J. F. RIDGWELL B.Sc

THE REMOTE OPERATION OF BROADCAST TRANSMITTERS

INTRODUCTION

The remote operation of transmitters is not new; even television transmitters containing hundreds of thermionic tubes have been used on unmanned stations for many years. References were made in this journal as far back as Vol.1, No.3 in 1960 to unattended v.h.f/f.m transmitters in Hong Kong and in Vol.2, No.3 in 1961 to remotely controlled transmitters in Norway. Currently, however, there is a greatly increased interest in this method of operation. This is due to several factors, the most important being the coincidence in time of steeply accelerating maintenance costs and the substantial technological improvements available in the latest generation of transmitters.

There is another way in which the relationship of these factors leads naturally to the implementation of a remote control policy. A station equipped with very reliable transmitters which are 'on programme' for the majority of hours in each day leaves little scope for the active employment of staff during shift hours. Good staff are discouraged by the ensuing boredom and lack of experience leads to inefficient work when a fault does occur. Indeed, the artificial creation of unnecessary 'maintenance adjustments' to mitigate boredom can even lead to an increase in fault incidence.

It is therefore necessary to decide what is meant by remote control of transmitters and to formulate principles to be observed in planning for a particular system.

Since the most complicated case is that of television transmitters, these are the subject of the following discussion, a similar approach being applicable to sound only transmitters.

DEFINITION OF REMOTE CONTROL

For present purposes a remotely controlled transmitter station is understood to be entirely unmanned except during regular visits of a maintenance team. (Unscheduled visits would result only from a fault requiring early correction.)

THE COMPLETE SYSTEM

The simplest form of remote control (excluding mechanical extensions) or telemetry is a pair of wires terminating in, for example, a switch, potentiometer, lamp or meter.

This is exactly what was done when 'remote control' meant controlling one or more transmitters from a central control console.

The more sophisticated forms of electronic remote control and telemetering have to achieve the same objects but over large distances and with many controls and parameters. The large distance precludes simple d.c signalling in most cases. Also, the number of signals requires some form of coding into one common link, since the cost of separate links would be prohibitive.

Direct connections are thus replaced by a control terminal, a link and a transmitter site terminal. The purpose of the terminals is simply to translate or

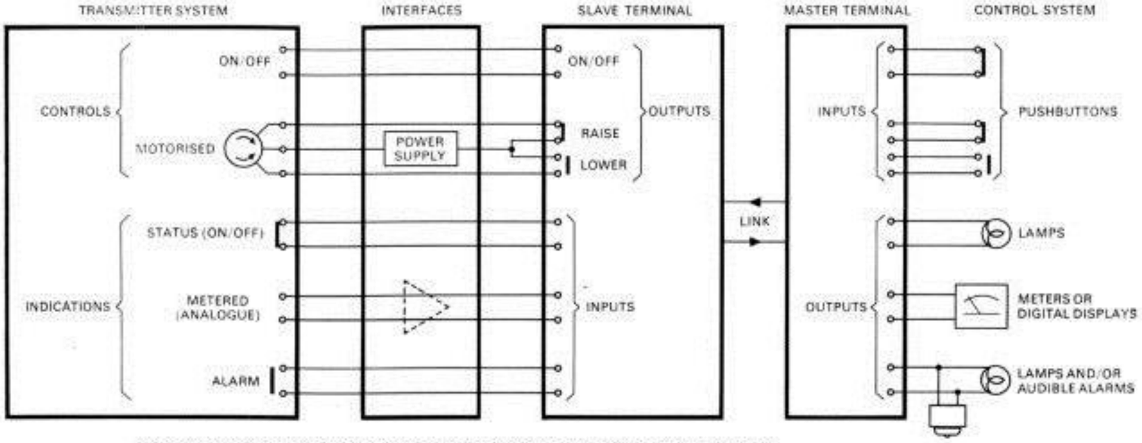

Fig.1 Schematic diagram of simple system showing types of inputs and outputs.

encode all data and control signals into a form suitable to be carried over the link, and to retranslate them at the other end.

In addition, the data, if complex, may require a great deal of organization before it can be used. A complex remote control and supervisory system can control many outlying stations from one control point and may employ a computer for data organization.

