RC640 – a new f.m mobile radio

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Summary The RC640 is a v.h.f, f.m mobile radio which, by the use of microprocessors, has greater operational flexibility than other commercial mobile radios. This flexibility is enhanced by a frequency management system which can alter the functions and channel frequencies. These changes can be made using a data fill gun after the radio has been installed in a vehicle.

Ancillary equipment allows the radio to be reconfigured to fill most of the roles that a mobile radio system may require of it.

Introduction

Following the World Administrative Radio Conference (WARC) in 1979, the frequency spectrum was reassigned and the RC690 was designed to fulfil the UK Home Office a.m requirements for police and fire services. It subsequently formed part of the largest single order ever placed by the Home Office for mobile radio.

The RC640 is an f.m mobile which was designed in parallel with the RC690. It has already been ordered by a UK regional health authority for its first-line emergency ambulances. The extensive commonality between the RC640 and RC690 reduces costs and shortens delivery times.

This article deals specifically with the RC640.

The RC640 comprises a control head which is mounted in, or near, the dashboard of a vehicle, and a transceiver unit located in the boot (trunk), the two units being connected by a multi-way cable.

The microprocessor-based control head, in conjunction with the micro-processor-based, synthesized transceiver, provides operational flexibility allowing access to a large number of channels in different operational modes. Up to 255 channels are possible and they may be allocated frequencies anywhere within the operational bandwidth of the equipment. The ability to isolate the transmit and receive functions electronically further increases the flexibility of the radio. In addition, all major interfaces and control functions are provided through a 15-way facilities connector to allow the use of external equipment such as modems or speech security systems. Audio interfaces are provided through this connector at 600Ω.

Control head

The control head circuitry is contained on three printed-circuit boards connected by ribbon cable (figure 1). Each board has a specific function, viz. control board (providing the interface with the user), a microprocessor board and an audio processing board (figure 2).

Control board

This is located immediately behind the front panel and houses a keypad, used for entering channel numbers, a 5-digit display and various other controls (figure 3). Switches and displays on the front panel are connected to the microprocessor via a bi-directional bus and are fully programmable.

Microprocessor board

This accepts the input from the front

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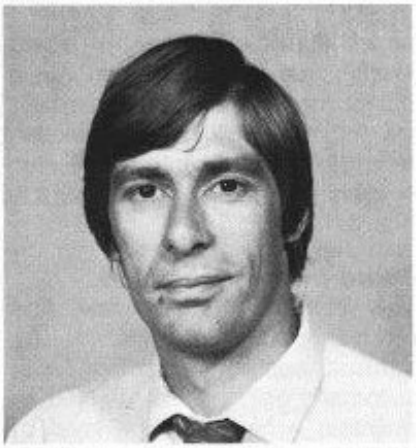
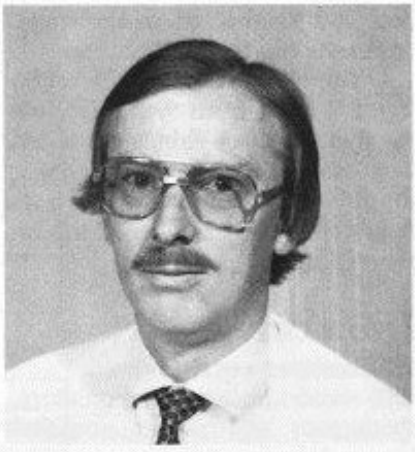
Colin Marscheider was educated at Dumfries Academy and Strathclyde University. He came to Marconi Communication Systems as a Graduate Trainee in 1978 and in 1979 joined Mobile Radio Division as a Junior Development Engineer. After a spell in the Service Department he returned to Development and was promoted Project Leader in 1983.



J. M. Turner
Jim Turner was educated at the Mid Essex Technical College and Thames Polytechnic. He joined the Marconi Company as a student apprentice in 1969, and in 1974 joined Mobile Radio Division as a development engineer. He was appointed Chief Service Engineer in 1979, becoming responsible for installation and after-sales service for many large mobile radio schemes. In 1984, Jim returned to development engineering and was appointed Project Leader for the RC640.



