SECTION 10

SINE-SQUARED PULSE AND BAR TESTING METHODS
AND
TEST SIGNAL GENERATORS

PART 1: PRINCIPLES*

Introduction

The sine-squared pulse and bar signal is used for testing apparatus and lines for the transmission of television signals. The introduction of this test signal was the result of an investigation of methods of testing and aligning equipment to permit rapid evaluation of results and to provide a criterion by which the degree of degradation of a video signal could be expressed quantitatively.

Requirements of Test Signal

General

It is a basic concept of communication engineering that any signal may be expressed as the sum of sinusoidal components. If a signal is to be transmitted through a channel, the necessary and sufficient conditions for there to be no degradation of the signal are that the amplitude response of the channel shall be flat over the region of the spectrum occupied by the signal, and that the phase/frequency characteristic shall be linear in this region, with a zero-frequency intercept which is zero or a multiple of 180 degrees. If these characteristics depart from the ideal, it is very hard to predict the precise effect that the imperfections will have on a picture signal; for this reason it is difficult to assign tolerances to the characteristics.

An alternative procedure to the measurement of amplitude and phase characteristics is to employ a test waveform from which the effect of the equipment on a picture can be assessed directly. Such a waveform must therefore have some of the commonly encountered features of a picture signal. The inclusion of a bar is desirable to enable sag and streaking to be rapidly perceived; a pulse waveform is also desirable, as representative of fine detail. These considerations have led to a test waveform of the type shown in Fig. 10.1. The pulse represents detail comparable to a picture element in size, and the bar represents a large area of constant tone of the order of half the picture width. The diagram gives the waveform of a complete line, including sync pulses.

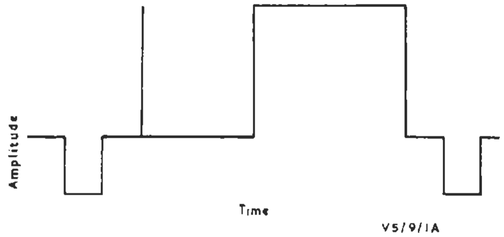

Fig. 10.1. Test Waveform

The choice of the pulse shape is governed principally by the following two considerations. Firstly, the pulse should be well-shaped and compact, that is it should be as free as possible from rings and long trailing portions at its beginning and end. These conditions ensure that any distortion suffered by the pulse is immediately identifiable, and not likely to be confused with or masked by irregularities existing in the original waveform. Secondly, the spectrum of the pulse should terminate completely at some upper limiting frequency, which for one of the tests can then be made the nominal upper frequency limit of the television system under test. This ensures that the irregularities in the output pulse due to distortions within the video

---

* Some of the information used in Part 1 of this Section was kindly provided by Mr. I. F. Macdiarmid, A.M.I.E.E. (Post Office Research Station) and certain of the diagrams are taken with permission from his paper 'Waveform Distortion in Television Links', *Post Office Electrical Engineers' Journal*, Vol. 52 Parts 2 and 3 (July and October 1959).

band are not confused by irregularities arising from distortions lying above the upper limit of the band, because such a pulse contains no energy above this frequency.

Unfortunately, these two sets of conditions are mutually incompatible. A pulse with a clean and abrupt beginning and end has a spectrum which trails away in oscillatory fashion, and conversely a pulse which has a terminated spectrum cannot be free from rings. However, it is possible to find compromise waveforms which possess only very small irregularities combined with a spectrum which possesses only a relatively small amount of energy above a limiting frequency. Such a compromise waveform has been chosen in the present instance. It is a very close approximation to the pulse of unit peak amplitude given by the expression $V = \sin^2 \frac{\pi}{4} \cdot \frac{t}{T} (0 \leqslant t \leqslant 2T)$ which, in fact, was used as an initial model, and hence is called the *sine-squared pulse*. In this expression $T = \frac{1}{2F_o}$, where F_o is the nominal upper limiting frequency. Although for most purposes the practical pulse can be taken to be the same as the sine-squared pulse, it is nevertheless important not to lose sight completely of the fact that the two are not absolutely identical.

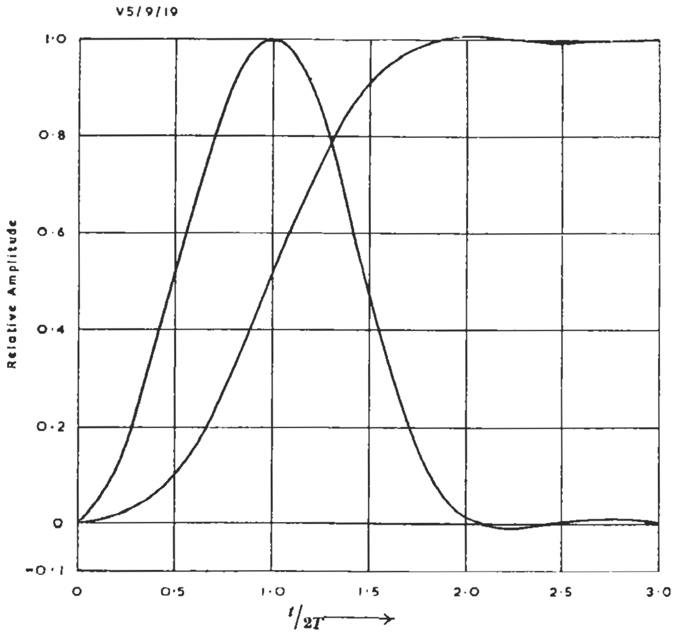

Fig. 10.2. Test Pulse and Bar Waveforms

The waveform of the practical pulse is shown in Fig. 10.2.

