G.E.C. Patents

FOUR-FREQUENCY DIALLING FOR RADIO LINKS

British Patent No. 644411.

Long-distance transmissions by HF radio are always subjected to the vagaries of the ionosphere, and at a particular receiving station the transmitted carrier may be severely reduced in amplitude or may completely disappear for short or long periods. In addition, although the carrier may be received at suitable strength, frequency selective fading may take place for short or long periods with the result that one or more bands of frequencies in the modulation characteristic might be reduced or suppressed.

Fading is particularly troublesome when selecting signals are being transmitted , the received intelligence might then be vastly different from that intended. The G.E.C. four-frequency dialling system, which is the subject of British Patent No. 644411, has been designed to provide a means for passing selecting signals over a radio link in such a manner that variation in the characteristics of the link cannot cause incorrect selection to take place. The system is ideal for application to a radio link between two automatic exchanges, but could also be incorporated in a remote supervisory control scheme that employs HF radio.

In a link combining two automatic exchanges, the transmitter and receiver at each end are operating continuously, different carrier frequencies being used for the *go* and *return* paths. Each carrier is modulated by four frequencies, (preferably in the voice-frequency range), and the modulated carriers are transmitted all the time that the link is not in use for calling or speaking.

When a subscriber dials the appropriate number to obtain a subscriber on the distant exchange, the first digit routes his call to a coder, which both encodes and decodes. The remaining digits of the number dialled are characteristic of the wanted subscriber All digits are stored in the coder before being translated into VF modulations of the transmitted carrier.

On receipt of the first train of impulses by the coder, the associated transmitter removes all modulation from its carrier to indicate tc the distant station that a signal is about to be sent. The distant transmitter then also removes the modulation from the *return* carrier. When carrier only is received at the originating station, the coder applies a group of modulation frequencies, indicative of the first digit dialled, to the transmitted carrier This modulation is maintained until a corresponding set of modulation frequencies is received from the distant station. All modulation frequencies are again removed by the originating transmitter, followed by the removal of the *return* carrier modulation frequencies. This cycle of modulation out, modulation back, and modulation completely

off is repeated until all the digits stored in the coder have been transmitted , both carriers then remain unmodulated except by speech.

At the distant station, the groups of modulation frequencies are arranged to step a selector or selectors on to the wanted subscriber's line. At the end of conversation, release of the originating coder by the caller results in replacement of all four modulating frequencies on the carrier The re-appearance of the four frequencies releases the distant coder and selectors.

Circuit Description

Receiving Station

The whole of a call receiving and setting up operation at one station will first be described, followed by the whole of a call originating action at the other station. If the circuit diagram (Fig. 1) firstly represents the distant station at which a subscriber is to be called, then relays RW-RZ are normally operated since each of the VF receivers W-Z normally receives a voice frequency. When a calling signal is first received, all four modulating frequencies are removed from the carrier and relays RW-RZ release.

Relays BU and H then operate through the RW1-RZ1 contacts in series. Contact BU1 holds relay H operated and operates relay HA via N6. Contact H7 prevents seizure of the coder by the exchange apparatus, while contacts HA1-HA4 disconnect earths from contacts N1-N5 to the VF oscillators WO-ZO, causing removal of modulation from the *return* carrier

The originating station next applies a combination of frequencies to the *go* carrier If two frequencies are received and relays RW and RY operate, contacts RW1 and RY1 open , relay BU does not release as it is held operated by RX2 and RZ2 via BU2. Contacts RW2 and RY2 operate relays TW and TY, and earth potentials are applied via HA1 and HA3 to oscillators WO and YO, causing the emission of modulation frequencies on the *return* carrier similar to those being received from the *go* carrier Contacts TW2 and TY2 apply earth to the ninth of the leads designated V for setting the vertical magnet of a selector as described later

When the frequency code modulated on the *return* carrier is checked at the originating station as being the same as that sent, the originating station again removes all modulation from its carrier and relays RW and RY release. Contacts RW1-RZ1 hold relay BU operated. Since relay TH is operated in series with the second coils of relays TW and TY, these two relays remain operated to earth via TH1 and H1. Contacts TH2-TH5 transfer the VF receiver relay contacts to a second group of storage relays UW-UZ.

