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An adaptive receiving system for u.h.f. television

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AN ADAPTIVE RECEIVING SYSTEM FOR UHF TELEVISION

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Summary

This report describes a u.h.f. television adaptive receiving system intended for use at transmitters fed by re-broadcast link, in cases where special measures are needed to reduce co-channel interference. The system automatically adjusts the directivity pattern of the receiving aerial array to place minima of response on bearings from which interfering signals are received.

The equipment was designed to respond to interference in the demodulated video signal over the range 1 Hz to 5·5 MHz and to reject up to six interfering signals simultaneously.

Many of the problems encountered with the design and operation of the equipment are described. These difficulties were not completely solved before work was stopped on the project due to changing requirements which have removed the demand for a system of this complexity.

Issued under the authority of

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Section Title Page

AN ADAPTIVE RECEIVING SYSTEM FOR UHF TELEVISION

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1. Introduction

When providing a u.h.f. television service in which a high proportion of the transmitters obtain the programme by means of a re-broadcast link there will inevitably be cases where interfering transmissions in the received channel make the provision of such a link difficult.

In these circumstances several approaches are possible: for example, a s.h.f. link from a more favourable receiving site, or a very large high-gain receiving aerial array may be used. In certain cases both these systems may be technically or economically impracticable. Another method is to use a simpler aerial structure together with an adaptive receiving system.[1] Such a system continuously makes adjustments to the receiving aerial directivity pattern so as to discriminate against interfering signals. Although such a system can only reject a limited number of sources of interference at any one time, the directions of rejection are continuously adjusted for prevailing conditions and thus it can deal with many possible sources of interference including sources not envisaged when the system was built. The system will also adjust for changes in the aerial system, such as differential feeder expansion with temperature, which would de-phase the elements of a fixed array. It can also compensate for the loss of, or damage to, part of the aerial array, although with some reduction in performance.

An experimental adaptive equipment, constructed to investigate the feasibility of the principle, has been described in an earlier Research Report.[2]

In many cases it would be sufficient to design an adaptive system to reject only television transmissions with the standard offsets. The equipment described in this report is more complex and intended to reject interference with all frequency spacings from the wanted vision carrier from a few Hertz up to the maximum video frequency of 5·5 MHz.

2. General description

The basic functions which the equipment is required to perform are to detect the presence of interference, to measure its magnitude and to manipulate the directivity pattern of the receiving aerial array so as to minimise the pick-up of interference. The means by which these functions are performed are shown in the simplified block diagram of Fig. 1.

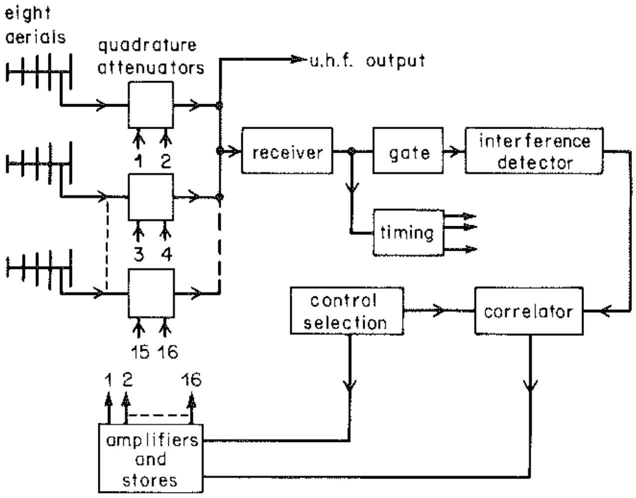

Fig. 1 - Simplified block diagram

The receiving aerial system consists of eight separate aerials, the outputs of which are fed through individual quadrature attenuators (see Section 3.2) before being combined to form the r.f. input signal used to feed both the adaptive system receiver and the re-broadcast frequency translator (or receiver and transmitter). The phase and amplitude of the contribution of each separate aerial to the combined r.f. signal can be varied by means of control voltages applied to the two control ports of the appropriate quadrature attenuator, thus varying the directivity pattern of the aerial system.

The interference measuring circuits operate on the video signal. Since the only parts of the video signal whose waveform is known in advance are those occurring in the synchronising intervals, these are used for the interference measurements. The output of the receiver is fed to both the synchronising pulse separator, for the general timing circuits, and a video gate which permits only the appropriate parts of the synchronising interval waveform to pass to the measurement circuits.

In order to obtain information to carry out the process of adaption, rectangular test pulses are added to selected control inputs of the quadrature attenuator for the duration of alternate line synchronising intervals and also during portions of the field synchronising interval. The selection of the particular controls to which the test waveform is applied is made by a pseudo-random sequence generator, a new selection being made at the start of every field. These test pulses will make small changes to the receiving aerial directivity pattern and hence to the level of interference. By correlating the change in interference level with the alternation of 'test' and 'normal' conditions of the aerial directivity pattern, it is possible to ascertain if the change is advantageous and, if so, to incorporate the change into the control settings before a new test sequence is started.