It has a small, rapidly damped oscillation following the trailing edge, and this must be kept within definite limits in the generator. In the BBC Sine-Squared Pulse and Bar Generator GE4/504 the first overshoot is limited to 0·9% ± 0·5% of the peak amplitude of the pulse.

1T and 2T Pulses

The spectrum of this pulse waveform is shown in Fig. 10.3. Zero values occur at frequencies given by $F_o = 1/2T, 3/4T, 1/T$, etc., where 2T is the half-amplitude duration of the pulse. Beyond the first zero value, at $F_o = 1/2T$, the amplitude of the spectral components is never greater than −30 dB with respect to that of the low frequency components. Thus if $F_o = 1/2T$ is made to correspond with 3 Mc/s, the resultant pulse has a spectrum substantially confined to the region below 3 Mc/s. However, the pulse spectrum falls rapidly above $F_o/2$ $(=1/4T)$ where the spectral components are 6 dB lower in amplitude than at low frequencies. Thus, such a pulse, while serving well to indicate distortion associated with the band of frequencies up to about 2 Mc/s, is rather insensitive in revealing distortions associated with the 2-3 Mc/s band. For this reason a choice of pulses is provided, one with the first zero in its spectral response at 6 Mc/s (the 1T pulse) and the other with its first zero at 3 Mc/s (the 2T pulse). The duration of the 2T pulse is twice that of the 1T pulse, but in other respects their waveforms are identical. The 1T pulse spectrum is 6 dB down at 3 Mc/s, and hence distortion of the pulse will indicate distortion associated with the upper end of the video signal range. The 1T pulse has components of appreciable amplitude beyond 3 Mc/s, and the interpretation of the results using this pulse must be made with this in mind.

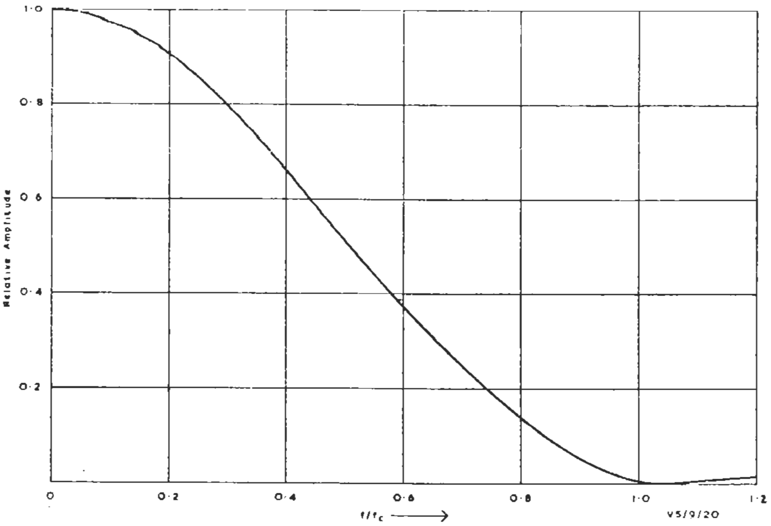

Fig. 10.3. Spectrum of Standard Test Pulse

The nominal length of the 2T pulse is 0·66 microsecond, and that of the 1T pulse 0·33 microsecond. It may be noted that, because $\sin^2\theta$ is equal to $\frac{1}{2}(1 - \cos 2\theta)$, the shape of the 1T pulse approximates to that of one complete cycle of a 3-Mc/s signal starting and finishing at the negative peaks; correspondingly the 2T pulse is equivalent to one complete cycle of a 1·5-Mc/s signal.

Because the precise start and finish of the pulse are difficult to perceive accurately, it is usual to quote the duration of the pulse in terms of the time between the points at which the pulse is at half its peak amplitude. For the 2T pulse, the half amplitude duration is 0·33 microsecond, and for the 1T pulse it is 0·167 microsecond.

The values so far quoted have been for the 3·0-Mc/s upper frequency limit of the 405-line television system. For 625-line measurements the upper frequency limit is taken as 5 Mc/s so that the half-amplitude duration of the 2T pulse is 0·2 microsecond and of the 1T pulse 0·1 microsecond. For the sake of simplicity from now onwards only figures applying to a 405-line system with a 3-Mc/s bandwidth are given.

Generation of 1T and 2T Pulses

The standard method used to generate 1T and 2T pulses was chosen to ensure that the output waveform is as consistent and accurate as possible. The method requires a filter network which approximates closely in its response to the spectral shape of a sine-squared pulse and has a linear phase characteristic over the frequency range of interest. This network is fed with pulses which have a substantially flat spectrum over the working range of the filter. It can be shown that a wide flat spectrum is associated with a short-duration impulse, and provided therefore that the pulses fed to the network are of this type, the output pulses from the network will have their characteristics determined entirely by the parameters of the network. The network frequency response is shown in Fig 10.2, together with the output pulse shape obtained with a short-duration pulse input.

