HOME OFFICE

Directorate of
Telecommunications

QSAM Radio Schemes
Their Preparation and Adjustment

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Quasi-Synchronous Amplitude Modulated Multi-Station Radio Schemes: Their preparation and adjustment.

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SECTION 1

PERFORMANCE OF RADIO LINKS IN RESPECT OF PHASE/AUDIO FREQUENCY CHARACTERISTICS

GENERAL

Our Users require simultaneous transmission of intelligence from all the Hill Top Sites in a Radio Scheme. Since the signal arriving at a Mobile or 'fixed' Mobile installation may be a composite of anything from two up to the total of sites in the Scheme, the components contributed by each Transmitter to this composite signal must not oppose each other as regards modulation content.

Except in special cases, all transmitters must then radiate a signal whose modulation components are in phase at any instant in time. These special cases only occur where a Radio Scheme uses a Hill Top Site placed well outside the territory in which the Modile Units circulate or conduct business.

The arrangements made in these special cases will be dealt with later.

TOLERANCES

Although the aim is to obtain zero error between sites, no material difference between a Scheme employing a single as against a number of sites is noticeable until the error between modulation envelopes exceeds 60 degrees of phase.

The noticeable difference is controlled by:

(a) The relative strength of the two Sites as received at the Mobile; being greatest with equal signals.

(b) The path length difference travelled by the two signals; again being greatest with equal signals.

COVERAGE

The fact that (a) and (b) are both at their most noticeable at the equi-signal condition need not be regarded as a reason for avoiding such a condition. The economic use of radiated power takes precedence over both considerations since adequate coverage of difficult areas is more likely to be the requirement. With a correctly phased Scheme, overlap areas are of no significance as far as readability is concerned provided that the 60 degree max difference between sites at any audio frequency, is maintained.

PHASE AND DELAY

Care must be taken at all times to define terms and particularly those relating to Phase and Delay in our Schemes. There are in fact only two parts of the signal path where Phase and Delay are directly related; those being (1) the Delay Units themselves and the air path between the Link Transmitters & Receivers and (2) the Air Path onwards to the Mobile aerial. Direct relationship exists here because the ether has, for most purposes, infinite bandwidth and therefore can be regarded as absolutely linear. All frequency signals are delayed by the same amount, ie twice the frequency means double the phase shift.

Provided we limit the upper frequency component to about half the cut off frequency, the same can be said of our Delay Lines.

This latter we do and our Delay Lines then qualify as linear devices.

The same cannot be said of other components in the Modulation signal route and our phasing work has largely centred around the latter items.

MEASUREMENTS

With the latter in view, the extent of phase distortion or non linearity is known through measurement, and the procedures have been explained in the H220 Documentation.

It should be remembered that the object of the work is to equalise phase distortion rather than correct it.

Phase distortion by itself does not materially affect speech recognition, but different amounts in each signal path to the Mobile, where the usual composite signal is being received, must be equalised. The same cannot be said where high speed data is concerned and phase distortion inherent in our Link routes sets limits to signalling speed, if character in the data stream are not to be distorted beyond correct identification at the receiving end.

AVERAGING OF CHARACTERISTICS

Many measurements have now been carried out on all the component parts of our Radio Schemes, particularly the Outgoing path to the Mobile. The phase shift response with frequency throughout the audio pass band for each item has now been established.

The figures chosen take into account the manufacturing tolerances in the equipment and can therefore be used for the calculation of the correct values of Delay Line to be fitted at each Hill Top Site, where required. There still remains the problem of non-frequency-conscious phase reversals which can occur throughout the signal route. These can take the forms of reversed responses from equipment, such as an incorrectly tuned Discriminator circuit in the Link Receiver or simply reversed wiring in equipment or racking, or even wiring differences in otherwise identical pieces of equipment.

Previously issued information indicates the correct polarity selection to be used throughout, and a careful check for a double reversal must be made. With the polarity check through from Control to each Hill Top Main Transmitter carried out, no further measurement of phasing or delay will be necessary.

SETTING UP PROCEDURE

Using the timing chart procedure, mark in the Link Delay figure for the Link equipment in use, ie

MkI L150 ...... 450 microseconds
MkII L150 ...... 640 microseconds
U450L...... 330 microseconds

The figure for MkI RLA assumes that no conversion to 12.5KHz has been carried out.

