# BTSC STEREO:

# TV Aural Proof of Performance Guide

NFT INC

$25.00

# BTSC STEREO
## AURAL PROOF of PERFORMANCE GUIDE

Includes Test Setup Procedures and
Tutorial with Test Charts and Logs

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# SECTION 1

# INTRODUCTION

TV Stereo broadcasting is here to stay and the BTSC (Broadcast Television Systems Committee) has outlined a standard for the U.S. market. It is a new challenge for TV broadcast engineers to convert their stations from mono to stereo broadcasting. The necessary performance measurements are, quite possibly, one of the most important tasks that a TV station engineer has to face. The Proof is important for at least three reasons: First, a Proof gives you the satisfaction that you are providing state-of-the-art stereo performance to the TV station's audience. Second, it gives a TV station the ability to demonstrate that it meets the FCC OST-60 technical guidelines, or at least better than the minimum guidelines. Third, it highlights problem areas.

This publication was designed to provide basic tutorial information on BTSC Stereo and the FCC OST-60 Bulletin, as well as to fill the need for a detailed guide to the TV aural transmitter and BTSC equipment performance measurements, based on the recommended practices of the EIA Television Systems Bulletin No. 5, MULTICHANNEL TELEVISION SOUND, BTSC SYSTEM RECOMMENDED PRACTICES, dated July 1985. Every effort has been made to answer questions that may arise and to present an efficient test format, complete with easy to use forms and graphs. In addition to aiding the engineer with the preparation of the Proof, and in-depth analyses of each procedure and standard, this booklet provides the reader with a genuine understanding of what the FCC guidelines are, and how these guidelines can be best met.

Ideally, every station would pass every Proof without a hitch, but in practice, this is not always the case. Sometimes, it is more time consuming to get a station to the point where it can pass the Proof than to actually make the measurements. For this reason, this guide also covers test procedures for sampling the BTSC signal at various points of the aural transmission system, and suggests methods of isolating problems and correcting them so that the Proof may be successfully completed.

While the use of this guide certainly has the effect of reducing the amount of time required to make the equipment performance measurements, its primary intent is to assist the engineer to make a more thorough, accurate, and meaningful aural Proof of Performance.

Individual forms and graphs for recording test data are provided in this guide.

It is TFT's desire to update this publication from time to time, and to supply this guide to TV broadcast engineers who would like to use it as a standard procedure to do a Proof. Your feedback, suggestions, or recommendations as to how this work can be improved are greatly appreciated.

# SECTION 2

# FCC OST BULLETIN NO. 60 AND EIA BTSC SYSTEM RECOMMENDED PRACTICES

## 2.1 FCC OST Bulletin No. 60

FCC OST Bulletin No. 60 contains technical specifications for the BTSC System developed by the Electronic Industries Association (EIA). These specifications have been published pursuant to the Report & Order in BC Docket 21323 adopted March 29, 1984, and are intended to be guidelines for stations employing the BTSC system of multichannel television sound (MTS) transmission and audio processing.

The Commission, in BC Docket 21323, has adopted very general technical rules that will allow the television aural baseband to be used for television stereophonic sound, second language programing, and any other broadcast or non-broadcast use.

The BTSC System uses a pilot aural subcarrier at 15,734 Hz. The pilot allows receivers to recognize that transmissions are in stereo and to switch into the stereophonic reception mode. To ensure compatibility and to prevent BTSC type receivers from falsely detecting other stereo formats, FCC Rule 73.682(c)(3) restricts emissions at 15,734 Hz by other TV broadcasters not using BTSC format. The purpose of this Bulletin is to give notice of the BTSC specifications referenced in Parts 73.681 and 73.682(C)(3) of the Commission's Rules.

OST Bulletin No. 60 also defines special terminologies applied to the BTSC System, transmission standards, transmission system requirements, modulation levels, baseband components, and encoding standards of the L-R channel.

### 2.1.1 Spectrum and Modulation Level

A summary of the BTSC composite signal standard and modulation level of each baseband component is illustrated by the graph and table, Figures 2-1A,B.

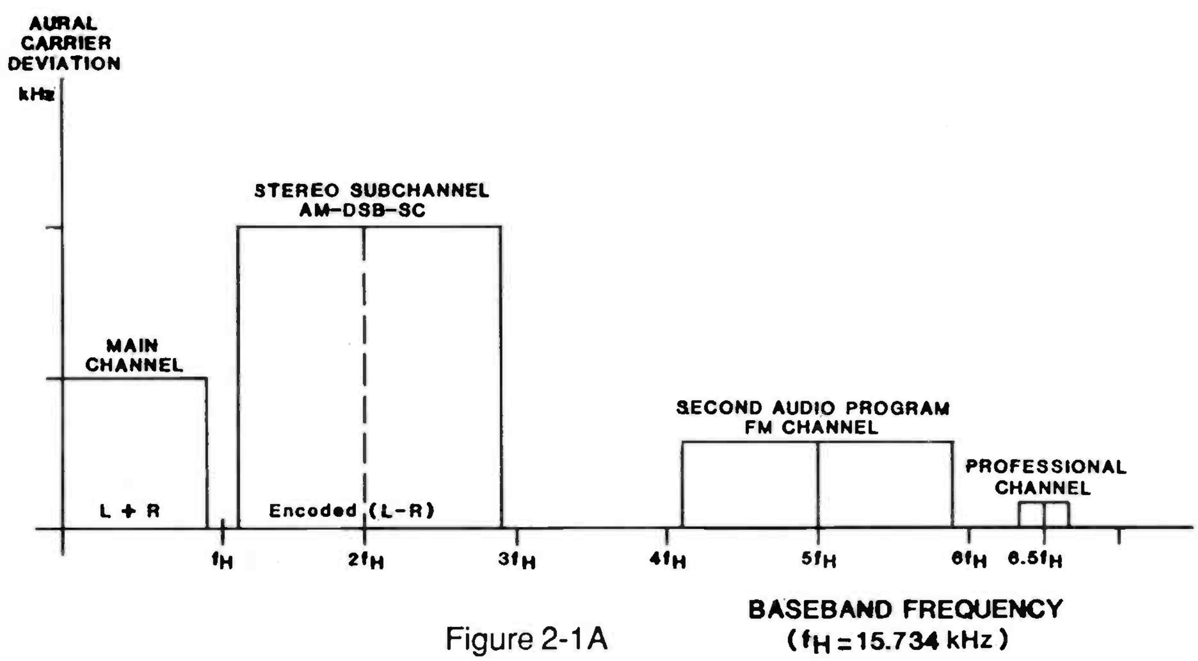


Figure 2-1A

| SIGNAL SPECIFICATIONS | | | | | | | |
|---|---|---|---|---|---|---|---|
| Service or Signal | Modulating Signal | Maximum Modulating Frequency kHz | Encoding or PreEmphasis | Subcarrier Frequency | Subcarrier Modulation | Subcarrier Deviation kHz | Aural Carrier Peak Deviation kHz |
| Monophonic | L + R | 15 | 75 µsec | | | | 25 † |
| Pilot | | | | $f_H$ | | | 5 |
| Stereophonic | L - R | 15 | dbx Encoding | 2 $f_H$ | AM-DSB-SC | | 50 † |
| Second Audio Program (SAP) | | 10 | dbx Encoding | 5 $f_H$ | FM | 10 | 15 |
| Professional Channel | Voice or Data | 3.4<br>1.5 | 150 µsec<br>0 | 6 $^1/_2$ $f_H$ | FM<br>FSK | 3 | 3 |
| | | | | | | TOTAL | 73 |

† Total does not exceed 50 kHz

Figure 2-1B: BTSC System Spectrum

## 2.1.2 Main Channel THD

Total harmonic distortion (THD) of the transmitting system measured within a 30 kHz bandwidth shall not exceed the values in Figure 2-2 at modulation levels of 25, 50, and 100%.

| Audio Frequency | Allowable THD | Measurement Bandwidth |
|---|---|---|
| 50 to 100 Hz | 3.5% | 30 kHz |
| 100 to 7,500 Hz | 2.5% | 30 kHz |
| 7,500 to 15,000 Hz | 3.0% | 30 kHz |

Figure 2-2: Allowable THD versus Audio Frequency

## 2.1.3 Stereo Channel Separation

It is recommended that the transmission system, excluding encoding, meet a 40 dB separation requirement when 75 µsec pre-emphasis is substituted for sound encoding in the stereophonic sub-channel (L-R).