In practice this method of test pulse generation works very well and enables the output pulse shape to be standardised to a high degree of accuracy.

Bar Waveform

The bar waveform is of 40 microsecond duration. The shapes of the leading and trailing edges govern the high-frequency spectrum of the bar, and it is again desirable that this spectrum should be limited to the same bandwidth as that occupied by the video signal. To achieve this, the bar waveform is also fed through the sine-squared pulse-shaping network. Provided that the rise and fall times* of the input bar are sufficiently short, the edges of the output bar are determined by the characteristics of the network, and corresponds to an integrated sine-squared shape. The approximate rise and fall times of the edges are 0·33 microsecond for the 2T network, and 0·167 microsecond for the 1T network.

One useful feature of the bar waveform is that because of its great length transient effects caused by the leading edge have died away before the centre of the bar is reached. The centre amplitude is thus a true indication of signal level. The slope of the bar top is a sensitive indication of the performance of equipment under test over the range of frequencies 10 kc/s to approximately 0·5 Mc/s.

The bar edge waveform could be used for measuring the high-frequency characteristics of a system but the indications given are less sensitive than from the test pulse because the harmonic amplitudes fall away more quickly than for the pulse. However, this statement is only strictly true when the test signal is applied to circuits which are linear, i.e., those having linear input/output characteristics. In vestigial sideband systems, for example, a transient form of non-linearity occurs, and the shape of the bar edges must be checked for overshoots (sometimes, from their appearance, termed pig's ears); if necessary, a compromise must be accepted between adjustments for best pulse shape and bar edge shape.

50-c/s Waveform

While the pulse and line bar waveforms provide a comprehensive means of checking performance in the range between 10 kc/s and 3 Mc/s, these waveforms do not indicate performance below 10 kc/s. To explore performance in this band, a separate waveform is used. This is a 50-c/s square wave with line sync pulses, as shown in Fig. 10.4. The waveform comprises alternate sections of signal at peak white level (10 ms) and at blanking level (10 ms). This waveform can be used to measure the very low frequency performance of a system because it behaves as a 50-c/s square wave and enables the usual measurements of tilt etc. to be made.

Response to Test Waveform

For an ideal network with a non-linear amplitude-frequency response it can be shown that the area of the output pulse is equal to that of the input pulse. If the system has a falling high-frequency response, the pulse height is reduced as the pulse passes through the system and the base of the pulse is correspondingly broadened: this is another way of saying that the rise time of the pulse is increased by its passage through the system.

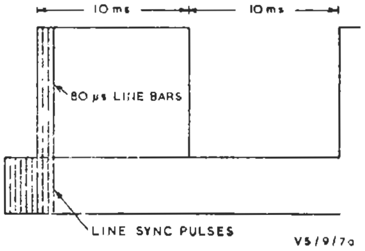

Fig. 10.4. 50-c/s Waveform

If the bar test signal is passed through this system, the bar height (at the centre) is not affected because high-frequency transient effects due to the leading edge of the bar have died away before the bar centre is reached. Thus, as might be expected, the ratio of pulse height to bar height may be taken as a measure of the high-frequency response of the system and hence its resolution. This ratio may also be used if the system under test includes an amplifier. Pulse height and bar height are both increased to the same extent by the amplifier and the ratio of the two again measures the resolution of the system. To enable the pulse/bar ratio to be used for this purpose, the initial heights of pulse and bar must be accurately equalised and provision is made in the test waveform generator for these heights to be equalised within close limits. It should perhaps be mentioned that the pulse/bar ratio is only a useful measure of resolution provided that there is no serious phase distortion in the system under test.

If the system under test includes an ideal low-pass filter, the pulse/bar height ratio gives a direct measure of the cut-off frequency of the system. Whenever the bandwidth is restricted without phase distortion, the pulse-bar ratio gives a

---

* The rise time of a waveform is the time taken for the transition between 10 per cent and 90 per cent of the final amplitude. Similarly, the fall time is the time taken for the transition between 90 per cent and 10 per cent of the initial amplitude.

measure of effective bandwidth and this is still approximately true for practical filters provided the phase distortion is not excessive. For the sake of example, the pulse-bar ratio and the half-amplitude duration of the pulse as a function of bandwidth for an ideal low-pass filter are shown in Fig. 10.6.