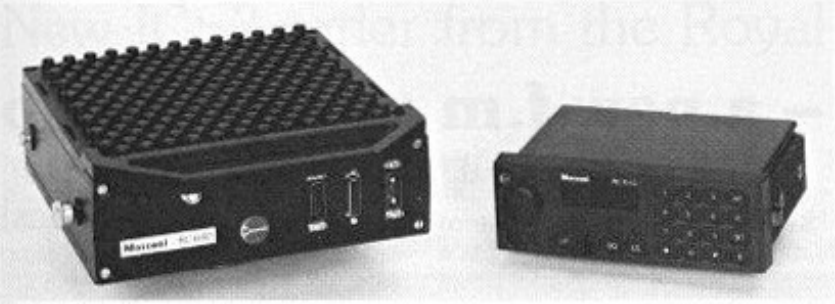


Fig. 1. Radio and Control Head

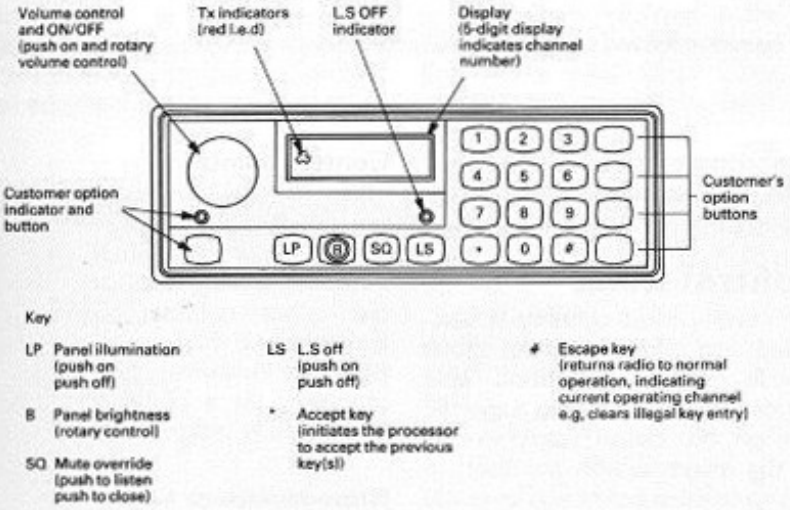


Fig. 3. Front panel layout of Control Head

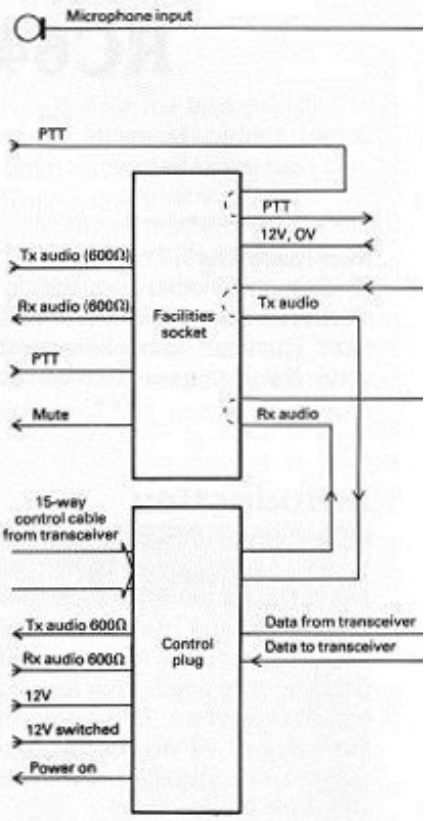


Fig. 2. Block diagram of Control Head

panel, controls the control board locally, and communicates with a microprocessor in the transceiver via the multiway cable. Selective calling (Selcall) transmit and receive circuitry is accommodated on this board.

Audio processing board

This contains the transmit and receive audio amplifiers. The transmit audio is amplified, with automatic gain control, limited to maintain a high average level of deviation with a low level of distortion. It is connected to the transceiver via the multiway cable.

On the receiver side, the audio signal is taken from the transceiver via the multiway cable and is fed into earpiece and loudspeaker amplifiers, the output levels of both being controlled by the main volume control.

Transceiver

Transmitter section

This section houses the regulators, synthesizer and power amplifier (figure 4).