The minimum stereo separation with BTSC encoding at 10% modulation level and 75 µsec pre-emphasis network is shown in figure 2-3:

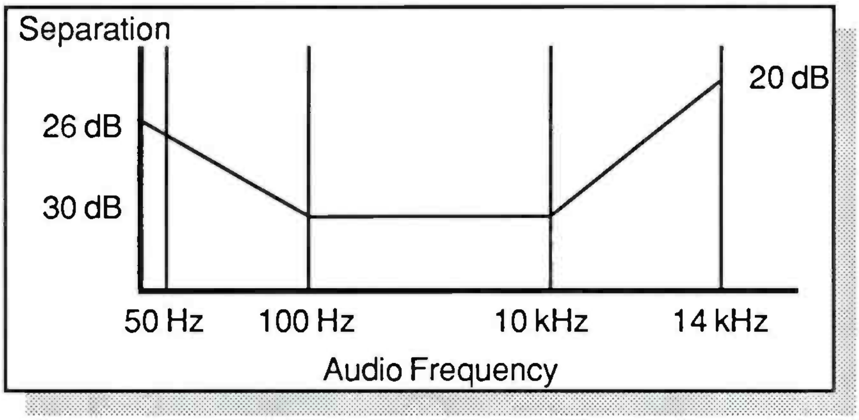


Figure 2-3: Minimum Stereo Requirement with Encoding of L-R

## 2.1.4 Crosstalk

OST-60 Bulletin also gives guidelines of crosstalk between sub- channels as follows:

| CHANNEL | GUIDELINES | REFERENCE |
|---|---|---|
| Stereo to Main | -40 dB | ±25 kHz Carr. Dev. |
| SAP/Pro to Main | -60 dB | ±25 kHz Carr. Dev. |
| Main to Stereo | -40 dB | ±50 kHz Carr. Dev. |
| SAP/Pro to Stereo | -60 dB | ±50 kHz Carr. Dev. |

Figure 2-4: Crosstalk Guidelines Between Channels

### 2.1.5 Signal-to-Noise Ratio (Noise Floor)

And the signal-to-noise ratio in each of the service channels is as follows:

| CHANNEL | SNR | 100% Reference | Measurement Bandwidth | De-Emphasis |
|---|---|---|---|---|
| Main | -58 dB | ±25 kHz | 15 kHz | Yes |
| Stereo | -55 dB | ±50 kHz | 15 kHz | Yes |
| Pilot (15,734 Hz) | -30 dB | ±5 kHz | 1 kHz | No |
| Stereo Subcarrier (31,468 Hz) | -26 dB | ±5 kHz | 1 kHz | No |

Figure 2-5: Signal-to-Noise Ratio Guidelines

### 2.1.6 Other Recommendations

In addition to the recommendations listed above, OST-60 recommends that the aural transmitter operate satisfactorily with a frequency deviation of ± 100 kHz, although the maximum allowable peak deviation is only ±73 kHz. It also recommends that the baseband frequency response of the transmitter be capable of transmitting frequencies from 50 Hz to 120 kHz.

Other guidelines include that the pilot be frequency-locked to the horizontal scanning frequency of the transmitted video signal. Although no recommendation is given to the phase relationship between the pilot subcarrier and the horizontal scanning frequency of the transmitted video, it is generally agreed by the BTSC that the phase error should be less than ±3 degrees in order to maintain good stereo performance.

The phase relationship between the pilot and the stereo subcarrier must also be kept within 3 degrees (approximately ±0.53 micro-seconds).

### 2.1.7 SAP Channel

Electrical performance standards for Second Audio Program (SAP) operation are also given in OST-60. The SAP channel shall have a frequency response from 50 to 10,000 Hz. The SAP subcarrier must be frequency-locked to the fifth harmonic of the horizontal line rate and it must be shut off when the SAP subchannel is not in use. The guidelines for THD in the SAP subchannel are as follows:

| Audio Frequency | Allowable THD | Measurement Bandwidth |
|---|---|---|
| 50 to 100 Hz | 3.5% | 30 kHz |
| 100 to 5,000 Hz | 4.0% | 20 kHz |
| 5,000 to 10,000 Hz | 3.0% | 20 kHz |

Figure 2-6: Allowable THD in SAP Subchannel

### 2.1.8 Crosstalk

Crosstalk into the SAP subchannel and signal-to-noise ratio guidelines are as follows:

| Channel | Guidelines | 100% Reference | Measurement Bandwidth |
|---|---|---|---|
| Main Channel into SAP | -50 dB | ±10 kHz | 50 Hz to 10 kHz |
| Stereo Channel into SAP | -50 dB | ±10 kHz | 50 Hz to 10 kHz |
| SAP Channel SNR | -50 dB | ±10 kHz | 50 Hz to10 kHz |

Figure 2-7: Crosstalk Allowable into SAP Subchannel and Signal-to-Noise Ratio in SAP Subchannel

The signal quality of additional subcarriers signal (e.g., Professional channel) on the aural carrier for non-program related purposes is not specified in OST- 60 except that the arithmetic sum of all subcarriers, other than the stereophonic and second audio program, is limited to ± 3 kHz deviation of the aural carrier. Frequency response and THD are not specified.

## 2.2 EIA / BTSC Recommended Practices

The Recommended Practices of the BTSC System for Multichannel Television Sound (MTS) have been prepared by the Ad Hoc Working Group of the Multichannel Sound Subcommittee's Steering Committee of the EIA Engineering Department's Broadcast Television Systems Committee. This document is intended to serve the industry in the form of recommendations for anyone wishing to practice Multichannel Television Sound (MTS) in accordance with the BTSC system and the FCC Rules governing its use in both the FCC Report and Order in Docket 21323 which authorizes MTS, and OST Bulletin No. 60.

The Recommended Practices is also a handbook which gives comprehensive technical coverage of the transmission system requirements, monitoring and measuring, and discusses issues relating to TV receivers. Its Appendices and Reference Sections consist of articles relating to BTSC stereo and recommended engineering practices.

This document can be purchased from Electronic Industries Association, 2001 Eye Street N.W., Washington, D.C., 20006.

# SECTION 3

# COMPANDING, STEREO SEPARATION AND MODULATION ACCURACY

## 3.1 Companding

The BTSC stereo system resembles the FM stereo broadcast system. The major differences are the pilot and stereo subcarrier frequency, and the use of companding in the L-R subchannel. BTSC companding is a noise reduction process used in both the stereophonic subchannel and the Second Audio Program (SAP) subchannel consisting of encoding (compression) before transmission and decoding (expansion) at reception. The specific BTSC encoding algorithm is described in detail in OST Bulletin No. 60. Tables for the amplitude and phase between the input and output of the decoder can be found in the appendices of the EIA's Recommended Practices. BTSC decoding is complementary to the BTSC encoding. A simplified system block diagram for the BTSC encoding and decoding is shown in Figure 3-1.

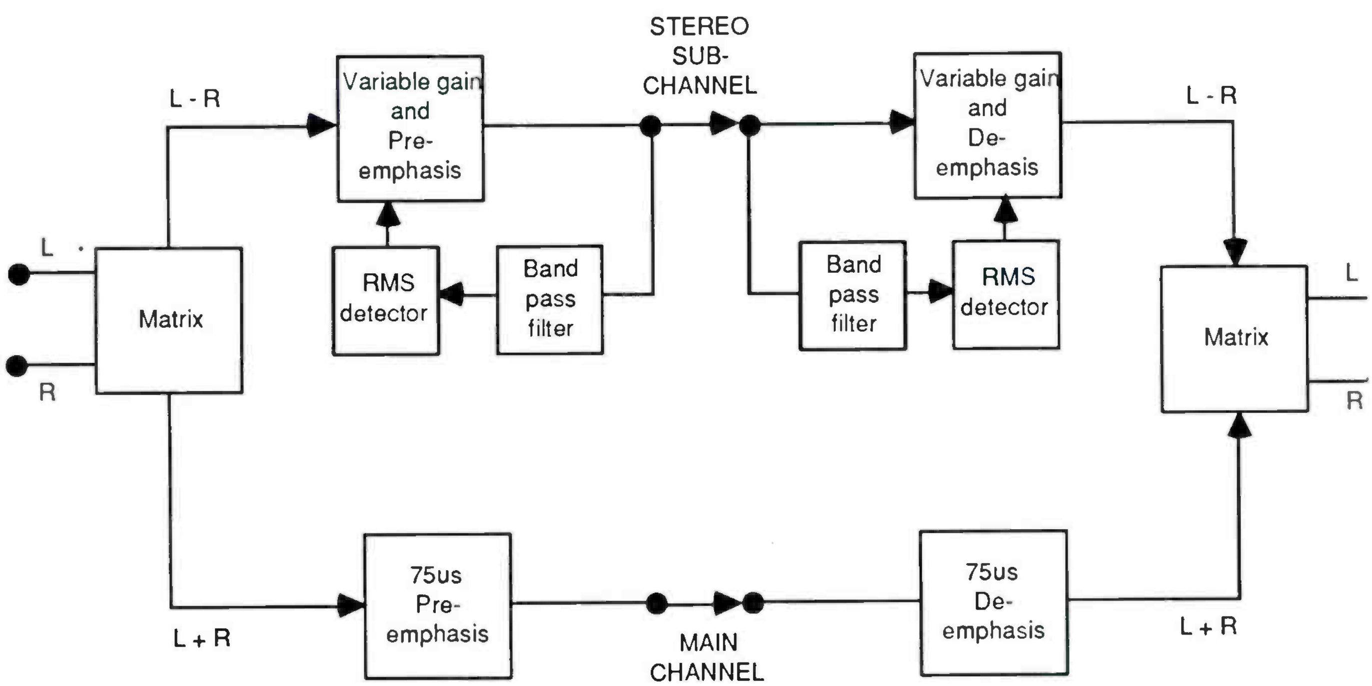


Figure 3.1: Block Diagram of the BTSC Companding System

Figure 3-1 shows that while the Main Channel (L+R) signal incorporates 75 µsec preemphasis at the transmitter and 75 µsec de- emphasis at the receiver (same as the monophonic standards), the L-R signal is "compressed" at the transmitter and correspondingly "expanded" at the receiver. With a perfect transmitter path and perfect circuit components, the companding system shown in Figure 3-1 is effectively transparent.

