VALIDITY OF SUBJECTIVE TESTING

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ABSTRACT

In view of the present FCC standards for CATV, there has been much discussion as to the validity of inexpensive test techniques; specifically subjective testing. A systematic study into test techniques and results was performed in an attempt to open up this needed field of testing. The goal was to provide the smaller or financially burdened operator with simple, inexpensive, repeatable, and valid alternatives to known, expensive instrumentation test techniques.

We chose to study three areas felt to be the most restrictive financially for the small operator; Intermodulation, Co-channel Interference, and Signal-to-Noise ratio. Using the technical standards suggested by the FCC in §76.605 (now partially suspended) we performed a comparison between an elaborate $11,000 test set, and a test set consisting of simple equipment and a TV set. The results we feel substantiate our theory, that subjective testing can be valid, and in some cases superior to other techniques.

INTRODUCTION

Subjective testing, it has been theorized, is the answer to inexpensive test techniques. After all, the basic test of a CATV system is it's ability to deliver a good picture. Cannot then, one use a TV as the test instrument?

Subjective testing in it's most pure form would involve looking at a TV picture and "quesstimating" the respective amounts of Noise, Crossmod, Intermod, Hum, etc. Many old timers refer to this form of testing as the "Calibrated Eyeball Technique".

Advocates of subjective testing are generally refering to a modified form of subjective testing. By controlling variables and providing the technician with reference distortions, subjective testing can be transformed from a "crystal ball" game into a highly valuable analysis tool. It is to this end I address the following discussion.

In spite of the discussions on subjective testing, little has been done to correlate procedures, accuracy, cost, and repeatability. My experiments are little more than a crude "stab in the dark" attempt to shed some light on subjective testing. Hopefully some direction and momentum can be developed to open up this needed field of testing.

TESTING USING DISTORTION PLATES

One modified form of subjective testing uses a series of calibrated plates (photographs) that represent various amounts of known distortions. The user simply selects the plate that most closely matches the picture on a test set and thereby ascertains the type and amount of picture impairment.

This form of testing has some definite drawbacks:

1. The plates are stationary representations of distortions that normally move or change on a TV screen.
2. The plates must be compared to picture material of various colors, hues, shades, etc.
3. TV sets vary, even among the same make and models. Sony Trinitrons, for instance, tend to indicate results 3 - 4 dB better than most other color portables.
4. Lighting of both the test plates and the TV screen is critical.
5. Multiple distortions or a combination of a distortion and low test drop strength can be difficult to interpret.

Even considering the drawbacks, I chose to go ahead and evaluate this technique. The results were suprisingly good. By controlling certain variables, the technique could yield quite useful results. In fact, in some instances of close in intermodulation distortions, the subjective technique was more sensitive in locating problems than other instrumentation techniques.

PREPARATIONS OF DISTORTION PLATES

The distortion plates are the key to the accuracy of this form of subjective testing. I chose to use a series of color plates as outlined in the following charts. I chose to limit the experiment to Intermodulation, Signal-to-Noise, and Co-Channel tests although subjective testing could be extended to include Hum, Ghosting, and Envelope Delay.

dB of Distortion	INTERMODULATION			CO-CHANNEL		S/N
	1 KHz	100KHz	1MHz	10KHz	20KHz	4MHz BW
50						
45						
40						
35						
30						
25						

Figure 1 Chart showing Distortion Plate Values

To control some of the variables, the following were observed for the preparation and use of the plates:

1. Two plates were prepared for each distortion value, one using picture material, and one using color bars. A total of 72 plates were prepared.

2. The picture material included a substantial amount of white or light colors, distortions being most readily visible in the lighter areas. Waiting for light scenes on the receiver would also help to improve test accuracy.