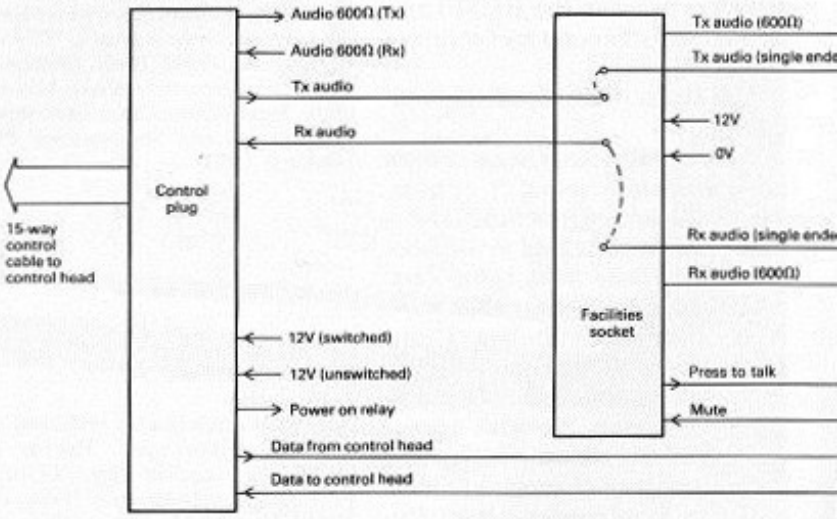
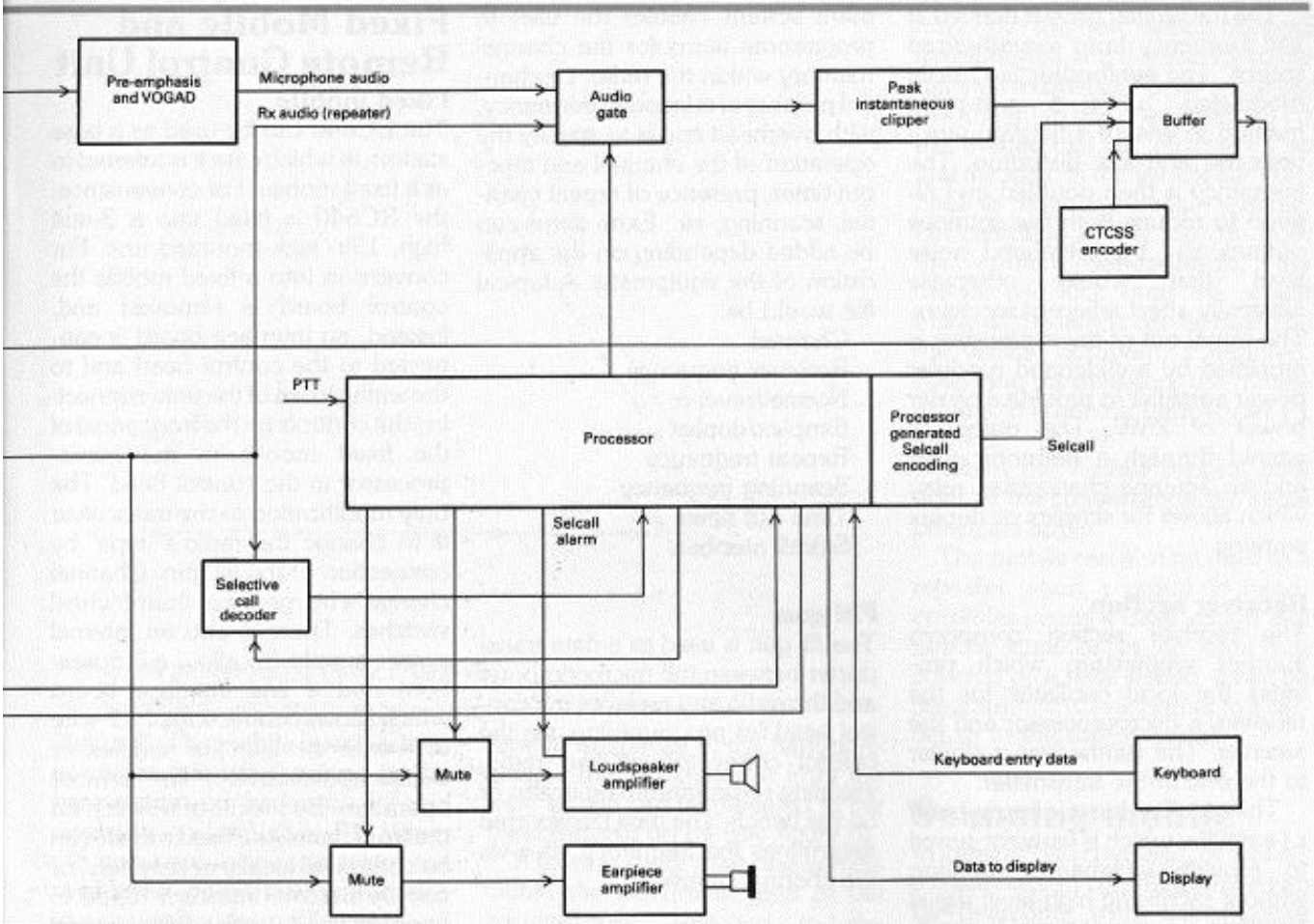