The interference detector[3] itself consists of three sections which measure, respectively, the upper-frequency interference about 300 kHz, the lower-frequency interference below 90 kHz, and the middle-frequency range of

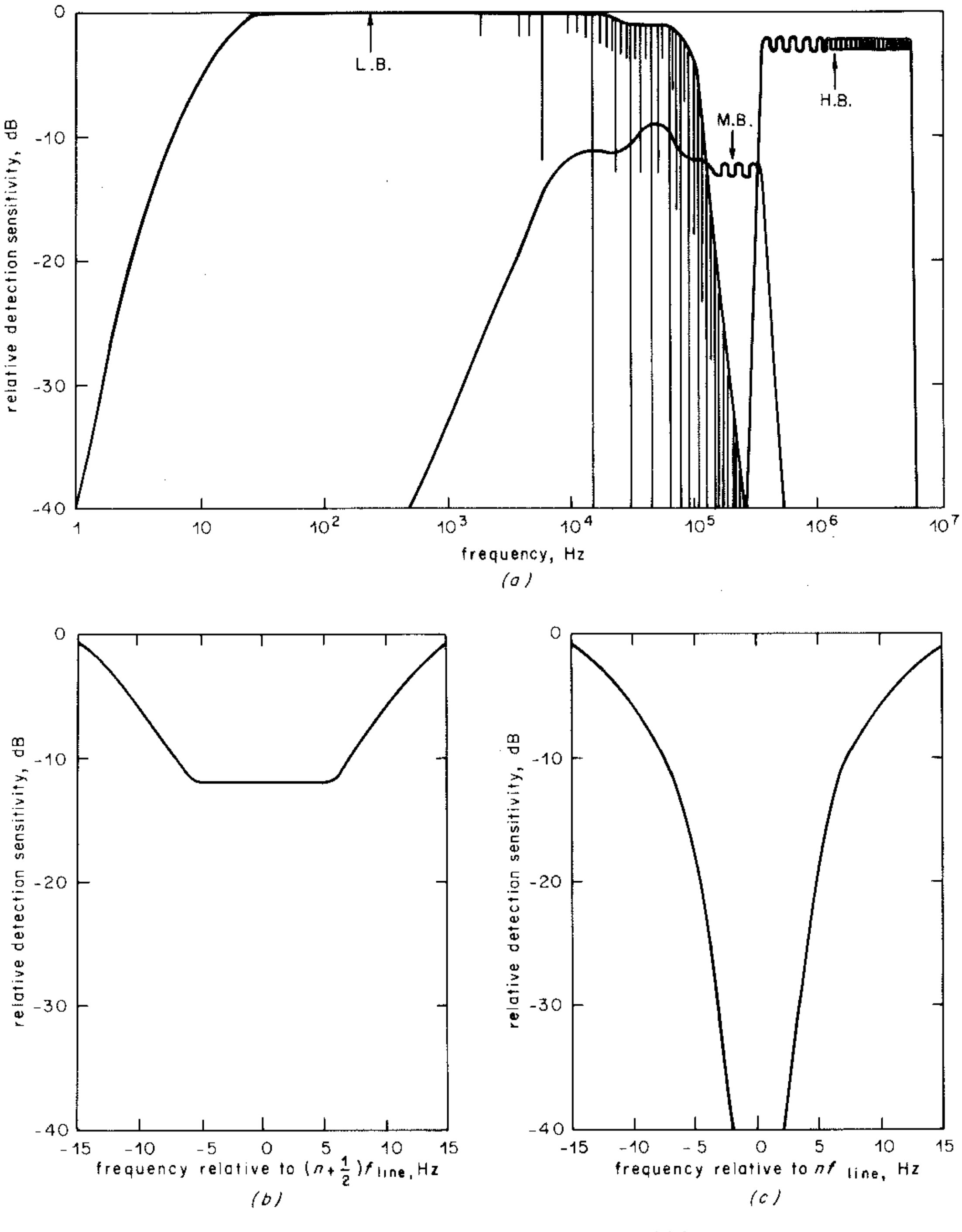

Fig. 2 - Theoretical relative detection sensitivity

(*a*) Overall response; LB = lower frequency band, MB = middle frequency band, HB = upper frequency band
(*b*) Half-line frequency notch (*c*) Line-frequency notch

interference from 10 kHz to 300 kHz. The upper-frequency interference is detected as a modulation of the nominally flat tops of the line synchronising pulses. The lower-frequency interference is detected as a perturbation of the envelope of the tips of these line synchronising pulses. The middle-frequency interference is detected as modulation of the received signal in the periods between the equalising pulses which occur during the field blanking interval. For the purpose of this report these periods will be called equalising periods.

