CATV DISTORTION MEASUREMENT TECHNIQUES

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The general industry acceptance of mid and superband channels heralds a new era in system maintenance. To meet the challenge one must understand the factors that contribute to the distortions and develop the techniques necessary to diagnose and remedy problems while in their infancy. The measurement of CATV distortions is not a difficult assignment, however it does require proper instrumentation.

One of the major points of this paper is to present one important fact, YOU CANNOT MEASURE COHERENT DISTORTIONS WITH A FIELD STRENGTH METER. To attempt to measure a component 55 dB below carrier in the presence of a 40 dB Carrier-to-Noise ratio is like looking for the proverbial needle in a haystack. The methods described in this paper are based on two receiving devices, (a spectrum analyzer and a wave analyzer).

The spectrum analyzer is a swept receiver that provides a CRT display of amplitude versus frequency. It shows how energy is distributed as a function of frequency, displaying the fourier components of a given waveform.

The wave analyzer can be thought of as a finate bandwidth window filter which can be tuned throughout a particular frequency range. Signals located on the frequency spectrum will be selectively measured as they are framed by the window.

Both of these units have one thing in common, narrow bandwidth. When the wave analyzer has a bandwidth of 25 cycles it will show an improvement over the 600 kc F.S. M. of 44 dB in regards to the measurement interference caused by system noise. A spectrum analyzer with 300 cycle bandwidth will offer a 33 dB improvement. Basically this means you can measure a second order component 66 dB below carrier in the presence of a 40 dB carrier-to-noise ratio, with either instrument. The F.S.M. is limited to about -35 dB below carrier at the same carrier-to-noise ratio.

SECOND ORDER

The mathematics that follow are not of any great importance to anyone other than a designer, however there are a few important aspects that the formulas clarify.

(1) Second order increases one dB for each dB increase of amplifier output level.

(2) Second harmonics are 6 dB less than sum and difference beats for the same output carrier levels.

SUM AND DIFFERENCE LEVELS IN dBmV AT AMPLIFIER OUTPUT

$L\,a\,b = K_2 + La + Lb$ (at $f_a \pm f_b$)

$L\,b\,c = K_2 + Lb + Lc$ (at $f_b \pm f_c$)

$L\,a\,c = K_2 + La + Lc$ (at $f_a \pm f_c$)

SECOND HARMONICS LEVELS IN dBmV AT AMPLIFIER OUTPUT

$L2a = K_2 + 2\,La - 6,$ at $2\ f_a$

$L2b = K_2 + 2\,Lb - 6,$ at $2\ f_b$

$L2c = K_2 + 2\,Lc - 6,$ at $2\ f_c$

where

k_1 and k_2 are constants. They are complex numbers describing the first and second order gain, phase shift and distortion properties of the amplifier. To permit easy mathematical development consider them to be constant for all input signal frequencies. Measurement on practical amplifiers prove that in reality this is not the case and care must be exercised before drawing conclusions concerning real amplifiers from the mathematical considerations.

K_2 is a decibel constant characterizing second order distortion.

$$K_2 = 20\ \text{Log}\ \frac{\dfrac{k_2}{\sqrt{2}}}{\left(\dfrac{k_1}{\sqrt{2}}\right)^2}$$

expressed in dBmV

Lab, Lbc, Lac = Sum and difference beats in dBmV

$L2_a$, $L2_b$, $L2_c$ = Second order harmonics in dBmV

La, Lb, Lc = First order output levels in dBmV

f_a, f_b, f_c = Corresponding frequencies

When you read a amplifier specification sheet the information you should be concerned with is listed in these terms Second Order = -66 dB at + 50 dBmV output. The equipment supplier is saying the following, (at +50 dBmV output, when operated within the recommended operating parameters i.e. slope, gain, tilt, etc. this amplifier will not produce a second order component that will not be less than 66 dB below the nearest carrier).

The trunkline amplifier is typically not operated at +50 dBmV output. If you operate the amplifier at +30 dBmV output the amplifier deration for second order will be 50 - 30 = 20 dB, and -66 - 20 = - 86 dB second order for this amplifier. When you have a cascade of 32 amplifiers identical to this amplifier you can expect the second order to increase 3 dB each time you double the cascade of 1, 2, 4, 8, 16, 32 is equal to five doubles. The expected second order will then be -86 + 15 = 71 dB below the nearest carrier. When the amplifier station is not a direct double subtract (dB - 10 Log_{10} N), from -86 where N = the number of amplifiers in cascade.

The above information will allow you to determine the level of second order you should expect. The remainder of the article will clarify the methods of measurement and the analysis of the results.

Figure 1 is a spectrum analyzer view of the new sum and difference components generated when two first order components are introduced to an amplifier with second order distortion. Note that in addition to the two original carriers, there are four additional new components. These are the sum and difference beats of F_1 and F_2 plus the second harmonics of F_1 and F_2.

Figure 2 applies the basic knowledge of figure 1 to a CATV system. The difference of channel 2 carrier and channel 6 carrier is 28 MHz. The second harmonic of channel 4 carrier is 134.5 MHz or channel C in the midband. Channel 8 carrier minus channel 2 carrier = 126 MHz. When the VHF carrier frequencies were assigned the second order problem was recognized and with the exception of channel 6 sound carrier (the second harmonic is 175.5 or channel 7) the 12 channel systems do not fall prey to second order distortion.

The addition of the mid and super-band channels increases the total number of beat products to a point of mass congestion.

Channel 13 - 2 = 156 MHz
Channel J - 3 = 156 MHz
Channel K - 4 = 156 MHz

The measurement of a singular second order product is increased in difficulty if you need to worry about additional products that may cloud the final results. Remove all carriers from the system with the exception of the contributing carriers and system support carriers, i.e. slope and gain control carriers, plus carriers adjacent to support carriers if necessary due to slope or gain dependency resulting from inadequate pre-selection in the amplifier circuitry.

Figure 3 depicts some carriers that may be used for the measurement. The basic reason these carriers were selected was due to their position within the passband. There is one low, one mid and one high. The worst case condition for second order distortion is usually a high minus a low falling into a mid band channel.

Channel 13 - 2 = 156 MHz. The second order beat will usually fall within 20 kc of 156 MHz depending upon the exact frequencies of channels 2 and 13. The beat will be 1.25 MHz below channel G visual carrier plus or minus the above mentioned 20 kc and any channel G deviation from standard frequency.

Figure 3 is representative of the results you would obtain with a spectrum analyzer with 70 dB dynamic range. The spectrum analyzer reads peak amplitude and the readout is directly in dB. This figure illustrates a second order product at 156 MHz. The product is 50 dB below the G carrier peak amplitude. The product at 110.5 MHz is the second harmonic of channel 2. Second harmonics are typically six dB less than sum and difference beats.

Figure 4 outlines the equipment setup.

The spectrum analyzer approach is the easiest method to measure second order. The three drawbacks to this approach are:

1. Cost
2. Portability
3. Measurement sensitivity

If you have ever priced a spectrum analyzer with a 70 dB dynamic range the first drawback is self-explanatory. If you plan to fly and check the unit as baggage, leave the office early, pack an extra tube of Ben Gay ointment and make sure your company carries insurance. This is due to the fact that the airlines will not accept liability in excess of $500.00 unless you ship it air freight.

Last and possibly least is the measurement sensitivity. The sensitivity crossover point in a typical system is 16 to 20 amplifiers in cascade. Prior to this point, the distortion will be undetectable.

WAVE ANALYZER APPROACH

When you select an alternate assignment of measurement carriers, the equipment costs are reduced to a more acceptable pricetag. The change involved is related to the channel G carrier. The frequency is shifted from 157.25 MHz to 156.00 MHz. The exact carrier frequency is trimmed up or down the required amount to place the second order beat at G carrier $\pm$ 5 kc. The second order beat will now become a channel G sideband displaced by 5 kc with an amplitude relationship to the G carrier equal to the differential in level.

The spectrum analyzer method allows a simultaneous view of the carrier amplitude and the second order beat amplitude which yields a simple interpretation of information. This advantage is not the case with the wave analyzer approach, which leads us to the calibrator that is necessary to establish the reference level required for the measurement by comparison technique.

Fig. 5

The calibrator R.F. input is derived from a standard V.H.F. signal generator tuned to 156 MHz. The switcher is driven by a variable rate generator. When the second order beat is 5 kc removed from the 156 MHz carrier the rate generator will then switch the R.F. carrier between the test and reference leg of the switcher at 5 kc rate. When you add 40 dB attenuation in the reference leg the switcher output will alternate between a test level and a reference level 40 dB down.

The output of the switcher is connected to a field strength meter. The field strength meter is tuned to the 156 MHz carrier and the manual gain of the meter is adjusted for +4 volts DC on the voltmeter.

Tune the wave analyzer to 5 kc. The indication on the meter at 5 kc will be the calibration reference. The reference will be 40 dB down from the 156 MHz carrier. Note the meter reading in terms of the number of dB's the indication deviates from full scale deflection.

When the above has been accomplished the system second order may be measured by changing the F.S.M. input lead from the switcher to the channel G bandpass filter that is connected to the system testpoint.

Procedure:

1. Check F.S.M. tuning and retune to 156 MHz if necessary.

2. Adjust manual gain for +4 volts DC on the meter.

3. Remove 30 dB attenuation from the wave analyzer and tune for maximum indication. The beat may not be exactly 5 kc due to instability of the contributing carrier generators.

4. The sum total of the -40 dB reference plus the amount of attenuation removed from the analyzer plus or minus the meter reading deviation from reference, equals the level of the second order component.

The second method of calibration is more difficult but utilizes equipment that is common and readily available. Fig. 6 illustrates the equipment and the procedure is as follows:

1. Remove the 40 dB pad.

2. Adjust the F.S.M. tuning to 156 MHz.

3. Remove output lead from Gen # 2.

4. Tune Gen # 1 to 156 MHz and adjust level to "0" dBmV.

5. Remove the output lead from Gen # 1.

6. Reconnect the Gen # 2 output lead.

7. Tune Gen # 2 to 156.00 MHz and adjust level to "0" dBmV.

8. Reconnect Gen #1 output load.

9. Tune wave analyzer to 5 kc and make a fine adjustment on the frequency of Gen #2 until the wave analyzer reading peaks, indicating a 5 kc difference between the two signals.