Although the natural division of the system, (figure 1), would appear to be into transmitter site, link and control site, it is more convenient for discussion to consider it under the following headings:

1 The transmitter site under remote control.
2 The remote control terminals, consisting of one at the transmitter site (the 'slave') and the control station terminal (the 'master').
3 The link, which is the bearer of information between the two remote control equipment terminals.
4 The control system (which may simply be a man).

The following discussion is intended to provide a guide when deciding:

1 The extent of control and monitoring required.
2 What type of terminal equipment is most suitable.
3 The type of link required (if a choice exists).
4 The nature of the control system.

THE TRANSMITTER SITE

On an unattended site there may be considerable delay before maintenance personnel can arrive to service a faulty equipment. Except for the least important stations, it is thus assumed that some form of standby equipment will be available.[1] It may be noted that, in the United States, the FCC have laid down mandatory requirements covering the provision of standby equipment unless the station is to be visited five times a week.[2]

Most stations eventually carry more than one programme and the conclusions of this article apply to the transmitters associated with each programme. Possible future extension should be allowed for when planning for remote control.

Fig.2 Motorized transmitter controls.

TRANSMITTER

Controls

Controls resolve into two types, 'on/off' and 'raise/lower' i.e, two-state and adjustable.

There is a bare minimum of control which must be exercised remotely. In an ideal situation this would consist of the operations 'switch on' and 'switch off'. (If the programme hours were entirely inflexible, even these could be discarded in favour of a local time switch.)

The basic 'on/off only' control should not be despised, even in practice. Several v.h.f/f.m broadcasting transmitters in Britain have operated in this way for many years; the installations, however, although unmanned are attached to manned television transmitter sites. It may reasonably be said that with modern, largely solid-state transmitters, the 'on/off only' approach will soon be, and in some cases is already a practical proposition. Nevertheless, there will be many broadcasters who feel that a limited amount of remote adjustment may avoid some unnecessary maintenance visits.

The basic on/off control may take the form of a two-stage operation if the high-power stages require a delay between the application of the heater voltage and h.t. Although normally covered by automatic delays built into the transmitter, many will prefer to be able, under remote control, to hold the transmitter at the 'ready' condition (i.e, after expiry of the delay but without h.t applied).

An apparently obvious 'raise/lower' control to add is some measure of adjustment of power output. However, this is not necessarily desirable. For example, some transmitters employ automatic feedback to hold the power level constant within close limits. An example is the B7103 series of television transmitters.[3] If the power level of such a transmitter were observed to alter significantly it may indicate a fault condition since the actual power shift has by then gone beyond the range of automatic correction. Also, adjustments involving an alteration of the total excursion on the characteristics of a television transmitter output stage frequently require complementary adjustment of the various precorrections, e.g, for differential phase and gain.

However, it is practical to remote certain rotary controls where this is thought desirable. An example of the substitution of motorized potentiometers is shown in figure 2.

As a general rule it is undesirable to provide remote adjustment of many of the variable controls since these are increasingly of the preset type, requiring readjustment only after major maintenance work. With modern solid-state technology and greatly improved vacuum tubes, the performance stability of a transmitter can be of a high order. Most adjustments consequent upon the gradual aging of components are usually better dealt with during the regular maintenance visits.

The majority of remote controls may thus be of the 'on/off' variety. Amongst the telemetry indicators discussed later are those which indicate a transient fault condition. It is useful to be able to cancel such an indication after it has been logged at the control station. This will ensure that frequent repetition of a transient fault in one area will be registered as such and not recorded as a single event. Such information can give valuable warning of the possibility of more persistent trouble developing later if unchecked.

Indications: Status, Analogue and Alarms

Indications again divide into two types 'on/off' (or 'status') and 'analogue' (continuously variable quantities).

The transmitter monitoring will have been carefully considered in the design and will serve three purposes:

(1) Status indicators giving the operational state of the transmitter e.g, Fils On, with h.t delay expired but h.t not yet applied, for which the appropriate indicator might read 'transmitter ready'.

(2) Monitoring useful during setting up and maintenance work e.g numerous voltages and currents.

(3) Diagnostic indicators which, in the event of a fault, give some indication of the area of the transmitter in which the fault has developed.

