Verifying CAS Test System Performance using the CAS2200 Software

Introduction

This application note outlines a procedure for verifying the performance of the AI 240 CAS Test System using the CAS2200 software. The AI 240 undergoes an extensive computerized testing and alignment procedure at the factory and normally should be re-calibrated at an interval of one year. However, sometimes it is desirable to perform more regular checks of key operational parameters at the user's location without a large amount of sophisticated test equipment. This application note describes such a procedure.

Equipment Required

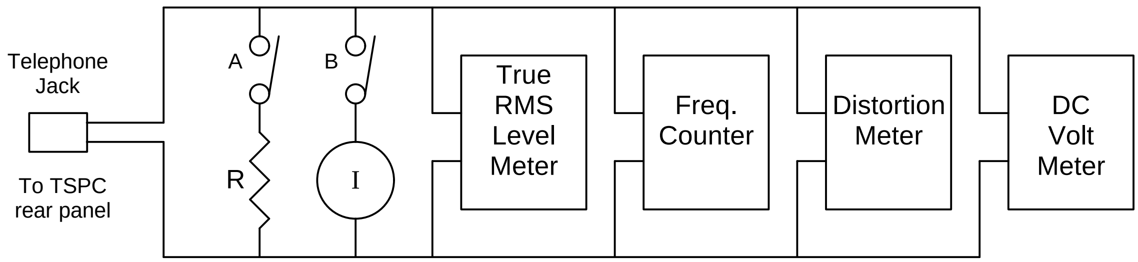
The equipment needed to perform the following tests consists as follows:

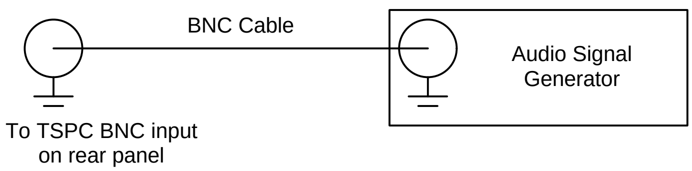
- **True RMS Audio Signal Level Meter:** The meter must have a bandwidth up to at least 20 kHz, with balanced floating inputs. The input impedance of the meter must be at least 100 Kohms.
- **Frequency Counter:** The frequency counter should have balanced floating inputs and an input impedance of at least 1 M ohms.
- **Audio Signal Distortion Meter:** The distortion meter should have balanced floating input and an input impedance of at least 100 Kohms. Also, it should have the option of inserting a C-message weighted filter in the signal path.
- **DC Volt Meter and DC current Meter:** The DC Volt meter must have at least a 1 M ohm input impedance.
- **Audio Signal Generator:** The signal generator required should be able to generate an accurate audio tone at a given frequency and level.
- **A 600 ohm 2 Watt Resistor:** This should be a high precision resistor with a low temperature coefficient. The value of the resistor should be measured before inserting into the test setup. Knowing the exact value of the resistor will improve the accuracy of the test setup, as a correction factor can then be calculated.

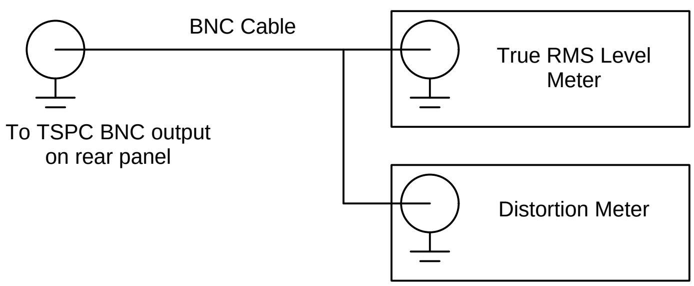
Many of the instruments listed above are generally available combined together into one instrument. For example, the HP34401A True RMS Multimeter can serve as the audio level meter, frequency counter, DC voltage meter, and DC current meter. Likewise the HP8903B Audio Analyzer can be used as the audio level meter, distortion meter, and audio signal generator.

Test Setup

The following diagram shows the test setup required to perform the following tests. Two switches label A and B are used to place the 600 ohm resistor R or a DC current meter across the tip and ring lines respectively. The other four instruments are also placed across the tip and ring lines, and can remain connected for the entire test. However it is important that the input impedance's of the instruments be very high. The loading of an extra 100 kohms will reduce the measured level by only 0.03 dB. However, two instruments at 100 kohms will reduce the measured level by 0.06 and three by 0.09 dB, which is becoming a significant amount. As such, it is important to be aware of the effect of the measuring equipment when attempting to take accurate measurements.