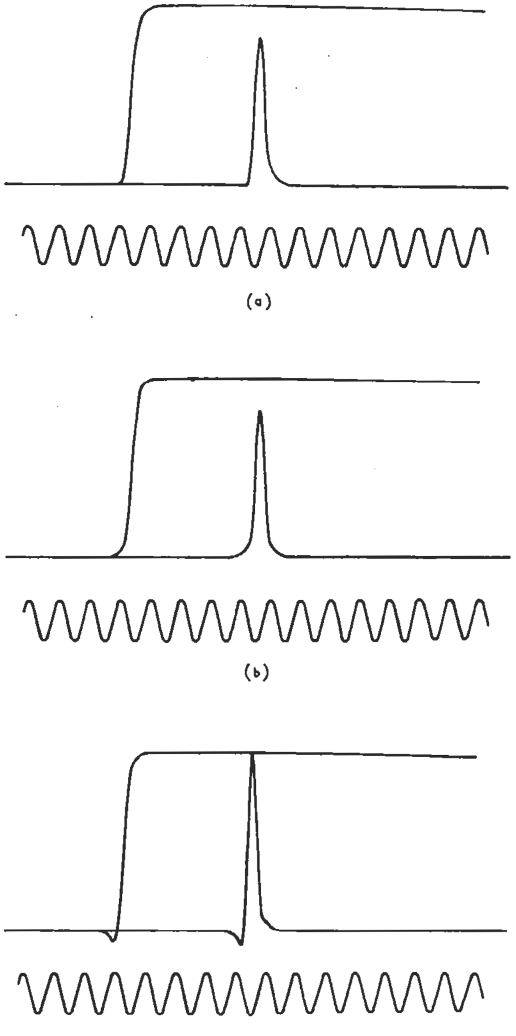

Fig. 10.5. Waveform Responses of Attenuation and Phase Distortions: (a) Both Attenuation and Phase Distortion. (b) Attenuation Distortion Only. (c) Phase Distortion Only

It is also instructive to consider the separate effects of amplitude and phase distortion at high frequencies. Normally these distortions occur together, but their effects can be considered separately for certain classes of network, and conclusions can be drawn which can be used as a guide to equalising procedure. Fig. 10.5 shows the effect of small amounts of attenuation and phase distortion applied both together and separately. In general, the effect of the attenuation distortion is to reduce pulse height, while retaining mirror symmetry about the centre line of the pulse. The general effect of phase distortion is to produce a response which is not materially affected in amplitude, but lacks mirror symmetry about the centre line of the pulse. Thus the optimum setting of a phase equaliser is that which minimises the degree of asymmetry about the pulse centre line.

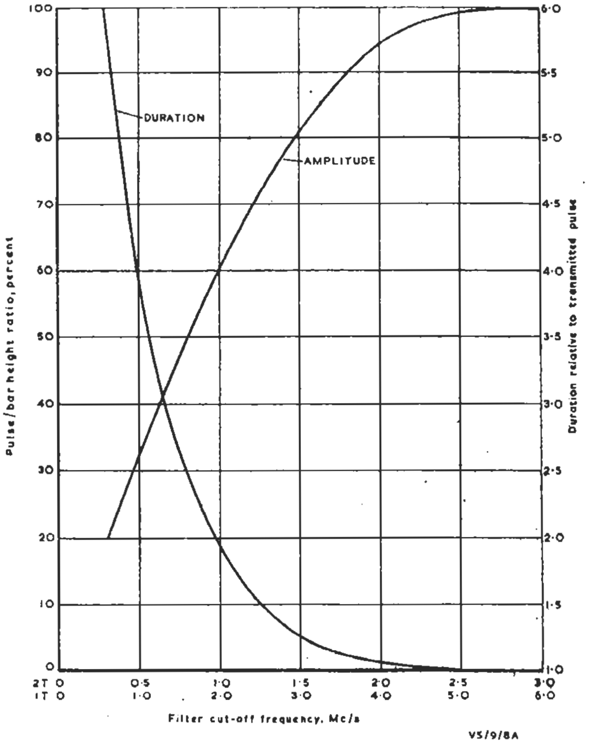

Fig. 10.6. Variation of Pulse Amplitude with Cut-off Frequency

The 1T pulse is particularly valuable as an aid to adjusting phase response at the upper end of the video frequency band. However, the relative amplitude of the 1T pulse and its duration cannot be accepted as reliable criteria of performance, as these depend upon the response of the circuit under test in the range outside the video signal band. From Fig. 10.6 it will be seen that with an ideal 3-Mc/s low-pass filter the amplitude of the 1T pulse is 82 per cent. of the bar height, while its half-amplitude duration is increased from 0·17 to

0·22 microsecond. It can also be shown that the pulse will be preceded and followed by a train of oscillations at a frequency of 3 Mc/s, with the first lobes having an amplitude of 13 per cent of the bar height. The degree of asymmetry of the pulse about its centre line is sensitive to variations of phase response, and provides a very useful guide in adjusting phase response in the range between 2 and 3 Mc/s. However, final adjustment of the phase response depends primarily on the requirement of symmetry of the 2T pulse, and the symmetry of this latter pulse must not be appreciably degraded to produce an improved symmetry of the 1T pulse.

‘k’ Rating

General Considerations

From the foregoing, it will be apparent that the test waveforms provide a check of circuit performance over the whole range of the video spectrum. The 50-c/s waveform checks the response at low frequencies (below 10 kc/s) and the bar top provides a most sensitive indication of distortion between line frequency and a few hundred kc/s; the 2T pulse covers approximately 0·5 to 3 Mc/s, and the IT pulse covers the range above 3 Mc/s. However, it will be apparent that under some circumstances it may be possible to improve the response of one waveform at the expense of one of the others, and a compromise must be accepted between conflicting requirements. The optimum adjustment is determined on the basis of minimising the overall '*k* rating' of the waveforms. The *k* rating is the highest of a set of *k* factors, one associated with each portion of the waveform. Each such *k* factor is an indication of the departure of its related part of the waveform from the ideal shape. The tolerance values of the *k* factors at each point of the test waveform have been fixed on an empirical basis, and are related to the degree of picture degradation perceptible.