10. Add the 40 dB pad to the output lead of Gen #2.

11. Retune the F.S.M. for peak reading on voltmeter.

The above results in a 5 kc sideband 40 dB down. The remainder of the procedure follows the outline presented for the first calibration and measurement method.

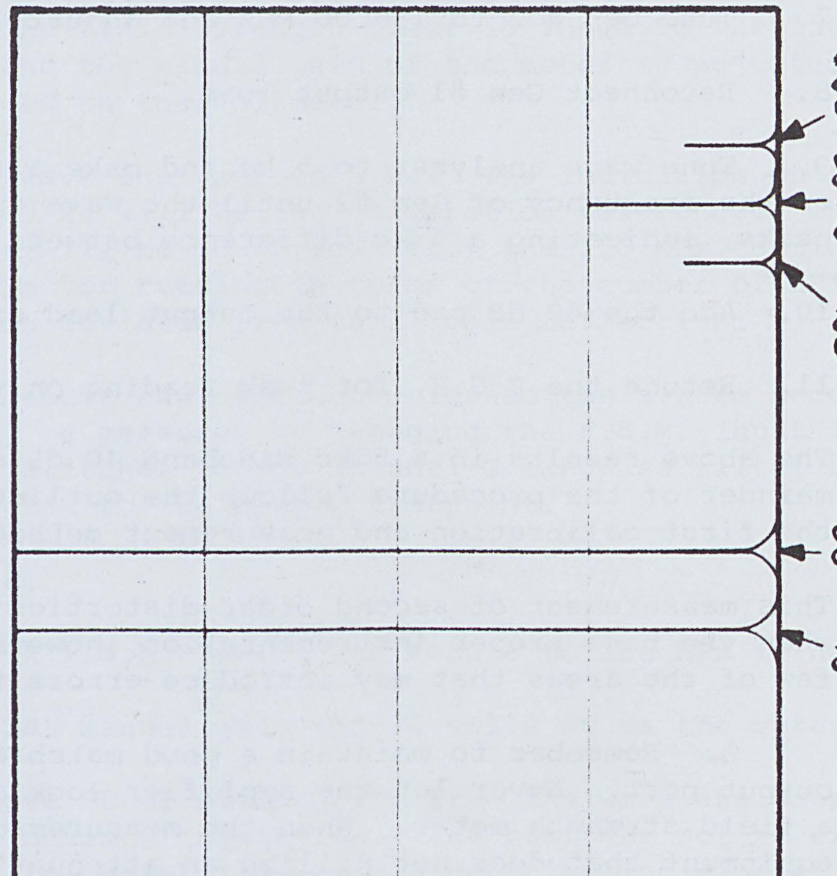
This measurement of second order distortion is not difficult when you have proper instrumentation, however I will list a few of the areas that may introduce errors in the reading.

A. Remember to maintain a good match at the amplifier output port. Never let the amplifier look directly into a field strength meter. When the measurement is made on equipment that does not utilize an attenuation test probe, or at least a 10 dB down testpoint, be sure to isolate the output match by installing a 10 dB pad directly on the output of the amplifier.

B. The bandpass filter at the input to the field strength meter or spectrum analyzer will prevent the generation of second order in the measurement receivers.

C. The calibration procedure at 5 kc is not correct for any other frequency unless you are sure the wave analyzer has a flat response to all frequencies. Check the response periodically with an audio oscillator of known flatness across the measurement frequencies.