Since the release of relays RW-RZ opens contacts RW2-RZ2, earths are removed from oscillators WO-ZO and all modulation is once more removed from the *return* carrier The originating station checks this condition, and then applies VF modulation to the *go* carrier to operate, say, relay RZ. Contact RZ2 operates relay UZ via H5, TH5 and UH5, and oscillator ZO is made operative via HA4. Contact UZ5 applies earth to the first of the wires designated R to set the rotary magnet of the selector to which the coder is connected. Relay BU remains operated via RW2, RX2, RY2 and BU2.

On receipt of *return* carrier modulated by oscillator ZO, the originating station removes all modulation from the *go* carrier and releases relay RZ. Contact RZ1 holds operated relay BU and operates relay UH in series with relay UZ , relay UH then holds operated via UH1 and H1 Contact RZ2 disconnects earth from oscillator ZO to stop further emission of the modulation frequency Contacts UH2-UH5 disconnect the second storage group of relays from the VF receiver relay contacts to prevent possible operation to subsequent speech frequencies. Earth via HA5 and UH6 is now applied to the start lead ST, and a two-motion selector steps vertically to a level marked by the earth on the ninth V lead. When this level is reached, the selector steps in a rotary direction until it reaches an outlet corresponding tc the position of the earth on the first R lead. The wipers of the selector are now positioned on the wanted subscriber's line, and further operations such as ringing