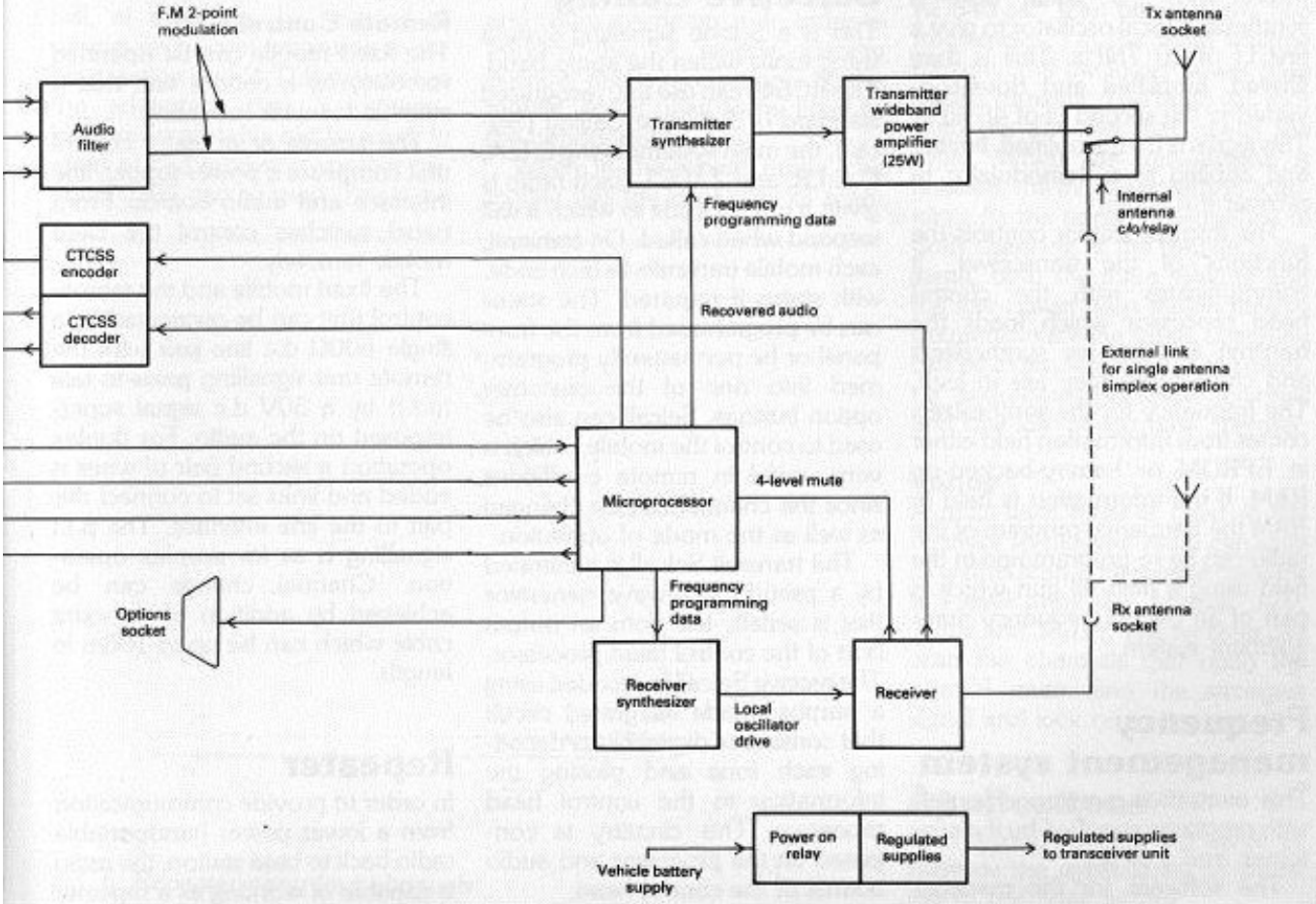