## 3.2 Stereo Separation and Modulation Accuracy

Stereo separation in the BTSC format is very sensitive to gain and phase errors in the transmission path. This is because the L+R and L-R signals are treated differently. In particular, L-R is companded while L+R is simply pre-emphasized and de-emphasized. The L-R and L+R signals must arrive at the receiver's decoder matrix, which yields L and R, with very small errors in gain and phase across the entire audio band from 50 Hz to 15 kHz. Figure 3-2 shows how stereophonic separation is affected by gain and phase errors in the L-R signal relative to the L+R signal at the input of the final matrix. Subjective tests show that an average listener begins to perceive a loss in the spatial character of stereophonic music material when the separation drops below 18 dB, and a separation of 15 $\pm$ 3 dB is generally considered adequate. Although the subjective effects of separation depend on the spectral distribution and other aspects of the audio material, it appears that a good engineering objective for the entire system is for separation to exceed 20 dB in the mid-range, decreasing somewhat at frequencies above 8 kHz. Figure 3-2 shows that a separation of 20 dB requires a gain error smaller than 1 dB, and a phase error of less than 10 degrees. The BTSC standards require that the potential separation of the radiated signal exceed 30 dB in the mid-band from 100 Hz to 8kHz, but that it may decrease at low frequencies to 26 dB at 50 Hz, and at high frequencies to 20 dB at 14 kHz. This requires that the gain and phase errors in the mid-band be smaller than 0.3 dB and 3.0 degrees respectively.

The total modulation level accuracy in BTSC stereo is far more critical than in FM stereo radio broadcasting in order to produce acceptable stereo separation. Due to the fact that L+R and L-R signal paths in BTSC are critically different because of the companding in the L-R path, and the two paths are not linearly related as in FM radio stereo systems, a small change of modulation level in the BTSC system will affect the stereo separation because it alters the amplitude and phase relationship between the L+R and L-R channel. If the total modulation level of the BTSC system is not maintained accurately, the dbx® decoder in the receiver will see an incorrect RMS level. The decoder, therefore, reproduces an L-R signal having an altered amplitude and phase. An incorrect L-R signal is fed to the matrix, and consequently yields poor stereo separation. In other words, the decoding characteristics of the BTSC decoder are sensitive to the RMS level of its input signal. Since the RMS level to the input of the decoder is directly proportional to the total modulation level therefore, the total modulation level in the BTSC transmitter must be accurately monitored in order to maintain good stereo separation.

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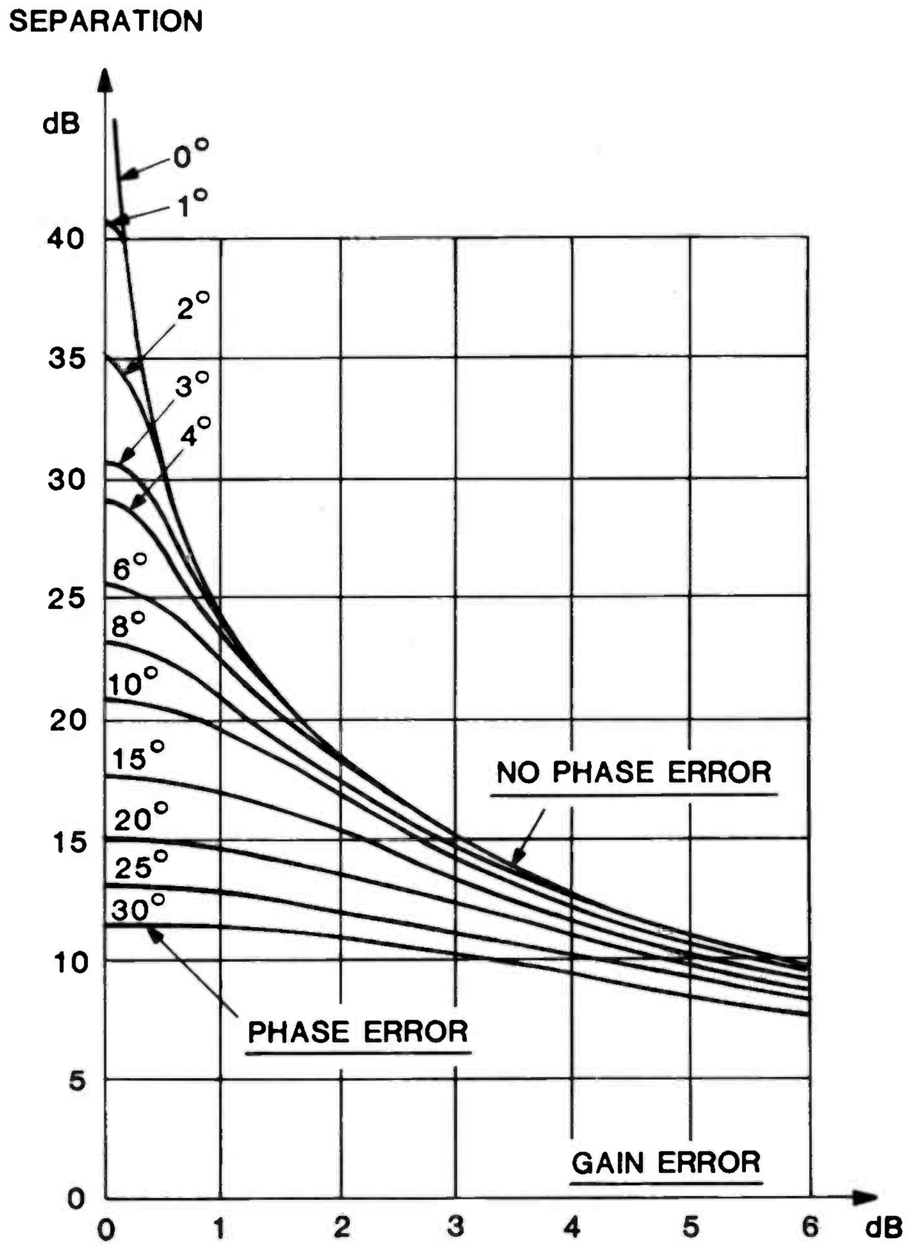


Figure 3-2: Stereo separation as a function of gain and phase errors in the L-R versus the L+R paths.

# SECTION 4

# TEST EQUIPMENT AND DOCUMENTATION

## 4.1 Test Equipment

Frequently, half of the battle in doing a Proof is in the preparation of the test equipment. Many hours of valuable time could be consumed at the transmitter site if the equipment is improperly checked out and out of calibration. Let's take a look at what test equipment is principally required and discuss the methods of checking their operation. The better we prepare in advance, the less time it will take to do a Proof. The following are recommended minimum test equipment and their features.

| Type of Equipment | Features |
|---|---|
| A. Audio Frequency Sine-wave Generator, two each | 30 Hz to 120 kHz, 0.1% THD or better |
| B. Distortion Analyzer | Having residual THD 0.1% or better |
| C. Digital AC Voltmeter | ±0.1 dB resolution and flat between 30 Hz and 120 kHz |

Figure 4-1: Minimum Test Equipment and Features

| Type of Equipment | Features |
|---|---|
| A. Oscilloscope | 10 MHz or higher |
| B. Variable Attenuator | 600 ohm, 0.1 dB resolution |
| C. Digital Ratio Meter | 30 Hz to 120 kHz frequency response, calibrated in dB |
| D. Digital Frequency Counter | Up to 10 MHz response |

Figure 4-2: Other Test Equipment and Features

Before proceeding, be sure that all test leads are equipped with the proper connectors for making solid, well-shielded contact. Alligator clip connections, sections of unshielded cable, and haphazard grounds often cause needless grief and lost time. There is also an understandable psychological advantage in starting out with a "tight ship".

## 4.2 Checking the Test Equipment for Response Variations

### 4.2.1 Checking the AC Voltmeter

Feed the output of the audio generator into the digital AC voltmeter, such as the TFT Model 860 Multi-function Analyzer. The generator output should be held constant while the digital AC voltmeter indicator in dB is observed. Vary the frequency from 30 Hz to 120,000 Hz and note any deviation from the 400 Hz value which is more than 0.1 dB. If there is no change in the indication, then the frequency response over the band that the Proof will cover is perfect and no corrections will have to be made to the data that are measured. If the digital voltmeter does show a deviation, record the error in 0.1 dB resolution at 50 Hz, 100 Hz, 400 Hz, 1 kHz, 5 kHz, 10 kHz, 14 kHz, 24 kHz, 31.5 kHz, 78.5 kHz, and 102 kHz.

If the audio generator employed has a built-in AC voltmeter and is accurately calibrated over the frequency range, you will find that it is quite easy to keep the output level perfectly constant while the frequency is varied so that no calibration chart is required. If the generator does not have a meter, then obviously we are relying on the accuracy of the digital AC voltmeter to check its output uniformity and it would be a good idea to double-check it by using a second meter and running the same spot checks. If you must use a calibration chart with your generator, remember to subtract the generator errors from the transmitter response deviations measured before entering them on the data sheet when you begin the Proof.

### 4.2.2 Check the Audio Generator Distortion Level

A harmonic distortion analyzer reads hum, white noise, and distortion as distortion. Consequently, we must remember that even if our generator is producing a perfect waveform, its output noise level must be less than 0.1% or -60 dB for the distortion analyzer to indicate less than 0.1%, assuming that the distortion analyzer is perfect. As a practical matter, most audio generators and harmonic distortion analyzers exhibit a noise level of around -80 dB or 0.01%. This is usually not a problem, as long as one is careful to avoid ground loops when making the connections to the equipment under test.

If the audio generator is fed directly into the harmonic distortion analyzer, the total hum, noise, and distortion for the combination may be measured. For BTSC Proof measurements, if the reading is 0.25% or less, the instruments may be considered satisfactory since this is 1/10 of the lowest recommendation for BTSC broadcast. Most distortion analyzer and audio generator combinations yield a residual hum, noise, and distortion level of about 0.1%.