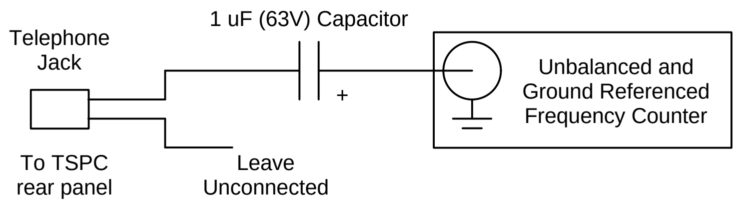






It is also important that the meters and frequency counters used have balanced and floating inputs. If this is not the case, then the CAS2200 will display "Unbalanced", indicating the lack of balanced floating inputs on the test equipment. While most meters have balanced floating inputs, it may be more difficult to locate a frequency counter with a balanced floating input. However, most often the audio signal meter includes the capability to measure signal frequencies.

If the frequency counter does not have balanced floating inputs, then for **only** the frequency measurements, use the following test setup.



Note: In this setup, if the frequency counter and PC that contains the TSPC are not **both** properly connected to earth ground, a large amount of 50/60 Hz hum noise can effect the measurements.

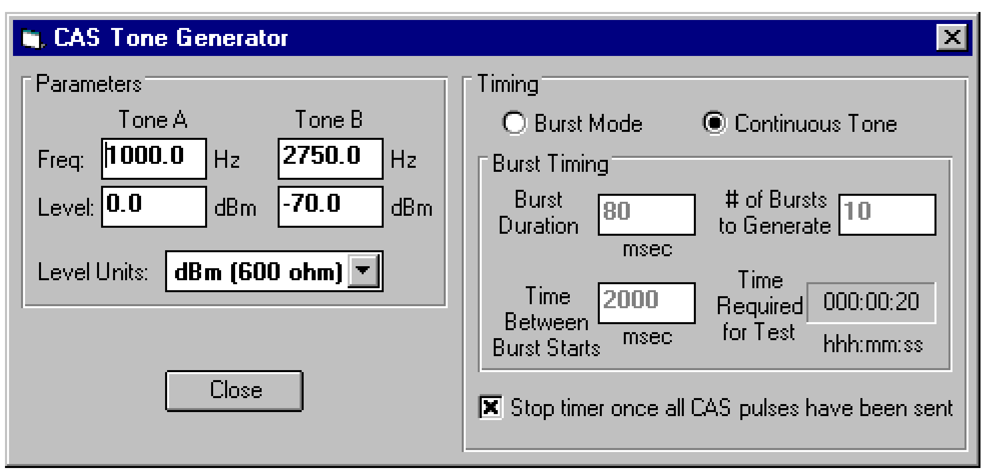
Testing Procedure

CAS2200 Program Setup

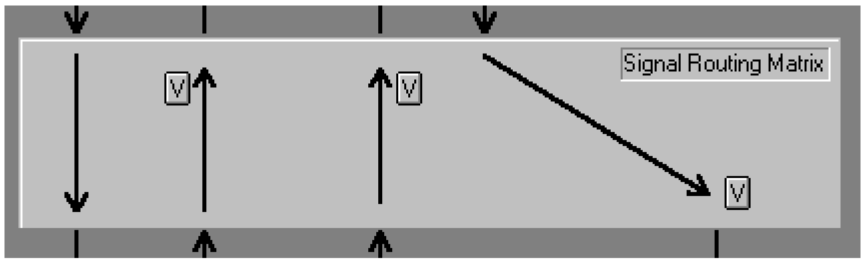
The first step in performing the tests is to properly setup the CAS2200 program. To accomplish this, follow these steps:

1) Run the CAS2200 program, by using either the Windows Program Manager, File Manager, or the Win95 Start button.

2) Display the CAS tone generator settings by either double clicking the mouse on CAS generator panel, or select the menu command [Settings] [CAS Tone Generator]. Change the Tone A settings to 1000 Hz at a level of 0 dBm. Also change the timing mode to “Continuous Tone” from “Burst Mode”.



3) Change the signal flow such that the equalizer output is only directed to the BNC output, as shown in the following figure.