Fig. 2(*a*) shows the theoretical relative sensitivity to c.w. interference in the three channels of the interference detector as a function of the beat frequency between the interference and the wanted carrier. Figs. 2(*b*) and 2(*c*) show the fine structure of the curve applicable to the lower-frequency band.

In the lower-frequency channel the information is sampled at line rate and, without adopting some special measures, it would therefore not be possible to detect

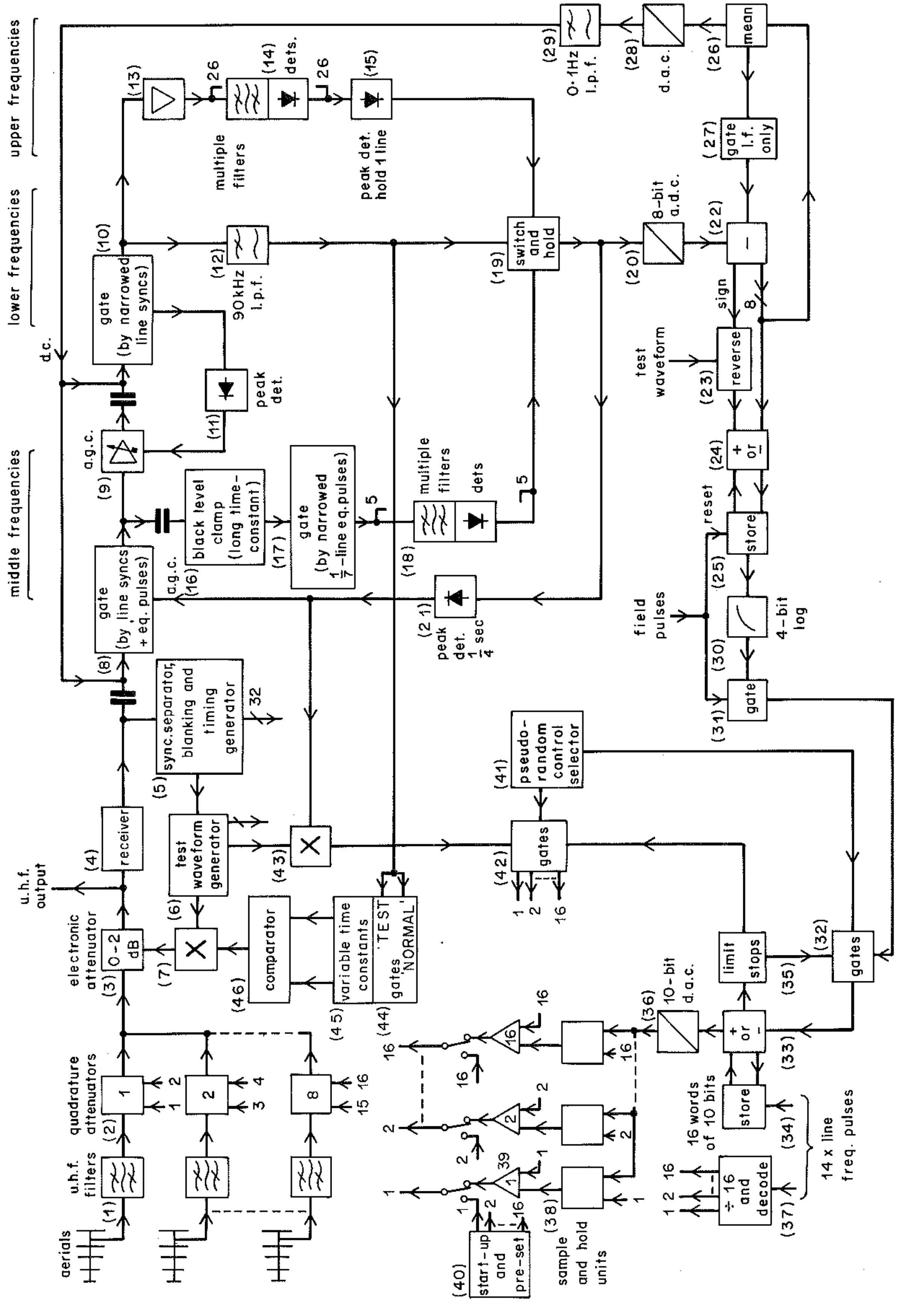
aerials
(1) u.h.f. filters
(2) quadrature attenuators
1
2
8
1 2
3 4
15 16
(3) electronic attenuator 0-2 dB
(4) receiver
u.h.f. output
(5) sync.separator, blanking and timing generator
32
(6) test waveform generator
(7)
(8) gate (by line syncs + eq. pulses)
a.g.c. (16)
(9) a.g.c.
(10) gate (by narrowed line syncs)
(11) peak det.
(12) 90kHz l.p.f.
(13)
(14) multiple filters dets.
26
(15) peak det. hold 1 line
(17) black level clamp (long time-constant)
gate (by narrowed 1/7-line eq.pulses)
5
(18) multiple filters dets
(19) switch and hold
(20) 8-bit a.d.c.
(21) peak det. 1/4 sec
(22)
sign
8
(23) reverse
test waveform
(24) + or −
reset
(25) store
field pulses
4-bit log
(26) mean
(27) gate l.f. only
(28) d.a.c.
(29) 0·1Hz l.p.f.
d.c.
(30)
(31) gate
(32) gates
(33)
(34) 14 x line freq. pulses
16 words of 10 bits store
(35) limit stops
(36) 10-bit d.a.c.
(37) ÷16 and decode
1 2 16
(38) sample and hold units
39
(40) start-up and pre-set
(41) pseudo-random control selector
(42) gates
1 2 16
(43)
(44) gates 'TEST' 'NORMAL'
(45) variable time constants
(46) comparator
lower frequencies
middle frequencies
upper frequencies