**CAUTION: The residual test equipment distortion MAY NOT be subtracted from the system distortion figures when doing the Proof.**

Subtracting the test equipment distortion is an invalid technique because distortions do not necessarily add. As a matter of fact, the only time they would add would be when all of the harmonics are exactly in phase; a near impossibility when you consider that this would have to be true for every modulating frequency. Non-linearities can also cancel each other if their transfer characteristics are complementary. This accounts for the fact that a studio with 1% distortion can be connected to a line amplifier with 1% distortion and the line amplifier connected to a transmitter with 1% distortion. One might expect the system distortion to be 3%, but typically it would test at about 1-1/2 to 2-1/2% because of the fact that distortion readings may not be added or subtracted.

It is a good rule of thumb that no portion of the system exceed 1/2 the distortion limit since at some modulating frequency the distortions could add. So to summarize, the fact that distortions usually don't add makes our broadcast systems better than the sum of their parts, but it also means that the test gear distortion cannot be subtracted.

The BTSC Committee recommends that the distortion measurements be made with a test bandwidth of 30 kHz (above the second harmonic of 14 kHz, the highest frequency test input), a requirement that is easily met since most harmonic distortion analyzers will pass at least 40 kHz. Noise tests must be made with a 50 to 15,000 Hz bandwidth, also easy to meet since most audio voltmeters are flat to 120,000 Hz.

**A word of caution here: If the AC voltmeter has a built-in 400 Hz high pass filter, it must be switched out. The required bandpass STARTS AT 50 Hz. The high pass filter is great for getting hum out of the measurements, but not out of the transmitter! These filters are installed in the test gear as a diagnostic aid to enable the user to determine how much of a noise or distortion reading is hum and how much is white noise or distortion.**

To check the residual noise level of the AC voltmeter or the distortion analyzer, short its input and switch it to the most sensitive range. It should have a noise level of more than 70 dB below the modulation monitor output level corresponding to 100% modulation. Obviously, the noise in the test equipment may not be subtracted from the system noise measured. Since the BTSC residual noise limit is -58 dB, we should be careful to optimize the noise performance of the system and take care to keep the test set-up noise free as this is not an easy test to pass, especially in stereo.

### 4.2.3 Checking the Monitors

Don't forget to check the operating condition of the modulation monitor as part of this exercise. If the modulation monitor, such as the TFT Model 850 is equipped with a frequency synthesized type of FM modulation calibrator, adjustment of the meter calibration from the front panel pots is all that is necessary. Otherwise, other type of modulation monitors require additional test equipment to perform a Bessel Null in order to assure the monitor's accuracy.

Don't forget the SAP and Professional channel monitor(s) if these subcarriers are part of the broadcast operation. These monitors usually require a signal feed from the main modulation monitor. Calibration procedures can be located in the Owner's Manual.

## 4.3 Test Documentation

A well-documented test procedure consisting of equipment list, setup block diagram, test points, and description will help speed up the Proof every time you repeat it. It is well worthwhile to make the initial investment so that it will pay off in the future.

Figure 4-3 gives an example of test points in a TV transmission facility, where the signal can be sampled for monitoring and measuring the BTSC stereo performance.

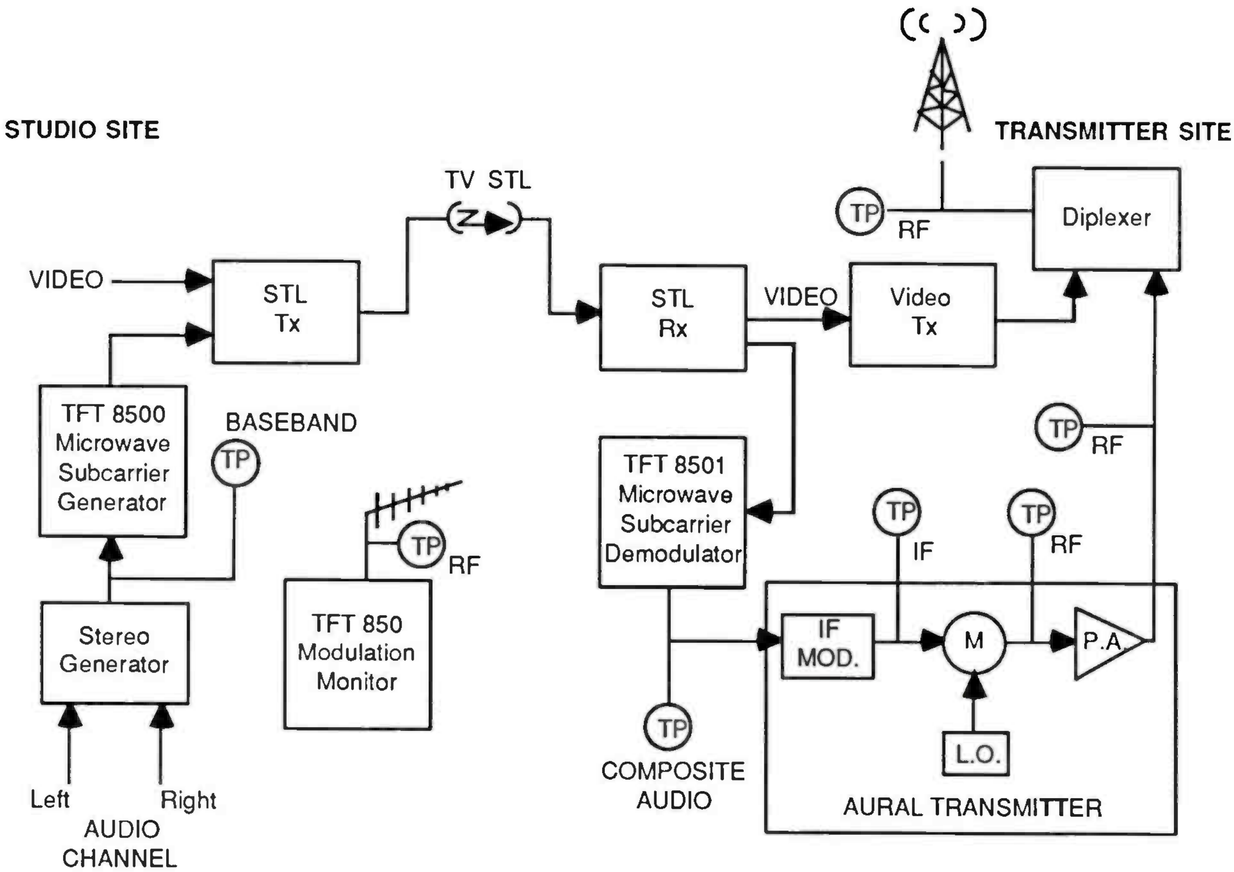


Figure 4-3: Test Points where Measurement can be Made

A written test procedure describing the control settings of the test equipment and the equipment under test, the adjustment of all station equipment relating to the test, and how the actual measurements are made, is an extremely useful document for doing a Proof in the future. Having these records and documents also make it easier to delegate the job to subordinates.

Table 6.1.1 in Section 6 of this manual is an example of how the test equipment record can be kept for future reference. Having this information available can speed up the process every time you do the Proof. An equipment connecting diagram, similar to Figure 4-4, provides a permanent record of the test setup as it illustrates the equipment interconnection.

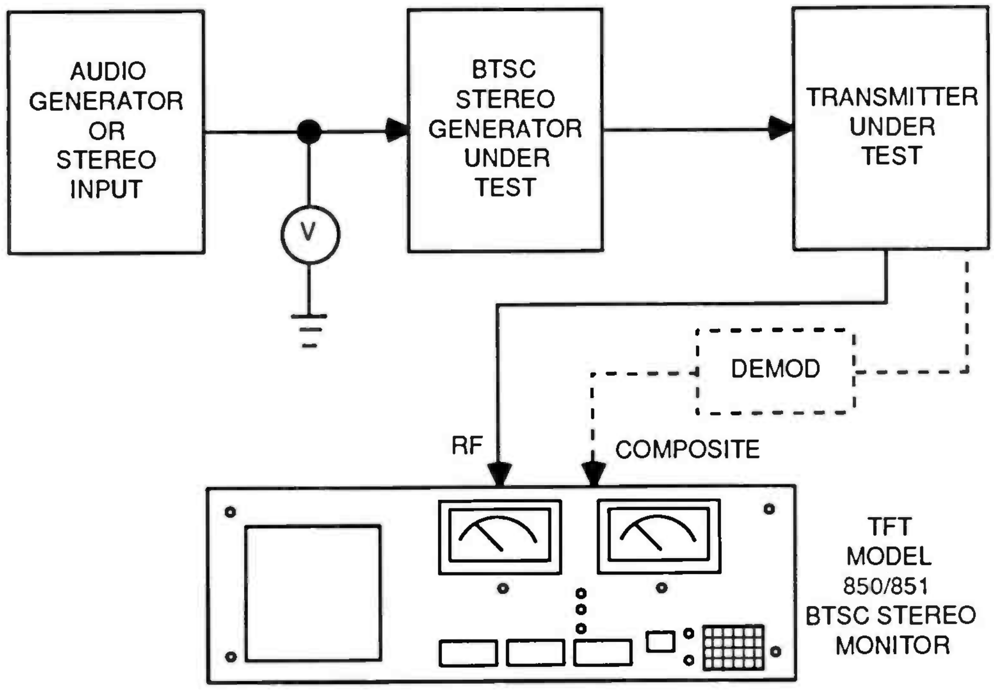


Figure 4-4: Example of Equipment Interconnections

# SECTION 5

# PRE-TESTING MAJOR SYSTEM COMPONENTS

## 5.1 Know the Characteristics and Inter-Connections in your Audio Link

Figures 5-1A and 5-1B show a truly balanced, transformer-coupled circuit. Note that each transformer is center-tapped to ground. This circuit will exhibit a degree of common mode rejection, which depends upon the accuracy of the transformer center tapping or "balancing". The effect is identical to that obtained with balanced push-pull amplifier circuitry. Frequently, operational amplifiers are used to achieve the balanced input circuit. This type of input circuit usually exhibits better low frequency response than the transformer type input circuit.

