MEASURING HUM MODULATION
USING MATRIX MODEL HD-500 HUM DEMODULATOR

The SCTE defines hum modulation as, “The amplitude distortion of a signal caused by the modulation of the signal by components of the power line frequency. **It is the ratio, expressed in dB, of the peak-to-peak variation of the carrier to the peak of the carrier**”.
This distorting modulation usually has some form of a trapezoidal waveform because the power supply used in most applications has a trapezoidal 60 Hz waveform.

The most common method of making this measurement is to input a single CW carrier into the device under test and connect the output of the device under test to a diode detector. The output of the detector is then amplified filtered and displayed on an oscilloscope. This setup is somewhat more complicated than indicated here because great care is required in calibration as well as shielding from residual signals. An oscilloscope with digital averaging is usually required because the signal is usually less than the noise level.

The MATRIX MODEL HD-500 has the ability to generate an output signal related only to the degree of the modulation and is independent of the carrier level over a 40 dB range. Further no calibration is required. Once the output signal is displayed and measured, the degree of hum modulation can be calculated or read from a graph. (See pages 5 and 6)

The FIG 1 is a block diagram of a setup for measuring hum modulation. The HD-500 uses a log detector, which has the characteristic of producing an output proportional to the degree of modulation, and independent of the carrier level over a range of 40 dB. This feature is very useful because it simplifies and speeds up the measurement without any loss in accuracy. The log detector clearly does distort the demodulated signal but for modulations of less than 1% the error is trivial and for modulations of 10% is still very small. 1% modulation from a standard signal source is –34 dB modulation under the SCTE definition,

1.0 SIGNAL SOURCE

For this application a signal source with residual hum and low frequency modulations must be lower than the levels that are to be measured. Many signal sources will have hum levels that limit the measurement floor.

2.0 MODEL HD-500 HUM MODULATION DETECTOR MODULE

The Model HD-500 HUM MODULATION DETECTOR MODULE is made up of two basic components.
A broad band Log-amp-detector and a low noise phase-compensated video amplifier with automatic DC zero.

2.1 LOG-AMP-DETECTOR

The log-amp-detector has the characteristic of generating a voltage proportional to the Log of the input carrier. This results in an output, which for the same modulation level, is independent of the carrier level. This characteristic is maintained over 40 dB of amplitude and over an RF input frequency range of 5 to 1500 MHz. The transfer constant, that is Volts per dB change in level is also stable. The use of a Log detector clearly distorts the detected waveform but for modulation levels of less than 1% the error is trivial.

2.2 INTERNAL AMPLIFIERS AND FILTERS

Following the LOG-AMP-DETECTOR is a 10 Hz high pass filter, a low noise video amplifier and a 500 Hz low pass filter. The output of the log-amp-detector is high passed through a 10 Hz HP filter to remove the DC component. It is then amplified by the low noise 60 dB gain video amplifier followed by a 500 Hz low pass filter. The low pass filter limits the bandwidth and the associated noise. Hum components above 360 Hz are negligible.

Because it is necessary to measure the peak-to-peak value of the distorting signal and the signal has components as low as 60 Hz the amplifier and the display must be able to display a 60 Hz square wave with out distortion. Most oscilloscopes can not meet this specification in the AC coupled mode and using the DC coupled mode requires some voltage offset voltage stability in the video amplifier. The usual coupling capacitor would have a relatively long settling time so an active circuit is used to provide low offset voltage.

The video amplifier also includes a phase compensating network so that the relative phase of the modulation components can be maintained. This assures that the amplifier does not distort the modulating waveform.

Also included are high and low level alarms, which provide a warning if the carrier level is too high or too low in level.

3.0 OSCILLOSCOPE

The choice of oscilloscope is not trivial. It may seem that the measurement of 60 Hz signals is an easy task but because the measurement requirements are so severe, a digital oscilloscope with 1 mV sensitivity and signal averaging is a minimum requirement. For applications where computer control of the measurements is desired, IEEE-488 control is also required.

4.0 OPERATION

The operation of the hum test is straightforward.

4.1 Install the device under test.

4.2 Apply a carrier at the desired frequency and at the normal operating level. Verify that the carrier level is not out of range by noting the carrier level status indicator.

4.3 Set the oscilloscope SYNC to LINE.

4.4 Set the sweep speed to approximately 50mS

4.5 Set input to DC coupled.

4.6 Increase sensitivity of oscilloscope until a signal is seen. If the distortion is small, it may be necessary to use averaging to suppress the residual noise.