If the Scheme being examined has been converted to 12.5KHz Link Bandwidth the following should be used:

MkI (Converted to MkII) L150 ..... 640 us
U450L Converted to 12.5 KHz ...... 390 us

Next add the route delay in microseconds to the receiving Hill Top Site. In a non-repeater Scheme the required correcting delay can be added into the shorter routes in the normal way. With a repeater Scheme using the older D of T constructed racks, no additional delay figures need be added for the Racks.

If, however, a MkII RLA Scheme is being considered, the H220 instructions should be carefully followed.

Some further explanation of the treatment of phase and delay through MkII Repeater Racks may be of assistance to those working on such schemes.

As the L150 type of Link Equipment shows considerable phase distortion at low frequencies, a Phase Compensation Unit (PCU) is added to the signal path to the second Link Transmitter in every repeated route in a scheme. This is done to try and equalise phase distortion and therefore phase difference between those signals arriving at the Mobile from Main Transmitters fed from the first Link as distinct from those fed from the second Link in a Scheme.

In addition, the RLA MkII Repeater Cabinets use an amplifier (CT 40070) in the signal route whose characteristic is utilised partly as a frequency sensitive phase shifter and partly as a non-frequency conscious reversal. Hence the requirement to reconnect terminals 24 and 25 in the C12 panel.

Reference to the attached table will make the procedure clear. The first line horizontally represents the test frequencies used. Immediately below is a typical phase versus frequency for an L150 MkII Link. Next down follows the phase shift created by the reconnection of the terminals in the C12 panel, the signal route through the Link and Repeater cabinets and finally the addition of the Phase Compensation Unit.

Since the route from Control is longest to Fairlight in the scheme configuration the phase shifts in this route are the first to be summated. Link equipment from the Repeater Site (Knockholt) adds further phase shift and the path length similarly, making the total into the Scheme Phase Shift summation at each audio frequency.

At the highest frequency (2777 Hz), the total phase shift is 1799° and all other routes are made up to this figure using Delay Lines.

It will be remembered that the phase shift indicated at 2777 Hz equates directly to the delay in microseconds, so that it is a simple matter to select the correct Delay values.

Furthermore, it becomes unnecessary to know every phase shift at each frequency and the figures in the column under 2777 Hz are all that are required to choose the correct value of the Delay Lines.

SPECIAL CASES

These arise where a Hill Top Site is placed well away from the service area of a Scheme.