Indications which cannot influence any action which may be instigated from the remote control position need not be repeated remotely.

Clearly type (1) indicators are essential at the control point as are some, if not all, of type (3). A case may sometimes be made for repeating some of type (2) if they also have diagnostic value.

A typical set of indications to be repeated might be: filaments on, h.t on, power output normal, lock-out indicator normal (all status indicators), trip indicators (on/off type diagnostic) drive level, h.t volts, measured power output (analogue type diagnostic).

To provide for the telemetry of every parameter in the initial transmitter design would be uneconomic as it would introduce an excessive amount of circuitry unwanted by many users. Some users will thus wish to wire in extra monitoring facilities for remote indication. This is fairly easy with lamp indicators where the lamp voltage can be used directly or via a relay. Meter circuits which are at a low potential with respect to earth are usually also easy by telemetering the voltage or current in the meter, subject to adequate safeguards against danger to personnel or external equipment under transmitter fault conditions. Meter circuits involving very low current may need d.c amplification before connecting to the telemetry terminal and meter circuits at high voltage require specialized isolation devices. Hence, modifications to the transmitter for telemetry and control purposes should ideally be entrusted to the manufacturer.

Alarms may be straightforward telemetered status signals from alarm circuits available on the transmitter. Additional alarms can be used, perhaps to give earlier warning of developing faults, by installing 'out of limits' alarm units associated with analogue readings. If installed at the transmitter station they will require additional status signalling facilities but may avoid the need to repeat the analogue as such to the master station. Alternatively, they can be installed at a master station to eliminate the need for constant visual monitoring. A two-level alarm is common, giving separate 'caution' and 'danger' signals. Such a unit can operate visual or audible alarms or both.

External Monitoring Instruments

In general, the monitoring arrangements in the transmitter are concerned with circuit parameters and are not therefore able to provide much information about the *quality* of the transmitted signal. For this purpose it is normal to install standard measuring instruments to provide the appropriate data. Many such measurements can be made off-air with a receiver at the control site, thereby requiring only one set of equipment for several transmissions. The practical realization of this ideal is, unfortunately, far from satisfactory. The degradation of the signal as a result of the propagation path is a serious obstacle while high-quality receivers of *known performance* are not readily obtainable commercially.

The next problem is that of how to measure the quality of the signal *during programme transmission*. This problem is largely solved for vision transmissions by the use of insertion test signals during the field blanking period. By measuring the demodulated interval test signals, quantitative measurements can be made of the quality of transmission in terms of pulse and bar response, differential phase and gain, noise and many other respects.[4]

It is the present day refinement of this technique which has enabled the FCC in the United States to lay down mandatory requirements regarding the use of interval test signals for quality control of all remotely controlled television transmitters.[5]

Techniques for on-programme quantitative monitoring of sound quality have not yet been fully established. Tentative experiments have been made employing very low-level superimposed test tones. If the transmitter remote control site carries programme a comparator could be used to provide some measure of the degradation of the demodulated transmitted sound and used to activate an alarm if the distortion passed a certain limit.

Automatic On-programme Monitoring

The establishment of the interval test signals for on-programme monitoring has, until recently, involved visual inspection and measurement of the extracted waveform and would therefore only be done at the control site. There are, however, commercially available equipments which will