FIG. 3

frequencies at or close to harmonics of line frequency. Since only alternate samples are used for the 'test' and 'normal' measurements similar blind spots occur at odd multiples of half-line frequency. The reduction of sensitivity at odd half-line multiples is limited to 12 dB (Fig. 2(*b*)) by interchanging the 'test' and 'normal' sequences every eight lines; this introduces a small (2 dB) loss at multiples of one eighth of line frequency. The range covered by the middle-frequency section has been extended downwards to cover the lower multiples of line frequency. Because this section uses the equalising periods, it does not have the line-frequency harmonic insensitivities, but, since the total time per field available for test in this channel is only one tenth of that in each of the other channels, the signal-to-noise ratio is 10 dB less. To prevent the system being dominated by this excess noise, the gain in this channel is reduced by 10 dB.

For frequencies above 300 kHz, at least one complete cycle of the interference occurs during the sampling time of 3·5 μs and information on the interference at line harmonic frequencies in the high-frequency section is not lost by the sampling process.

When a shot change occurs in the television picture, it is quite common for a transient, persisting for several fields, to appear in the amplitude of the synchronising pulses. The magnitude of this effect is insufficient to disturb a normal receiver but it is interpreted as an interference by the adaptive system. Reversing the sequence of 'test' and 'normal' conditions at intervals of eight line periods, as mentioned above, helps to minimise the disturbance to the adaptive process that these transients would otherwise produce.

3. Detailed description

Fig. 3 gives a more detailed block diagram of the complete system.

3.1. Aerial filtering

In the complete equipment the aerials are followed by filters (1) which pass only the wanted channel, thus rejecting other u.h.f. transmissions which could give rise to intermodulation products. Each of these units is a four-resonator comb-line filter with a low-gain (7 dB) buffer amplifier built into the filter box. These amplifiers provide a constant-impedance termination for the filters and isolate them from the variable input impedance of the quadrature attenuators.

3.2. Quadrature attenuator unit

In the quadrature attenuator unit each of the aerial inputs passes through a separate quadrature attenuator (2) before they are combined in pairs by low gain amplifiers. The resulting four signals are then combined into one output by 3 dB couplers and amplified. The amplifier is followed by a simple p.i.n. diode attenuator (3) (range ± 1 dB) and then a further coupler supplying the two r.f. outputs. One output provides a feed to the rebroadcast receiver or transposer and the other drives the system receiver.

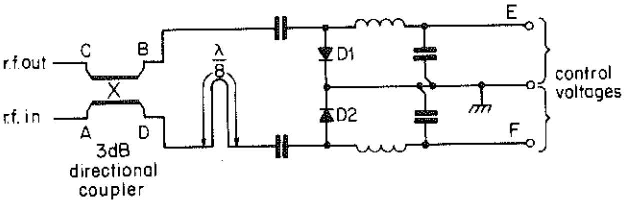

Fig. 4 - Quadrature attenuator

The purpose of the small-range attenuator (3) is to provide a fast a.g.c. system, working only during the synchronising pulses, to eliminate small gain changes resulting from the test changes in the aerial directivity pattern.

The quadrature attenuator, shown in detail in Fig. 4, consists of a 3-dB directional coupler with each of the two input ports B and D terminated by a p.i.n. diode. The electrical length of the line connecting port D to its diode is greater by one eighth of a wavelength (at the mid-band frequency) than that for port B. Any power reflected by the diodes is recombined by the coupler and provides an output at port C. Varying the direct current through the diode D1 varies the magnitude and polarity of the in-phase component at the output port. Similarly, varying the current through D2 varies the magnitude of the quadrature component. Thus, adjustment of the voltages applied to the control ports E and F permits both the amplitude and phase of the output to be adjusted as required.