Fig. 4. Block diagram of Transceiver


Pre-emphasis and VOGAD
Microphone audio
Rx audio (repeater)
Audio gate
Peak instantaneous clipper
Buffer
CTCSS encoder
PTT
Processor
Processor generated Selcall encoding
Selcall
Selcall alarm
Selective call decoder
Mute
Loudspeaker amplifier
Keyboard entry data
Keyboard
Mute
Earpiece amplifier
Data to display
Display


F.M 2-point modulation
Tx antenna socket
Audio filter
Transmitter synthesizer
Transmitter wideband power amplifier (25W)
Frequency programming data
Internal antenna c/o relay
CTCSS encoder
CTCSS decoder
Recovered audio
External link for single antenna simplex operation
Microprocessor
4-level mute
Options socket
Frequency programming data
Rx antenna socket
Receiver synthesizer
Local oscillator drive
Receiver
Power on relay
Regulated supplies
Regulated supplies to transceiver unit
Vehicle battery supply

The transmitter drive is derived at half frequency from a synthesized source. The synthesizer is directly modulated using a two-point method to ensure a flat frequency response and low distortion. The frequency is then doubled and filtered to reduce both the spurious outputs and the wideband noise level that would otherwise adversely affect adjacent receivers. The signal out of the synthesizer is amplified by a wideband modular power amplifier to provide a carrier power of 25W. The output is passed through a harmonic filter and an antenna changeover relay which allows for simplex or duplex working.

Receiver section

The receiver section comprises another synthesizer, which provides the local oscillator for the receiver, a microprocessor and the receiver. The synthesizer is similar to the one in the transmitter.

The receiver has a narrow-band r.f amplifier which is varactor-tuned to provide wideband operation without sacrificing high-level signal handling. The input signal is amplified by the r.f amplifier and then mixed with the signal from a synthesized local oscillator to give a first i.f of 10·7MHz. This is then filtered, amplified and downconverted to the second i.f of 455kHz. This signal is then amplified, limited and applied to a demodulator to recover the audio.

The microprocessor controls the functions of the transceiver. It communicates with the control head processor which loads the transmit and receive synthesizers and checks that they are in lock. The frequency for the synthesizers comes from information held either in EPROM or battery-backed-up RAM. If the information is held in RAM the frequency program of the radio can be re-programmed in the field using a data fill gun which is part of an overall frequency management system.

Frequency management system

This comprises a microcomputer, with programs specified by the customer, and a fill gun.

The software for the management system enables the user to programme items for the channel memory within the radio, i.e channel number in relation to frequency, with overhead codes to specify the operation of the channel and time-out timer, presence of repeat channel, scanning, etc. Extra items can be added depending on the application of the equipment. A typical file would be:

Channel
Receiver frequency
Normal/reverse
Simplex/duplex
Repeat frequency
Scanning frequency
Time-out timer
Selcall number

Fill gun

The fill gun is used as a data transporter between the microcomputer and the radio and replaces the control head for programming, via the control connector on the radio, enabling re-programming in situ or on the bench. The data transported determines the frequency vis-a-vis the channel number.

Selective Calling

This is a 5-tone signalling system using tones within the audio band. The RC640 can use any recognized standard of Selective Calling (Selcall), the main systems being E.E.A, C.C.I.R, and Z.V.E.I. Each radio is given a unique code to which it will respond when called. On transmit, each mobile transmits its own code, with status if required. The status can be programmed from the front panel or be permanently programmed into one of the customer option buttons. Selcall can also be used to control the mobile, which is very useful in remote conditions since the channel can be changed as well as the mode of operation.