Part A: CAS Tone Generator

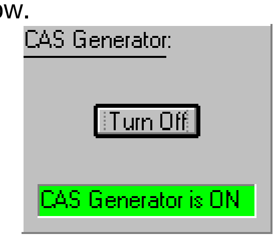
The proper calibration of the CAS tone generator is verified by measuring its absolute level accuracy, flatness over frequency, frequency accuracy, and distortion. The specifications are as follows:

Specifications:

Measurement	***Specification***
Absolute Level Accuracy at 1 kHz, 0 dBm	+/- 0.3 dB
Level Flatness from 100 Hz to 5 kHz at 0 dBm	+/- 0.1 dB
Level Flatness from 50 Hz to 10 kHz at 0 dBm	+/- 0.3 dB
Frequency Accuracy at 1 kHz, 0 dBm	+/- 0.015 %
C-message Weighted Distortion at 1 kHz, 0 dBm	< 0.09 %

Procedure:

1) Terminate the telephone into 600 ohms by closing switch A in the test setup. Then enable the CAS tone generator by clicking the mouse on the on/off button in the CAS tone generator panel window. The CAS2200 program should indicated that the telephone line is “off-hook” along with the tone generator being active, as shown below.



2) Record the level present at the Tip and Ring leads with the Audio Signal Level Meter. If the resistor R has an impedance of exactly 600 ohms, then the measured level must be within +/- 0.3 dB of 0 dBm. If the resistor R is not exactly 600 ohms, use the following formula. The result must be within +/- 0.3 dBm. This result is the absolute level accuracy at 1 kHz.

$$Vmeas(dbm) - 7.959 - 20 \cdot \log\left[\frac{R}{R+900}\right]$$

3) Zero the audio signal level meter, or if the meter does not support that option, record the level at 1 kHz. Change the frequency of the tone being produced to each of the following frequencies. Then record the reading of the level meter, assuming the level meter has been zeroed. If not, record the difference between the level meter reading and the recorded reading taken at 1 kHz.

Frequency	***Level Relative to 1 kHz (dB)***	***Flatness Spec***
50 Hz		B
100 Hz		A
200 Hz		A
400 Hz		A
1000 Hz	0.00	A
1500 Hz		A
2000 Hz		A
5000 Hz		A
7000 Hz		B
10000 Hz		B

In the region of 100 Hz to 5 kHz (flatness spec A), the absolute maximum value recorded in the above table must not exceed +/- 0.1 dB.

Likewise in the region of 50 Hz to 10 kHz (flatness spec B), the absolute maximum value recorded in the above table must not exceed +/- 0.3 dB.

4) Return the frequency of the tone to 1 kHz.

5) Using the frequency counter measure the frequency of the tone. The error in the frequency is given by the following formula. The result must not exceed the specification of +/- 0.015 %.

$$\left[\frac{Fmeas - 1000}{1000}\right] \cdot 100\%$$

Note: Verify that the frequency counter used provides at least resolution to 0.01 Hz. Otherwise the measurement will have a high degree of uncertainly.

6) Using the distortion meter, with the C-message filter engaged, measure the THD+N (total harmonic distortion plus noise) of the 1 kHz signal. The measurement must be below 0.09% or -61 dBc.

Part B: CAS2200 Level Meter

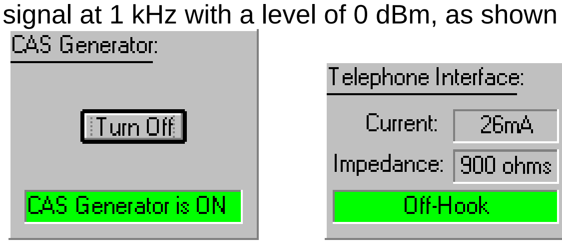
The level meter present in the CAS2200 software can be verified in one of two manners. These are by measuring a known signal on the Tip and Ring leads, or by measuring a known signal on the BNC input connector. This procedure uses the former. The key specifications for the level meter are absolute accuracy at 1 kHz and the flatness range over 100 Hz to 5 kHz.