It follows that two systems of equal *k* rating may be expected to have equally perceptible degrees of picture degradation. although these may not necessarily be of the same type. Further, in the process of equalising, a criterion of judgment is provided which sets limits on the process of improving the response of one part of the waveform at the expense of another.

The basic type of distortion used as a reference is that of a long-term echo of about 3 microseconds delay. The amplitude of an echo of a 2T pulse is the fundamental unit in terms of which the subjective effect of other types of picture distortion is assessed. Thus a *k* factor of one per cent indicates that the perceptible effect of the distortion is about equally as objectionable as the effect of a reflection producing a one per cent echo of a 2T pulse at 3 microseconds delay.

The *k* rating of a circuit is specified in terms of the *k* factors associated with the 2T pulse and the line bar only. The reason for this is that distortion of the picture signal associated with the low-frequency performance can usually be substantially reduced by clamping; hence the *k* factor associated with the 50-c/s waveform is quoted separately, and used only as a check upon circuit performance. Similarly, the 1T-pulse response depends largely upon circuit performance above the video signal band, and hence no attempt is made to include a *k* factor for the 1T pulse response in determining the *k* rating However, for a circuit of the sharp cut-off type, a *k* factor for the 1T pulse can be determined. The factor is quoted separately, and used as a check upon performance at the highest video frequencies; this is done as an interim measure, and will not be necessary if the Post Office method discussed on pages 10.9 and 10.10 is adopted.

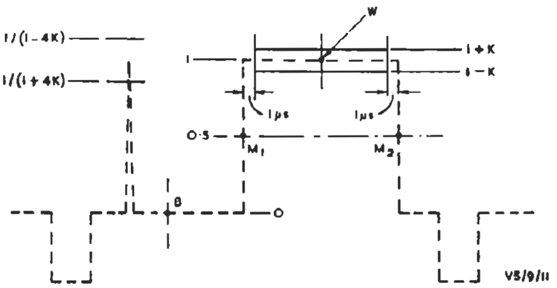

Fig. 10.7. Pulse and Bar Response Limits

Routine determinations of *k* rating are made directly from measurements obtained with an oscilloscope fitted with a graticule. The following three *k* factors are measured:

1. k_{bar}. Ignoring the first and last one-microsecond periods of the bar to eliminate the effect of transients, such as overshoots, the maximum deviation of the height of the bar top from that at the mid point is measured. This deviation, expressed as a fraction of the mid-point height, is the factor k_{bar} which measures the long-term bar-top slope. This is shown diagrammatically in Fig. 10.7, where the separation B-W is taken as unity and the two solid lines are

the limit lines enclosing the bar top for a given value of k.

2. k_{pb}. The height of the 2T pulse is measured, taking the height of the middle of the bar top as unity. The pulse height is equal to $1/(1 \pm 4k_{pb})$. This is shown diagrammatically in Fig. 10.7. If the pulse height (h) is greater than unity, the k factor is found using

$$k_{pb} = \tfrac{1}{4}(1 - 1/h)$$

and correspondingly, if the pulse height is less than unity, from

$$k_{pb} = \tfrac{1}{4}(1/h - 1).$$

3. k_{2T}. The third k factor is a function of the shape of the response to the 2T pulse. The height of the 2T pulse is taken as unity, and a series of limit lines is constructed on 14 limit points, as shown in Fig. 10.8. The factor k_{2T} is then given by the minimum value which can be found for k for which the limit lines totally enclose the response to the 2T pulse.* Note that the practical pulse has a quite visible asymmetry, even when generated by equipment which is operating correctly.

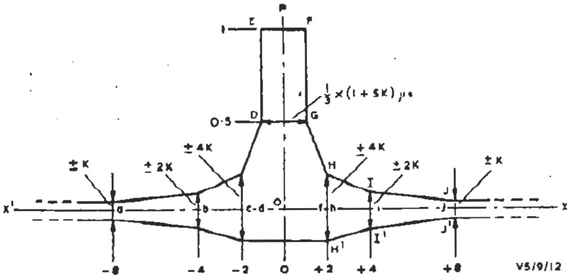

Fig. 10.8. *Sine-squared Pulse Response Limits (Units of Time: 0·167 μs for 2T Pulse)*

Two further k factors are quoted separately: these are $k_{50\text{-c/s}}$ and k_{1T}. They are determined as follows:

$k_{50\text{-c/s}}$ is found in a manner similar to k_{bar}, i.e., the height of the bar (B-W in Fig. 10.9) is taken as unity, and ignoring the first and last 250-microsecond periods of the bar, the maximum deviation of the bar-top height is measured. This is then equal to *twice* the $k_{50\text{-c/s}}$ factor. (See Fig. 10.9.) This factor is not included in the overall k rating, because the measurement may be affected by the presence of hum, and in any event both tilt and hum are largely removed by the clamp at the transmitter.

k_{1T} is applicable only to circuits of the type with a sharp cut-off above 3 Mc/s. For this type of circuit, the half-amplitude duration is measured, and also the relative amplitude of the first negative-going lobes (leading and trailing) and the second positive-going lobes (leading and trailing). The k_{1T} rating is then found from Table 1, being the minimum rating as given in the top line for which the limit on each parameter is greater than the measured value. The absolute value of k_{1T} is of no significance in itself, but should be constant for a given type of apparatus.