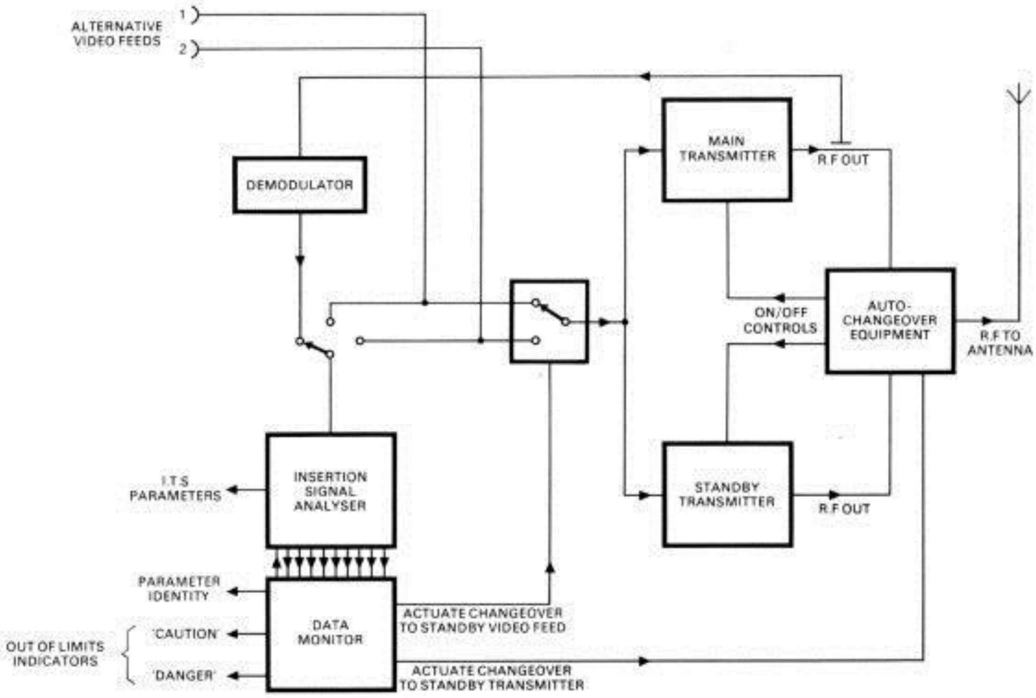

Fig.3 Schematic diagram, automatic programme monitoring.

measure automatically the various video parameters which can be deduced from the demodulated waveforms. With such equipment installed on the transmitter site, and supplied with a demodulated signal from a coupler in the output transmission line, the deterioration resulting from the propagation path is eliminated. A typical instrument produces measurements corresponding to each parameter in binary coded decimal form which can then be connected to the telemetry system.[6] Alternatively, it can be used with an associated 'out of limits' unit to provide 'warning' and 'alarm' signals which are remotely monitored as additional status signals (figure 3).

CHANGEOVER EQUIPMENT

Whatever the type of standby arrangement, the normal operating condition usually requires one equipment to be selected as the 'preferred' or operational equipment. Such a choice may exist on the drives in a paralleled system, or between the two transmitters if the standby is of equal power to the working equipment. This choice should certainly be available remotely.

The decision must then be made whether to provide automatic on-site changeover equipment in the event of the working equipment failing, or to instigate the changeover remotely from the control point as a result of telemetered data. Most operators would prefer the automatic on-site facility since this maintains station reliability even in the event of loss of remote control. Historically, automatic changeover equipment has usually taken executive control in the event of a loss of output power below a predetermined limit. If the system installed is limited to this condition it is imperative that it should be possible to override local autochange equipment from the remote control point. This is to allow changeover to be made to the standby equipment in the event of performance deterioration in other respects than power level. The remote override facility in any case is desirable.

It is now possible, using the monitoring equipment shown in figure 3, to initiate such changeover automatically.[7] Such a monitor will continually measure selected parameters of the transmitted signal. If one or more of these passes outside a predetermined tolerance value, the monitor provides an 'executive' signal which can be used to operate the automatic changeover equipment.

The changeover equipment itself may vary from the simple to the very complex. A simple example is a single motorized coaxial changeover switch with interlocked transmitter switching (since the faulty transmitter must be switched off before changeover of coaxial connections, and the standby switched on subsequently) and status signalling circuits. The more complex may involve combining and splitting arrangements in the coaxial path to the antenna, bypassing of certain transmitter stages and/or vision and sound combining unit, and perhaps also changeover to standby programme feeds to the station. Designed into the changeover equipment will be a logic system which must be made compatible with the remote control logic.

Part of the function of a changeover system must be to allow a maintenance team to work in complete safety on one transmitter while the other is radiating. It must thus be possible to switch to local control with absolute assurance that no operation at the remote control point can have any effect on the site, other than switching on and off the operational equipment.

Automatic operation will involve changes in the transmission line path by the use of motorized changeover switches. For both economy and safety alterations in the coaxial configuration which may be made for test purposes only are usually achieved by manually adjusted U-links. This imposes disciplines on the maintenance team which are dealt with later. Although not under remote control at such times it is desirable that the transmission line configuration (i.e, 'Status') be constantly telemetered to the control centre.