The transmit Selcall is generated by a pseudo sine-wave generator that is serially-fed from an output port of the control head processor. The receive Selcall is decoded using a purpose-made integrated circuit that consists of digital filters decoding each tone and passing the information to the control head processor. This circuitry is contained on the processor and audio boards of the control head.

Fixed Mobile and Remote Control Unit

Fixed mobile

The RC640 can be used as a base station, in which case it is referred to as a fixed mobile. For convenience, the RC640 is fitted into a 3-unit high, 19in rack-mounted unit. For conversion into a fixed mobile the control board is removed and, instead, an interface board is connected to the control head and to the wiring loom of the unit, connecting the controls on the front panel of the fixed mobile to the microprocessor in the control head. The only modification to the transceiver is to change the radio's 'type' by connection of the fill gun. Channel change is by means of thumbwheel switches. There is also an internal power supply (to allow a.c operation) and a line interface board which allows connection of a 2-wire or 4-wire d.c line (for simplex or duplex respectively) for remote operation. By means of a switch on the front panel, the fixed mobile can be controlled locally or remotely, or can be used in intercom mode to communicate with the control centre.

Remote Control Unit

The fixed mobile can be operated remotely by a control unit that is suitable for desk mounting.

The remote or operator control unit comprises a power supply, line interface and audio boards. Front panel switches control the fixed mobile remotely.

The fixed mobile and the remote control unit can be connected by a single 600Ω d.c line pair with the remote unit signalling press-to-talk (p.t.t) by a 50V d.c signal superimposed on the audio. For duplex operation a second pair of wires is added and links set to connect this pair to the line interface. The p.t.t signalling is as for simplex operation. Channel change can be achieved by addition of an extra cable which can be up to 100m in length.

Repeater

In order to provide communication from a lower power handportable radio back to base station, the radio is capable of working as a repeater

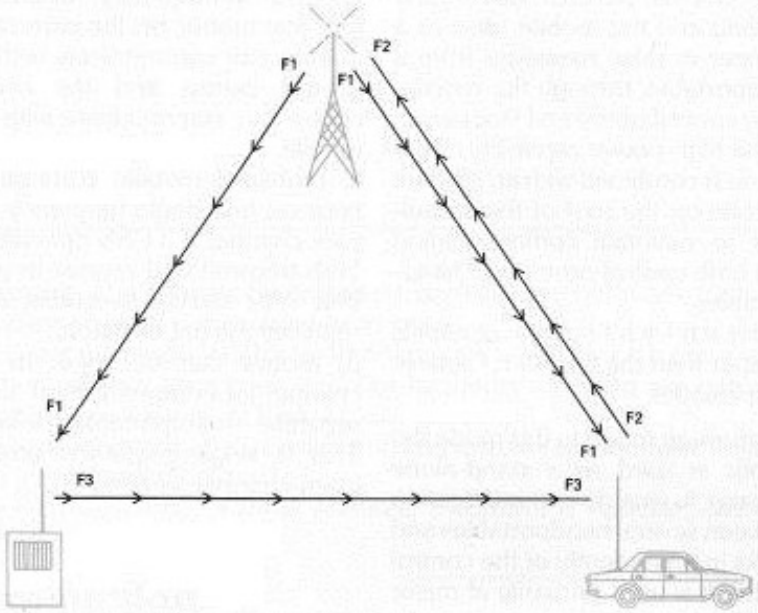


Fig. 5. Repeater using three channels

(figure 5). The mobile operates in its normal mode, transmitting to the base station on frequency F2 and receiving on frequency F1. When the occupant wishes to leave the vehicle he would take with him a low-power handportable which will receive on F1 but transmit on F3. The vehicle-mounted equipment will, at this time, be selected to receive on F3 and retransmit to the base station on F2. This system has the advantage that a low-cost, low-power portable can be used. In areas of bad reception another frequency, F4, can be used. This is the receive frequency of the handportable so that the message from the base station can be repeated to the handportable on F4 (see figure 6).

