it allows more avenues of communication to be accommodated in a particular channel or, conversely, more channels in a certain bandwidth. Time saving in data communications is more abstract since, although the chief economy is in channel occupancy, it is offset to some extent by the time taken for message preparation.

Signalling in 'Data'

A block of information in 'data' is characteristically sent out (transmitted) in spurts of electrical impulses with varying lengths of gaps between the impulses. Both the impulses and the gaps within the blocks are meaningful and provide a two-state or binary level of signalling, namely On or Off. This signalling form, for teleprinters operating over radio circuits, is modified to use audio frequency tones and means in practice that one tone frequency, say 1000 Hz, is the impulse and another frequency, say 1800 Hz, is the gap. Each gap or impulse must be of defined length or duration since in the coding of each block of information several gaps or impulses may be put together in sequence. In telegraphic terminology an impulse is known as the 'A' condition corresponding to the On or active state, and a gap is called the 'Z' condition for the Off or inactive state. These are written as 1 and 0 respectively in binary code. Each alpha-numeric character of the message is composed of its own individual combination (or information block) of 5 or 7 consecutive 1's and 0's, dependant on the code used, and transmitted as precise duration bursts of each tone frequency.

Another tone frequency, say 1500 Hz, is transmitted at the beginning of the message to start up the remote mobile teleprinter.

When data is being sent to the mobile teleprinters a listener on the radio network would hear a continuous musical warble as the signal rapidly changes from one note to the other.

Most of the mobile teleprinters available, all of which are designed to operate within a speech channel of 300 to 3500Hz, do not allow the simultaneous occupancy in the channel of speech and data. It is thus speech or data but not both together. Combined speech and data working at a comparatively slow rate of 50 baud for the teleprinter (Telex speed) is possible by electrical filtering and a suitable choice of tone frequencies, and at least one mobile teleprinter manufacturer offers this combined facility in his design. Generally, however, it is not technically feasible to squeeze, for other than slow data, both types of information simultaneously into a mobile radio speech channel without suffering unacceptable degradation in speech quality. This sharing of the channel may not always be necessary, for when working at an upper speed (for mobile teleprinters) of 30 characters/second, quite a long message may be sent in a few seconds and hence does not greatly disrupt the use of speech communication. Also the system may permit the data message to be temporarily suspended for speech break-in and later renewed without loss of copy. At a slower data speed of 7.5 characters/second, the chief drawback to the use of mobile teleprinters in a radio speech channel is the disturbing effect to the recipients of the tones used in the data transmission. This can be minimised by selective addressing.

Selective Addressing

This is a means whereby individual, or groups of vehicles, including all vehicles in a mobile radio network, can be selected for message routing. The system, which also employs audible tones arranged in an addressing code, inhibits the receipt of a message to other than those for whom it is

intended and this facility makes it attractive for data communication over a speech radio network. By its provision a muting action can also be automatically placed on the loudspeaker circuit of the mobile radio receiver during data transmission. Data messages which advantageously can be recorded at the mobile when its crew are absent, may be either automatically acknowledged by the selective addressing system or manually by the crew on return.

Privacy

Data transmission to mobiles imparts a fair measure of privacy since the radio channel transmissions are unintelligible to the random listener.

Character Formation

At the mobile teleprinter, dependent on the system adopted, characters may be impact or non-impact printed in one of two ways, either as written by a conventional typewriter or built-up by a combination of closely-spaced dots. The latter method operates on the dot matrix principle and is so called because the print-head of the machine selects and imprints dots singly or several at once, within a matrix formation (possibly 7 x 5 = 35 dots) to form the shape of the character.

A 7 x 5 dot matrix can be regarded as an imaginary grid formed by 5 equally-spaced parallel vertical lines intersected at right angles and enclosed by 7 equally-spaced parallel horizontal lines. The dots are placed at all points of intersection of the imaginary lines.

There are wide variations in the dot incidence for the print-out of characters; for example to print out the letter B in a 7 x 5 matrix could take twenty dots, whereas a 1 would only require seven. This appears at first sight to be a cumbersome method of printing characters, but there are good reasons. All communications systems suffer to a greater or lesser degree from noise, which in sufficient intensity will degrade the system performance and, for data messages, create errors resulting in a change of information. If each transmitted 'block' of coded information signifies a complete character, then any appreciable alteration produced by noise may result in character error. By sending out much more information for each character, in effect to pin-point the individual dots, the probability of loss or change of the character is greatly reduced since the omission of several dots may not, in itself, lead to confusion in character recognition.

At the expense of the additional bandwidth required for any given print-out speed, the system is then deemed to be more tolerant to high noise conditions and is said to make use of 'redundancy' - a term used to signify that more information than is otherwise strictly necessary is transmitted for error masking. Not all matrix-type printers depend on 'redundancy' transmission for their operation; the choice for this print-out method is then based solely on mechanical considerations.