3. The plates were taken from a standard color portable with an input of +5 dBmV, using a shadow mask tube.

4. The plates were of sufficient size to permit easy viewing (5 x 7 ").

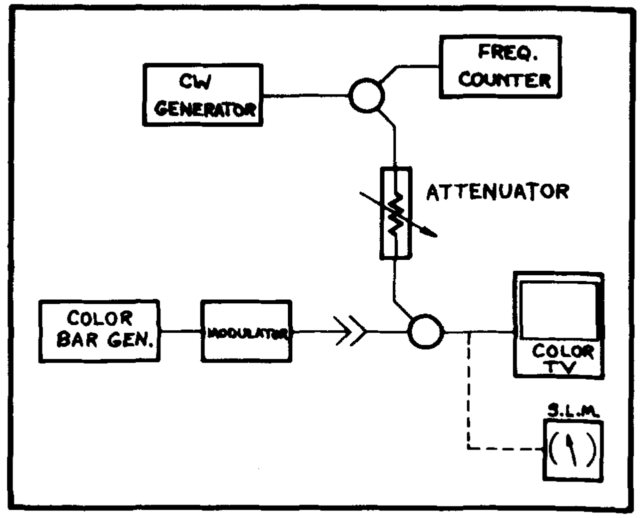


Figure 2 Setup for producing Intermod and Co-Channel Plates

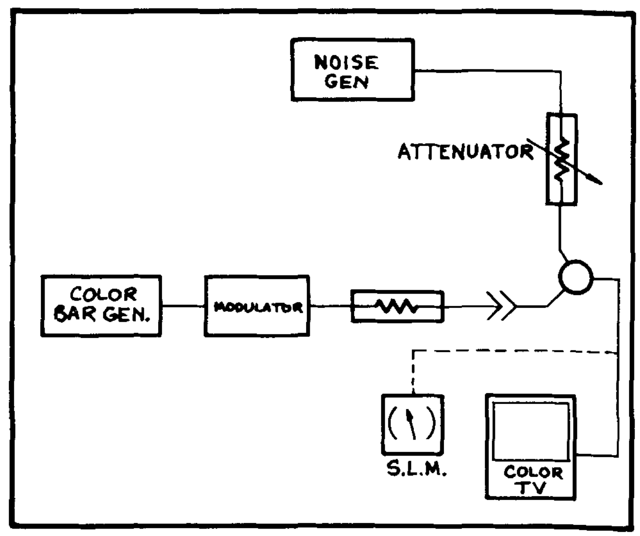


Figure 3 Setup for producing Noise Plates

ACCURACY TEST

A series of sample tests were performed using a group of random observers. The distortions were imposed over standard network program material and the observers were given as much time as necessary to analyze each distortion.

Figure 4 Using Distortion Plates

Six distortions were selected in each of six categories; and the subjects were told the type of distortion, such that the only subjective variable was the amount of distortion.

Verification of the amount of each distortion actually on the TV screen was made using a Tektronix 7L12 - 7L13 combination.

A total of eight observers used the distortion plates, and while the results are inconclusive at this time, some important observations could be drawn.

1. Most subjects could determine within ± 5 dB, the amount of an impairment.
2. Using color bar plates and test signals, the subjects could measure distortions in the higher ranges (30 to 45 dB) with high accuracy.
3. Accuracy on all distortions, especially Signal-to-Noise was spotty above 45 dB.

CONCLUSIONS

I feel that this form of testing, while having definite limitations, can be refined into a valuable evaluation tool for the CATV industry. A large scale subjective test should be setup to further refine both the distortion plate technique, and distribute the results to the industry.

TESTING USING A TV SET COMPARISON TECHNIQUE

This second technique for performing subjective testing relies upon a comparison between two live TV pictures, thereby eliminating many of the variables encountered using the distortion plate technique. The only equipment required is a TV set, an attenuator, a CW signal generator (units in the $100 price range work satisfactorily) and an A-B coax switch.

The theory of testing involves taking a clean TV picture and purposely distorting it by a known amount. Then the pictures are compared visually (subjectively) with the system pictures and an evaluation is made as to the amount of a distortion.

To control as many variables as possible, the following is suggested:

1. To eliminate differences in sets, it is recommended that an A-B switch be used with one set for the comparisons as shown in the figure.

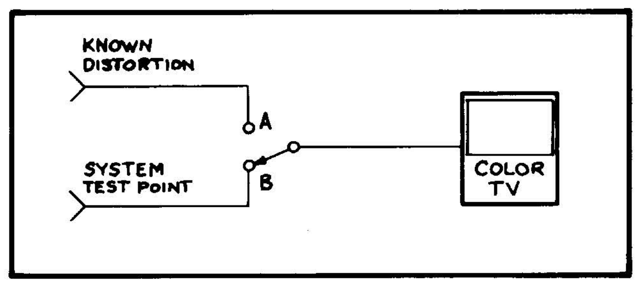


Figure 5 Comparison using A-B RF Coax Switch

2. A clean signal can be derived from a test antenna in most systems. In systems where there are no off-air signals, the output of an inexpensive rainbow-bar-dot generator can be used.
3. The "known distortion" line should have the same carrier strength as the "system test point".
4. The comparisons in most cases will be between two different pictures containing different programming. Different scenes camouflage or highlight some distortions.