If there is more than one vehicle within the catchment area of the handportable, switched to the repeat mode, then the portable may access more than one mobile and cause interference. In order to prevent this, a vehicle identity encoder that is recognizable by the mobile would need to be fitted to the handportable.

When in the repeat mode, the mobile has the capability of scanning both the base station transmit frequency F1 and the handportable transmit frequency F3. By spending the minimum time necessary on F3 the mobile can still receive F1 so that the radio in the vehicle can continue to monitor the main scheme. On reception of the identity from the correct handportable, the mobile will lock onto the repeat mode and sidetone can be heard by the vehicle occupant, if required. Following transmission, the mobile returns to scanning frequencies F1 and F3.

When the mobile repeats both sides of the conversation the same principles apply.

The mobile can also be used as a repeater when a group of handportables needs a base station in a remote area or in an area not covered by a base station. It can be programmed to react either to a carrier or to the use of Selcall.

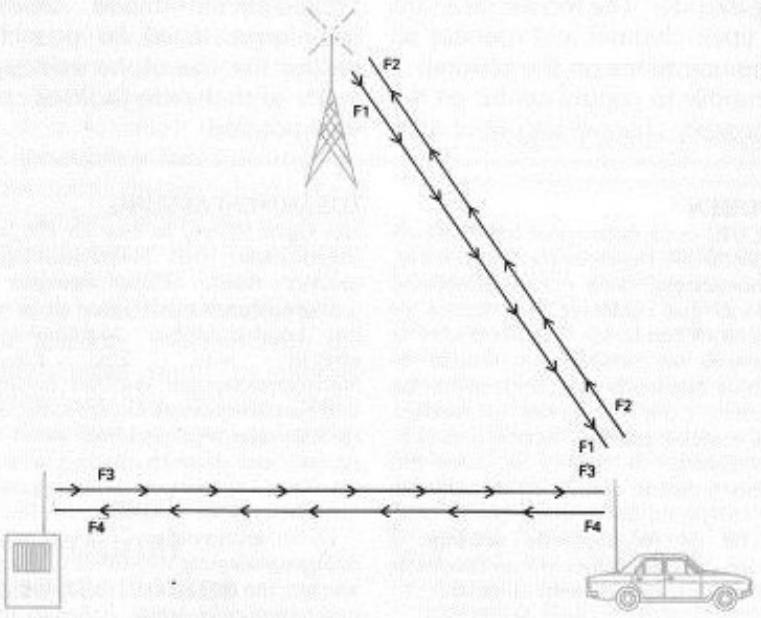


Fig. 6. Repeater using four channels

Scanning mobile

In areas of bad coverage, or 'holes', the difficulty of communication can be overcome with a low-power base station on another frequency to that of the main base station. The RC640 can scan between the two frequencies, i.e, the main scheme transmit and the lower power base station transmit. The radio will lock onto the channel that opens the mute. When the transmission is finished, the mobile reverts to scanning. As the transmit frequency of both channels in the mobile is the same, both the main scheme and the low-power base station receive frequencies are the same. Scanning can be extended to three channels, i.e, two channel or main schemes and one low-power base channel.

Voting

A multi-level mute is fitted to the receiver so that the radio can vote as well as scan. The mobile contains a 4-level mute (i.e, normal, 3μV, 10μV and 30μV). The receiver can scan the channels that open the normal mute, find the strongest signal and lock on to it.

Applications

Two typical systems will serve to illustrate the applications to which the RC640 may be put.

System for ambulance service
The first, in use with an ambulance service, is fully duplex and operates in the following modes.

Control mode This provides two-way communication between a vehicle and the ambulance control centre on a selected control channel.

Handportable mode This enables an ambulance man entering a building (e.g a high-rise block of flats) to attend an incident to communicate, via a handportable radio, with the ambulance driver. This saves valuable time and, in a serious emergency, probably also saves lives.

In this mode the mobile monitors the control channel so that messages from the control centre can be heard whilst the mobile is scanning the handportable channel for a minimal period. When a message from a handportable is detected, the mobile locks on to its frequency for the duration of the message. After the mobile has sent its reply it returns to the scanning mode, listening to the control channel whilst scanning the handportable channel.

Repeat mode It is imperative that ambulance men are able to keep in communication with the control centre even after they have left the ambulance, so that they may seek medical advice and keep the control centre advised of the situation.