4.7 Read the peak to peak voltage in millvolts. Record as Vdis.

4.8 Calculate the hum modulation as

HUM(dB) = -40 dB + 20 log(Vdis/3000 mV)

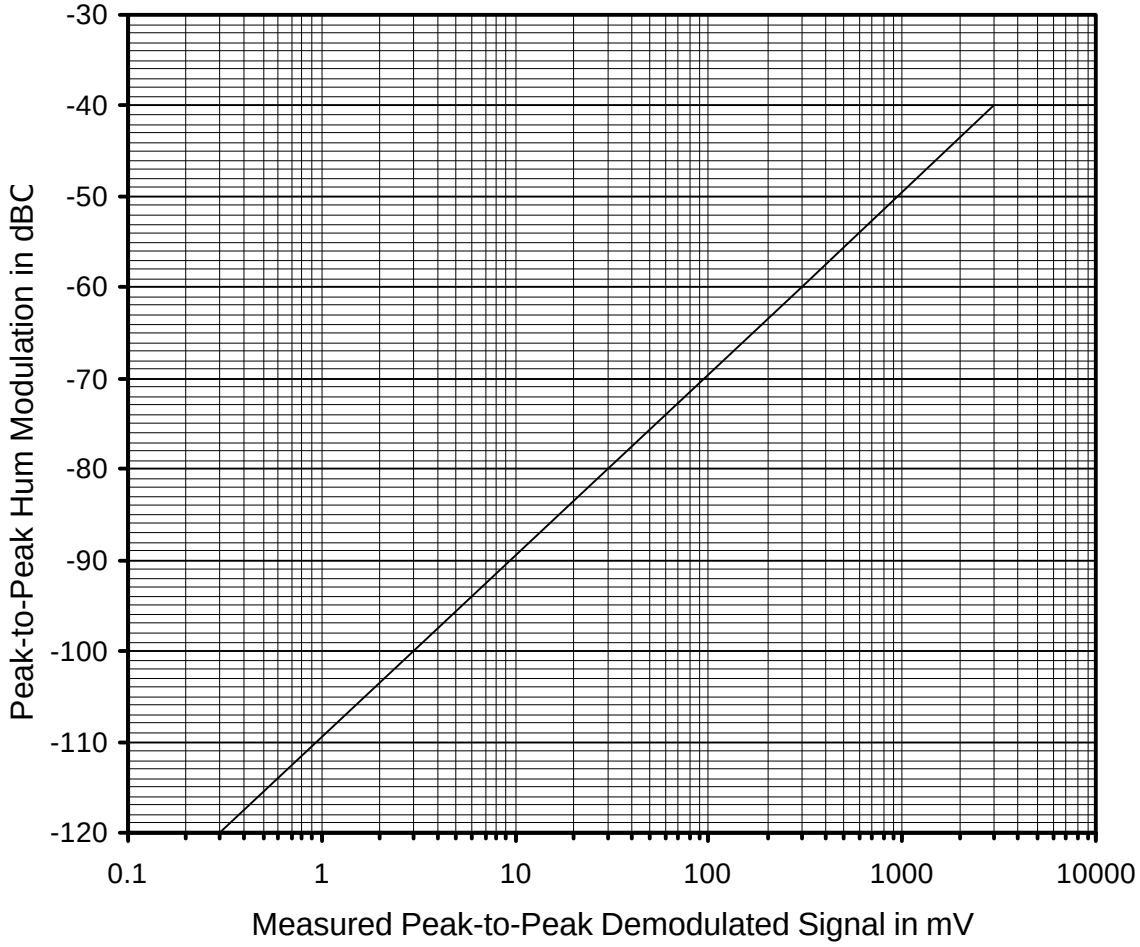
For example if Vdis = 100 mV

HUM(dB) = - 40 dB + 20 log(100 mV/3000 mV)
= - 40 dB - 29.5 dB
= - 69.5 dB

If Vdis = 10 mV

HUM(dB) = -40 dB + 20 log(10 mV/3000 mV)
= -40 dB - 49.5 dB
= - 89.5 dB

MATRIX TEST EQUIPMENT MODEL HD500 HUM DEMODULATOR
Peak to peak Hum (dBC) Vs Measured Peak to Peak Demodulated Signal(mV)



MATRIX MODEL HD-500
HUM DETECTOR (DEMODULATOR)

The MATRIX Model HD-500 is a detector-amplifier designed to demodulate the low frequency amplitude modulations on any RF carrier over the range of 5 to 1500 MHz. These modulations are usually the undesirable result of the 50 or 60 Hz power source and are not necessarily sinusoidal. The unit is calibrated to the SCTE definition of hum modulation, which is the ratio of the peak-to-peak hum modulation to the peak of the carrier. The magnitude of the demodulated signal is proportional to the degree of modulation and independent of the carrier level over a range of -10 to -50 dBm.

Some of the important specifications follow.