FIG. 1



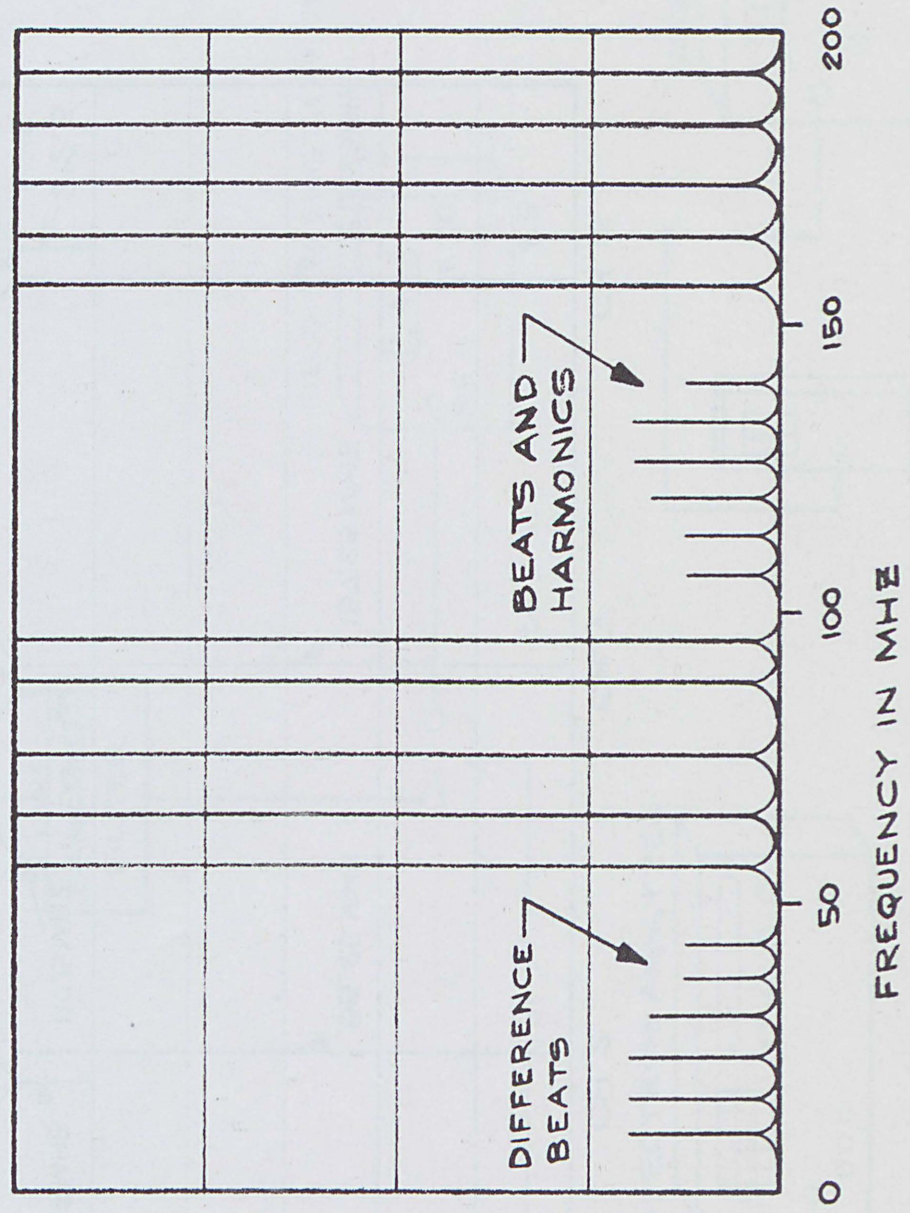

BEATS AND HARMONICS
DIFFERENCE BEATS
0
50
100
150
200
FREQUENCY IN MHZ

FIG. 2

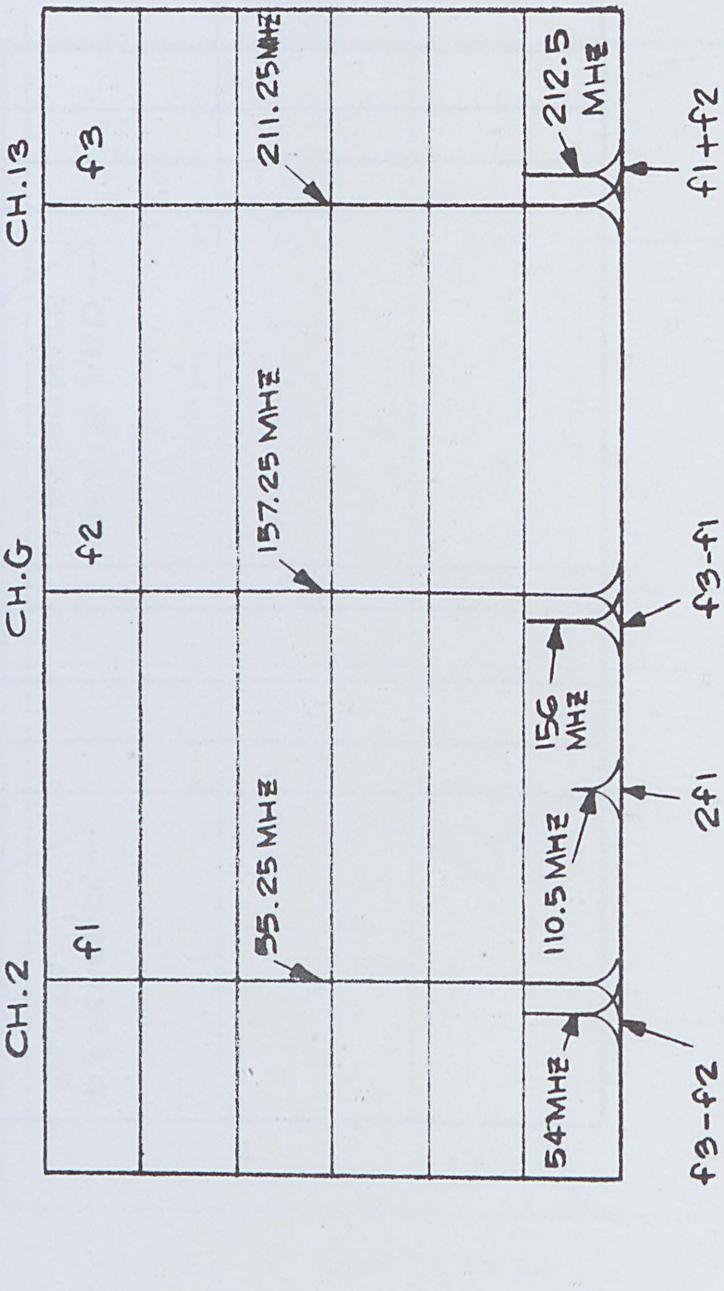
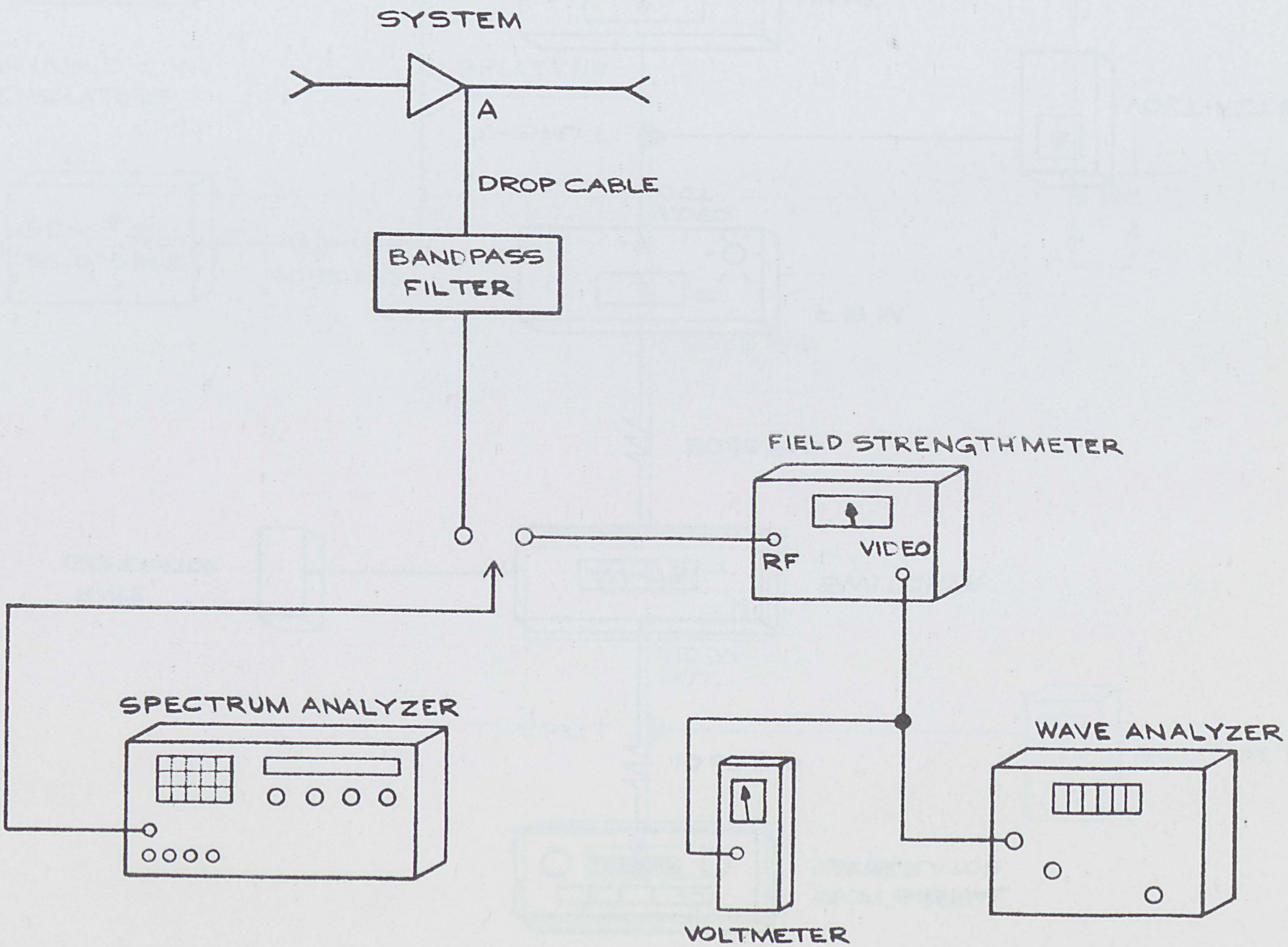

CH.2
f1
55.25 MHZ
CH.G
f2
157.25 MHZ
CH.13
f3
211.25 MHZ
54 MHZ
110.5 MHZ
156 MHZ
212.5 MHZ
f3-f2
2f1
f3-f1
f1+f2