Provision is also made to energise, as required, a noise diode[4,5] across each of the inputs. This provides a test facility. When any one of these controls is operated, continuous noise appears at the output, which should then be rapidly eliminated as the system re-adapts to the new conditions. The adaptive controls for that input are then known to be operational.

3.3. Receiver

The main requirements for the adaptive system receiver (4) are that (i) it should not distort or clip any interference on the tips of the synchronising pulses, (ii) it should have a good a.g.c. characteristic with a long time constant, (iii) it should have a good amplitude response over the full video bandwidth and extending downwards in frequency to at least 0·2 Hz. The group-delay characteristic is relatively unimportant since it does not significantly affect the response to interference; it need only be sufficiently good to avoid picture waveforms and synchronising-pulse edges affecting the centre portion of the line synchronising pulses.

In the system, it was convenient to use a commercially-available receiver, the Decca type RU3911. This was modified to improve the low video-frequency response by increasing the a.g.c. and video-coupling time constants, and by stabilising the detector bias supply and the main d.c. supply. This last modification also reduced the hum level.

3.4. Timing unit

The timing unit consists of two main sections, the synchronising-pulse separator (5), and the pulse generators to drive the timing (5) and waveform (6) generators.

The commonly-used 'slicing' type of line synchronising-pulse separator is not satisfactory for use in an adaptive system since it has been found that, if the interference consists of another television transmission with a slightly higher line frequency, then, as the interfering synchronising pulse advances through the leading edge of the wanted synchronising pulse at slicing level, it will take control and the adaptive system will lock onto the interference and treat it as the wanted signal. The system used here is a tracking gate where the divided-down output of a 2·1875 MHz crystal oscillator is phase-locked to the incoming synchronising pulses. A pair of adjacent pulses, each of width equal to one half of the line synchronising pulse, are used to gate the incoming signal. If the integrated outputs from this pair of gates are equal then a correct lock has been established. If not, then the differential output from the integrators is used to steer the crystal oscillator frequency until locking has been achieved. This method uses information from the whole of the synchronising pulse and is thus relatively immune to interference. A disadvantage of the method is that it is slow to acquire initial lock.

The frequency of 2·1875 MHz (140 times line frequency) was chosen as a suitable clock frequency to drive the analogue-to-digital converter (20) in the error signal chain. Dividing this frequency by ten provides a clock input to a divide-by-fourteen counter. The processed outputs from this counter provide a whole series of pulse trains, each at line frequency, outspaced in time by intervals of one fourteenth of the line period, to control the various line-frequency operations in the equipment.

A combination of one of these pulse trains and one of the outputs from the previous divide-by-ten stage enables a train of pulses to be generated coinciding in time and duration with the passage to the synchronising pulses through the quadrature attenuators. Adjusting the tap on this divide-by-ten stage permits the receiver delay to be compensated in 0·46 μs steps. Further taps on this divider permit narrowed line synchronising pulses to be generated for use in the line gating circuits (8), (10) and (17). The synchronising pulses are trimmed by 0·92 μs on the leading edge and 0·46 μs on the trailing edge. This removes any unwanted transients that may be generated in the tracking system or by the receiver.

The timing requirements for the field synchronising pulse separator are far less severe and a standard integrate-and-slice circuit is adequate although some compensation for severe interference has been added to the slice-level circuit. The field synchronising pulses are used to reset a divide-by-625 counter which is clocked by twice-line-frequency pulses. Suitable gating circuits on the outputs of this counter give all the necessary field interval driving pulses.

The sequence of operations during each field, starting at line 8 (or 321), is as follows.

1. Clear the main error store (25) and hold cleared.
   Make a new aerial control selection (41).
   Change the time constants (45) affecting the electronic attenuator (3) to the short time constants.

2. At line 39 (or 315).
   Release main error store for use.
   Return electronic attenuator time constants (45) to the long-time-constant condition.
   Commence line sequence.

3. At line 307 (or 619).
   Stop line measurement entry into main store (25).

4. At line 311 (or 623).
   Start measurement in middle-frequency channel.

5. At line 318 (or 6).
   Conclusion of tests. Change aerial control setting if an improvement has been achieved.

6. Re-start sequence.

The sequence of operations during each measurement line is as follows:–

1. Open the gate (10) to pass the line synchronising pulse to the filters.

2. Hold (15) the outputs of the filter and detector units (14).

3. Convert (20) the output of the lower-frequency circuit (12) to digital form.

4. Subtract (22) the long-term mean (26) from this last reading.

5. Add or subtract (24) the result to the contents of the main error store (25).

6. Convert the output of the upper-frequency peak detector holding circuit (15) into digital form (20).

7. Add or subtract (24) this result to the contents of the main error store (25).

8. Clear the hold circuits.

9. Change to the next 'test' or 'normal' condition.

10. If the result of stage 9 is 'test' for the next line, then apply the selected changes to the appropriate quadrature attenuators for the duration of the next line synchronising pulse.