OTHER EQUIPMENT

A remote control and telemetry system will not only involve the transmitter and changeover equipment but also other items, for example, the building, mast and antenna system. Aviation lighting, antenna de-icing and general site security alarms are obvious possibilities for control and/or monitoring. Roll-type air filters may be installed on some sites which can be remotely monitored and advanced, if desired. On sites where water is employed for cooling, e.g, for klystrons, it will be important to avoid freezing during transmitter shut down periods. Automatic means of so doing will usually be employed but, again, remote monitoring and override can be used to increase site reliability.

INTERFACES

With the almost universal use of solid-state techniques the question of the form of the interconnections at the interface between equipments arises. If logic signals are presented at terminals, they are by their very nature not isolated. They are therefore subject to problems of incompatibility of levels, interaction and externally generated spurious signals. On the other hand isolated contacts have only been available from relays. A recent tendency for many engineers, based on experience, is to prefer solid-state components to relays for reasons of reliability. It is impossible to be dogmatic on this point. Other things being equal, isolated contacts are probably easier to deal with and many feel quite confident when high-quality modern relays are used. The further development of optoelectronic components, being essentially semiconductor devices with a very high degree of isolation, may provide the answer in future. Many currently available equipments do provide a choice between connecting directly into the semiconductor circuit or connecting via a relay.

MAINTENANCE WORK

It is most important that a firm discipline be exercised following a maintenance visit at unattended stations or equipment in perfect working order may be left in an unsatisfactory operational condition. A maintenance team might leave the site with the 'working' transmitter directed into the test load by means of manually adjusted U-links or a frequency modulator pre-emphasis switch in the 'pre-emphasis in' on a stereo station. Or, since the changeover to remote control must only be possible on site for safety reasons, the maintenance team could leave the site with the remote control system ineffective.

The system design should include integral safeguards against such eventualities, even when maintenance disciplines are of a high order. One comparatively simple method is to use what has been dubbed in the United Kingdom a 'go-home' circuit. This is simply a series connection of auxiliary contacts in all items which can be left in a non-operational condition, although the equipment is apparently working satisfactorily. Examples include the test load connection and the local-to-remote control switch. If these are in the wrong position the circuit is not made and the 'go-home' lamp will not light.

THE REMOTE CONTROL TERMINALS

Both indication and control signals are pieces of information. When a large number of pieces of information are to be sent over one link they must be 'multiplexed' onto one or more carrier frequencies in some way. One method is to send them one at a time together with synchronizing signals (time division multiplex). If many pieces of information are to be passed simultaneously, it will be necessary to use frequency division multiplex, when several data items can occupy the bandwidth of the link at the same time. In practice a combination of the two is commonly used. In either case, the greater the rate of transmission of data the greater the bandwidth required. This rate of transmission has some importance. For a given link there is no theoretical limit to the number of pieces of information which may be passed. However, if it takes five minutes to discover that a transmitter has failed, and another five minutes to command the changeover system to operate, the resulting ten minutes break in programme is unlikely to be acceptable to most viewers! The number of transmitter controls and indications are therefore directly related to the capability of the remote control equipment and associated link. The most frequently used equipment is designed for use in the voice frequency (v.f) band i.e, one with an upper frequency limit of 3,180Hz.

THE CODING EQUIPMENT

Low Density Systems

The most common system of coding used is frequency shift signalling. Audio frequencies in the v.f band are used, one to designate the 'on' condition and another the 'off'. At the distant terminal these are converted into the required signals. The 'raise' and 'lower', as has already been shown, are equivalent conditions and can be similarly signalled. An analogue quantity is converted into a frequency proportional to its value. At the distant terminal the reverse process occurs.