FIG. 3

SECOND ORDER

FIG. 4



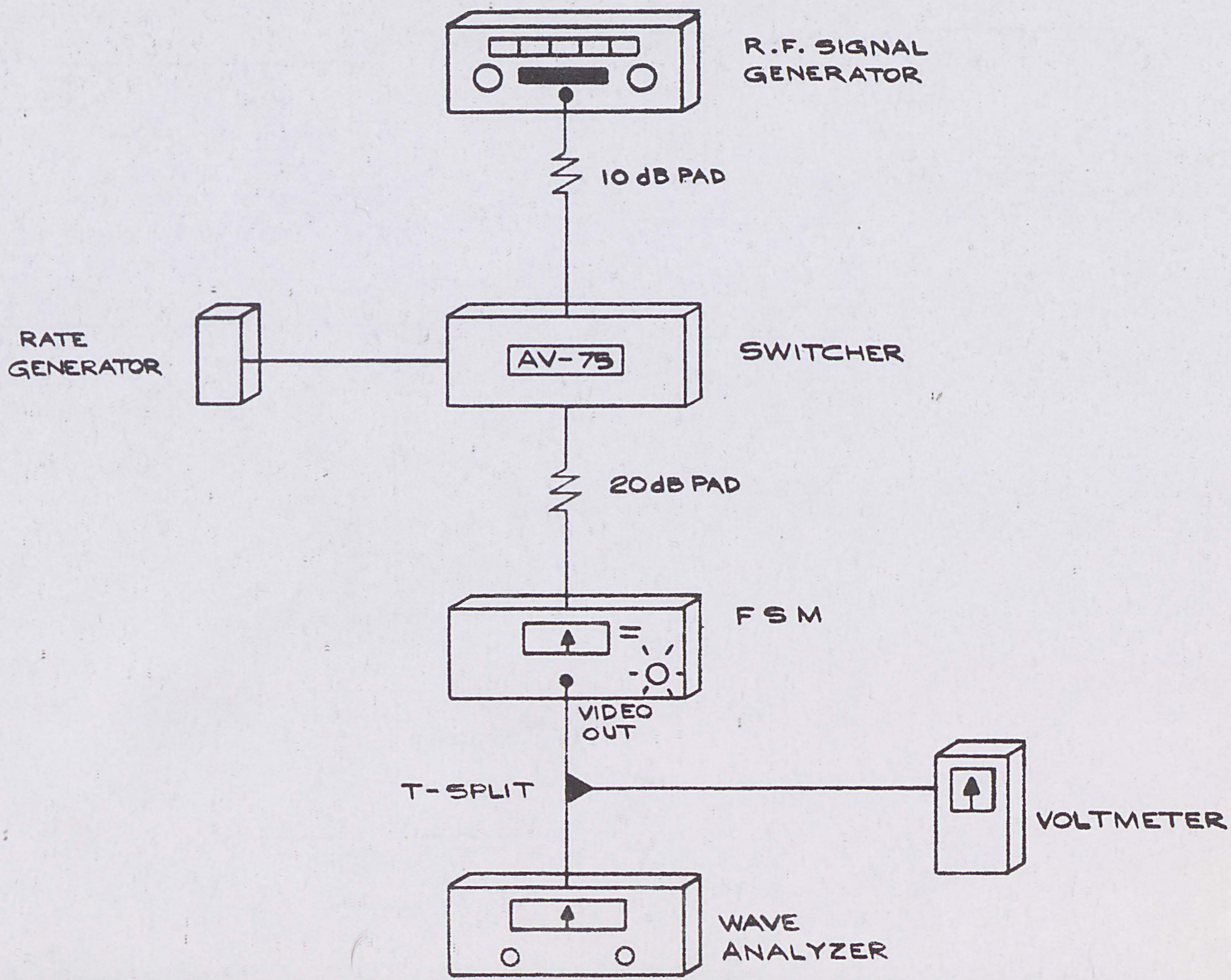

R.F. SIGNAL
GENERATOR
10 dB PAD
RATE
GENERATOR
AV-75
SWITCHER
20 dB PAD
FSM
VIDEO
OUT
T-SPLIT
VOLTMETER
WAVE
ANALYZER

FIG. 5

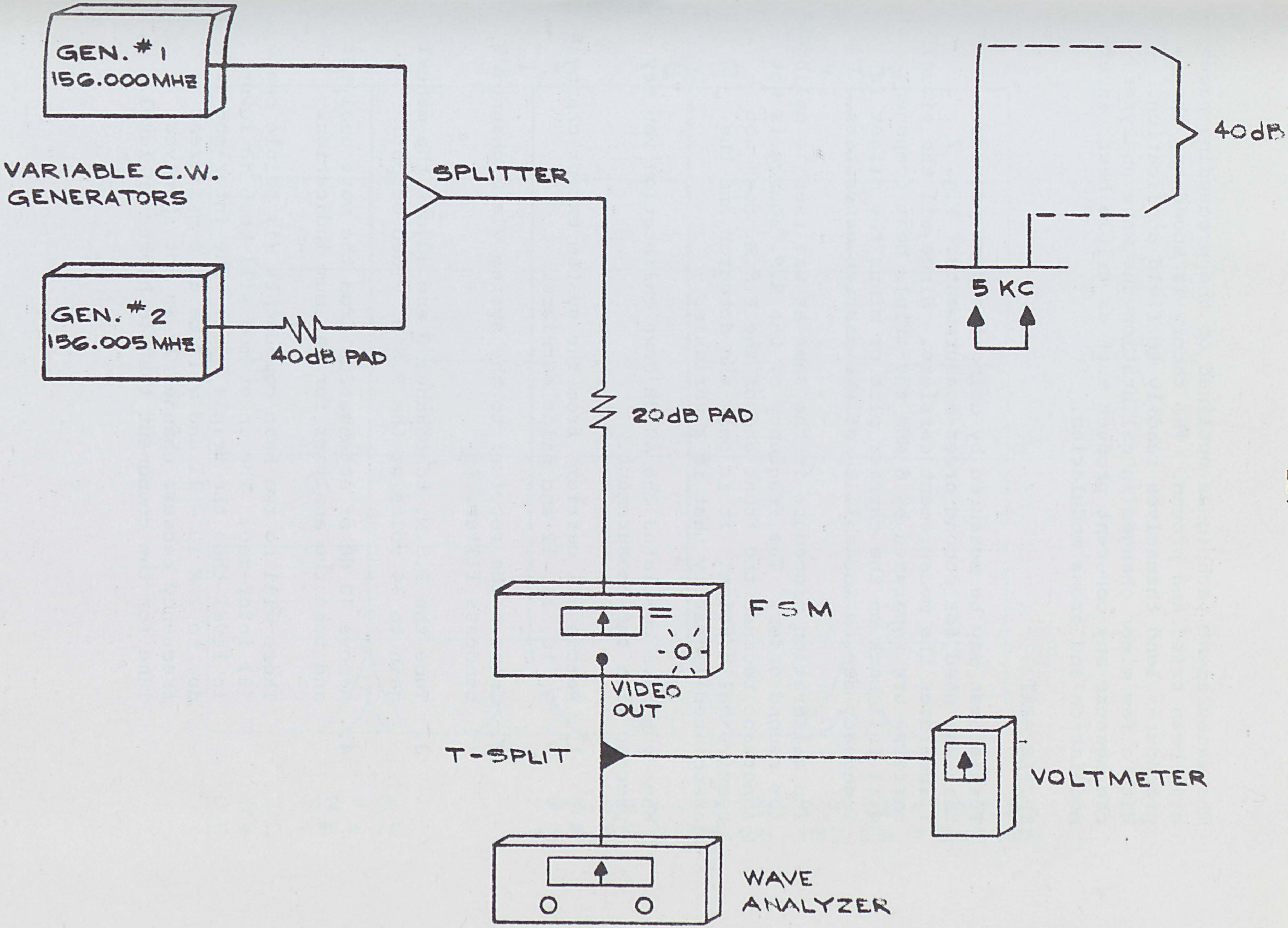

GEN. #1
156.000MHZ
VARIABLE C.W.
GENERATORS
GEN. #2
156.005 MHZ
40dB PAD
SPLITTER
20dB PAD
FSM
VIDEO
OUT
T-SPLIT
VOLTMETER
WAVE
ANALYZER
40dB
5 KC

FIG. 6

The measurement techniques outlined on the preceeding pages have been tried and proven. The theory is sound and the procedures lend themselves readily to field application. With a few minor changes in calibration the wave analyzer can measure any coherent product such as triple beat, intermodulation and cross modulation.

TRIPLE BEAT

Triple beat may be measured by using the same procedure that was used for second order measurements. Fig. 7 illustrates the measurement carriers. Since all the visual carriers are separated by 6 MHz the triple beat component will fall back on the carrier plus or minus the offset in frequency due to instability of the carrier generators.

The calibration procedure is the same as was used to calibrate for second order. The frequency of the R.F. source is not important because the front end of the F.S.M. does not require calibration. It is only the detector and the associated linearity that is a variable.

When you have completed the 40 dB down calibration you may proceed with the measurement.

1. Remove all carriers from the system except channels 9, 10, 11, 12 and pilot carriers.

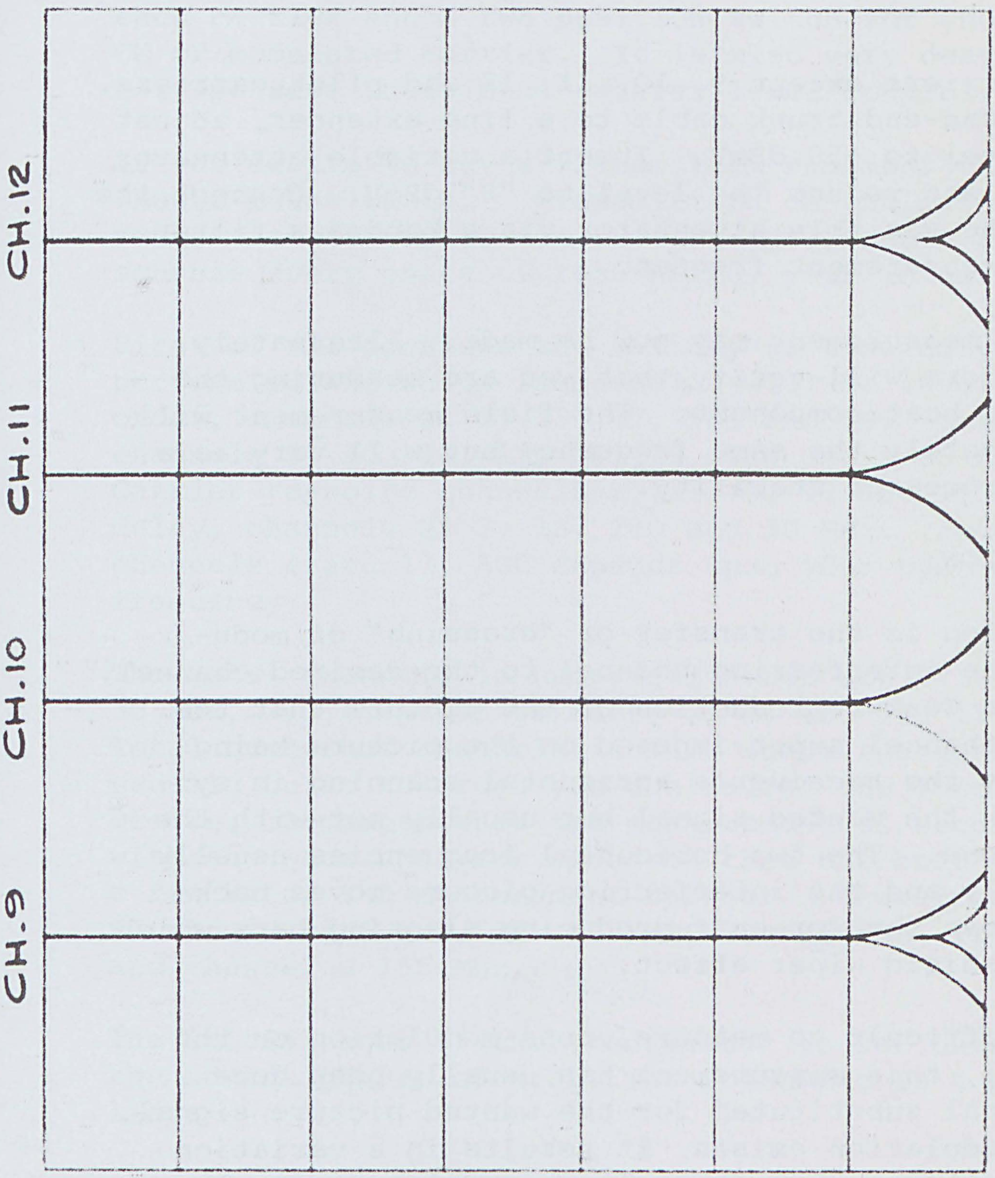
2. Connect the receiver to the system via a channel 9 bandpass filter.

3. Tune the F.S.M. to channel 9 and adjust the manual gain to +4 volts at the F.S.M. video output.

4. Remove 40 dB of attenuation from the wave analyzer and tune the analyzer for maximum indication.

   There will be two beat components (1) triple beat (2) inter-mod. The inter-mod will be 6 dB lower in level than the triple beat. The inter-mod is due to 2 X 10 - 11 and will be at a different frequency because channel 12 is not involved. Tune for the component that is higher in level.

TRIPLE BEAT



10 + 11 − 12 = 9
10 + 11 − 9 = 12

193.25 + 199.25 − 205.25 = 187.25
193.25 + 199.25 − 187.25 = 205.25

FIG.7

5. The sum total of the -40 dB reference plus the amount of attenuation removed from the analyzer plus or minus the meter reading deviation from reference, equals the level of the triple beat.

It may be desireable to perform a reference test at the head-end. This will yield an indication of the probable beat frequency and prove the validity of the field measurements.

Remove all carriers except 9, 10, 11, 12 and pilot carriers. Connect the head-end trunk cable to a line extender, adjust the output level to +50 dBmV. Insert a variable attenuator on the output and reduce the level to "0" dBmV. Connect the receiver to the variable attenuator via a bandpass filter tuned to the measurement frequency.

The reference measurement may now be made. Alternately removing carriers will verify that you are measuring the desired triple beat component. The field measurement will be at approximately the same frequency but will vary as a function of processor stability.

CROSS MODULATION

Cross modulation is the transfer or "crossing" of modulation from the interferring channel to the desired channel, resulting in a weak reproduction of the picture that the interferring channel super-imposed on the picture being viewed. Since the receiver's horizontal scanning is synchronized with the wanted signal but usually not with the interferring one. The two horizontal frequencies usually differ slightly and the interferring picture moves back and forth across the screen reproducing slanting bars which give the windshield wiper effect.

Since it is difficult to measure cross-modulation on the wanted channel, this measurement has usually been done with a CW signal substituted for the wanted picture signal. Where cross modulation exists, it results in a variation in the peak voltage of an otherwise unmodulated signal substituted for the wanted carrier. Percent cross-modulation is defined as 100 times the ratio of this variation to the maximum peak voltage.

The equipment required to measure cross-modulation will consist of a transmitting and a receiving package. The most desirable transmitting package is a multi-carrier signal generator. Output frequencies corresponding to the standard VHF channel assignments plus additional mid, sub and super-band frequencies. This head-end substitution transmitter must also contain individual modulators for each carrier and a two position switch for choosing either CW or modulated carrier. It is also very desirable if the unit possess individual carrier level control.

If you desire to buy a transmitter remember the old saying, "haste makes waste." Transmitters on the market today range from $7,000 to $14,000, and you should attempt to squeeze every ounce of return from your investment.

First of all consider the variety of testing you will be performing and which frequencies will be involved. Second order, channels 2, G, 13, T7, T8, and T9. Triple beat, channels 9, 10, 11, 12, T8, T9, T10 and a 30 MHz carrier. Carrier-to-noise channels 2, 13, 0, T7 and T10. Group delay, channels 2, 3, 13, T10 and 30 MHz. Automatic slope channels 4 and 11, AGC depends upon your system pilot carrier frequency.

The total channels in numerical order are T7, T8, T9, T10, 30 MHz, 2,3,4, pilot carrier, G, 9, 10, 11, 12, 13 and 0. Total number of channels is 16. Since the generators are usually built to order you can select the frequencies you desire. Remember that the measurement of second order with the wave analyzer requires that the beat falls within a few kc of the measurement carrier. Therefore channel T7 should be 6 MHz, T8 12 MHz, T9 18 MHz, T10 24 MHz and channel G 156 MHz.