Any hum or noise would have to enter the top and bottom halves of the circuit, 180 degrees out of phase, to be passed to the output. Any interference affecting the top and bottom halves in common, as a hum field would, causes its own cancellation or rejection, hence, the term common mode rejection. (This type of truly balanced circuitry makes long distance wire transmission possible with surprising noise immunity, but is seldom found in studio equipment as the distance of transmission over the connecting lines is usually a matter of feet rather than miles.)

It is very important to know how your audio input is wired and unfortunately, the manufacturers usually call any transformer-coupled circuit "balanced". Figure 5-1C shows what would happen if the audio generator's unbalanced half grounded output were to be connected to a balanced input. As you can see, the impedance mis-match would be 2 to 1. On the other hand, Figure 5-1C shows what happens when a transformer with a balanced secondary is used to couple to a floating but unbalanced input configuration. It opens the door for "ground loops" due to multiple ground connections. Adding a transformer to the audio generator's output is not a cure-all. There is no substitute for knowing the characteristics of the input circuit and making an intelligent decision on the proper coupling technique. **If connecting a matching transformer to your audio system is required, be sure that it is included in your test equipment response checks so that any effect that it might have is recorded.** Load the secondary of the transformer with a resistor equal to the channel input impedance, if it is an unbalanced secondary. If the secondary is balanced, leave the

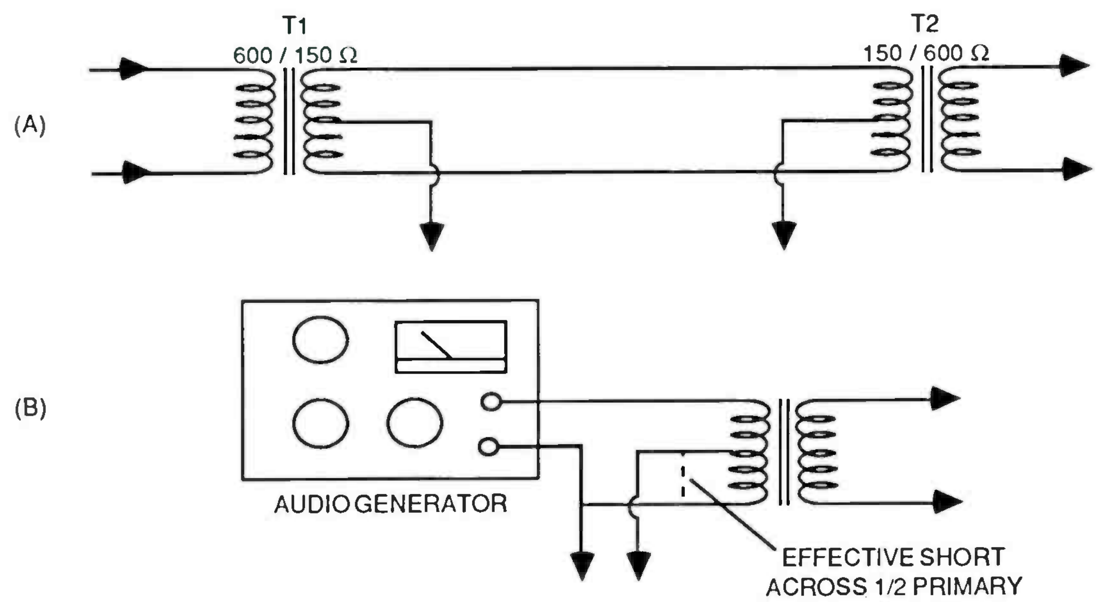


Figure 5-1A and 5-1B: Direct connection across a truly balanced input can result in severe mismatching and test conditions not simulating normal operation of the input circuit.

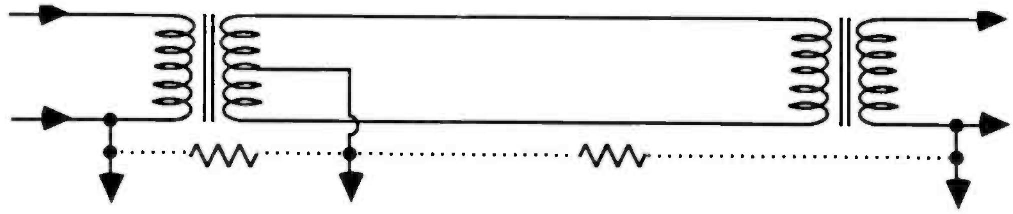


Figure 5-1C: Multiple ground connections open the door for "ground loops" that could render the measurements invalid.

secondary center tap disconnected for coupling to the unbalanced voltmeter input so the transformer may be checked.

If you have noise problems in your pre-test measurements, but these don't show up on the air, and are obviously in your test setup, try an isolation circuit between the modulation monitor instrument output circuit and the harmonic distortion meter/voltmeter input. We are assuming that the distortion meter itself is well shielded; if changing the position of the instrument changes the amount of noise, infiltration through the distortion meter housing itself should be suspected. The most common problem, however, is the development of an RF potential across a ground loop. Remember that a quarter wave of FM and TV frequencies is only a couple of feet long! Simple 60 Hz hum can invade the test input in much the same way, of course.

If your modulation monitor does not have a built-in distortion analyzer or digital AC voltmeter, you may want to consider the high impedance isolation circuit shown in Figure 5-2 which usually takes care of either problem. Isolating the modulation monitor ground from the distortion meter ground eliminates the ground loop, and the limited frequency response of the transformer blocks the RF. The frequency response of the transformer must meet the 30,000 Hz requirement. The transformer distortion is important too, because these measurements must be made through it. Better quality matching transformers will pass the instrument output voltage with less than 0.1% distortion in most cases so it should not be difficult to find a suitable unit.

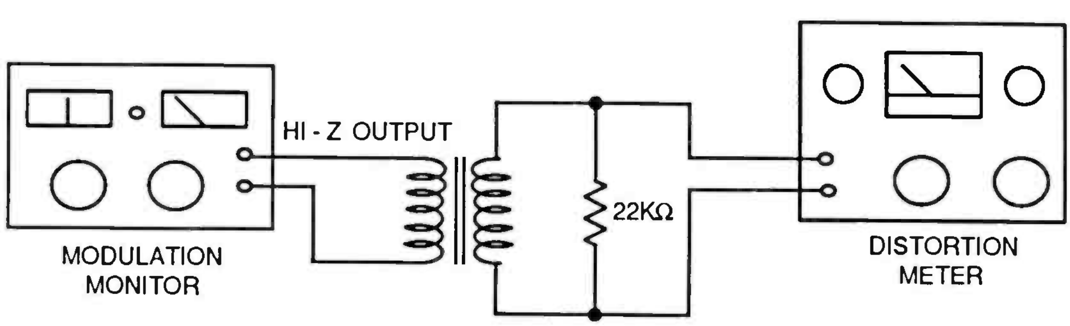


Figure 5.2: A Ground Isolation Method

## 5.2 From the Audio Console to the STL Input

For an engineer to be able to efficiently progress through the equipment performance measurements with a minimum of wasted time, the facility must of course be up to par. You must remember that if you have completed part of the measurements, and then find that an adjustment to the transmitter is required, the tests that have been completed are usually invalid. As a practical example, if we begin by making a complete frequency response and distortion measurement series only to find that a defect in the STL from the studio has rendered our noise level unusable, we must re-run the same series of tests after the audio path problem has been serviced. Repeating the noise test alone will not suffice because whatever repair or adjustment was made to correct the noise could possibly alter the frequency response or distortion performance.

Obviously, it doesn't take many of these unexpected little setbacks to turn a seemingly simple Proof into an all-week affair. The best way to ensure that this won't happen is to pre-test the major system components. There are many ways to quick-check a facility, but probably the best method is to determine which portions of the measurements will be the most difficult to pass and then prepare a pre-test procedure in order to be sure that the toughest requirements can be met.

### 5.2.1 From the Audio Console to the Aural Transmitter Input

Use the techniques described in the beginning of this section. Feed an audio signal into the audio console and terminate the output with the TFT Model 860 Analyzer or equivalent. Compare the measurements to the limits shown in Figure 5-3. The signal at the output of the audio console generally feeds the TV STL.