This sequence lasts for a total of 268 lines using an alternate line sequence of 'test' and 'normal' aerial directivity patterns. The sequence is reversed every four pairs of lines.

The sequence of operations during the equalising periods is as follows:

1. Wait for $^1/_{14}$ line in order to miss the first equalising pulse.

2. Pass (17) the input signal through the middle range filters (18) for $^1/_7$ line.

3. Convert the middle range detector output to digital form (20) and add or subtract (24) this result to the contents of the main store (25).

4. Repeat (2) and (3) twice during the two immediately succeeding $^1/_7$ line periods.

This whole sequence takes ½ line and is repeated five times in the 2½ lines of the first equalising pulse group and a further five times on the second group.

The full sequence of operations is now concluded.

3.5. Filter unit for middle- and lower-frequency ranges

In the error-signal processing circuits for the middle- and lower-frequencies the video signal is d.c. restored so as to maintain constant the long-term mean level of the synchronising pulses. This signal is then gated (8) to remove the video information. Since the equalising periods are at a level different from that of the line synchronising pulses, the resultant gated signal is combined with a pair of pulses covering the equalising periods and of an amplitude to cancel this offset. The resultant signal, which now consists of bursts of interference, is controlled in level in (8) and (9) so as to prevent overloading of the analogue-to-digital converter. At this point the signal is split to divide off the middle-frequency range.

The signal for the lower and upper ranges is further amplified and gated (10). The gate is open only for approximately the centre 3·25 μs of the line synchronising pulse duration. The output from this gate splits to drive the multiple filter unit (14) and the 90 kHz low-pass filter (12) of the lower-frequency channel. This low-pass filter (12) is designed so as to remove as much higher-frequency information as possible whilst still passing sufficient information to determine the mean height of the pulse. The interference is delayed by approximately 4·6 μs ($^1/_{14}$ line) in passing through the filter. The combining switch (19) connects a storage capacitor across the filter output during the rise time of the interference pulse and, on opening holds the peak value for conversion by the analogue-to-digital converter (20). The switch circuit (19), being closed for $^1/_{14}$ line half way through the line period, passes the output of the upper-range peak detector (15) to the same storage capacitor. A buffer amplifier is used between the storage capacitor and the analogue-to-digital converter (20).

The middle-range output from the initial gate (8) is re-gated (17) to pass only the $^1/_7$ line portions of the equalising periods. The bias for this gate and its output amplifier is set by an integrating amplifier in a feedback loop. This circuit maintains the mean potential of the equalising periods at zero and thus eliminates any permanent gating pulse in the output. Five filters, each with its own full-wave detector, (18) are driven by this gate and amplifier. Three of the amplifiers are band-pass filters of 85 kHz bandwidth with centre frequencies of 115 kHz, 200 kHz and 285 kHz whilst the other two are low-pass filters of bandwidths 50 kHz and 80 kHz. The detectors are of the emitter follower type with a common capacitative load. Since only the filter with the largest output will cause its detector to conduct, the output contribution due to white noise will be reduced in power by the ratio of the bandwidth of the contributing filter to that of the overall middle-frequency channel. A c.w. interference will pass unattended to its appropriate detector. The detect output is switched (19) into the common storage capacitor at the appropriate times in the equalising periods. Since this middle-range detector circuit necessarily has a time constant long compared to the measurement period, it must be discharged after recording each measurement.

The small changes in aerial directivity which occur during the test period will in general change the wanted input signal and steps must be taken to counteract this effect or else the whole system may become unstable. These gain changes are detected by gating (44) an output from the 90 kHz low-pass filter (12) into one of two integrating capacitors. These two capacitors correspond to the 'test' and 'normal' conditions. The difference (46) between the two potentials on these capacitors is integrated and used as a fast a.g.c. control for the test condition of the system, being applied to the electronic attenuator (3) during the synchronising pulse periods corresponding to the 'test' condition so as to maintain equality of wanted signal between the 'normal' and 'test' conditions. Since the required control voltage for this a.g.c. changes at the start of every field, the time constants (45) of the integrators are reduced at the start of the field to permit rapid resetting. They are then restored to normal as soon as measurements are being recorded, i.e. at line 39 or 351. The long time constant conditions is necessary to avoid low-frequency interference cancellation in the measuring circuits during the course of a field.