The initial cost of the transmitter is far outweighed by the advantages it offers. The following is a partial list:

1. Due to the fact that the system service must be interrupted for cross-mod testing, the available testing time is limited to two or three hours of early morning work. Time then becomes a very important commodity and efficiency is the word of the day. The carrier generator will allow you to reduce the equipment set-up time in the head-end by a factor of 10, which allows you more time for system testing.

2. Since the head-end remains basically intact you do not run the risk of head-end equipment malfunction due to re-arrangement of processor operating parameters and levels.

3. If you have ever desired to build a independent lab for evaluating products, this unit is definitely for you.

Figure 8.a. depicts the second method which requires a processor that has provisions for modulating the internal standby carrier. Some processors have terminal strips that will accept baseband information and produce an output that is modulated at the aforementioned baseband frequency. If your processor does not have this capability you may be able to use a alternate method depending upon the availability of a 45.75 MHz I.F. tie point. The sequence is outlined by figure 8.b. and the following procedure:

An audio frequency generator with a 15,750 Hz square wave output is utilized to modulate a modulator at 100%. The frequency is relatively unimportant but it can serve as one of the modulated carriers. A sample output can serve as the input to a processor, whouse output in turn would serve as the second modulated carrier. The processor I. F. module output then can be sampled with a directional coupler and the processor output level re-established with the coupler insertion loss in place.

The sample signal at the I.F. frequency is then divided equally and inserted at the input of the I.F. amplifier in each of the remaining channel processors. All of the outputs including the CW outputs which are established by the signal replacer of the desired test channels should be operated at normal system levels.

Before leaving the head-end you should always make a reference cross-modulation measurement to assure the receiving package is in good working order. Normally the measurement will be very low and will be noise limited in the range of -90 to -100 dB.

Referring to figure 4 for receiving point test set-up the measurement is accomplished as follows:

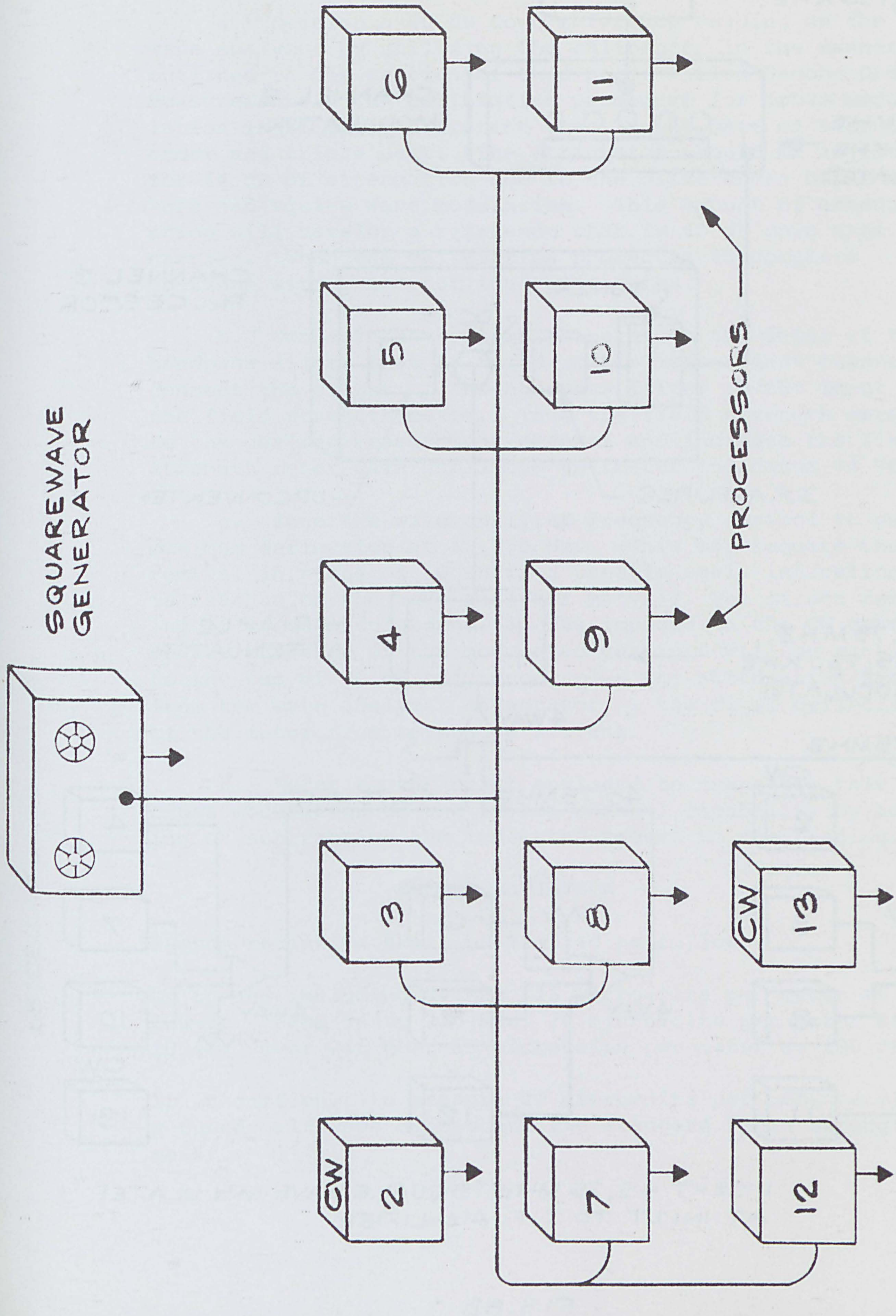
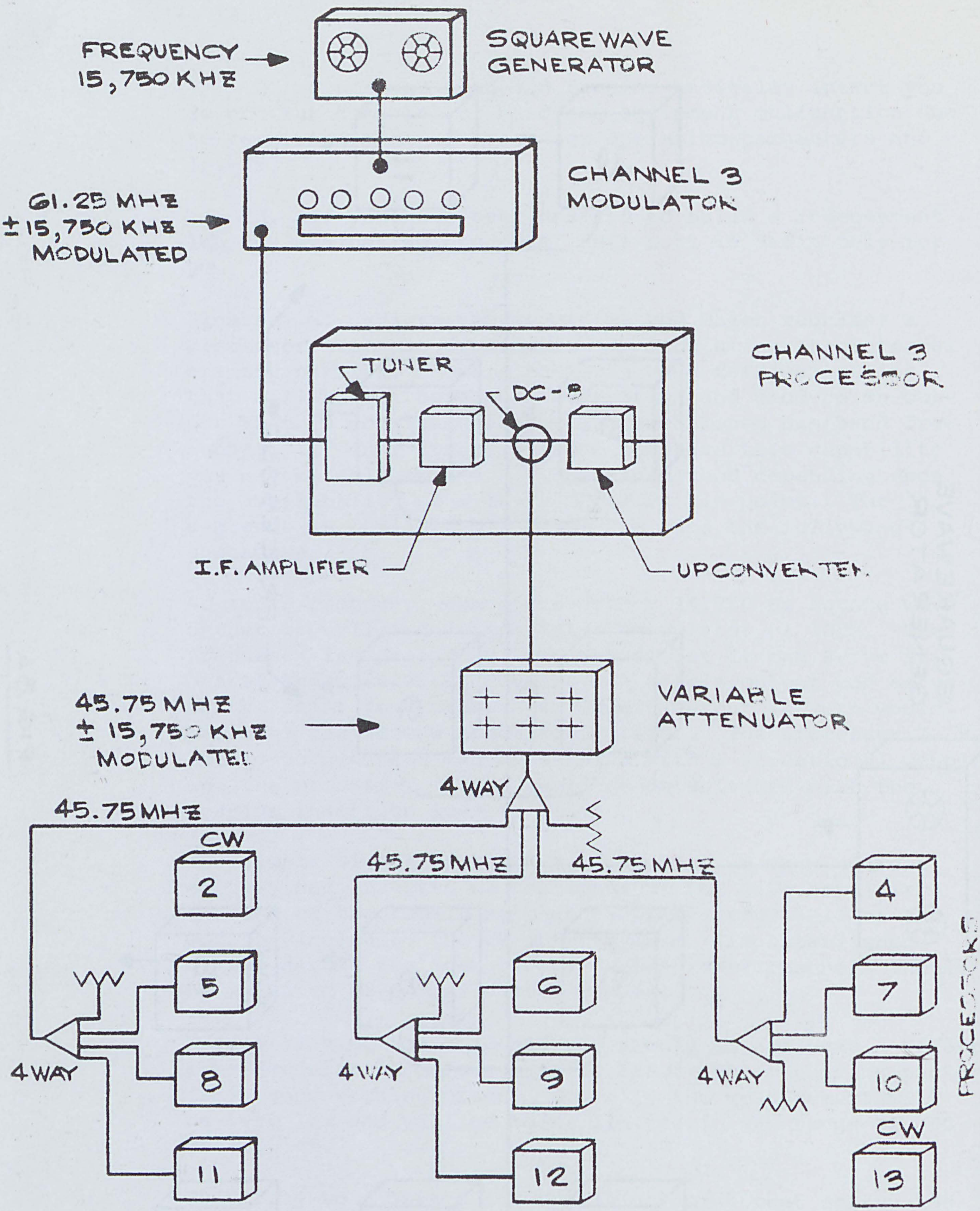


FIG.8A



INSERT 45.75 MHZ "SQUARE WAVE MODULATED" AT INPUT TO I.F. AMPLIFIER

FIG. 8B

a. Develop a 40 dB down reference reading on the wave analyzer by utilizing the calibrator in the manner outlined in the section of this paper titled Second Order Measurements. The calibration procedure for cross modulation is slightly different than in the case of second order and triple beat. The attenuator should be adjusted for 44 dB of attenuation due to the differences of sine wave and square wave modulation. This amount of attenuation will develop a reference that is 40 dB down from carrier. When the calibration procedure is complete continue with these outlined procedures.

b. Connect the system testpoint to the input of the bandpass filter that is tuned to the measurement channel. Connect the output of the bandpass filter to the input of the field strength meter. Tune the field strength meter to the desired measurement channel and increase the field strength meter gain until the voltmeter indicates +4 VDC.

c. Tune the wave analyzer frequency control to obtain maximum deflection at 15,750 Hz. (This may require the removal in steps of 10 until a useable scale indication is reached on the wave analyzer meter). The direct reading of cross modulation, (in dB) imposed on the CW carrier by the presence of the modulated carriers will be equal to the sum of 40 dB reference, plus the attenuation removed from the wave analyzer attenuator, ± the final deflection of the meter from reference setting.

d. Refer to the chart enclosed to translate this cross modulation to the system channel capability by adding or subtracting the indicated amount to the reading.