Typical proprietary equipment designed to meet CCITT Recommendations uses an audio frequency which is shifted +30Hz by an 'on' or 'raise' signal and by −30Hz by an 'off' or 'lower' signal.[8] In the same equipment range an analogue equivalent

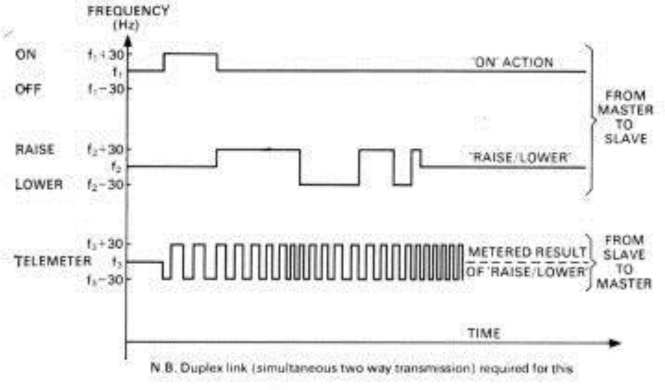

Fig.4 Typical frequency-shift signals on link, (duplex link).

frequency is a series of ±30Hz pulses at varying repetition rates[9] (figure 4).

Such equipment is limited to about 24 channels each 120Hz wide in the v.f band and the use of a number of such channels would be an example of frequency division multiplex enabling up to 24 sets of controls and indicators to be simultaneously available. This is a costly process involving separate frequency generators, coders and decoders for each channel, and using up the complete v.f band for only 24 controls and indications. In addition 24 channels would often be insufficient.

There are relatively few items of data or control which need to be *continuously* available. If they can be easily selected, or regularly scanned, this is usually quite sufficient. It is therefore common to use a time division multiplex approach on one, or a few, frequency channels. The simplest method of doing this is by manual selection. Typically, one frequency channel is used to send, in response to a manual control, a series of pulses which will cause a selector at the slave station to switch to the desired parameter which is then monitored on another frequency channel. A third channel is used for control purposes on the same selection. This means that the one manual operation selects both an indication and a control simultaneously. They may, but need not be, directly related. A number of small remote control systems specifically designed for the broadcaster are available, chiefly from the United States, which operate in this way.[10] These represent a simple, unsophisticated method of exercising a limited amount of control and supervision. Because they are custom designed for the broadcaster, economies in hardware are possible and choice of frequencies, etc, can be made without regard to interchangeability with other equipment.

	TRANSMITTED	ERROR	RECEIVED	REMARKS
SINGLE CHARACTER	1	—	1	ACCEPTED, CORRECTLY
	1	0 SUBSTITUTED	0	ACCEPTED, WRONGLY (MESSAGE VALID)
	1	3 SUBSTITUTED	3	REJECTED, BUT REPEAT 1 OR 0 STILL OF LOW CERTAINTY
ADDED 'REDUNDANT' CHARACTERS	111111	—	111111	ACCEPTED, WITH HIGH CERTAINTY
	111111	— — 0 — — —	110111	COULD REJECT (INVALID) OR COULD ASSUME CORRECTION WITH FAIR CERTAINTY
	111111	— — 0 0 0 —	110001	REJECTED, REPEAT REQUESTED

Fig.5 Message security by redundant characters.

The next step in sophistication is to include automatic, constantly cycling, scanning systems synchronizing between master and slave, and providing, by means of an intermediate store at the control point, a constantly up-dated readout of data. On/off controls can be exercised in exactly the same way from the master to the slave. A typical equipment allows up to 120 separate points of 'on' or 'off' type information to be sampled sequentially and transmitted on one frequency channel.[11] When using one 120Hz channel the scanning rate is 15 points per second; thus all 120 points will be scanned in eight seconds. Using all 24 channels therefore 120 × 24 = 2880 conditions can be transmitted in eight seconds. The scanning speed can be increased to 100 points per second when using the 480Hz CCITT channels when the 120 points on each channel can be scanned in 1·2 seconds. There are four such channels available in a v.f band hence 480 conditions can be transmitted in 1·2 seconds. This illustrates the customary inter-relation of rate of transmission of information and bandwidth.

High Density Systems

All the systems so far discussed suffer from some disadvantages. All the status and control signals are represented by one of two states that is, they are of binary digit form. Distortion of these signals as a result of equipment malfunction, induced noise, etc, can still produce a valid signal i.e, the other terminal has no reason to reject it, but which is in fact wrong. This is the problem of message 'integrity'. Noise is one cause of distortion although more likely to be so on an automatic scanning system than one with manual selection which has inherently low signalling speed. Analogue signalling can suffer from gain drift and require frequent calibration. Both can suffer if the selectors or scanners at the two terminals get out of step as there is no return confirmation that the point selected is the correct one, i.e, there is no 'handshake' in data processing jargon.