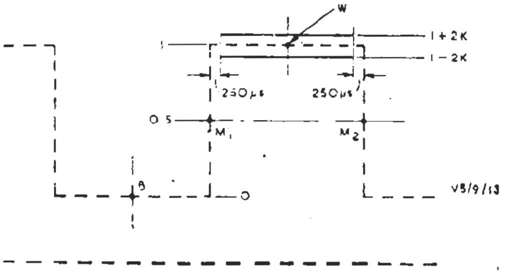

Fig. 10.9. 50-c/s Waveform Response Limits

TABLE 1. k_{1T} RATINGS

k_{1T} Rating	1%	2%	3%	4%	5%	6%
Maximum Half-amplitude Duration: Microseconds	0·245	0·250	0·255	0·260	0·265	0·270
First Lobe (Negative) Leading or Trailing: Maximum Per Cent	10	12	14	16	18	20
Second Lobe (Positive) Leading or Trailing: Maximum Per Cent	6	8	9	10	11	12

NOTE:—Applicable only to circuits with sharp cut-off at 3 Mc/s.

Practical Application of 'k' Ratings

It is usual for convenience to express k ratings in percentage form. As a guide to the order of magnitude of k ratings encountered in practice, it may be noted that a modern video amplifier should have a k rating of much less than 0·5 per cent, while a poor circuit may have a k rating of 6 per cent. A

---

* The factor k_{2T} is quite suitable for circuits and links in which there is measurable distortion at frequencies up to 3 Mc/s. In a single video amplifier, however, the distortion must be much lower because it is common for a number of such amplifiers to be connected in cascade in a television service. Measurements of k_{2T} using the 2T pulse are very difficult to make for a single amplifier and it is customary to make measurements as for k_{2T} using the 1T pulse. The resulting k factor is known as k_T, which should not be confused with k_{1T}.

k rating of 3 per cent is usually held to indicate just perceptible distortion, while a rating of 5 per cent would indicate a picture of impaired but acceptable quality.

As explained previously, the k rating of a circuit is taken as equal to the worst of the individual k factors associated with the bar and 2T pulse. Thus a particular circuit might have the following parameters:

k_{pb}	2 per cent
k_{bar}	1 per cent
k_{2T}	4 per cent
$k_{50\text{-c/s}}$	1 per cent

The k rating would be 4 per cent. If the k_{pb} factor deteriorated to 2·5 per cent, then it would be expected that the subjective effect would be no worse than formerly. However, from the maintenance viewpoint any departure of k_{pb} from 2 per cent would be considered a danger signal.

There is an additional check on the response at 3 Mc/s relative to that at 10 kc/s: it is that the response at 3 Mc/s should not exceed that at 10 kc/s by more than 1 dB per 1 per cent of k rating. Any rise at 3 Mc/s is not detectable by the maintenance test because the spectrum amplitude is zero at this frequency. If such a rise occurred in a number of systems connected in cascade, serious overloading could result.

Experience has shown that the greatest failing of the k-rating system is that it is based on linear circuits, whereas in practice there is inevitably some non-linearity in Post Office carrier and radio link systems. The area under a sine-squared pulse transmitted over a non-dissipative linear system having amplitude or phase variations with frequency over the relevant part of the band will remain constant. If non-linearity is present this will not be true and therefore one visible result of non-linearity will be that the half-amplitude duration of the sine-squared pulse does not agree with the theoretical value. Another common result is ' pig's ears ' at the line bar edges on vestigial sideband carrier systems due to quadrature distortion.

It will be appreciated that in a linear circuit the first and last microseconds of the line bar can be ignored for rating purposes as k_{bar} is intended to be a measure of the relatively low frequency distortion only and consequently distortions due to high-frequency effects are irrelevant. Also, the line bar corners which occur at black level should be similar to the corresponding corners at peak white and so can be ignored. In the presence of any non-linearity these propositions no longer hold and so objectionable effects such as ' pig's ears ' are not truly assessed by the k rating.

'k' Rating of Tandem Connections

When a number of *dissimilar* links are connected in tandem the overall k rating may be obtained from the following empirical expression due to Dr. N. W. Lewis*

$$\text{overall } k \text{ rating}$$
$$(k_{r1}{}^{3/2} + k_{r2}{}^{3/2} + k_{r3}{}^{3/2} + \;.\;.\; + k_{rn}{}^{3/2})^{2/3}$$

Acceptance-test Method of 'k' Rating

The acceptance-test method of determining k rating is more complicated than the routine-test method described above and involves microscope measurements on photographs of waveforms. It is also more accurate than the routine-test method, but a determination takes longer. It is usual to determine four factors, k_1, k_2, k_3 and k_4, the first two of which are very similar to k_{2T} and k_{pb} measured in the routine-test method. The remaining two factors can be defined as follows:

k_3. This factor is similar to k_2 (i.e., k_{pb}) but applies when the test signal is a hypothetical pulse and bar waveform in which the pulse is an ideal filtered impulse.

k_4. This factor places an upper limit on the average amplitude, ignoring signs, of the 16 central echo terms of the filtered impulse-response time series.