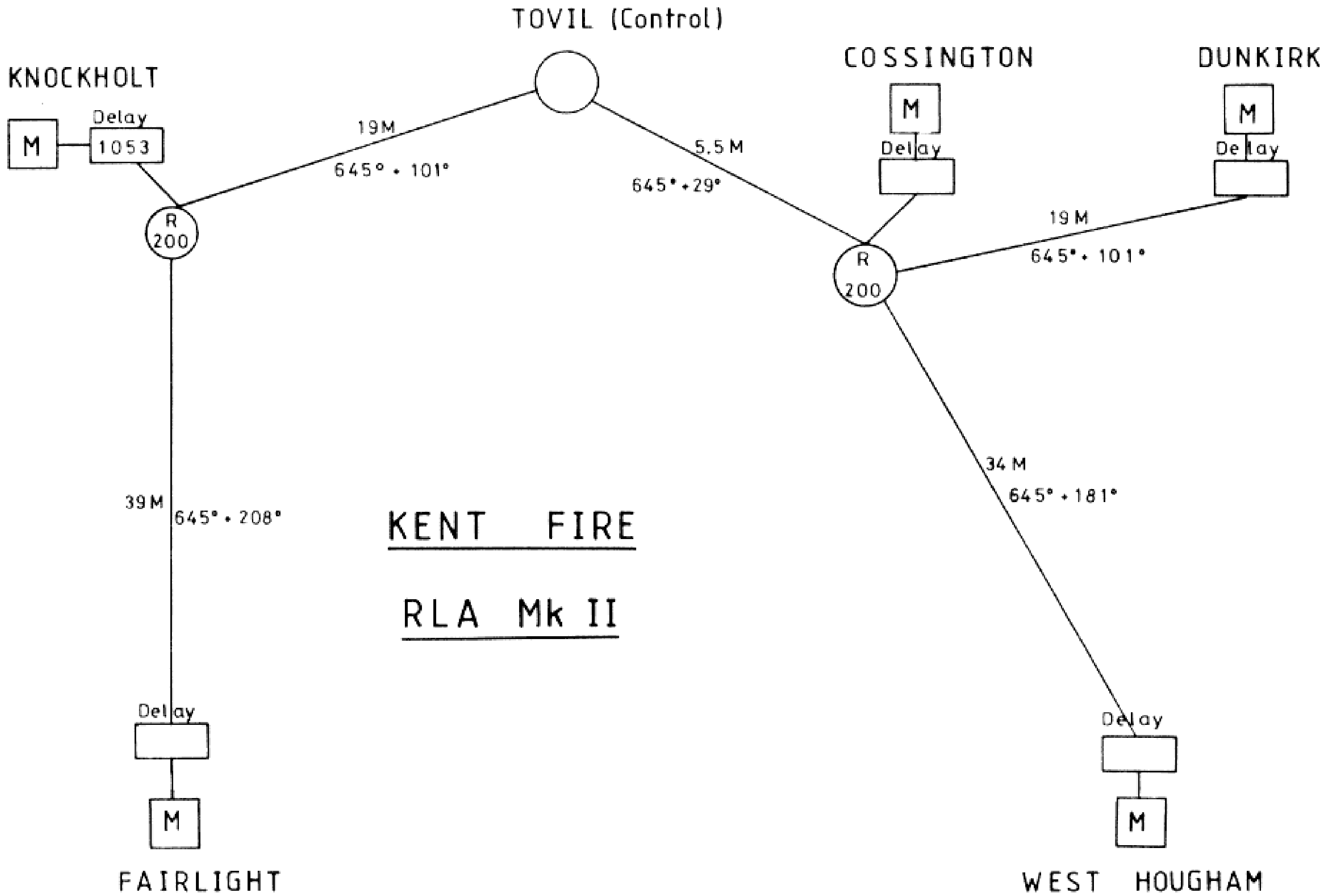
This may be to provide service in a sea-side town which is screened by high ground from inland Hill Top Sites. An increased delay correction must be made for this "out-of-area" site amounting to the link delay plus that of the return path of the mobile.

By adding delay at all other sites the "out-of-area" site is brought electronically "in-area" and will not produce "out-of-specification" phase errors with other sites in the scheme.

KENT FIRE SERVICE

RLA MkII

TEST FREQUENCY Hz	300	400	700	1000	1500	2000	2500	2777
CONTROL TO FAIRLIGHT								
PHASE SHIFT IN DEGREES								
LINK(TOVIL-KNOCKHOLT)	-72	-15	+98	+166	+312	+445	+576	+645
ROUTE(TOVIL-KNOCKHOLT)	+11	+15	+25	+36	+56	+73	+91	+101
KNOCKHOLT R'DTR CABINET + PCU	+147	+176	+159	+167	+175	+188	+197	+200
LINK(KNOCKHOLT-FAIRLIGHT)	-72	-15	+98	+166	+132	+445	+576	+645
ROUTE(KNOCKHOLT-FAIRLIGHT)	+22	+30	+52	+75	+112	+150	+187	+208
SCHEME PHASE SHIFT	+36	+191	+432	+610	+967	+1301	+1627	+1799
CONTROL TO KNOCKHOLT								
LINK(TOVIL-KNOCKHOLT)	-72	-15	+98	+166	+312	+445	+576	+645
ROUTE(TOVIL-KNOCKHOLT)	+11	+15	+25	+36	+56	+73	+91	+101
DELAY UNIT ADDED TO MAKE 1700° = 1053°	+114	+152	+265	+379	+569	+758	+948	+1053
PHASE SHIFT TO KNOCKHOLT MAIN TRANSMITTER	+53	+152	+388	+581	+937	+1276	+1615	1799
ERROR BETWEEN FAIRLIGHT AND KNOCKHOLT		+39	+44	+29	+30	+25	+12	0
(INPUT TO MAIN TX'S)	-17							
CONTROL TO WEST HOUGHAM								
LINK(TOVIL-COSSINGTON)								+645
ROUTE(TOVIL-COSSINGTON)								+29
COSSINGTON RDTR + PCU								+200
LINK(COSS-W HOUGHAM)								+645
ROUTE(COSS-W HOUGHAM)								+181
DELAY ADDED TO 1799° =								+99
								1799°