The lack of message 'integrity' arises from the lack of 'redundancy' in the coded message, because *all* of the signal is used for essential information. This may be illustrated in the following way. A person reading a garbled telegram can often 'correct' the result successfully. This is largely because there is considerable redundancy in everyday written languages. However, one could imagine, for example, someone foolishly arranging for a colleague to economize in some business negotiations by sending the single number '0' to represent the instruction 'sign the contract' or '1' for 'do not sign'. If a transmission error led to '0' being received instead of '1' the message would not only be in error but the recipient would have no reason to even suspect an error. Another number altogether would indicate an error which could be queried but still not guarantee accuracy when repetition produced an '0' or '1'. However, if the code had been ten '0's in a string for 'sign' or ten '1's in a string for 'do not sign' the message

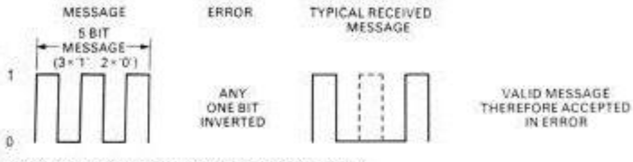

Fig.6a 5-bit message, all combinations valid.

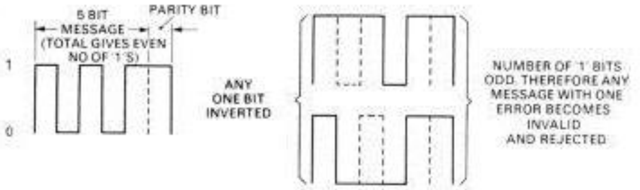

Fig.6b 5-bit message plus parity bit – only combinations including even number of '1' bits are valid ('even' parity).

integrity would be high since any mixture of numbers would be invalid and the likelihood of all '0's being turned into '1's or vice versa is very low indeed. All the extra digits add nothing to the basic information, i.e, are 'redundant', but help considerably in identifying errors of transmission. He would then feel very confident that he had actually received the message correctly, (figure 5). At this point the only uncertainty exists in the mind of the distant colleague, who will not know if his instruction has been acted upon. Confirmation to him of such action is the final event in that 'control process'.

To extend this illustration one stage further it can be imagined that the person sending the '0's or '1's is controlling several negotiators in different places. He must than ensure that his messages are correctly addressed. Because these might get distorted in transmission, he insists that the recipient shall repeat back his own address, before the instruction is sent to him. (This is the 'handshake' referred to earlier.) In this way he can use the same coded instructions for everyone, without fear of confusion.

The more complex supervisory systems are organized along similar lines. However, where a person might use codes involving all the numerical digits and all the alphabet, practical control systems today use binary digits and the addresses, instructions and data will have to be coded in sequential binary digital form. This means that instead of complete strings of zeros or ones only, the coded addresses, instructions and data must be mixtures of the two. In practice, each 'bit' (one binary digit) is a specified time period during which the signal is either at one known level corresponding to a '1' or at a second known level, corresponding to a '0'. The addresses, instructions and data are coded into 'words' made up of a given number of bits transmitted sequentially.

The number of different meanings to be assigned to a word determines the minimum number of bits in the word. One bit can have two meanings, two bits four meanings, three bits weight meanings, or in general 2^n meanings where n is the number of bits.

If, however, all possible meanings are used there is no 'redundancy', one word being as valid as another and the possiblity of detecting errors is very limited. Therefore a certain number of 'parity' bits are usually added to enable error detection circuits to be used. In some systems the possibility of undetected errors becomes very low indeed. Although the theory of error detection is the subject of mathematical treatment quite outside the scope of this article, the type of approach is illustrated by the simplest method of adding one parity bit to a word having an odd number of bits. The sending coding equipment then counts the number of bits of a given polarity in the correctly coded word, and inserts the parity bit so that there is always an even number of bits of that polarity in the transmitted word. For example, in a five bit word having three bits at '1' and two bits at '0', the parity would be '1', giving an even number of '1' bits. A single bit error in transmission would result in an odd number of '1' bits being received. The receiving terminal would reject this an an 'invalid word' and would request a repeat (figure 6).