SYSTEM RADIATION

System radiation shall be limited as follows:

Up to and including 54 MHz, 15 microvolts per meter at 100 ft. From 54 to 216 MHz, 20 microvolts per meter at 10 ft. Over 216 MHz, 15 microvolts per meter at 100 ft.

It is difficult to measure 20 microvolts per meter utilizing a tuned half wave dipole and the standard field strength meter.

To clarify the point, assume that the cable system is radiating 20 microvolts per meter at 10 ft. on channel 12. If this is the case the standard field strength meter connected to the output of the dipole antenna must be capable of measuring a -46 dBmV. This is not practical with the standard field strength meter. However, you may make the situation slightly more tolerable by adding a pre-amplifier between the dipole antenna and the field strength meter and the level will be within the sensitivity range.

The additional noise from the field strength meter due to the low input level will further obscrure the reading when the measurement is attempted. At 300 MHz, expect the carrier-to-noise to degrade by an additional 3.3 dB. When the measurement is made at channel 2 expect the carrier to noise to improve by 11.3 dB.

In summation the technique is useable for frequencies up to 100 MHz, but for frequencies higher than 100 MHz the results would be questionable. The aforemention analysis is predicated on the assumption that the field intensity of cosmic noise, atmospheric noise, and man-made noise is not excessive.

Unfortunately the median value of both urband and suburban man-made noise is in excess of 10 microvolts per meter when measured with a 600 kc bandwidth field strength meter. The facts at this point indicate that the field strength meter is not the receiving instrumentation necessary to measure such low values of radiation.

However these low values can be measured if we utilized the spectrum analyzer. The spectrum analyzer can perform the measurement for two basic reasons. Increased sensitivity and the ability to reduce the receiver bandwidth to the point that noise is not objectionable.

CARRIER-TO-NOISE

The average field strength meter is designed to measure the voltage and the dBmV levels of CW, FM carriers and television signals in cable systems. Although it is not calibrated for noise levels, with suitable correction, a meter can be used for this purpose.

Two factors prevent it from reading noise levels directly and both must be taken into account in the correction. One source of error is in the bandwidth of the average field strength meter which is approximately .6 MHz. Since noise power is proportional to bandwidth, the apparent noise will be reduced by a factor of 8.2 dB, which is the decibel equivalent of a power ratio of 4 MHz divided by .6 MHz. The second error occurs in the opposite direction. It is due to the fact that the average field strength meter utilizes a peak detector. Peak detectors will attempt to respond to the noise peak better than reading the RMS noise. Since noise has a higher peak to RMS ratio than the CW signals the detected output reads high. As its output is reduced the efficiency of the detector is lowered and reads closer to RMS so more total correction is needed at the low end of the meter scale.

Figure 9 illustrates the maximum, average and minimum correction values dependent upon the needle position on the dBmV scale of the field strength meter. The appropriate correction corresponding to the needle position on the scale is then added to the measured level to obtain true noise level.

TEST DESCRIPTION

The carrier-to-noise ratio should be measured utilizing the lowest and highest carrier frequency transported by the transmission system. These frequencies should generally be considered to be the worst cases if the system frequency response is held within ± 3 dB. The carriers shall be generated by the head-end processing equipment and the receiver package shall consist of one variable attenuator and one field strength meter. Previously mentioned field strength meter correction factors can be verified by measuring any known noise source, but this is usually not essential.

TEST PROCEDURE

A. Connect a drop cable from the system testpoint to the input of variable attenuator.

B. Connect the output of the variable attenuator to a bandpass filter that is tuned to the measurement channel.

C. Connect the output of the bandpass filter to the RF input of the field strength meter.

D. Insert 60 dB of attenuation in the variable attenuator; operate the field strength meter at the range required to obtain a meter deflection of 0 dBmV on the scale when tuned to the measurement carrier.

E. Remove the measurement carrier from the transmission system.

F. Remove attenuation from the variable attenuator until the meter deflection returns to 0 dBmV output on the scale.

G. Tune the field strength meter plus or minus 1 MHz and null the meter reading.

H. Remove attenuation from the variable attenuator until the meter indication returns to 0 dBmV on the scale.

I. Note the total amount of attenuation removed, this indicates the uncorrected carrier-to-noise ratio.

J. Subtract the 4.2 from the above curve for the true carrier-to-noise ratio.

There are a few procedures that must be followed to insure that the measurements are accurate. Step G indicates that the field strength meter tuning should be moved above and below the carrier in search of a null. The reason for this becomes quite apparent when we attempt to measure the carrier-to-noise in the feeder system.

When channel 13 is used as the referenced carrier for noise measurements there will be a discrepancy in the reading due to the addition of triple beat. A 12 carrier CATV system will produce 13 triple beats that fall directly on channel 13 plus or minus the frequency stability and their respective output converters.

The noise level measured when channel 13 is removed is equal to the noise plus 13 triple beat components that fall within the field strength meter passband.

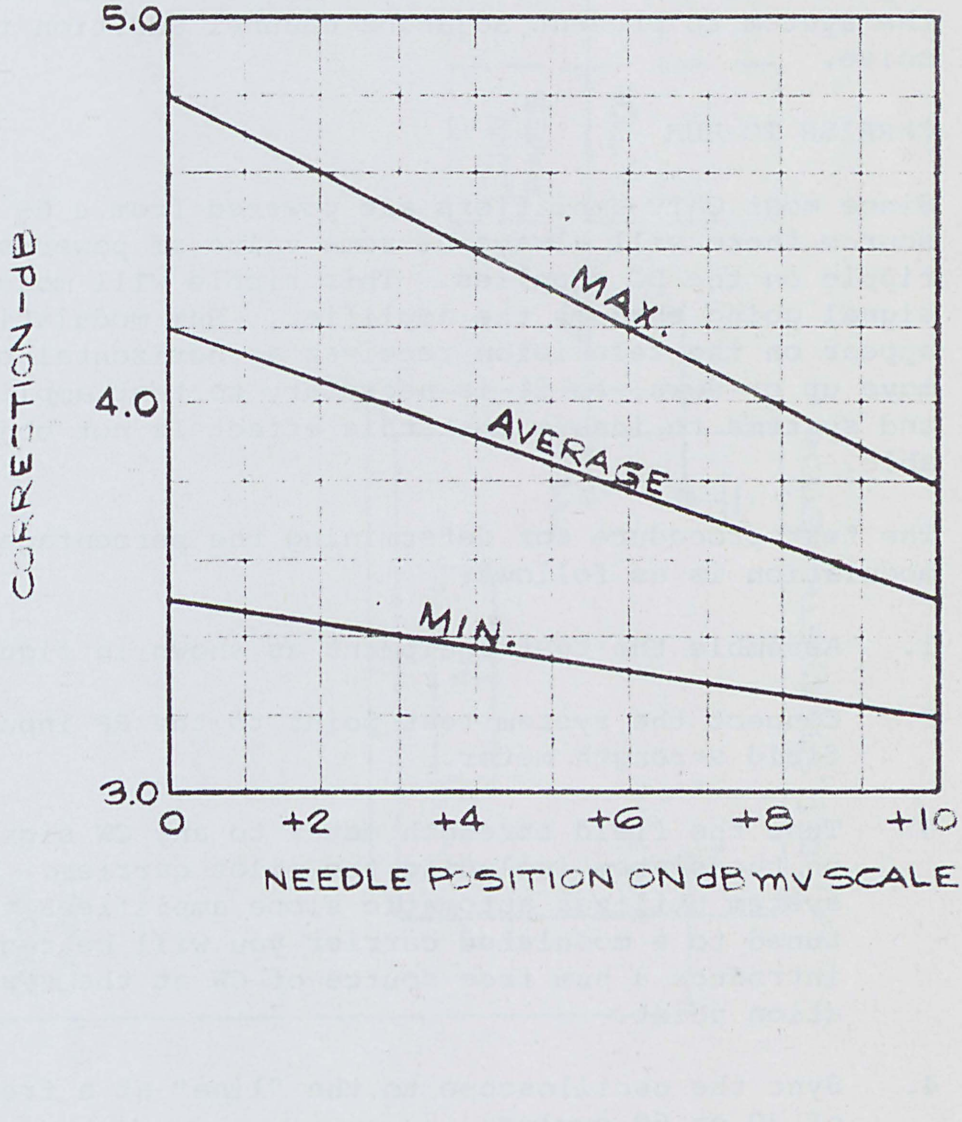

5.0
4.0
3.0
CORRECTION-dB
MAX.
AVERAGE
MIN.
0
+2
+4
+6
+8
+10
NEEDLE POSITION ON dBmV SCALE

FIG.9

The de-tuning of the field strength meter will result in some relief due to triple beat interference. It would be advantageous to remove all the carriers from the system except the pilot carrier, slope carriers, and carriers adjacent to these control carriers. The bandpass filter preceding the field strength meter is required basically to reduce any possible beat combinations within the meter.

In the attempt to measure a 50 dB carrier-to-noise ratio care must be taken not to introduce errors due to the selectivity of the field strength meter. The channels adjacent to the measure carrier should be removed from the system to prevent adjacent channel addition to the noise.

CARRIER TO HUM

Since most CATV amplifiers are powered from a 60 cycle AC source there will always be some value of power supply ripple on the DC supplies. This ripple will modulate the signal going through the amplifier. Hum modulation will appear on the television receiver as horizontal bars that move up or down, so it is necessary to test amplifiers and systems to insure that this effect is not objectionable.

The test procedure for determining the percentage of hum modulation is as follows:

1. Assemble the test equipment as shown in figure 10.

2. Connect the system test point to the RF input of the field strength meter.

3. Tune the field strength meter to any CW signal present on the system including the pilot carrier. When the system utilizes automatic slope amplifiers that are tuned to a modulated carrier you will be required to introduce a hum free source of CW at the system origination point.