The TV set comparison technique shows the highest promise of satisfying the accuracy requirements for the financially encumbered operators. Procedures were devised for Intermodulation, Co-Channel, and Signal-to-Noise (Carrier-to-Noise as defined in §76.605).

SUBJECTIVE-COMPARISON TECHNIQUE FOR INTERMODULATION

Two parameters can be obtained using this technique; the frequency of the interfering carrier, and the level of the interfering carrier relative to the picture carrier.

To obtain a rough idea of the interfering frequency, the number of bars cutting across one horizontal line can be counted as indicated in the two photographs. Then, for most TV sets, the frequency is determined:

Bars x line rate x frame rate x (1.4) correction factor = frequency

For example

$$23_{\text{Bars}} \times 525_{\text{Lines}} \times 30_{\text{Frames}} \times 1.4 = 507 \text{ KHz}$$

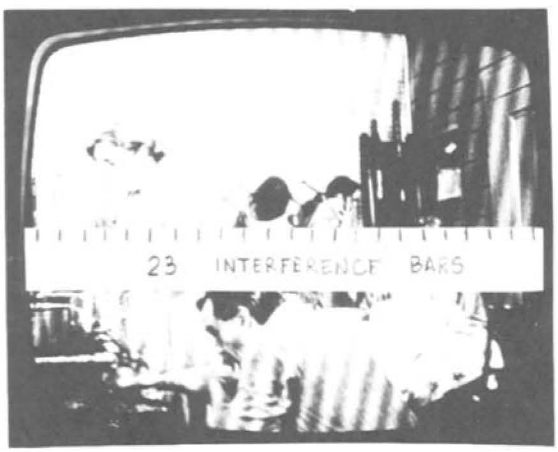


Figure 6 500 KHz Intermodulation

Figure 7 Count the Bars on one H Line in Center of Screen (1 MHz Intermod)

Generally, intermod frequency below 50 KHz will appear as multiple horizontal lines sometimes called the "venetian blind effect". Higher frequency intermods up to 3 MHz will appear diagonally, and can be counted using the formula.

On color sets, intermodulation products within 500 KHz of the color subcarrier will cause colored bar patterns. A strong intermod within 50 KHz of the color subcarrier will cause the color to drop out entirely causing a monochrome picture.

To evaluate the relative strength of a distortion, a known or calibrated distortion must be generated. Equipment is setup as illustrated in Figure 8.

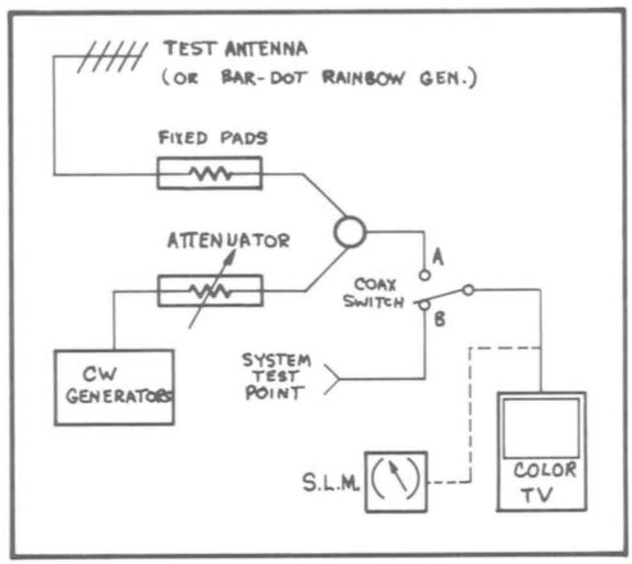


Figure 8 Setup for Subjective Intermodulation Test

The antenna is used as a source of a clean signal. If no off-air signals are available, then and inexpensive bar-dot-rainbow generator (such as a Heathkit IG-28) should be utilized. This clean signal should then be attenuated using fixed pads until it is equal in strength to the system test point. The CW generator should be adjusted to the frequency of the clean signal and with the ATTENUATOR in the thru position (no pads inserted) the generator output should be set equal to the clean signal and the system test point.

The attenuator can then be adjusted for calibrated amounts of distortion, the pads inserted equal to the dB down of the intermodulation carrier.

Starting in the B position, select channel 2 on the test set, and note any picture impairments associated with intermodulation (beat bars). Then select position A and the clean channel on the TV set, and using the attenuator and the CW generator frequency control, match the distortion pattern and intensity. This procedure should be repeated until a subjective match is produced.

The bar pattern frequency can be determined using the formula (as discussed), and the dB down of the interfering carrier is the dB of pads inserted with the variable attenuator.