TOVIL (Control)
KNOCKHOLT
Delay
M
1053
COSSINGTON
M
Delay
DUNKIRK
M
Delay
R
200
19M
645° + 101°
5.5 M
645° + 29°
R
200
19 M
645° + 101°
39M
645° + 208°
KENT FIRE
RLA Mk II
34 M
645° + 181°
Delay
M
FAIRLIGHT
Delay
M
WEST HOUGHAM

SECTION 2

ADJUSTMENT PROCEDURE FOR CFAM, CARRIERS & MODULATION

The following assumptions are made:

(1) That an examination of all rack and equipment internal wiring has been made to ensure identical paths (with the exception of different Delay Line settings as required at all but the furthest site from Control.

(2) That the phase and delay adjustment and measurement has been carried out on the Link Route to each Hill Top Site in the Scheme, from the last common point outwards from Control to a polarity of modulation from each Hill Top Site main transmitter. Care must be taken to ensure that correct polarity is not achieved in any route by a double reversal.

Preparations

It is essential to have a signal strength meter incorporated with the Monitor receiver. Calibration of this instrument is not required but the speed of response of meter display should be such that it be at all times in step with the AGC voltage of the receiver and must not introduce any delay of its own. The Monitor receiver will be required to operate on FM as well as AM and therefore should be checked before work commences. Ensure that a fully modulated AM signal does produce any audio output when the receiver is switched into the FM code.

Procedure

(1) Carrier Checks

Adjust all modulation levels at Control to zero.

Mute all but two Hill Top Sites in the Scheme so that two carriers only are being radiated, without discernible modulation.

Position a mobile receiving site such that a complete null is obtained when these two radiations are in phase opposition at Radio Frequency. Arrange the drive sources to provide a slow beat, aiming at 1 to 2 Hz as an ideal for the adjustment of the Scheme during the test period.

Listen carefully to the noise level as the carriers cancel with the Receiver switched to AM mode. Unless very high signal levels are involved, this noise level should compare favourably with the noise floor output of the receiver with the mute open and all transmitters switched off. An alternative procedure may be used by comparing the noise of a carrier cancellation point against that from the receiver when switched to a near neighbouring unoccupied channel.

Listen particularly for extraneous audio noises and the hum level. Hum levels which are acceptable in a spaced Scheme will easily mar a CFAM Scheme since they present as residual modulation in the latter. Transmitter faults, such as unstable driver stages; and Stable frequency sources whose noise output is excessive or unequal to others in the Scheme will be revealed in this test.

With an impression of the null noise level in mind, select another Hill Top Site and remove the muting.

By comparing sites in pairs, any defects in the Link Routes and Hill Top Site equipment can be detected and position located without abortive travelling. It may be necessary to move the Monitor receiving site when the technique is applied to a Scheme covering a large User area.

(2) Modulation Checks

Select two Hill Top Sites and position the Monitor receiver in an equi-signal area as before.

Modulate the sites with a sine wave tone at 800 Hz approx and ensure that the monitor aerial is so positioned as to give a deep null, when carriers oppose each other.

Listen carefully to the resultant signal, particularly to the timbre or quality of the 800 Hz tone during the null periods. There should not be any alteration in quality of modulation as the signals cancel.

Audio phase errors in the Link route at any particular frequency will produce distortion and a tendency to increase second harmonic. Polarity reversal of wiring at Hill Top Sites and in Transmitters can negate a good result. Confirm the observation by switching the Monitor receiver to the FM Mode. Note carrier level using the Signal Strength Meter and listen for residual modulation. None should be audible even when the carriers cancel and the Signal Strength Meter falls to zero carrier level indication.

Slight evidence of modulation may appear close to the null in the form of faint scratching noises but there should be no evidence of an 800 Hz tone. Check the remainder of the sites in pairs and finally all together. Choose a location for monitoring which gives deep nulls occasionally from a combination of all stations.

Finally test the Scheme with a clear speech using the same steps.

It will be found that when distortion at or close to null points has been cleared, then overlap areas and beat rate between carriers are no longer critical adjustments. The monitor receiver should, with advantage, have a 12.5 kHz IF bandwidth. This will improve the apparent tonal performance of the Scheme and corresponds to the results to be obtained with the WARC channel spacings.