When the output of the audio console is terminated with the same impedance as the input of the TV STL Subcarrier Generator, the signal level must be adjusted to the same as the normal operating level of the STL at 10% modulation on the subcarrier. Record this infomation on the data sheet provided in Section 6.

| Pre-Test | Audio Frequency | Limit |
|---|---|---|
| A. Check signal-to-noise ratio from audio console to the STL input | 400 Hz | Better than -66 dB below 100% modulation level |
| B. Spot check THD | 50 Hz<br>1000 Hz<br>14 kHz | 0.5 % |
| C. Spot check audio frequency response | 50 Hz<br>400 Hz<br>14 kHz | Flat within ±0.1 dB |

Figure 5-3: Pre-Test Limits from Audio Console to the STL Input

## 5.2.2 From the STL Transmitter Input to the STL Receiver Output

Similar methods may be used to check the STL system's audio channels. If dual subcarriers are used to bring the R and L channels separately to the transmitter site, each one of these channels should be checked separately. The STL Owner's Manual gives detailed information as how to do a Proof of the STL system, but the following data in Figure 5-4 can help you to determine if the STL has any major deficiency. Again, modulate the STL subcarrier generator at the normal 100% level when doing these checks.

| Pre-Test | Audio Frequency | Limit |
|---|---|---|
| A. Check signal-to-noise ratio from the STL subcarrier generator | 400 Hz | -65 dB below 100% modulation |
| B. Spot check THD | 50 Hz<br>1000 Hz<br>14 kHz | Below 0.5% |
| C. Spot check frequency response | 50 Hz<br>1000 Hz<br>14 kHz | ±0.5 dB |

Figure 5-4: Pre-Test Limits from STL Tx to STL Rx

## 5.2.3 Pre-Testing the BTSC Stereo Generator

There are a variety of stereo generators being used by TV broadcasters, some with built-in audio processing and some without. It is important to review the Owner's Manual to become familiar with the controls and adjustments.

It is much easier to check out a stereo generator, if the modulation monitor has a calibrated input for the composite signal, as does the TFT Model 850. Using the Model 850 to measure an external BTSC stereo composite signal requires that the external stereo generator be matched to the monitor's input requirement. The best stereo separation is achieved when the output level of the encoder in the stereo generator matches the input level to the decoder in the monitor. The stereo generator must be capable of providing at least a 1 Volt RMS output level for ±73 kHz deviation in order to operate the Model 850 properly.

The level adjustment may be accomplished by adjusting the output level of the stereo generator or the input level to the monitor as follows:

a. Connect the BTSC stereo generator, a unit whose encoder has been recently calibrated, to the COMPOSITE INPUT on the rear panel of the Model 850. Ensure that the INT/EXT switch on the monitor rear panel is in the EXT position.

b. Apply a 1 kHz tone to the LEFT channel of the stereo generator.

c. Set the Model 850 to LEFT Channel (Keyboard Address 05). Set a reference on the distortion analyzer using the LEVEL DB RATIO function.

d. Set the monitor to RIGHT channel (keyboard Address 06) and adjust the following for best stereo separation:

   1. Output of the stereo generator or,

   2. The COMPOSITE INPUT LEVEL ADJ on the rear panal of the Model 850.

e. When a composite input of 1 Vrms is achieved at the rear panel of the Model 850, it is equivalent to $\pm$73 kHz deviation. The system is now calibrated for making measurements of the stereo generator.

f. Compare the data to the limits shown in Figure 5-5.

| Pre-Test | Modulation Monitor Readings | Limit |
|---|---|---|
| A. Check signal-to-noise ratio, use 400 Hz as reference | 100 % | 70 dB |
| B. Spot check THD<br>50 Hz<br>1000 Hz<br>14 kHz | 100 % | 0.5 % |
| C. Spot check stereo separation at 1000 Hz | 10 - 30 % | 36 dB (Encoder in) |

Figure 5-5: Pre-Test Limits for a BTSC Stereo Generator

## 5.3 Pre-Testing the Aural Transmitter

### 5.3.1 Sampling a Signal from Antenna Diplexer Output

Taking pre-test measurements from the output of the antenna diplexer can often reveal the performance characteristics of the complete BTSC stereo system. Measurements made at this point reflect the performance of the entire audio chain, the modulator section, and the RF section.

The RF level available at the output of the diplexer or the RF feed line to the antenna is usually much greater than the signal from an outdoor antenna. It is necessary to know the approximate level of the RF voltage that appears at this test point, since monitors such as the TFT Model 850 are designed to accommodate one to five volts of RF without overheating the input attenuator. If the voltage is much higher than 5V RMS, you should reduce it or add a 10 to 20 dB attenuator pad in series with the monitor input.

After the test equipment is properly set up, connect the audio into the input of the aural transmitter. The limits for this pre-test should yield the following minimum results:

| Pre-Test | Audio Frequency | Limit |
|---|---|---|
| A. Check signal-to-noise ratio | 400 Hz | 60 dB below 100% modulation |
| B. Spot check THD | 50 Hz<br>1000 Hz<br>14 kHz | Below 1.0% |
| C. Spot check frequency response | 50 Hz to 50 kHz<br>50 kHz to 120 kHz | ±0.1 dB<br>±0.5 dB |

Figure 5-6: Pre-Test Limits, Aural Transmitter

### 5.3.2 Sampling a Signal from the Aural Transmitter

If there is difficulty in obtaining the desired performance in the pre-test step 5.3.1, go back one stage in the block diagram of the transmission link by making a pre-test measurement at the output of the aural transmitter. This process will exclude any degradation of performance due to the diplexer.

The limits of this measurement ought to result in data equal to or better than the numbers shown in Figure 5-6.

### 5.3.3 Sampling a Signal from the IF Stage of an IF Modulated Transmitter

The TFT Model 850 monitor is equipped with a switch for selecting 41.25 MHz or 32.5 MHz IF input at the rear panel for the purpose of checking the IF section of an IF modulated transmitter. If the aural transmitter tested per Paragraph 5.3.2 does not result in meeting the pre-test limits, the modulating circuit, and/or the IF bandwidth of the aural transmitter may require service or adjustment, this will show up in this pre-test step.

If the station can pass the basic series of tests described in this section, then the chances are very good that it will breeze through the complete Proof, as the above requirements describe the all-out performance demands placed on the system. It is well worth the time that it takes to go through this electronic assurance routine.

# SECTION 6

# DATA SUMMARY SHEETS AND METHOD OF MEASUREMENTS

## 6.1 DATA SUMMARY SHEETS

The purpose of the data summary sheets is to provide an organized plan for recording the test results as they are obtained. The value of this organization will be appreciated later when we draw from this collection of figures for analysis of performance.

Tables 6.1.1 and 6.1.2 are for record-keeping of test equipment and characteristics of major test points of the Transmission System as described in Section 4.3. The frequency response sections (Figures 6.1.3 and 6.1.4) contain two columns: one for the original audio generator output voltages and the other for the actual response deviation figures. It is important that any possibility for error in transferring the test results from the meter face to the data sheet be eliminated, and that is the reason for recording the audio generator output settings or exact level read by a AC digital voltmeter. While it is not difficult to figure out the response deviations mentally as the data is measured, an error in addition or subtraction may never be discovered and erroneous data would be recorded. By recording the generator output, the engineer is free to concentrate on the tests at hand and worry about the math later. There is also a record of the original data that can be double-checked with the deviation figures to ensure accuracy.

Filling in the distortion figure is straightforward and can be done at the same time the response data are gathered. When recording distortion figures of less than 1% or response deviations of less than 1 dB, it is customary to place a 0 to the left of the decimal point to preclude any ambiguity about whether the number is whole or fractional. In a group of numbers, -.2 dB does not look too different from -2.0 dB, but -0.2 dB is at once recognizable as a different numeral.

### 6.1.1 Record of Test Equipment

| Type | Manufacturer | Model No. | Serial No. | Date Last Calibrated |
|---|---|---|---|---|
| Audio Generator | | | | |
| Distortion Analyzer | | | | |
| Digital AC Voltmeter | | | | |
| Modulation Monitor | | | | |
| Stereo Generator | | | | |
| Frequency Counter | | | | |
| Oscilloscope | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Recorded by: ____________________

Date: ____________________

### 6.1.2 Signal Level and Line Impedance at Major Test Points

| Test Point | Millivolts | dBm | Impedance |
|---|---|---|---|
| Input to Stereo Generator | | | |
| Output from Stereo Generator | | | |
| Input to SAP Generator | | | |
| Output from SAP Generator | | | |
| Input to the STL Subcarrier Generator | | | |
| Output from the STL Subcarrier Demodulator | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Recorded by: ____________________

Date: ____________________

## 6.1.3 Data Summary Sheet - Composite Baseband Frequency Response

| ± 50 kHz DEV. | Freq (Hz) | Generator output | AC meter reading | Corrected response |
|---|---|---|---|---|
| | 50 | | | |
| | 100 | | | |
| | 400 | | | |
| | 1 k | | | |
| | 5 k | | | |
| | 10 k | | | |
| | 14 k | | | |

| Freq (kHz) | Generator output | AC meter reading | Corrected response |
|---|---|---|---|
| 16.5 | | | |
| 21.5 | | | |
| 26.5 | | | |
| 31.5 | | | |
| 36.5 | | | |
| 41.5 | | | |
| 47 | | | |

| ± 25 kHz DEV. | | | | |
|---|---|---|---|---|
| | 63.7 k | | | |
| | 71.2 k | | | |
| | 78.7 k | | | |
| | 86.2 k | | | |
| | 93.7 k | | | |

| | | | |
|---|---|---|---|
| 94.4 | | | |
| 98.7 | | | |
| 103 | | | |
| 111.5 | | | |
| 120 | | | |

Note: See Section 6.2 for instructions and limits

All Tests Performed By: ____________________

Date: ____________________

## 6.1.4 Data Summary Sheet - Main Channel

| | Freq (Hz) | Generator output | AC voltmeter reading | Corrected response |
|---|---|---|---|---|
| 100 % MOD ( ± 25 kHz DEV.) | 50 | | | |
| | 100 | | | |
| | 400 | | | |
| | 1 k | | | |
| | 5 k | | | |
| | 10 k | | | |
| | 15 k | | | |
| 50 % MOD ( ± 12.5 kHz DEV.) | 50 | | | |
| | 100 | | | |
| | 400 | | | |
| | 1 k | | | |
| | 5 k | | | |
| | 10 k | | | |
| | 15 k | | | |
| 25 % MOD ( ± 6.25 kHz DEV.) | 50 | | | |
| | 100 | | | |
| | 400 | | | |
| | 1 k | | | |
| | 5 k | | | |
| | 10 k | | | |
| | 15 k | | | |

AM Signal-To-Noise Ratio – ________ dB

FM Signal-To-Noise Ratio – ________ dB

Crosstalk from L - R – ________ dB

Crosstalk from SAP – ________ dB

All Tests Performed by: ________________

Date: ________________

Note: See Section 6.3 for instructions and Section 2 (Fig. 2-2, 2-4 and 2-5) for limits.