SUBJECTIVE-COMPARISON TECHNIQUES FOR CO-CHANNEL

Although Co-Channel and Intermodulation are two very different distortions in origin, they appear similar in effect. For subjective testing Co-Channel can be considered to be little more than a special case of intermodulation. Specifically, Co-Channel appears as beats due to either a 10 KHz or 20 KHz intefering TV station.

The beat pattern produced by a Co-Channel situation is very distinctive. The picture will be cut by 30 to 40 almost horizontal beat bars. Once recognized, the technician will have no trouble differentiating between Co-Channel beats and Intermodulation beats.

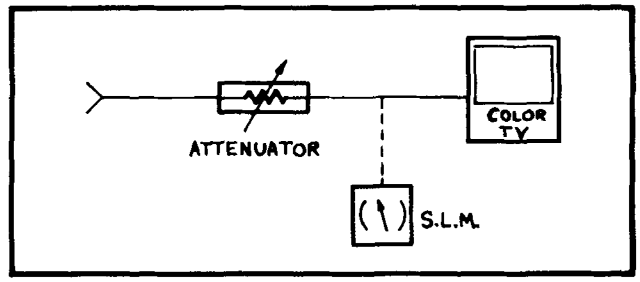
The equipment setup is the same as the Intermodulation setup (Figure 8). The CW generator should be carefully set 10 or 20 KHz from the picture carrier of the clean signal. This is easily accomplished by carefully zero beating the generator. This will be evident when the picture is cut with one vertical bar; half the screen dark, and the other half light.

Then the generator is carefully tuned until the pattern turns horizontal. This will be the 10 KHz reference. Continue tuning the generator until the pattern once again becomes vertical (two light and two dark bars), and then becomes horizontal. This will be the 20 KHz reference.

The same A-B comparison technique is followed as in the Intermodulation technique. Again, the pads inserted in the attenuator will be the dB down of the interfering Co-Channel after a satisfactory match is made between the distorted signal, and the incoming signal.

SUBJECTIVE-COMPARISON TECHNIQUE FOR SIGNAL-TO-NOISE

The Signal-to-Noise Technique actually yields a Carrier-to-Noise ratio. The distorted picture could be generated using a noise generator, however, this is not usually standard equipment for a small operator. We have instead derived a chart based upon the fact that, as signal strength is reduced, a standard TV set AGC will increase the noise on the screen in an almost perfect 1 dB correlation. This correlation is illustrated in the figure below.



C/N	55dB	50	45	40	35	30	25
SIGNAL LEVEL	6dBmV	1	-4	-9	-14	-19	-24

Figure 9 Signal Level v.s. Signal-to-Noise for a Standard Test Set

This correlation assumes many variables, however, after careful checks, it was found that the standard transistorized American TV sets vary ± 2 dB at the most from the chart. One must be careful of the following:

1. The clean signal must be free from any visible noise.

2. At some point in reducing the input to a TV set, the limit of the AGC range will be reached. Generally this will be coincident with a loss of sync lock.

3. The chart assumes a front end noise figure of 7 to 9 dB (normal for most portables).

The equipment for the actual test is setup as shown in Figure 10. The Signal Level Meter is used to monitor the distortion channel (A). The technician compares one channel at a time to the distortion channel to obtain a match. The attenuator is adjusted as necessary. Then using the S.L.M. values, the actual Signal-to-Noise ratio is derived from the chart (Figure 9).