3.6. Filter unit for the upper-frequency range

The filter unit consists of an input buffer amplifier driving twenty-six amplifiers each with its own filter and detector. The individual filters (14) have a 1 dB bandwidth of 200 kHz and are centred at 200 kHz intervals from 400 kHz to 5·4 MHz. Each filter consists of an overcoupled pair of tuned circuits giving a 1 dB dip at midband. Thus this unit covers the frequency range from 300 kHz to 5·5 MHz with a 1 dB ripple over the band. Low frequencies require a full-wave detector to give a satisfactory measurement, there being only about one cycle of interference per synchronising pulse at the lowest frequency. Above 1·1 MHz, where there are several cycles of interference per pulse, a half-wave detector is adequate. The individual detectors are of the emitter follower type and have a common capacitative load. Hence only the detector having the largest input will determine the output, as in the filter unit for the middle range.

Since there is some difference in delay times between the different filters, a peak detector is used (15) to obtain a true largest output and hold this value until it has been switched to the analogue-to-digital converter at the mid-line time. Towards the end of the line period, the storage capacitor of this peak detector is discharged ready for the next measurement.

3.7. Analogue-to-digital converter, processing and storage unit

The analogue error signal into this unit is converted into an 8-bit digital signal by a successive-approximation analogue-to-digital converter (a.d.c.) (20). The clock used for this conversion is the 2·1875 MHz oscillator output from the timing unit.

During the measurements in the upper and middle ranges these digital signals are passed directly to the main store (25), being added (24) if the 'test' condition for the aerial directivity pattern is in use and subtracted if the 'normal' condition is operative.

For the lower range, the error signal first has the long term mean subtracted, is then digitally rectified (23) and finally contributes to the main store in the same manner as the other error signals.

The digital filter (26) used to obtain the long-term mean consists of an accumulator of 20 bits capacity summing the outputs from the subtractor. The output from this accumulator when divided by 2^{12} gives the required mean signal. The cut-off frequency is approximately 4 Hz.

In order to maintain the a.d.c. near the centre of its operating range the mean output is reconverted (28) to an analogue signal by a simple resistive network, further filtered (29) and used to bias the gates (8, 10) which remove the picture information.

The sign digit of the subtractor (22) is used to invert (23) the sense of the 'test condition' signal into the adder/subtractor (24) for the main store (25). This has the effect of rectifying the error signal and thus for the lower interference frequencies the amplitude of the deviation from the mean synchronising pulse amplitude becomes the value stored.

When a positive number is held in the main store (25), indicating an improvement for the test, the position of the most significant bit of the stored number is determined (30). This number, the logarithm (base 2) of the stored value, is used to set (32) the number of steps to be taken by the aerial controls when the new control settings are made.

3.8. Control selection unit

The control selection unit selects one or more of the sixteen aerial controls to which the test change will be applied for any particular field period and determines the polarity of the change for each control. Thus, for any individual control, the change can be zero, positive or negative, corresponding to unselected and selected with positive or negative test change.

The required control selection waveforms could be produced by sixteen independent random ternary sequences. This would change each control, on average, for two fields out of every three and only very rarely would the period between changes for any one control exceed $^1/3$ second. It would not be satisfactory to use a simple ternary divider chain because, with this method, one control would change every field while others would change only every few hours.

Since it is not practical to generate truly random sequences, these are approximated by pseudo-random ternary sequences (PRTS). Even these cannot readily be generated for 16 elements,[6] so one control uses a ternary divider and the other 15 controls are driven from the PRTS generator (41).

The sequence is generated by forming the modulo-three sum of the outputs from the second and last stages of a fifteen stage shift register. This feedback configuration has three stable sequences. The 'all zeros' sequence is detected and forcibly changed if it ever occurs. The other two sequences are each of half the maximum possible length ($3^{15} - 1$). Since both these sequences are equally useful and will take several days to repeat, it is not considered necessary to interconnect them to make one long sequence. Experience has shown that it is better to limit the number of selected controls to 10 and, if this number is exceeded, new selections are made until a satisfactory control selection is found. The total number of different selections used is 9751455, giving a repetition of the selections every 54 hours.

The outputs from the sequence generator are not used directly but are used to set auxiliary stores at the start of each field. If any control, having been selected, is at the end of its range for the selected direction of movement than the appropriate auxiliary store is cleared and that individual control selection cancelled.

The auxiliary stores operate analogue gates which pass the test pulses of appropriate polarity to the corresponding aerial controls. The test pulse amplitude itself is a function of the level of interference, being reduced as the interference level falls.