It is very often impossible to communicate from a low-power handportable direct to the control centre, which may be some distance away, perhaps from inside a steel-framed building.

In the repeat mode the ambulance can be parked near to the building and the mobile used as a repeater to relay messages from a handportable, through the mobile, to the control centre and vice versa.

The high-power capability of the mobile is combined with an efficient antenna on the roof of the ambulance to maintain communication with both control centre and handportables.

This v.h.f-v.h.f repeat concept is cheaper than the v.h.f-u.h.f system it supersedes.

Talkthrough mode In this mode the mobile is used as a stand-alone repeater to enable communication between several handportables and works independently of the control centre. It is used primarily at major incidents such as motorway crashes.

System using CTCSS
The second application example makes extensive use of the continuous tone-coded signalling system (CTCSS) facilities in the radio. The software programme provides different CTCSS functions automatically on channel selection.

The system is configured such that communications are available from:
a) mobile to control centre on three channels. These channels are 2-frequency simplex. The mobile transmits a CTCSS tone on p.t.t in order to prevent access to base stations not fitted with the relevant tone decoder. The mobile receivers are open channel and monitor all communications on the channel,
b) mobile to control centre on the emergency channel for out-of-area use. This works open channel (no CTCSS) 2-frequency simplex so that any mobile on the correct frequency can communicate with the control centre and the control centre can communicate with any mobile,
c) mobile-to-mobile communications on one single-frequency simplex channel. CTCSS operates on both transmit and receive in order that only mobile-to-mobile communications are available,
d) mobile can be used on one channel for communication with a separate handportable scheme. This is single-frequency simplex, open-channel working.

Conclusion
The RC640 mobile radio is microprocessor-controlled for operational flexibility. It is intended that this one type of radio will be capable of meeting all the requirements of f.m users both in the UK and overseas. The radio is supplied to the customer with the software required for his particular application, but this software can be modified to include additional facilities to meet the customers' ever-changing mobile communications requirements.

Technology now becoming available means that the size and component count of the radio can be reduced considerably. With the increasing use of surface mount, printed-circuit board assembly techniques, it will be possible to reduce the size of the existing circuitry so that extra facilities can be incorporated.

RÉSUMÉ
Le RC640 est une radio mobile m.f pour hyperfréquences qui, par l'utilisation de microprocesseurs, possède une plus grande souplesse opérationnelle que les autres radios mobiles commerciales. Cette souplesse est encore augmentée par un système de gestion de fréquence qui peut modifier les fonctions et les fréquences des canaux. Ces changements peuvent être effectués en utilisant un introducteur de données après avoir installé la radio dans un véhicule.

Les équipements auxiliaires permettent de reconfigurer la radio afin de remplir la plupart des rôles exigés par un système à radio mobile.

RESUMEN
El RC640 es un radio móvil m.f de hiperfrecuencia que, mediante el empleo de microprocesadores, tiene mayor flexibilidad funcional que cualquier otro sistema de radio móvil comercial. Esta flexibilidad se incrementa en virtud de un sistema de ajuste de frecuencia que puede alterar las funciones y las frecuencias de canales. Estos cambios pueden hacerse utilizando un disparador de relleno de datos tras haberse instalado el radio en un vehículo.

El equipo auxiliar permite que el radio que ha de reconfigurarse satisfaga la mayoría de las funciones que un sistema de radio móvil pueda requerir de aquél.

ZUSAMMENFASSUNG
Das Gerät RC640 ist eine für FM-Betrieb eingerichtete VHF Mobilfunkanlage, in welcher durch Mikroprozessoren eine größere Anpassungsfähigkeit als bei anderen handelsüblichen Mobilfunkanlagen erreicht wird. Ein Frequenz-Managementsystem, welches Funktionen und Kanalfrequenzen ändern kann, erhöht die Anpassungsfähigkeit noch weiter. Diese Änderungen können nach Einbau des Geräts im Fahrzeug mit einer sogenannten Datenladepistole ausgeführt werden.

Durch entsprendes Zubehör kann die Anlagenauslegung zweckmäßig umgestellt werden, um die meisten, von einem Mobilfunksystem geforderten. Rollen zu spielen.