RF frequency range	5 to 1500 MHz
RF input power range	-10 to -50 dBm
Input return loss	> 15 dB, 50 Ohm 75 Ohm optional
Output voltage	3000 mV peak to peak for -40 dBC Hum 300 mV peak to peak for -60 dBC Hum 30 mV peak to peak for -80 dBC Hum 3 mV peak to peak for -100 dBC Hum
Noise floor	< -105 dBC
Maximum output voltage	20 Volts peak to peak
Modulation bandwidth	5 Hz to 500 Hz. Internal amplifier provides linear phase response. A 60 Hz square wave is reproduced with less than 2% tilt.
Power requirements	+15 Volts and -15 Volts @ 50 mA each
External equipment required	1. Digital storage oscilloscope with signal averaging capability. 2. Carrier source with hum modulation levels lower than the levels that are to be measured.
Overall accuracy	+/- 1 dB for carrier and modulation levels specified above

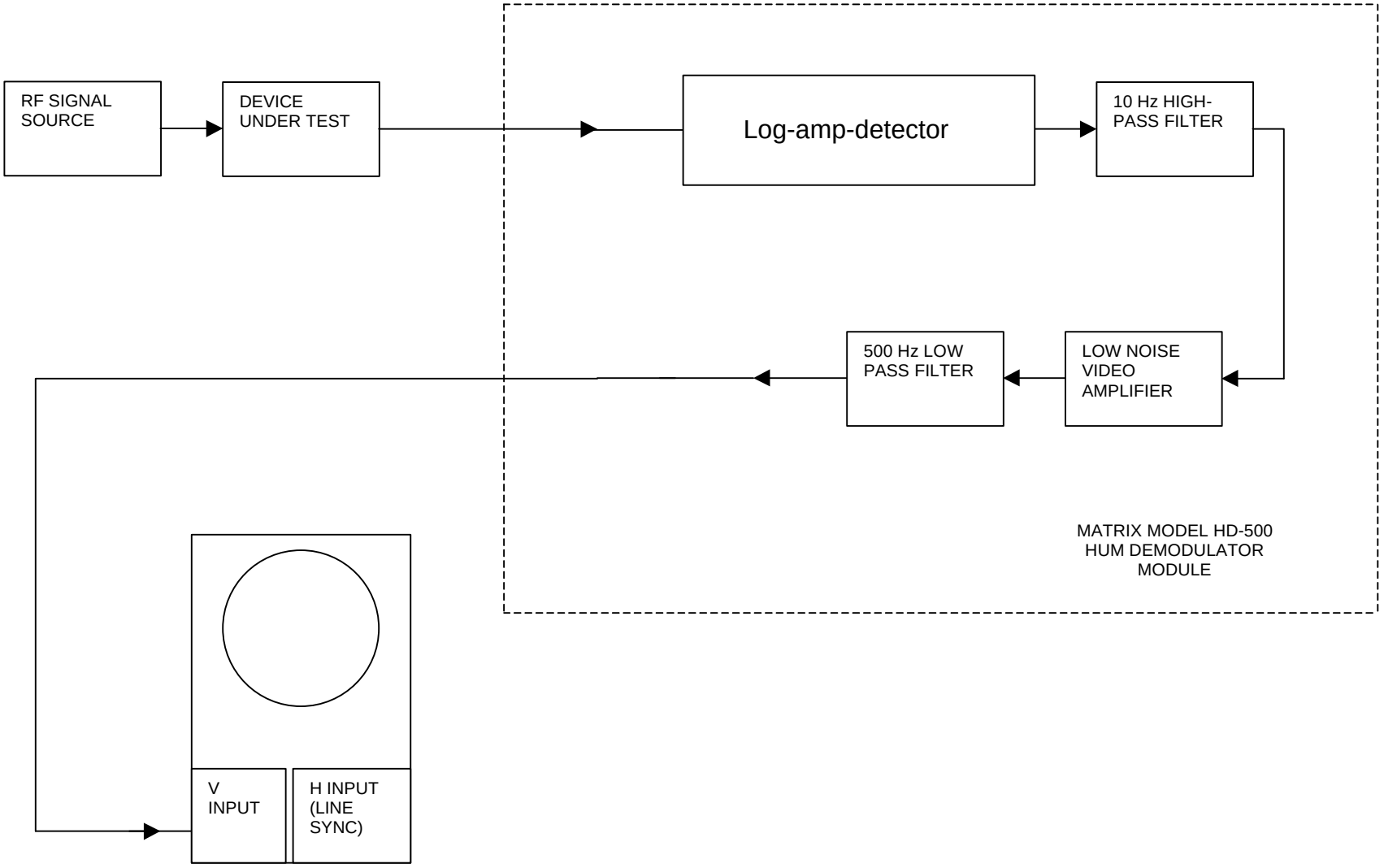


FIG. 1
HUM MODULATION TEST BLOCK DIAGRAM