Specifications:

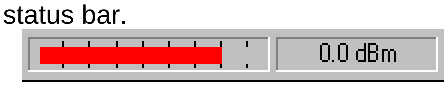
Measurement	*Specification*
Absolute Level Accuracy at 1 kHz	+/- 0.2 dB
Level Flatness from 100 Hz to 5 kHz	+/- 0.2 dB

Procedure:

1) Continuing from the setup in the previous test, the CAS2200 program should be indicating an “off-hook” state. Also the tone generator should be active, producing a signal at 1 kHz with a level of 0 dBm, as shown below.



2) Record the level reported by the true RMS level meter connected to the tip and ring leads in the table below. Also record the CAS2200 level meter reading as displayed on the status bar.



Frequency (Hz)	*Level Measured on Tip and Ring (dBm) A*	*Level Measured by CAS2200 (dBm) B*	*Column A - B (dB)*
100 Hz			
200 Hz			
400 Hz			
1000 Hz			
1500 Hz			
2000 Hz			
5000 Hz			

3) Repeat for all of the other frequencies listed in the above table. Then compute the difference in level measured by the two meters. The maximum difference must not be more than +/- 0.2 dB.

4) Disable the CAS tone generator by clicking the mouse on the on/off button in the CAS tone generator panel window. Also open switch A, such that the telephone interface panel is reporting the line condition as “on-hook”.

Part C: Signal Equalizer

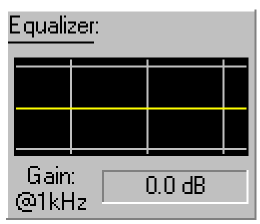
The signal equalizer is normally used to apply either a level gain or loss to a voice signal for talkoff and talkdown testing, along with having the ability to change the spectral shape of the voice signal. In order to verify its performance, a known signal is injected into the BNC input connector while a level meter and distortion meter measure the signal characteristics at the BNC output connector.

Specifications:

Measurement	***Specification***
Absolute Level Accuracy at 1 kHz, 0 dBV	+/- 0.3 dB
Level Flatness from 100 Hz to 5 kHz at 0 dBV	+/- 0.2 dB
C-message Weighted Distortion at 1 kHz, 0 dBV	< 0.09 %

Procedure:

1) Verify that the equalizer is set to a flat response with a gain setting of 0 dB, as shown below.



2) Enable the signal generator connected to the BNC input, with a 1 kHz tone at a level of 0 dBV. If unsure of the accuracy of the signal generator, connect the signal meter to the output of the signal generator and verify its output level.

3) Using the signal level meter, measure and record the output level present at the BNC output connector. The difference between this output level and the level at the input BNC connector must be less than +/- 0.3 dB. This value represents the absolute accuracy of the signal equalizer. Place this value in all rows for column B in the table below.

4) Change the frequency of the signal generator to the values in the table below. Measure and record, in column A, the BNC output levels for all of the frequencies listed. If unsure of the flatness of the generator, measure the generator output level for each frequency and record the difference between the output and input values.

Frequency (Hz)	***Level Difference Between Input and Output (dB) (A)***	***Level Difference Between Input and Output Relative to 1 kHz (dB) (B)***	***Column A - B (dB)***
100 Hz			
200 Hz			
400 Hz			
1000 Hz			0.00
1500 Hz			
2000 Hz			
5000 Hz			

5) Computer the difference between column A and column B. This column represents the flatness of the equalizer. The maximum value must be below +/- 0.2 dB.

Part D: Telephone Interface

The telephone interface is characterized in terms of its DC parameters and its AC source impedance. The DC parameters consists of the open circuit voltage present on tip and ring, and the short circuit current flowing between tip and ring. For these two measurements, the DC voltage meter and DC current meter are needed. The AC source impedance is verified by measuring the AC signal change between terminated and unterminated conditions.

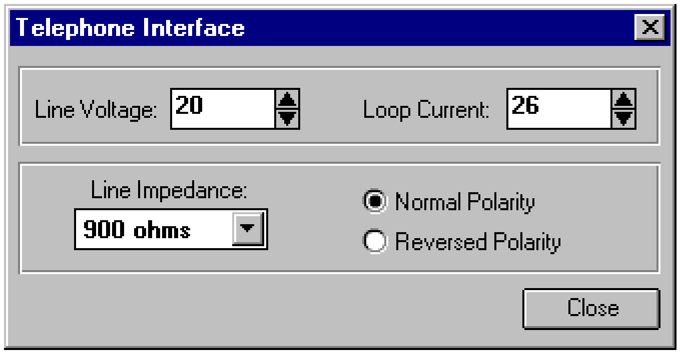
Specifications:

Measurement	***Specification***
Line Voltage Accuracy from 20 V to 52 V	+/- 1 V
Loop Current Accuracy from 20 mA to 40 mA at 48 V*	+/- 10 %
600 Ohm Source Impedance Accuracy at 1 kHz	+/- 2 %
900 Ohm Source Impedance Accuracy at 1 kHz	+/- 2 %

* After two minutes in order to stabilize thermal drifts

Procedure:

1) Using the Telephone Interface Settings window, set the Line Voltage to 20 Volts. Record the measurement of the DC voltage meter in the table below. Repeat the procedure for all of the different voltage points. The measured voltage should be between the given minimum and maximum values. Note, that depending on the polarity of the DC voltage meter, the measured value may be negative in value. In that case reverse the leads of the voltage meter.



Voltage Setting (V)	*Measured Voltage (V)*	*Lower Limit (V)*	*Upper Limit (V)*
20		19	21
30		29	31
40		39	41
48		47	49
52		51	53

2) Now, reverse the polarity of the telephone interface and verify that the voltage changes polarity from positive to negative and is between the values of -51 and -53 volts.

3) Return the polarity back to the normal setting.

4) Set the Line Voltage back to the default setting of 48 Volts. Then set the Loop Current to 40 mA. Close switch B in the test setup. This places the DC current meter across the tip and ring leads, and starts the flow of current. Thermal effects in the telephone interface will cause the current reading to slow drift downward. As such, the reading should be taken after approximately two minutes to allow the thermal effects to stabilize. Repeat this procedure for loop currents of 30 mA and 20 mA. The measured currents should be between the given minimum and maximum values. Note, that like the voltage reading, the DC current meter may be reading a negative value depending on the connection polarity. If so, reverse the leads on the current meter.

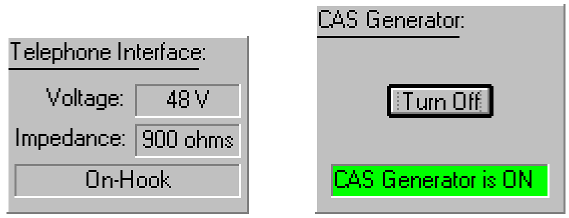
Current Setting (mA)	*Measured Current (mA)*	*Lower Limit (mA)*	*Upper Limit (mA)*
40		36	44
30		27	33
20		18	22

5) Now, reverse the polarity of the telephone interface and verify that the current changes polarity from positive to negative and is between the values of --18 mA and -22 mA.

6) Return the polarity back to the normal setting and set the current to the default value of 26 mA.

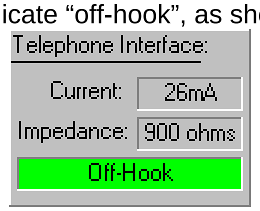
7) Open switch B to disconnect the DC current meter from the tip and ring leads.

8) Enable the CAS tone generator for a 1 kHz tone at a level of 0 dBm. As shown below, the program should indicate an “on hook” state, with the tone generator enabled.



9) Using the audio level meter, measure the signal level across the telephone line. Record this value as Vref. This level should be close to 7.96 dBm.

10) Close switch A to terminate the line into resistor R (600 ohms). The telephone interface panel should indicate “off-hook”, as shown below.



11) Using the audio level meter, measure the signal level across the telephone line. Record this value as V900. This level should be close to 0 dBm.

12) Using the formula below, calculate the value of Imp900. It should be within 2 % (18 ohms) of 900 ohms. Note that for the following formula, the units of V900 and Vref are dBm.

$$IMP900 = \frac{R \cdot \left[1 - 10^{\left[\frac{V900 - Vref}{20}\right]}\right]}{10^{\left[\frac{V900 - Vref}{20}\right]}}$$

12) Change the telephone interface source Impedance setting to 600 ohms. Again measure the signal level with the Audio Level meter. Record this value as V600. This level should be close to 0 dBm.

12) Using the formula below, calculate the value of Imp600. It should be within 2 % (12 ohms) of 600 ohms. Note that for the following formula, the units of V600 and Vref are dBm.

$$IMP600 = \frac{R \cdot \left[1 - 10^{\left[\frac{V600 - Vref + 1.94}{20}\right]}\right]}{10^{\frac{V600 - Vref + 1.94}{20}}}$$