### 6.1.5 Data Summary Sheet for Stereo Channel

Pilot Injection (15,734 Hz) ________%

Pilot Interference Level ________dB

Signal-To-Noise Ratio, Right Channel – ______dB

Signal-To-Noise Ratio, Left Channel – ______dB

**Stereo Separation without Companding**

| Residual Left in Right (dB) | Frequency (Hz) | Residual Right in Left (dB) |
|---|---|---|
| | 50 | |
| | 100 | |
| | 400 | |
| | 1 k | |
| | 5 k | |
| | 10 k | |
| | 14 k | |

**Stereo Separation with Companding**

| Residual Left in Right (dB) | Frequency (Hz) | Residual Right in Left (dB) |
|---|---|---|
| | 50 | |
| | 100 | |
| | 400 | |
| | 1 k | |
| | 5 k | |
| | 10 k | |
| | 14 k | |

**Total Harmonic Distortion**

| THD Right Channel | Frequency (Hz) | THD Left Channel |
|---|---|---|
| | 50 | |
| | 100 | |
| | 400 | |
| | 1 k | |
| | 5 k | |
| | 10 k | |
| | 14 k | |

**Crosstalk Into Stereo Sub-channel**

| Frequency (Hz) | Due to Main Channel | Due to SAP Channel |
|---|---|---|
| 100 | | |
| 400 | | |
| 1k | | |
| 5 k | | |
| 10 k | | |
| | | |
| | | |

Stereo Subcarrier (31,468 Hz) Suppression –________ dB

All Tests Performed By: ____________________

Date: ____________________

Note: See Section 6.4 for instructions and Section 4 for limits.

### 6.1.6 Data Summary Sheet for SAP Channel

**SAP Channel Signal-To-Noise – ______ dB**

**Frequency Response and THD of SAP Channel**

| 100 % MOD (± 15 kHz DEV.) | Freq (Hz) | Generator output | AC meter reading | Corrected response | THD |
|---|---|---|---|---|---|
| | 50 | | | | |
| | 100 | | | | |
| | 400 | | | | |
| | 1 k | | | | |
| | 5 k | | | | |
| | 10 k | | | | |

Crosstalk due to Main Ch. – ________ dB
(4.5 kHz, ±25 kHz Dev.)

Due to Stereo Ch. and Main Ch. – ________ dB
( 2 kHz L=R, 8.6 kHz L only)

SAP Subcarrier Frequency (78,670 Hz) ___________ Hz (±500Hz)

Note: See Section 6.5 for instructions and Section 4 for limits.

All Tests Performed By: ______________________

Date: ______________________

## 6.2 Composite Baseband Characteristics - Method of Measurement

Data Summary Sheet 6.1.3 is recommended for use to measure the baseband frequency response of the aural transmitter. In order to achieve stereo separation in excess of 40 dB in the radiated signal of a transmitter, it is required that the amplitude response should not vary by more than +/-1.0 dB and the phase response should not vary by more than ± 3.0 degrees, over a band of frequencies from 50 Hz to 47 kHz and for an aural carrier deviation of 50 kHz. Since such tight tolerances of amplitude and phase are difficult to measure, an alternate practice may be used. This alternate method is to measure stereo separation without the compander, (first table in Paragraph 6.1.5). If the results are 40 dB or more over the range of frequencies and signal levels (± kHz deviation), the amplitude and phase tolerance over the band of frequencies from 50 Hz to 47 kHz can be considered to comply with the recommended practice.

For the frequency band from 47 kHz to 120 kHz, the amplitude response should not vary by more than ± 1.0 dB from a phase response. The phase response should not vary by more than ± 10 degrees, both conditions are for an aural carrier deviation of ± 25 kHz.

This measurement should be performed with the aural modulation monitor in the split-sound mode.

## 6.3 Main Channel Characteristics - Method of Measurement

The main channel is the segment of the detected aural composite baseband spectrum that ranges from 50 Hz to 15,000 Hz. The main channel signal represents, within specified tolerances, the L+R signal that modulates the aural transmitter with an audio frequency range of 30 Hz to 15 kHz.

### 6.3.1 Total Harmonic Distortion

This measurement requires the use of aural monitoring and measuring equipment in the split-sound monitoring mode. The single tone audio input to the transmitter should be supplied from a source having less than 0.055% total harmonic distortion. The measurement is typically performed with a total harmonic distortion (THD) analyzer. The instrument should have a residual THD of its own of 0.1% or less. The amplitude of the audio signal should be adjusted to keep the aural carrier frequency deviation constant at 6.25 kHz or 12.5 kHz or 25 kHz. The 75 μsec deemphasis network is used. The aural carrier is modulated by the main channel only; the pilot and all sub-carriers are off. If the visual transmitter is equipped with a notch-diplexer, it can be turned either on or off. Verification that this has no influence on the measurement results is recommended. Visual transmitters without notch diplexers should be turned off. The monitor should be fed from a directional coupler in the transmission line that feeds both visual and aural (if not possible, aural) carriers to the transmitting antenna. If an off-air feed is used, the operator should be aware of the possibility that multipath effects may increase measured distortion.

### 6.3.2 Signal-to-Noise Ratio

The radiated aural signal may include AM noise and FM noise. Additionally, the visual carrier may have spurious visual phase modulation in the frequency range of the main channel and the aural carrier may be contaminated by spectral overflow. OST 60 (C) (a) (13) allows at most -58 dB FM noise in the main channel of 50 - 15,000 Hz (25 kHz peak deviation as reference, 75 usec deemphasis). The OST rule is to be interpreted to hold when the visual transmitter is turned on. It is recommended that the Type I (diagonal) pattern be used. Transmitters without notch diplexing should use a Type II pattern (multiburst).

Set up a zero dB reference for 100% modulation (± 25 kHz deviation) by applying a 400 Hz tone equally to the L and R channels of the stereo generator. Measure the residual noise level on the digital AC voltmeter after switching off the 400 Hz reference tone. Turn on and off the visual transmitter with program material and record the difference in noise measurements. Add pattern to the visual carrier and check for degradation in SNR.

### 6.3.3 Crosstalk Into the Main Channel

Monitoring the output of the main channel output, set up a 0 dB reference (± 25 kHz deviation) by applying a 400 Hz tone to the L and R channel, (L+R) of the stereo generator, using the split-sound monitoring mode. Remove the 400 Hz tone, and measure the residual noise in the main channel by applying an audio signal L=-R to the stereo generator with the compressor bypassed. Adjust the level for ± 50 kHz stereo subcarrier deviation of the aural transmitter and sweep the audio generator from 50 Hz to 14 kHz; record the worst reading in dB and audio frequency at which the reading is taken. Repeat this process by modulating the SAP channel without the compressor (encoder out) in the circuit. Adjust the SAP to a deviation of ± 10 kHz and an injection level to the aural transmitter of ± 15 kHz. Measure the worst case residual noise in the main channel. Record level in dB and frequency.

## 6.4 Stereo Sub-Channel - Method of Measurement

### 6.4.1 Pilot Injection Level

OST 60 specifies aural carrier modulation by the pilot subcarrier of 5 kHz deviation with a tolerance of ± 0.5 kHz. For this measurement, a 15.734 kHz pilot frequency bandpass filter is used to separate the pilot from other modulating signals. The operator should be aware that the radiated signal's pilot carrier can be contaminated and interfered by horizontal video components. The source of interference may be located by turning the visual carrier on and off and also by switching in different types of visual patterns.

### 6.4.2 Pilot to Interference Ratio

The ratio between the nominal pilot level in the aural radiated signal and the RMS interference in a 1 kHz bandwidth at a center frequency of 15,734 Hz is 40 dB. OST 60 specifies this value as the current standard, but the EIA committee is proposing to lower this to 30 dB. The measurement shall be performed with the monitor in the split-sound mode and with thevisual carrier turned on. Also the measurement is to be made in the split sound mode and in the intercarrier mode (if available). Adjust the aural carrier deviation by the pilot to 5 kHz. Measure the pilot level on the monitor "pilot" position. Turn off the pilot and take the reading on the digital AC voltmeter.

### 6.4.3 Stereo Separation With and Without Companding

Recommended stereophonic separation without BTSC companding is 40 dB (OST 60) over the band of frequencies from 50 to 14,000 Hz. Stereophonic separation, including BTSC companding, at 10% and 75 μsec equivalent input modulation, shall meet or exceed the following requirements:

a. 30 dB separation from 100 Hz to 8 kHz;

b. Smoothly decreasing separation below 100 Hz to 26 dB at 50 Hz;

c. Smoothly decreasing separation above 8 kHz, to 20 dB at 14 kHz;

d. At other 75 μsec equivalent input modulation levels between 1% and 100%, from 100 Hz to 8 kHz, the separation shall equal or exceed 26 dB.