In addition other bits are required to synchronize decoders and a complete word may contain start and stop bits, address bits, message bits and parity bits. This would be typical of a control instruction. Analogues would be coded into words by analogue/digital convertors. Where analogues are already available in parallel digital form, parallel to series convertors are used. Status indications may be combined, many to each word, since each bit is a status indicator (redundancy, however, is lost when this is done).

With a system that 'talks' in digital words great flexibility is possible, but it requires a fairly complex control system to be economic and is usually applied where one centre is used to control a number of outstations. The use of words containing unique addresses allows the use of a common link system (or 'data highway') to several outstations. Each one will only then respond to command words containing its own address. This principle can even be extended beyond station addresses to 'point' addresses inside the slave station.[12] (figure 7).

It should be noted that a system using digital words only achieves its advantages in security and flexibility at the expense of either speed or bandwidth.

The Link

Virtually all commercially available remote control systems are designed to operate over a two or four-wire circuit on one or more voice-frequency carriers, the information being conveyed by frequency-shift modulation.

The most commonly available circuit is a subscriber's telephone circuit. The complexity and importance of the system will determine whether, if a telephone line is used, this should be an exclusively rented circuit or a switched circuit. Provided that the maximum probable delay in establishing a connection between the master and slave is operationally acceptable, considerable

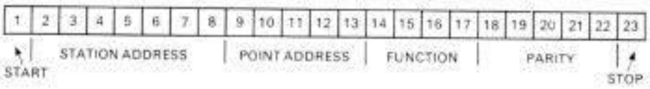

Fig.7 Structure of typical complex 'instruction' word.

savings will be obtained by using the latter.

Control and monitoring can also be exercised via any form of radio link which can carry v.f channels, either as the fundamental modulation or as a modulated sub-carrier. Aural programme links can be used in this way where local conditions permit.

High-speed, high density systems may require wide bandwidths and call for special channels to be installed, but these are only likely to be used by the most complex systems when the full requirements will be the subject of a detailed examination by the customer and system contractor.

The Control System

For most comparatively simple systems control will be exercised by a man who will have a control position with various pushbuttons and display devices (lamps, meters, digital displays etc) in front of him.

To eliminate the need for the operator to log various readings an automatic data-logger, of which there are several types available, should be installed at the control site. This will log data in printed form regularly and can be arranged to print 'out of limits' data in a different colour.

For complex, digital word organized systems, the use of a small computer may be worthwhile. This can be used for logging and analyzing recorded data, analyzing fault reports and can be programmed to take a certain amount of supervisory control. It is unlikely that many systems will justify the exclusive use of even a small computer. However, if employed on a time-sharing basis, the many other administrative and technical data handling problems of a broadcasting organization may well justify such an installation.

CONCLUSION

This article attempts to trace in an orderly sequence the problems of remotely controlling transmitters and to examine the means of solving them. While it has not been possible to go into full details, which vary greatly from one equipment to another, it is hoped that the general principles outlined will provide a framework for remote control system planning.

REFERENCES

1 S. S. Spraggs: Transmitter Reserve Facilities, Sound and Vision broadcasting, Vol.12, No.3, Winter, 1971.
2 FCC rule 73.676(g).
3 J. F. H. Binns: A Single-Valve 1kW v.h.f Television Transmitter, Sound and Vision broadcasting, Vol.12 No.2, Summer, 1971.
4 L. E. Weaver: Television Video Transmission Measurements, published by Marconi Instruments Limited.
5 FCC Rule 73.676(f).
6 Marconi Instruments TF 2914 Insertion Signal Analyser.
7 Marconi Instruments TF 2915 Data Monitor.
8 GEC-Elliott Automation 'Teleshift Mark II'.
9 GEC-Elliott Automation 'Teleducer Mark II'.
10 For example, Marti, Moseley Associates or Spantronic.
11 GEC-Elliott Automation 'Telecode Mark IV'.
12 GEC-Elliott Automation 'Telespace'.