3.9. Amplifiers and stores

Each of the quadrature attenuator control diodes has a voltage amplifier (39) associated with it. These amplifiers provide a d.c. output dependent on the stored setting for that channel. This storage is in two parts. A common digital store (34) consisting of ten sixteen bit shift registers hold the information for all controls. At intervals of $^1/14$ line these shift registers are stepped on and thus each channel will have its stored value available for about 4 μs every $1^1/7$ lines. These digital numbers are converted (36) to analogue signals which are stored (38) on individual holding capacitors on the inputs of the aforementioned voltage amplifiers. Provision is made to adjust the range centre point for each amplifier to match its associated diode.

The contents of the shift registers are continuously circulated (37) through adders (33) which, at the end of the field, add or subtract any change of setting which the adaptive process has found to be an improvement.

The six most significant bits of the stored numbers are tested (35) to check whether any quadrature attenuator is approaching the limit of its control range. If so, a signal is generated to cancel any control selection which could cause this limit to be exceeded.

3.10. Control changeover unit

The control changeover unit (40) combines the control diode d.c. drives with the test waveforms in a resistive attenuator network. The resulting control signals are normally fed direct to diode current amplifiers in the quadrature attenuator unit.

On switching on the adaptive system the control logic will have a random setting and, if these settings were applied to the quadrature attenuators, it is possible that the strongest signal received would be that of an unwanted transmission. In order to reduce the possibility of this happening the control diode currents are initially pre-set to values which have been adjusted to give an aerial directivity pattern which, under most circumstances, is near optimum for the wanted signal. When the system has locked its synchronising pulses on to the incoming signal the controls are switched, one at a time, to the adaptive system. The switching rate of 1 per 2 seconds allows the system to retain the wanted signal whilst bringing all controls rapidly to near optimum. This start-up procedure is also invoked if the incoming signal is lost at any time. Provision is also made to use this procedure under external control if required.

3.11. Power supplies

Stabilised power supplies are used for all units. The main logic supply is +5V, with a −5V supply for a few circuits. The analogue circuits run from ±15V supplies with separate supplies to the r.f. amplifiers and quadrature attenuator controls. A floating 5V supply is used for the control changeover unit.

4. Adaptive receiver problems

During the initial laboratory alignment tests of the equipment on off-air signals, its operation was found to vary erratically. On occasion it would adapt to produce only a poor output signal-to-interference ratio or, having suppressed the interference almost completely, would suddenly revert to an unadapted condition.

This was at first thought to be due entirely to instrumental faults in the equipment but subsequent investigation has shown that causes external to the apparatus may have been responsible for part, possibly the larger part, of the trouble experienced.

The first of these external causes is signals reflected from aircraft. In the area in which the BBC Research Department is situated, it has been found that aircraft reflections, at a level of about −40 dB relative to the peak signal, are liable to occur as frequently as every few minutes during certain periods in the day. These are quite imperceptible as perturbations of the picture in normal reception but are interpreted by the adaptive system as co-channel interference, which indeed they are. They rise and decay too rapidly for the adaptive process to follow and merely produce error signals that confuse the adaption to any steady interference that may be present.

The second external cause is picture-dependent modulation of the synchronising pulses in the transmitter and transmitter distribution network.

This can take two forms; a large transient change of the synchronising pulse level following a shot-change in the picture or a more-or-less continuous low-frequency modulation. Identical effects can be produced by instrumental deficiencies in the adaptive system reciever, notably by the automatic gain control system or if the low-frequency response after the detector is not maintained down to a sufficiently low frequency.

In the adaptive system tests, the receiver was contributing some synchronising pulse modulation. However, later investigations have shown that the residual level of such modulation in the signal radiated by the BBC Crystal Palace u.h.f. transmitters can be as high as −45 dB to −50 dB. This would severely limit the maximum signal-to-interference ratio achievable by the adaptive system and it seems reasonable to assume that the synchronous pulse modulation by picture would reach a significantly higher level at transmitters more remote from the network origin point, since more links in the distribution chain, including re-broadcast links, would be involved.

Neither of these effects has been found to cause trouble with the earlier experimental adaptive system that had been designed to assess the feasibility of the principle.[1] This was presumably because that equipment was relatively insensitive to interference producing video beat frequencies below about 2 kHz. A high sensitivity to interference at offsets down to a few Hz is, of course, essential in an operational equipment in order to deal with co-channel transmissions with nominal zero offset.

5. Conclusions

In view of the problems with the development of this equipment, and the fact that the primary requirement for which the equipment was designed appears to have been met by other means, the development has been terminated. Originally it was intended to use this equipment for the r.b.l. reception in the Channel Islands.

The problem of achieving adequate rejection of nominally co-channel interference with very low frequency offsets in an adaptive system of this type has not been solved and might prove insoluble.

Other types of adaptive system, for example those aimed at signal maximising, could be realised with simpler equipment and would be both cheaper and more reliable.

6. References

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