Message Origination

At Control the messages could be prepared by an operator/typist on a tape punch machine to provide both a print-out of the message and a punched paper tape, which most probably will be in the International Telegraph Alphabet No. 2 code employed for Telex and other data communication. The punched tape would then be fed by the operator into a tape transmitter directly connected to a code translator for the conversion of the message into a suitable signalling form for onward transmission over the radio channel. Except for the code translator the equipment is similar to Telex and has the same limitations in dealing with errors incumbent during message preparation.

A more flexible system for message origination makes use of a device known as a visual display unit (VDU) and offers considerable scope for manipulation by the operator. A VDU has an in-built computor type store (or register) whereby instead of message proof print-out on to paper in front of the operator, the information is presented on a TV tube display. The entry keyboard is as a typewriter for setting up the message on the screen, but any errors or redundant information can be instantly deleted or altered. When the operator is satisfied with the content of the message he has the choice of forwarding it or placing the information in a temporary storage for later transmission. A VDU may also be pre-programmed to give routine message headings of Classification, Date, Time, etc to ease work tedium. The operator does not need personally to maintain a handwritten log for record purposes since the device can be connected to a more permanent storage system such as magnetic drums or discs or, if required, to a nearby fixed-installation teleprinter for print copy. The various facilities of a VDU terminal are much too numerous to discuss here and indeed, as a measure of its extreme versatility, its cost can be relatively high compared to the more modest Telex type terminal. A VDU typically has an output signal in the 7 unit International Telegraph Alphabet No. 5 allowing more individual code combinations than ITA 2 but, as before, its output has to be put through a code translator for conversion into suitable signalling form for transmission over the radio channel to the mobile teleprinter receiving stations.

Classification of Machines

For mobile use there is not a great deal of choice of teleprinters at present and there are fewer than ten different models available from the European or USA markets. The price range for a single machine complete with its decoder, exceeds the cost of a typical VHF mobile radio installation by 50 to 100%. All the machines fall into one of two categories, viz impact or non-impact types, but can be further classified into their various methods of producing print copy. As would be expected, impact type machines are the noisier breed, but this feature is greatly dependent on the mechanical system employed for print formation. The alpha-numeric character is printed by a print wheel or probe (in matrix print-out), on to pressure-sensitive paper or through an inked ribbon on to ordinary paper. Impact printing allows simultaneous multi-copying, not usually possible by non-impact methods, and up to four copies can be obtained by the use of pressure-sensitive manifold paper. Rapid repeat copying without the need for further transmission is a possible feature of non-impact models.

Non-impact printers can be sub-divided into four main categories:

a. Electrostatic
b. Electromagnetic
c. Electrothermal
d. Character formation by electric arc

Electrostatic: (deposition) The paper is given an electrical charge by a moving stylus in a pattern corresponding to the shape of the letter or numeral and then developed by applying a chemical toner. The process is 'permanized' by passing the paper over a heated plate. Fast and virtually noiseless print-out is achieved by this method but for a single copy only. Instant reading of the message is not possible due to the short delay imposed by the heat process.

Electromagnetic: (deposition)	In a similar fashion to a tape recording, alpha-numeric characters are recorded on to the surface of a magnetically-sensitive material. This surface is then passed through a powder consisting of resin-coated ferrite particles. These particles are attracted to the magnetized areas and, in turn, deposited by close contact on to paper to give the printout. The printout is permanized by heat which melts the resin. Like the electrostatic method, has the capability of noiseless, extremely fast printout, and also allows repeat copying until the information is erased.
Electrothermal:	A character is formed by localised heat from the print head on to a heat-sensitive paper, whereby the colour of the paper alters at the point of heat application. Permits fast noiseless action for single copy only.
Character formation by electric arc:	This technique is applied to metallized paper tape, the metal being removed by the heat of the arc to form the character.

Print-out speeds for the various categories of teleprinters listed are typically 7.5 to 30 characters/second but electrostatic deposition machines, in particular, are capable of operating at speeds above 150 ch/sec. There are other types of teleprinter working on the ink jet or electrochemical or electro-optical principles but these have not yet been adapted for mobile use. For compatibility, the mobile teleprinter must operate from a 12 volt battery supply and certain features such as solenoid-actuated probes for printout, synchronous motor carriage drive, thermal print head, etc raise problems which have simple solutions in mains operated equipment. A mobile teleprinter must also be capable of operating in less stable conditions of vibration and temperature.

The machines print on to either roll paper or, as in some models, on to paper tape. Roll paper is mostly adopted with no obvious standardisation of width, although in most cases it can broadly be classified as half page in comparison to a standard desk-top teleprinter.

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