4. Sync the oscilloscope to the "line" at a frequency of 30 or 60 cycles.

5. Adjust the oscilloscope coupling to D.C.

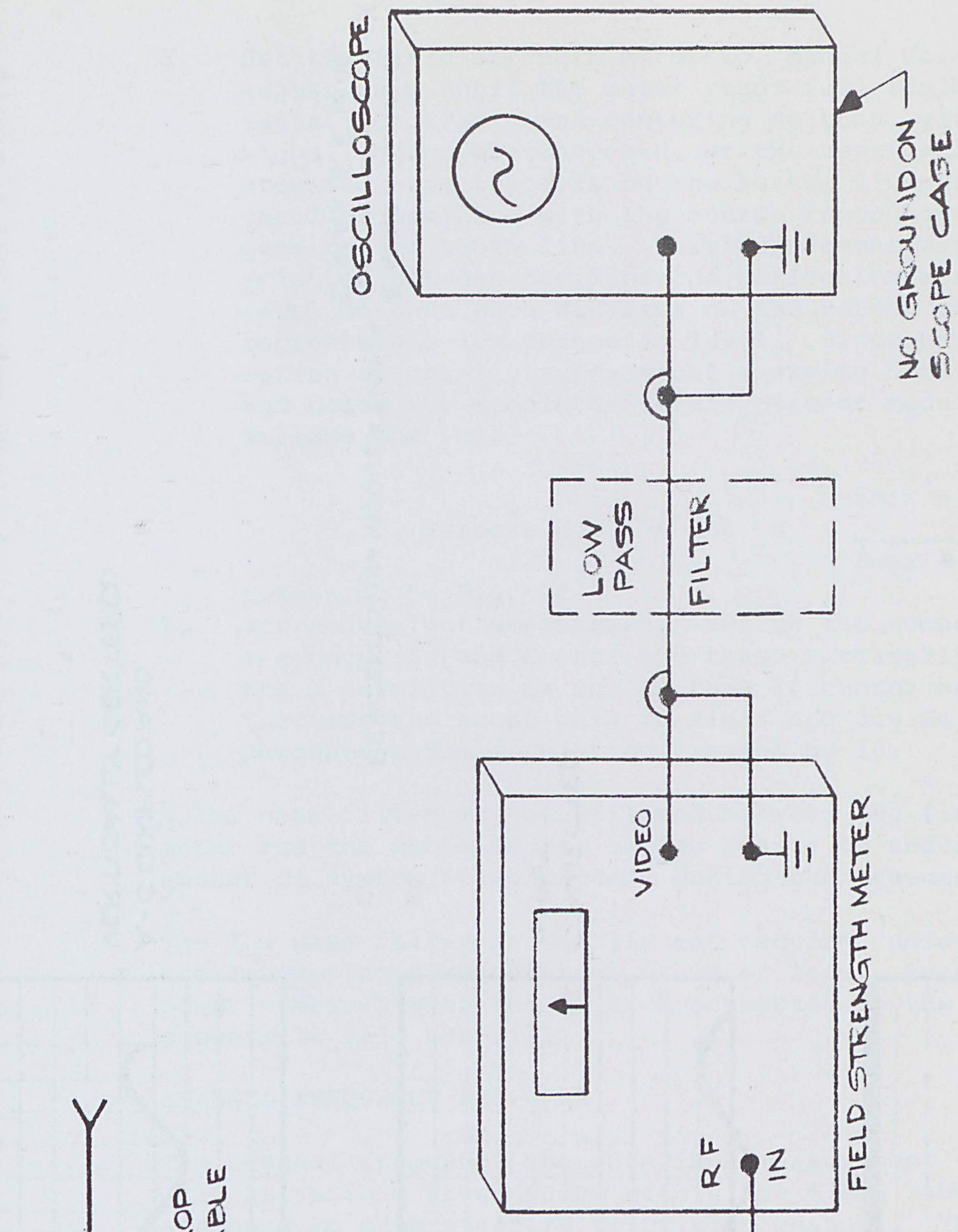
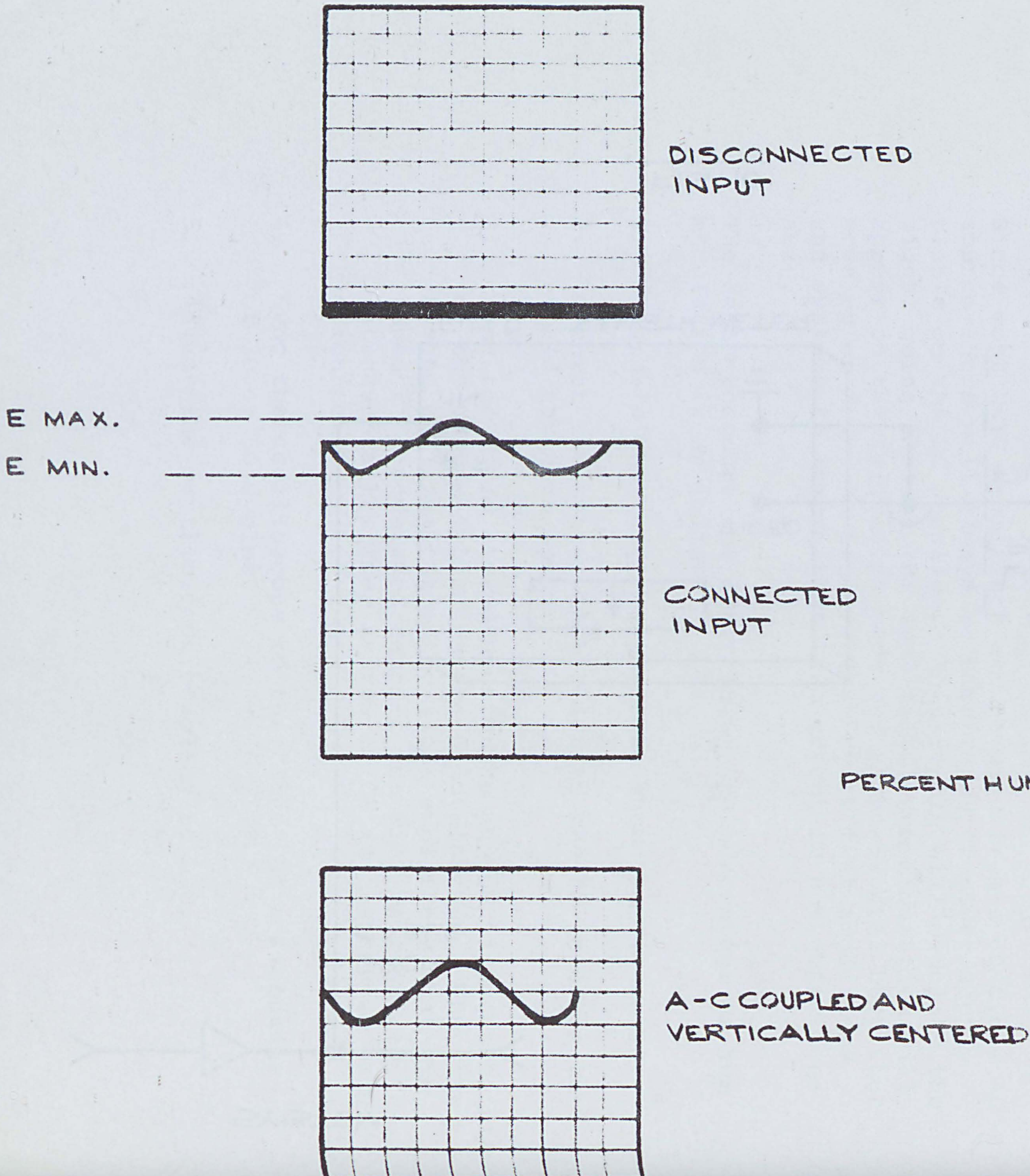

OSCILLOSCOPE
NO GROUND ON SCOPE CASE
LOW PASS FILTER
VIDEO
FIELD STRENGTH METER
RF IN
DROP CABLE
SYSTEM

FIG.10



$$\text{PERCENT HUM MODULATION} = \frac{\text{E MAX.} - \text{E MIN.}}{\text{E MAX.} + \text{E MIN.}} \times 100$$

FIG. 11

6. Set the field strength meter to "Manual Gain" and adjust gain until the meter reads full scale. Now adjust scope gain and centering so that, with the signal source disconnected, or the vertical input grounded, the trace is on the bottom line of the oscilloscope, and with the source reconnected it goes to the tenth line. This adjustment sets the relation between oscilloscope deflection and C-W level so that each division on the screen utilized represents a 10% change in level. Since hum modulation is usually symmetrical (varying both above and below the modulated level) percent modulation follows the rule

$$\text{Percent Mod.} = 100 \times \frac{\text{Emax} - \text{Emin}}{\text{Emax} + \text{Emin}}$$

Referring to Fig. 11

7. For convenient measurement, switch the scope to a a-c coupling and center the trace vertically. If the % modulation is so low that it cannot be measured, increase the scope gain 10 times and divide the final percentage hum modulation reading by 10.

A low pass filter may be utilized between the field strength meter and the oscilloscope if you desire to reduce the amount of system noise present during the measurement.

The low pass filter is usually not required unless you are attempting a measurement of 1% or less. An ordinary power combiner with the AC side connected to the oscilloscope will fill the bill.

CHANNEL FREQUENCY RESPONSE

The channel frequency response is a measurement of system gain at various frequencies within the 6 MHz bandwidth assigned to each standard television channel. The methods of measurement are related in concept to the approach taken in normal bench sweep techniques with a few changes in procedure necessary to insure accurate results.

1. The continuous method.

   a. Standard sweep generator located at head-end, operated at low sweep levels.

b. Produces severe interference on television receivers.

c. Requires traps at AGC carrier frequencies to reduce sweep energy contribution, which alters AGC amplifier levels.

2. The simultaneous method.

a. Simultaneous sweep transmitter located at head-end, operated at high sweep levels.

b. Produces unobjectionable interference on television receivers.

c. Increased equipment cost.

Both approaches are basically the same. A carrier is swept from the lowest system frequency to the highest. The effects of system gain at various frequencies within the system pass-band produce variations in the amplitude of the CW carrier as it travels through high and low gain points in the passband. The sweep receiver unit transforms the RF amplitude variations to DC variations. The DC variations are then displayed on an oscilloscope in the form of a trace. The high and low points of the trace can be frequency identified by mixing a known RF signal with the sweep prior to detection. This will cause a beat on the trace at the point the sweep frequency coincides with the known RF marker signal. The difference in system gain at different frequencies may now be determined by adding a variable attenuator prior to the sweep receiver and adding attenuation until the frequency with the highest amplitude rests at the same point on the oscilloscope as the frequency with the lowest amplitude occupied prior to the level decrease.