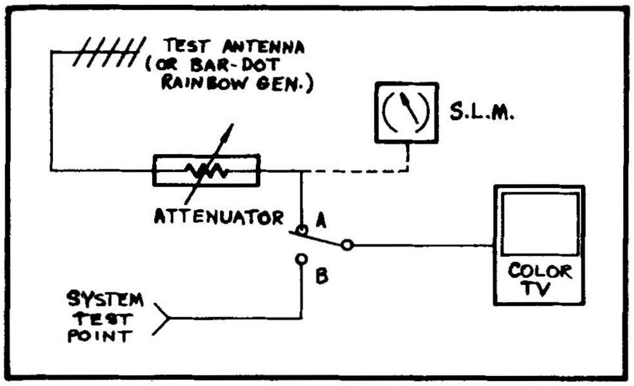


Figure 10 Equipment Setup for Subjective Signal-to-Noise (C/N) Test

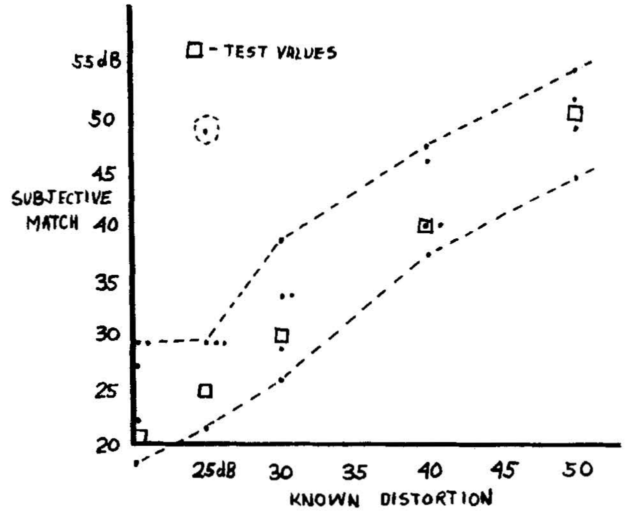


Figure 12 Validity of Subjective Intermod Test

VALIDATION OF SUBJECTIVE-COMPARISON TECHNIQUE

To get a rough idea of the accuracy one could expect from this form of testing, six observers measured the distortions on TV picutres. The distortions were also measured using a Tektronix Proof-of-Performance Package.

Standard off-air TV pictures were used. Some of the program material varied during the tests from excellent to marginal. No special precautions were observed as it was felt that the tests must represent a true, real life situation.

Figure 11 Using the A-B Comparison Technique

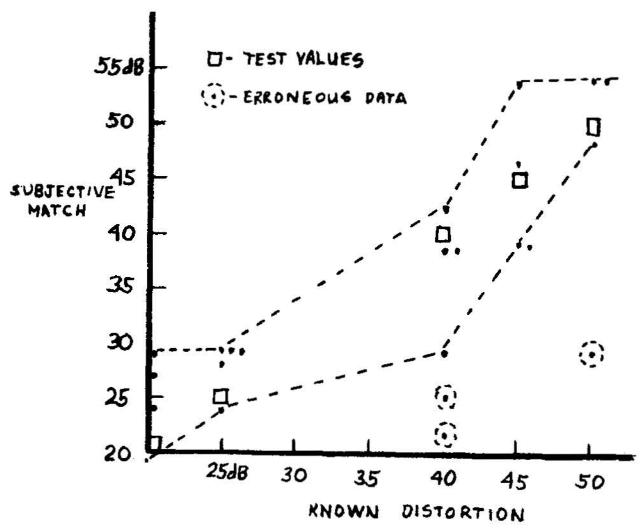


Figure 13 Validity of Subjective Co-Channel Test

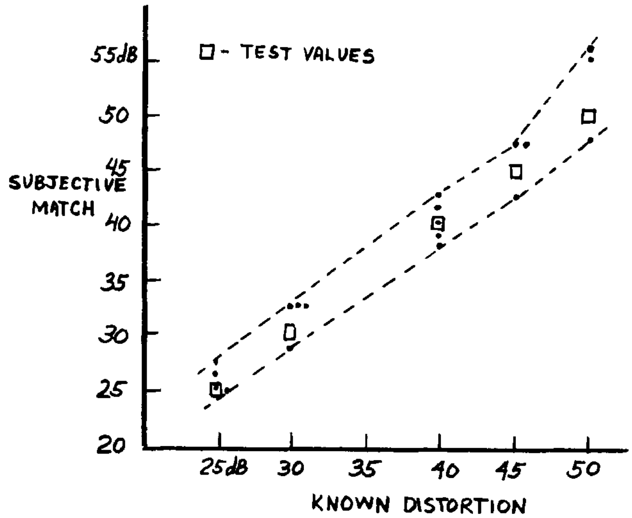


Figure 14 Validity of Subjective Signal-to-Noise Test

CONCLUSIONS

The results of this experiment were gratifying. It proved that subjective testing must be considered as a test technique. The remainder of the conclusions cover a variety of areas and are listed.

1. This experimant was only a start. Much work needs to be done in the area of subjective testing.

2. Subjective testing can be used to evaluate one and possibly two simultaneous distortions, such as intermodulation and noise. Beyond two, the test becomes quite confusing.

3. The lower ranges of each distortion are easiest to measure. CATV operators may have difficulty measuring higher distortion values (generally in excess of 50 dB) however, within the ranges recommended by the FCC as the minimum acceptable values, subjective testing can yield results within $\pm$ 5 dB or better.

4. Subjective testing is influenced by picture content. Various techniques should be explored such as B & W vs color, and raised contrast levels to make distortion more recognizable.

5. Simple training of the subjects increased accuracy tremendously. Some of the subjects could match within $\pm$ 2 dB consistently on some of the tests.