Note there is no BTSC recommendation regarding separation above 14 kHz when BTSC compression is included. The reason for this is that at the time of this writing, no information is available as to the long-term stability of skirt response of the very sharp cutoff (L+R) and (L-R) audio lowpass filters in the BTSC stereo generator.

A sine wave signal variable in the band of frequencies from 50 Hz to 14 kHz is supplied to the left (or right) audio input port of the stereo generator. The other audio input is grounded. After adjusting the aural carrier deviation, the reference level is measured (without 75 μsec deemphasis when measuring without companding) at the left (or right) audio output. Next, the residual level is measured in the right (or left) audio output. A visual transmitter without notch-diplexer should be turned off.

### 6.4.4 Signal-to-Noise Ratio in L and R Channel

The aural carrier stereophonic subchannel radiated signal may include thermal noise. Additionally, the visual carrier may be one of the potential interference sources, some of which may cause noise and/or interference in some receivers. The potential visual interference sources are spurious visual phase modulation (example ICPM) and aural and visual phase noise in intercarrier-sound receivers as well as in split-sound receivers. The stereophonic subchannel, when not (or only partially) energized, may include input noise amplified by the BTSC compressor.

OST 60 specifies -55 dB or less FM noise in the stereophonic channel radiated signal, referenced to 50 kHz aural carrier deviation, and measured after demodulation without BTSC expanding but with deemphasis. The modulation monitor is fed with an RF signal from a directional coupler in the transmission line feeding the antenna, using the forward wave. The function switch of the monitor is switched to (L+R) + (L-R) position.

Apply a 400 Hz test tone to the input of the Stereo Generator and allow L=-R. Set the modulation level of the transmitter to 50 kHz deviation with the BTSC decoder out of demodulation path. Then measure the noise level after switching off the 400 Hz reference tone. The 75 μsec deemphasis network should be selected.

## 6.4.5 L and R Channel THD Measurement

OST 60 lists the following maximum distortion percentages:

3.5% (RMS) (50 - 100 Hz)
2.5% (RMS) (100 - 7,500 Hz)
3.0% (RMS) (7,500 - 15,000 Hz)

The modulation percentages are 25, 50, 100% of 75 usec equivalent input modulation, with harmonics to be included to 30 kHz. (BTSC companding is included.) The measurement should be performed with the monitor in the split-sound mode.

Apply a sinewave of 50 Hz to 14,000 Hz to the input of the Stereo Generator; allow L=-R. Adjust the modulation level of the aural transmitter to the specified (12.5, 25, or 50 kHz). Measure the distortion of the signal at the L (or R) audio output of the monitor with a distortion analyzer. Make certain that the audio frequency accuracy should be sufficient to prevent measurements beyond 14 kHz.

## 6.4.6 Crosstalk Into Stereo Channel

Crosstalk into the stereophonic subchannel is the ratio of the reference level in the stereophonic subchannel to the level measured in the stereophonic subchannel when only the crosstalking channel(s) is (are) energized to its (their) nominal subcarrier and/or aural carrier deviation. Crosstalk attenuation from the main channel into the stereophonic subchannel is required to exceed -40 dB referenced to 50 kHz deviation and 60 dB from another subchannel. The measurement shall be performed with the monitor in the split-sound mode. When measuring an internally diplexed transmitter, the visual carrier shall be turned off.

a. Apply a 400 Hz tone, L=-R, without BTSC companding. Adjust the level to 50 kHz stereo subcarrier deviation. Remove the pilot and all other subcarriers.

b. Set the reference level (± 50 kHz deviation) using the L-R reading of the monitor.

c. Switch the modulation input to L=R and, if possible, switch off the stereophonic subchannel from the radiated signal. The digital AC voltmeter reading is the crosstalk from the main channel (and may include stereo subcarrier leakage, unless the subchannel is off). To measure crosstalk from another subchannel, remove the L, R inputs and energize the other subchannel to the nominal deviation and injection. The digital AC voltmeter reading is the crosstalk. For each case, vary the modulating frequency in the talking channel for constant deviation, to determine the maximum crosstalk in -dB.

## 6.4.7 Stereo Subcarrier Suppression

OST 60 requires less than 250 Hz aural carrier deviation by the level of the spurious 31,468 kHz signal component in the radiated aural carrier. This level should be 46 dB below the reference level of ± 50 kHz. The measurement shall be performed with the monitor in the split-sound mode. When measuring an internally diplexed transmitter, the visual carrier should be turned off.

a. Set up the reference level as under Crosstalk Measurements.

b. Remove modulation, pilot, and all subcarriers. Read the level from the monitor's 2 x PILOT position in dB.

## 6.5 Second Audio Program (SAP) - Method of Measurement

The SAP subchannel is the segment of the detected aural composite baseband spectrum that ranges from 63 to 94 kHz. The SAP subcarrier of a nominal frequency of 78.670 kHz is frequency modulated by the BTSC compressed SAP signal, limited to an audio bandwidth of 10 kHz, to a peak deviation of ±10 kHz. The modulated SAP subcarrier modulates the aural carrier to a peak deviation of ±15 kHz. A SAP monitor is required to perform this Proof.

### 6.5.1 SAP Noise Floor

OST 60 requires the noise floor to be -50 dB or better below 100% modulation (± 10 kHz subcarrier deviation and ±15 kHz injection level to the aural carrier). A SAP monitor used in conjunction with an AC digital ratio meter would be handy for this measurement. First, set up a 100% modulation level by reading the output via the SAP monitor. Let this reading be the 0 dB reference at the ratio meter. Switch off the modulation and read the residual noise level in dB from the AC digital ratio meter.

### 6.5.2 SAP Channel THD

The SAP distortion is the total harmonic distortion of the modulating signal of the SAP subcarrier of the radiated aural carrier.

OST 60 lists the following maximum distortion percentages:

| | |
|---|---|
| 3.5% (RMS) | (50 - 100 Hz) |
| 4.0% (RMS) | (100 - 5,000 Hz) |
| 3.0% (RMS) | (5,000 - 10,000 Hz) |

Measure at modulation percentages of 25, 50, and 100% 75 µsec equivalent input modulation. (100% corresponds to 10 kHz SAP subcarrier deviation.) The measurement shall be performed with the BTSC monitor in the split-sound mode. When measuring an internally diplexed transmitter, the visual transmitter shall be turned off.

Adjust the SAP subcarrier deviation to 75 µsec equivalent input modulation at the chosen modulation percentage and at the chosen modulating frequency. To achieve this, replace the BTSC compression by 75 µsec preemphasis. Feed a sine wave of the chosen frequency into the BTSC SAP generator and adjust the level until the desired deviation is reached as read on the SAP monitor. Next, switch the BTSC compression back into the circuit (replacing the 75 µsec pre-emphasis). Measure the level at the monitor SAP output with a distortion analyzer and subsequently measure the total harmonic distortion (THD).

### 6.5.3 Crosstalk Into SAP Channel

The crosstalk into the SAP channel must be equal to or less than -50 dB according to OST 60. This measurement shall be performed with the aural monitor and measurement equipment in the split-sound mode. When measuring an internally diplexed transmitter, the visual transmitter shall be turned off.

a. The reference level in the SAP channel is measured as follows:

   (1) Replace BTSC compression with 75 µsec pre-emphasis.

   (2) Modulate the SAP subcarrier with a 400 Hz tone and adjust the level to a deviation of 10

kHz as read on the SAP monitor. Verify that the SAP subcarrier injection is 15 kHz.

(3) Measure the SAP audio output with a digital AC voltmeter via 75 µsec deemphasis (replacing BTSC expansion). Turn off the 400 Hz signal.

b. To test crosstalk from the main channel into the SAP channel, modulate the aural carrier with a monophonic 4.5 kHz tone to a deviation of 25 kHz. Measure the crosstalk on the digital AC voltmeter.

c. To test crosstalk from the composite stereo subchannel into SAP, modulate the aural transmitter as follows:

(1) Apply a 2 kHz tone (L=R) to the main channel to produce an aural carrier deviation of 12.5 kHz.

(2) Apply a Left-only 8.6 kHz tone at a level resulting in a total aural carrier deviaton by the main and (BTSC compressed) stereo subchannel of 25 kHz. (A second oscillator is necessary.)

(3) Applying both the 2 kHz signal and the 8.6 kHz signal should result in aural carrier deviation by the main channel only of 25 kHz and by the composite stereo signal (minus pilot) of 50 kHz.

(4) The pilot and the SAP subcarrier should be turned on. (The resulting modulation is described in detail in Appendix I of the BTSC Recommended Practices.)

d. Measure the crosstalk at the SAP audio output with the digital AC voltmeter.

### 6.5.4 SAP Subcarrier Frequency Measurement

The SAP subcarrier frequency is nominally equal to $5f_H$ = 78.670 kHz ($f_H$ = horizontal scanning rate = 15,734 Hz). When frequency modulated, the average carrier frequency may show a deviation from the nominal value. The SAP subcarrier frequency may deviate from the nominal value of $5f_H$ = 78.670 kHz by not more than ±500 Hz in the absence of modulation.

## 6.6 Professional Channel

The TV station operator has considerable freedom in operating non- program related subchannels; details are found in Section 2.2.8 of the Recommended Practices, where FCC and OST references are also listed. The professional channel subcarrier frequency is centered at 102.271 kHz.

The only measurements relating to the Professional Channel are to ensure the injection level is no more than ± 3 kHz deviation of the aural carrier and the peak deviation to the Professional subcarrier is no more than ± 3 kHz.

The Professional Channel should not introduce noise to the SAP and stereo channel. This test can be added on to the noise floor measurement in the stereo and SAP noise floor test by turning the Professional Channel subcarrier on and off.