A direct method for the measurement of k_3 has been devised. A 1T pulse is passed through the appropriate link filter and the value of k_3 is obtained from the pulse-bar ratio by means of a table. However until a direct method of measuring k_4 has been found, the usefulness of the k_3 measurement is somewhat restricted. If and when such direct methods are discovered the BBC will accept these methods and the acceptance test method of measuring k rating will then replace the routine test method described in this Instruction.

Practical Testing of Circuits using Sine-squared Pulse Test Signals

Test Equipment

The pulse and bar generator must be set up for unity pulse-to-bar ratio at the beginning of a measurement and an error will be introduced if the waveform monitor used for the adjustment has

---

* N. W. Lewis " Tentative Requirements for the Transmission of 625-line Television Signals," Post Office Research Report No. 20661.

a poor amplitude-frequency characteristic. Provided this lack of flatness is only slight the error can be avoided by ensuring that the amplitudes of the pulse and bar are initially adjusted on the waveform monitor which is to be used for the measurements on the circuit or apparatus under test. Where this is not possible every effort should be made to ensure that the responses of the waveform monitors used are satisfactory, by checking the amplitude characteristics and transient responses of the Y amplifiers.

If the oscilloscope can be double-triggered, so that the sine-squared pulse can be displayed in the centre of the bar waveform, exact equality of amplitudes can be achieved by increasing the pulse height until a bright spot appears on the bar trace, indicating that the pulse tip coincides with the bar top.

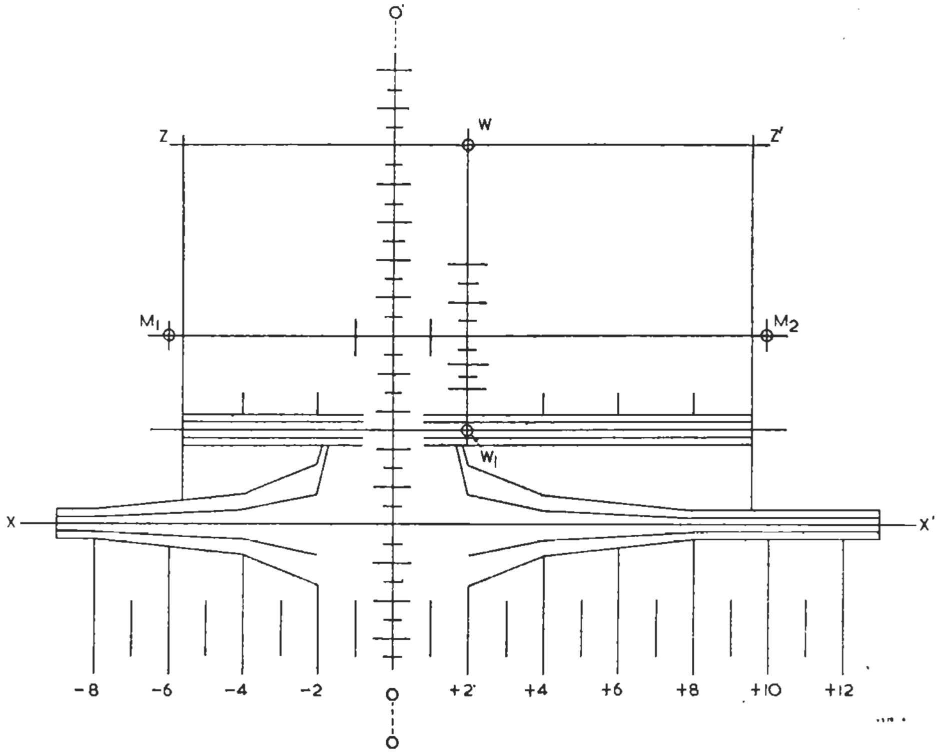

Fig. 10.10. Graticule for Sine-squared Pulse and Bar Testing

'*k*' *Factor Graticules*

In order to expedite the determination of k factors, graticules are used. These are engraved with limit lines for selected values of k for each portion of the test waveform, as indicated by Figs. 10.7 to 10.9. Thus, if a graticule is engraved with the limit lines for k equal to 2 per cent and 4 per cent, the values of k can be rapidly found by interpolation in the range 0 to 4 per cent. The BBC standard graticule designed for this purpose is shown in Fig. 10.10, where the limit lines for k_{2T} and k_{bar} are for 2 and 4 per cent respectively. For the measurement of k_{2T}, lines have been marked at ±T intervals about the intersection of OO′ and M_1M_2 to assist in the symmetrical placing of the pulse.

The graticule shown in Fig. 10.10 is used to determine k_{2T} and k_{bar} as follows. The bar waveform is centred on the graticule, and the Y gain is adjusted until the bar height fills the space between the lines XX′ and ZZ′; the X gain is then adjusted until the points M_1 and M_2 correspond with the mid points of the bar edges. Final adjustment of Y gain is made to set the bar-centre height to the line ZZ′ at the point W corresponding to the bar centre. The Y-shift control is then adjusted to bring the bar top centre to the point W_1. The k_{bar} factor is then determined by noting that the five horizontal lines superimposed on the bar top correspond (from top to bottom) to values of k_{bar} equal to 4, 2, 0, 2 and 4 per cent respectively.