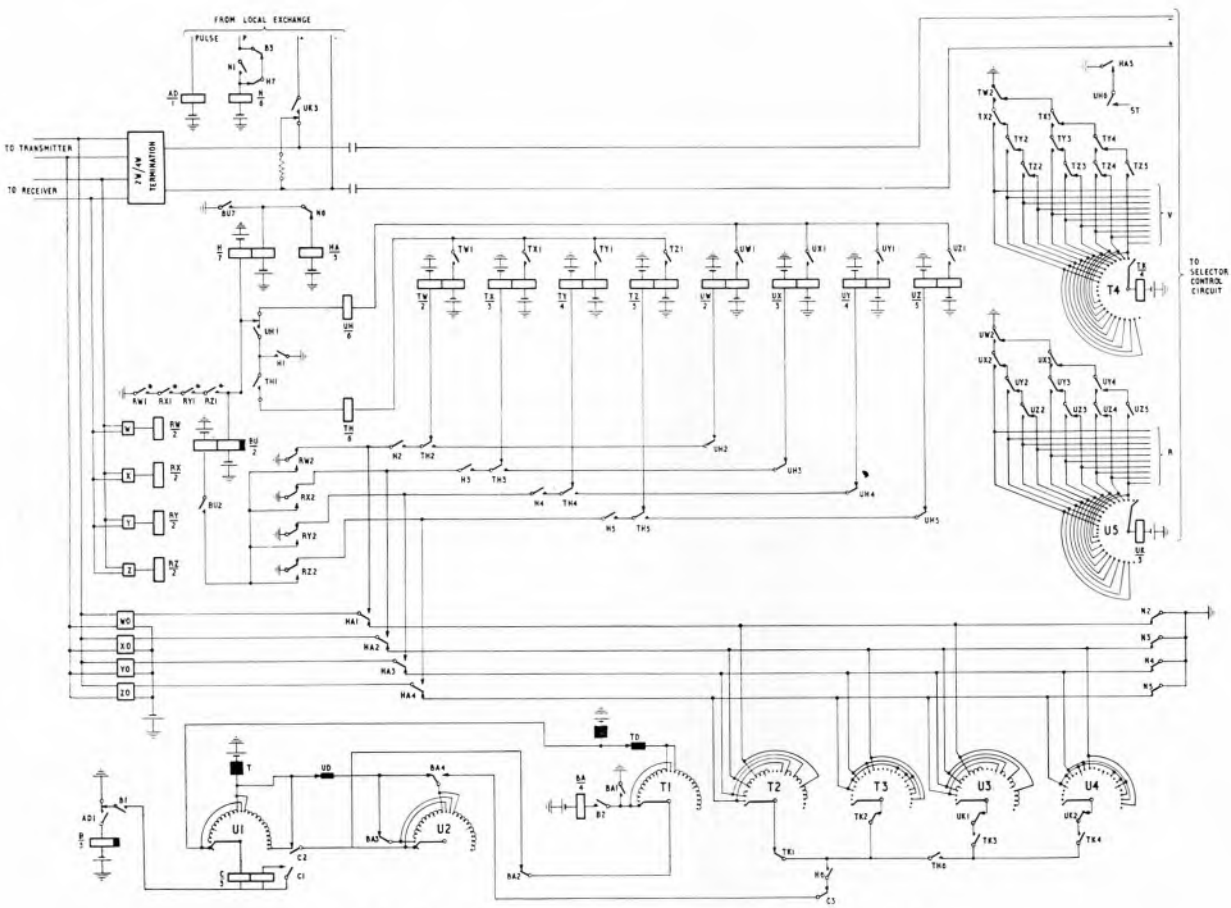

Fig. 1. Circuit Diagram of Four-Frequency Dialling terminal.

No. dialled	Oscillator energised	Receiver relays operated	Storage relays operated 1st. digit	Storage relays operated 2nd. digit
1	ZO	RZ	TZ	UZ
2	YO	RY	TY	UY
3	ZO YO	RZ RY	TZ TY	UZ UY
4	XO	RX	TX	UX
5	XO ZO	RX RZ	TX TZ	UX UZ
6	XO YO	RX RY	TX TY	UX UY
7	WO	RW	TW	UW
8	WO ZO	RW RZ	TW TZ	UW UZ
9	WO YO	RW RY	TW TY	UW UY
0	WO XO	RW RX	TW TX	UW UX

Oscillators energised and Relays operated for Digits 1-0.

the subscriber's bell and providing talking battery are performed in a conventional manner. The originating subscriber is connected to the wanted subscriber via the radio link and hybrid coil HY, which separates the incoming and outgoing speech.

At the conclusion of the call, re-application of all four frequencies to the carrier by the originating station causes operation of all relays RW-RZ. Contacts RW1-RZ1 and RW2-RZ2 release relay BU, and contact BU1 releases relays H and HA. Contact H1 releases relays TH and UH, and any storage relays that are operated. Contact HA5 removes earth from the start lead to release the selector taken into use, and contacts RW2-RZ2 connect earth to oscillators WO-ZO. With the re-application of all four frequencies to the *return* carrier, the circuit is ready to be set up for another call in either direction.

Originating Station

A subscriber wishing to make a call dials a number which connects him to the coder at his exchange. The call arrives over the leads from the local exchange, and earths extended from the exchange selectors operate relays N and AD. Contact N1 holds relay N operated, while contacts N2-N5 remove earths from oscillators WO-ZO to cut off modulation to the *go* carrier Contact N6 prevents operation of relay HA. Contact AD1 operates relay B, and contact B2 operates relay BA to earth via wiper U2, contact BA2 and wiper T1 Contact BA1 holds relay BA operated, while contacts BA3 and BA4 disconnect homing circuits for uniselector driving magnet U After a short interval the four modulation frequencies normally received from the distant station are removed from the carrier, and relays RW-RZ release. Contacts RW1-RZ1 operate relays BU and H, and relay H holds operated via BU1 Contacts RW2-RZ2, by opening, prevent premature operation of the storage relays TW TZ and UW-UZ.

The caller proceeds to dial the first of the two digits associated with the distant wanted subscriber Earth is removed and re-applied a number of times corresponding to the digit, and relay AD releases and reoperates in synchronism. When relay AD first releases, contact AD1 operates relay C and energises magnet T via B1, coil of relay C and wiper U1 Relay B is slow-to-release and remains operated throughout the call. Contact C1 short-circuits one coil of relay C to make the relay slow-to-release (and also slow-to-operate). Contact C2 energises magnet U from earth on wiper U2. On re-operation of relay AD, magnet T is de-energised and the wipers step to the second outlets. Relay C does not release until the end of the impulse train. If digits 3 and 4 are being sent, then at the end of three cycles of release and operation, relay AD is operated. Relay C releases shortly afterwards , contact C1 makes relay C quick-to-operate once more, and contact C2 de-energises magnet U All U wipers take one step.