Fig.12 is an illustration of the simultaneous sweep system. The sequence is as follows for a 500 kc to 300 MHz sweep.

1. A variable rate generator in the transmitter triggers a ramp generator.

2. The ramp generator begins at "0" volts and increases in a linear fashion to seven volts.

3. The ascending ramp voltage frequency modulates the sweep generator. When the ramp voltage increases the sweep generator output frequency increases.

4. The output of the sweep generator is passed through a "diode gate," and into the trunk system.

5. During the 2 millisecond sweep time the CW carrier has progressed from 500 kc to 300 MHz and the system non-uniformities in gain have acted on all the individual frequencies within the system passband.

6. The sweep receiver detects the sweep signal and displays the resultant information on a CRT.

Fig.13 indicates two time marks. Ignoring any delays in time due to signal propagation or group delay will aid in explaining the trace display.

Time 1 shows the ramp voltage at four volts. When the ramp input to the sweep generator is four volts the sweep generator output is at 160 MHz and the system for this instant in time is amplifying a CW carrier at 160 MHz. The trace on the CRT indicates the amount of gain the system exhibits at 160 MHz.

Time 2 shows the same informations, only this time at 240 MHz. Ramp voltage = 6.2 volts, frequency = 240 MHz. The trace indicates that 160 MHz is 3 dB lower in amplitude than 240 MHz. This may be due to lower amplifier gain at 160 MHz relative to 240 MHz, or excessive loss in a passive or passive devices at 240 MHz.

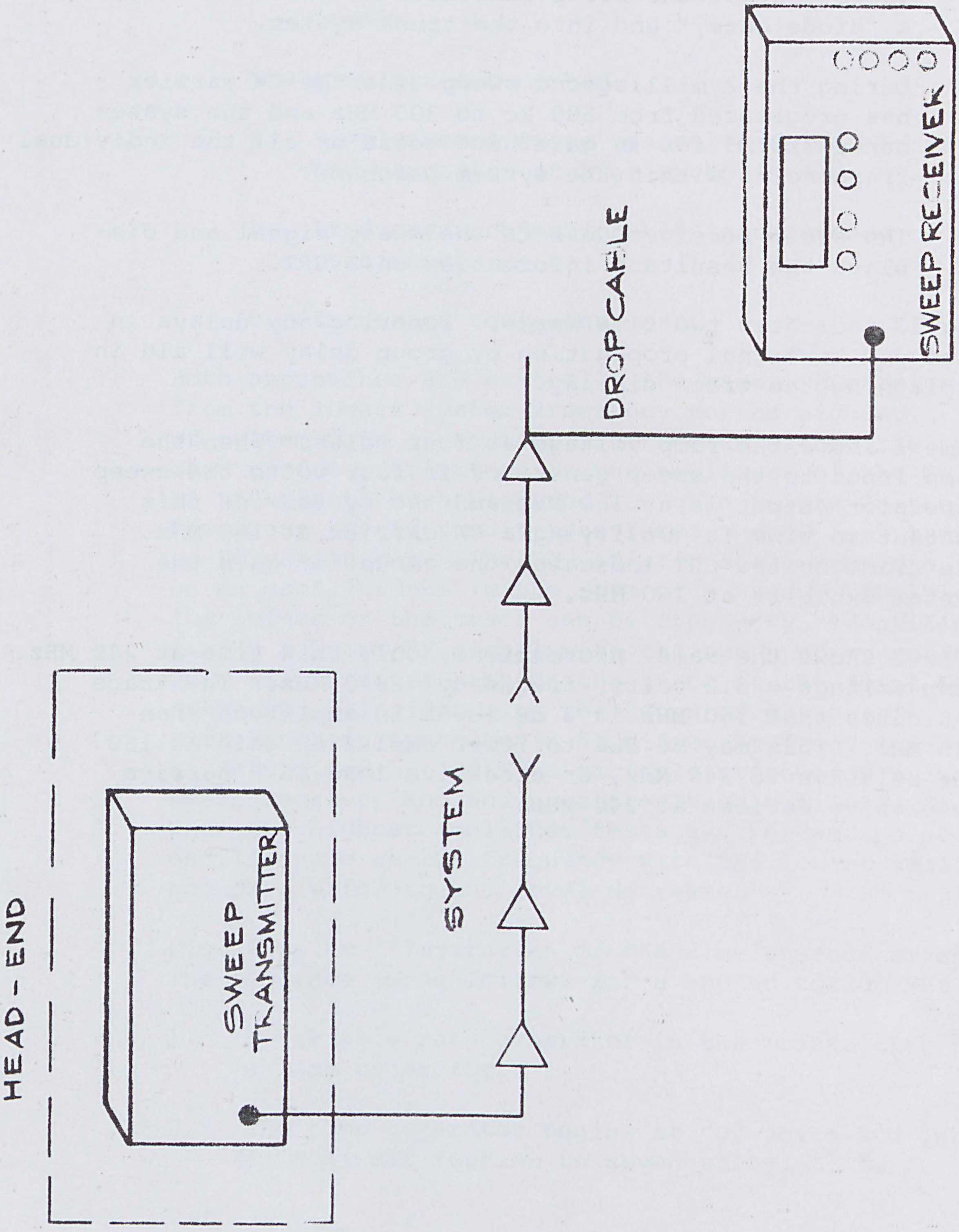
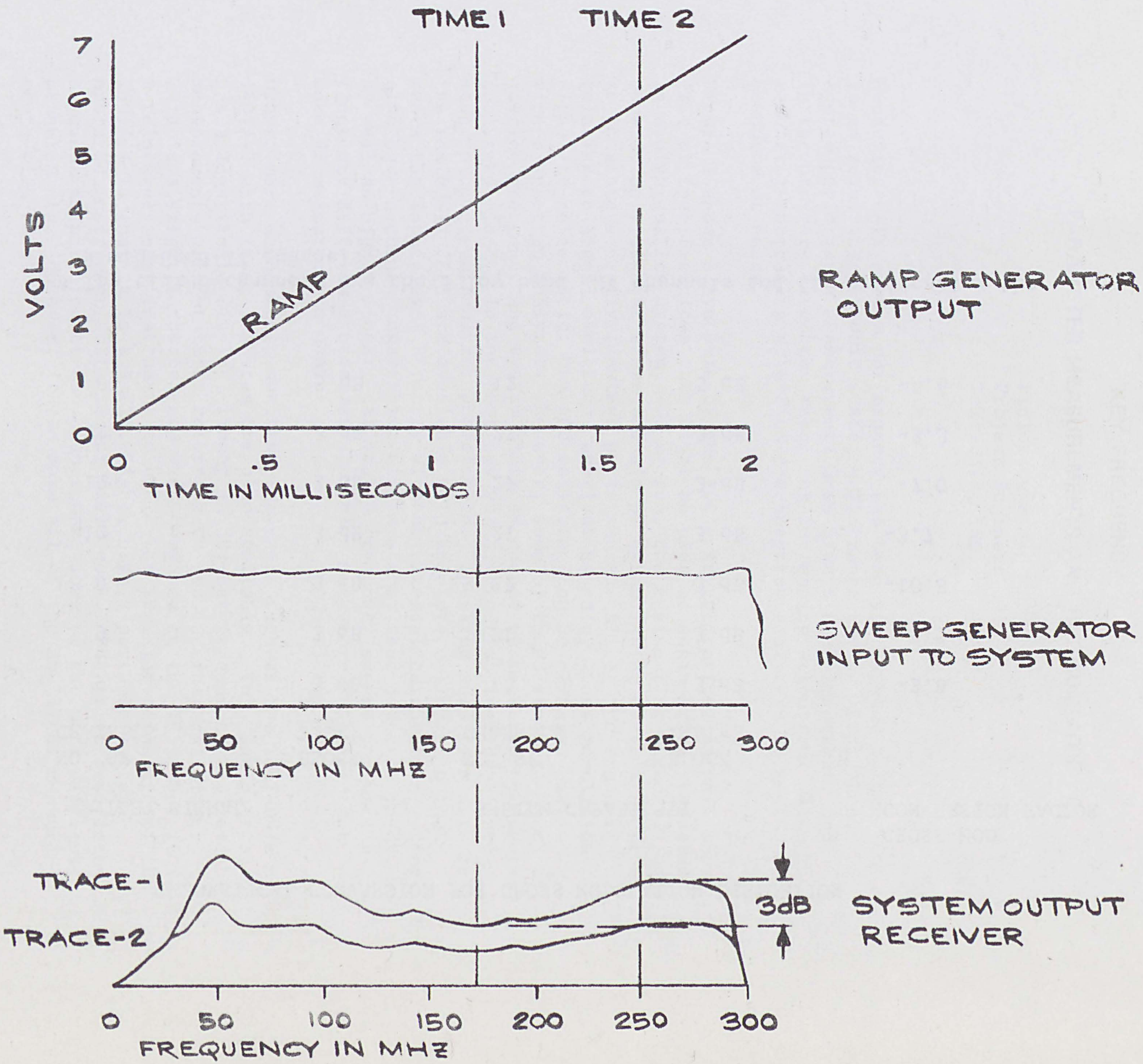

HEAD - END
SWEEP TRANSMITTER
SYSTEM
DROP CABLE
SWEEP RECEIVER

FIG. 12

SIMULTANEOUS SWEEP SYSTEM

FIG. 13



THEORETICAL CONVERSION FOR CROSS MODULATION DISTORTION

TEST SIGNAL		SYSTEM CAPABILITY		CROSS-MOD CONVERSION FACTOR
NO. OF CHANNELS	BLOCK TILT*	NO. OF CHANNELS	BLOCK TILT*	
9	3 dB	12	3 dB	-3.8
9	3 dB	21	3 dB	-7.5
9	3 dB	27	3 dB	-10.8
12	3 dB	21	3 dB	-3.7
12	3 dB	27	3 dB	-7.0
21	3 dB	27	3 dB	-3.3
9	5 dB	12	5 dB	-4.4

* The tilted channels are the 5 low band VHF channels and (if applicable) the 9 mid-band TV channels.