To determine k_{2T} a timing wave is superimposed on the trace, and the X gain and sweep velocity are adjusted so that the unit timing intervals marked below XX′ are equal to 0·167 microsecond. (With 3-Mc/s markers, the marker pips are located on alternate timing-interval lines.) The 2T pulse is then displayed, and the Y controls and X shift are adjusted so that the pulse is centred about the line OO′, using the pair of inner vertical lines on M_1M_2 as a guide with blanking level along XX′ and the pulse peak touching ZZ′. When the pulse is centred between the inner pair of vertical lines, the peak of the pulse may not be upon OO′. The outer limit lines apply when k_{2T} is equal to 4 per cent and the inner lines when k_{2T} is equal to 2 per cent.

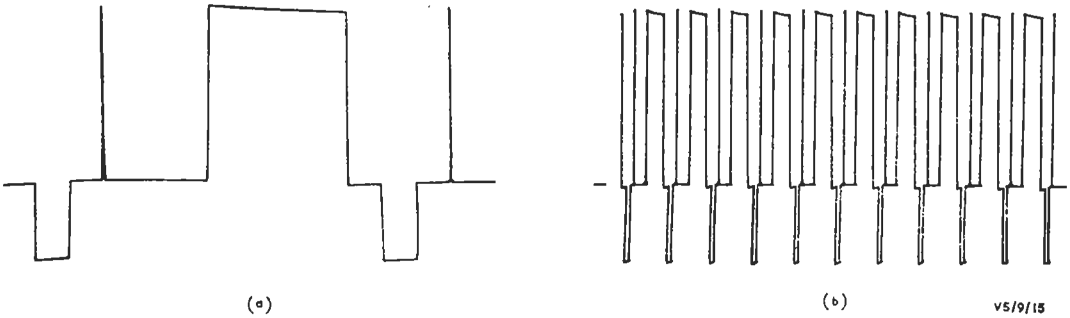

Fig. 10.11. Effect of Time-scale on Visibility of Waveform Distortion

$k_{50\text{-c/s}}$ is measured in much the same manner as k_{bar}, except that the limits are doubled. In view of the lesser importance of this parameter, the diagram has not been cluttered up by increasing the number of limit lines for the purpose; if necessary, the expanded limit lines about XX′ can be used.

k_{pb} is measured by setting the base-line of the pulse and bar along XX′, and the centre-point of the bar on W. If it is possible to trigger the waveform monitor in such a way that the peak of the pulse lies on WW_1, this should be done. Otherwise (a) the shifts only are operated until the centre of the bar passes through the intersection of WW_1 and M_1M_2, and then (b) the X shift alone is varied until the peak of the pulse lies on WW_1. The value of k_{pb} can now be read from the scale provided, in which the main lines indicate 2 and 4 per cent, and the shorter interpolated lines indicate 1 and 3 per cent.

Equalising Procedure

When an amplifier is being adjusted for minimum distortion, or a circuit is being equalised, the waveform at the output should, ignoring absolute delay and amplitude, be a replica of that at the input. In practice, it is usually possible to get a very close likeness to the input signal from a video amplifier, but from an average line or radio circuit it is seldom possible to achieve this, and some compromise between conflicting requirements is necessary. In order to achieve the best compromise when using the pulse and bar test signals, adjustment of the circuit under test should be carried out as follows:

(a) Reduce the line-bar slope to a minimum by varying the circuit response at the lower frequencies. Bar slope can most readily be perceived by using a timebase sweep of about one millisecond. (See Fig. 10.11.)

(b) Attempt to obtain a 100 per cent pulse/bar ratio using the 2T pulse, by adjusting the middle and high frequency response of the circuit. Take care to keep a good sine-squared pulse shape with any lobes on the pulse at minimum amplitude. If it is not possible to obtain a 100 per cent pulse/bar ratio without large lobes then a compromise must be accepted. The best compromise can be seen by reference to the subsection headed '*k*' *Rating*.

(c) Now correct the phase response to obtain equal lobes leading and trailing the 2T pulse. Next, on a 1T pulse, check the phase distortion as shown by the relative amplitudes of leading and trailing lobes. In practice, adjustment of the phase correction on a 2T pulse to give equal lobes may produce fairly large discrepancies between the lobes of a 1T pulse. This is due to the phase response being corrected over the lower frequencies, contained in the 2T pulse, but not over the wider spectrum of the 1T pulse. Here, again, a compromise has to be accepted, and the lobes on the 1T pulse adjusted to be as nearly equal as possible consistent with a good lobe balance on the 2T pulse. Note that varying the phase response does not affect the pulse amplitude or the pulse/bar ratio. With linear circuits the slope of each line bar transition over the first microsecond can be ignored, as the information is better given by the sine-squared pulse shape. With non-linear circuits (e.g., vestigial sideband systems) however, considerable differences can occur. For example, the sine-squared pulse shape may be quite acceptable whereas the pig's ears on the bar are excessive. In these circumstances the sine-squared pulse shape will have to be degraded to reduce the pig's ears to reasonable limits.