When digit 4 is dialled, magnet U is energised four times via bank U1 and relay C, which again operates. At the end of the impulse train, the wipers of uniselector U stand on the sixth outlets, and the release of relay C applies earth from U2 via BA4, C3, H6, TK1 and TK2 to wipers T2 and T3. This earth is extended through the T2 and T3 banks to operate oscillators YO and ZO. Corresponding frequencies returned from the distant station operate relays RY and RZ. Contacts RY1 and RZ1 de-energise one coil of relay BU, but contacts RW2 and RX2 hold BU operated on the other coil. Contacts RY2 and RZ2 operate relays TY and TZ. Contacts TY4 and TZ4 apply earth from TW2 to outlet 4 of bank T4 if the frequency check is correct, and relay TK operates because wiper T4 is standing on this outlet. Contacts TK1 and TK2 remove earths from oscillators YO and ZO, causing carrier modulation to cease.

Removal of modulation from the *go* carrier results in removal of modulation from the *return* carrier, and relays RY and RZ release. Contacts RW1-RZ1 hold operated relay BU and operate relay TH via the second coils of relays TY and TZ. Contact TH6 applies earth from U2 via BA4, C3, H6, TK3, UK1, U3, outlet 6 and HA2 to oscillator XO, which emits its frequency over the carrier Similar modulation of the *return* carrier operates relay RX. Contact RX2 operates relay UX via H3, TH3 and UH3. Contact UX3 applies earth from UW2 to outlet 6 of bank U5, and relay UK operates if the frequency check is correct. Contacts UK1 and UK2 remove earths from wipers U3 and U4, and oscillator XO cuts off its emission.

Contact UK3 loops the caller's – and wires on to the hybrid coil HY Relay BU remains operated via RW2, RY2, RZ2 and BU2.

Removal of modulation from the locally-generated carrier causes removal of modulation from the received carrier, and relay RX releases. Relay UH now operates in series with relay UX.

With the distant selector positioned and the digits checked at the originating station, the wanted subscriber's bell is rung , conversation can proceed without interruption since modulation is not present on either *go* or *return* carriers.

At the end of the call, the caller replaces his handset and earths are disconnected from the P and *Pulse* leads. Relays AD and N release. Contacts N2-N5 apply earths to the oscillators and the carrier is modulated with all four frequencies. Contact AD1 releases relay B, and contact B2 releases relay BA. Contacts BA3 and BA4 connect earth from U2 via interrupter contact UD to magnet U, and the U uniselector homes by self-interruption until its wipers reach the first outlets. Earth from wiper U2 via BA2, bank T1, and interrupter contact TD now homes uniselector T to its first outlets. When the four modulating frequencies are received from the *return* carrier, relays RW-RZ operate and contacts RW1-RZ1 and RW2-RZ2 release relay BU Contact BU1 releases relay H, and contact H1 releases relays TH, UH and any operated storage relays. Storage relay contacts release relays TK and UK, and the circuit is ready to receive further calls in either direction.

Selection Safeguards

Incorrect selection of a wanted subscriber cannot take place with this four-frequency dialling system. If fading should occur, the circuits wait until the signal strength is up to normal and then carry on with the process of selection.

If a digit represented by a W and X frequency combination is being transmitted, relay BU remains operated by contacts RW1-RZ1 if signals are absent altogether, and by at least two of the contacts RW2-RZ2 if any signal, correct or incorrect, is being received. The selection cycle cannot, however, proceed until the correct combination of operated relays has operated relay TK or UK. The originating station therefore continues to send the correct code although probably receiving back an incorrect code. When the receiving station receives the correct signal undistorted by fading, it returns the correct code and the selecting cycle proceeds. Similarly, if a station is receiving a code and on returning a correctly-modulated carrier fails to receive an unmodulated carrier, then the contact chain RW1-RZ1 is broken because at least one of the parent relays is operated. Relay TH or UH fails to operate, and a start signal cannot be given to the selector mechanism. The circuits remain receptive, however, until the correct signal is received or until the cleardown signal of all four modulation frequencies terminates seizure of both originating and receiving equipment.