

A TEST SYSTEM FOR CONTROLLED SUBJECTIVE TESTING OF CABLE SYSTEM IMPAIRMENTS

Tom Elliot
Cable Television Laboratories, Inc.

Joseph B. Waltrich
Jerrold Communications
Applied Media Lab

ABSTRACT

This paper describes an integrated test system for generating controlled CATV impairments. This system is being used in a program of subjective testing to evaluate the effects of these impairments on cable television transmission. This study is sponsored by CableLabs and is being conducted at the Jerrold Communications Applied Media Lab in Hatboro, PA. The system described herein is capable of generating controlled levels of five different impairments, singly or in combination. Provision is made for automated system operation, including acquisition of viewer opinions of picture quality.

INTRODUCTION

This paper presents a detailed description of the impairment test hardware originally described by Jeffers [1]. The test system described herein is capable of generating the following impairments to NTSC transmission:

- o Random Noise
- o Distortions
- o Phase Noise
- o Chroma/Luma Delay
- o Micro-reflections

The system is capable of generating these impairments singly and in any combination. The system is an automated system in which impairment levels, viewer response and subjective test data acquisition are all under computer control.

SYSTEM DESCRIPTION

General Description

A block diagram of the test system is shown in Fig. 1. For subjective testing, the input video source is a Pioneer LDV8000 Laser Disk Player. Source material for the tests consists of a series of still sequences which were recorded onto the disk from D2 tape. Weighted video SNR of the source is in the range 53 - 55 dB, depending on the scene selected. A mechanical routing switcher is inserted between the video source and the system in order to facilitate input of test signals for system setup and calibration.

All impairments are generated at RF with the exception of Chroma/Luma delay and phase noise, which are generated at baseband and IF, respectively. A 64 channel headend is used to generate distortion products. Cable ready receivers are used to view the

system RF output. The demodulated output is also fed to an Anritsu MS6301B video signal analyzer for measurement of various video parameters. A D2 VCR is available for recording impaired output sequences.

A Jerrold Commander V frequency agile modulator is used for RF conversion of the baseband signal. The modulator output (47.5 dBmV) is attenuated, combined with the headend output and amplified prior to being input to the impairment generation circuitry at a level of 35 dBmV. The frequency of the reference channel modulator was set to Channel 38 (307.26 MHz).

IMPAIRMENT GENERATION

Chroma/Luma Delay

A series of cascaded allpass networks (Fig. 2) are used to generate chroma/luma delay. Each section of the cascade will produce a delay of about 50 nS. The cascaded sections are switched in binary combinations of 100, 200 and 400 nS to generate a maximum delay of 700 nS. System delay was calibrated by inputting a 12.5T pulse and measuring the C/L delay using the video analyzer.

Random Noise

A Noisecom Model 8110 noise generator is used as a noise source. This generator produces random noise in the frequency range 100 Hz to 1 GHz at an output level of 33 dBmV. Noise is added to all of the channels in the system prior to generation of distortion products. A programmable attenuator at the output of the noise generator permits control of the noise level.

Weighted video signal to noise ratio was measured using the Anritsu analyzer. The system is capable of generating SNR's in the range 24 to 50 dB.

Random noise can also be added to the baseband video signal as shown in Fig. 1. A second output from the noise generator is resistively combined with the video signal and the combined signal + noise is fed to the television receiver baseband input. Signal to noise ratios measured at baseband were essentially the same as those measured at RF.

Distortions

A 64 channel headend is used to generate distortion products. The headend uses a total of 16 video sources, each of which is split 4 ways at IF and then up-converted to RF. The headend is capable of being operated in standard, HRC and IRC modes. The headend output and the reference channel are combined and input to a cascade of four Jerrold XRTM-550 amplifiers to generate distortion products. Fixed attenuators are placed between each stage of the cascade and the gain of each amplifier is adjusted to produce 8 dB gain through the cascade. (The 8 dB gain figure is used in order to compensate for insertion losses of the external attenuators and couplers).

Composite distortions are produced by overdriving the cascade. The input level to the cascade can be varied from approximately 16 dBmV (no distortions) to 31 dBmV via a programmable attenuator. A second programmable attenuator is located at the cascade output. The cascade input and output attenuators are

ganged so as to produce a constant level of 20 dBmV at the attenuated output of the cascade.

Using the above-mentioned headend, the number of triple beats falling into the reference channel is in excess of 1100. The reference channel receives about 18 second order beats. The range of distortion levels is controllable from -25 to -55 dB.

Phase Noise

Phase noise is generated by inserting a variable phase shift network in the IF loop of the modulator. The phase shift network is driven by a pseudorandom data generator (Fig. 3) whose output is low passed to 300 KHz and amplitude limited under control of the system computer. Phase noise is measured using the method described by Pike and Pidgeon [2]. The system is capable of generating phase noise in the range -59 to -93 dBc/Hz.

Micro-Reflections

The circuitry for generating micro-reflections is shown in Fig. 4. The signal out of the cascade is split into five separate paths: an undelayed path and four delayed paths. RG-11 cable, having an attenuation of approximately 2.5 dB per 100 ft. at 300 MHz, is used to produce the desired delays. Cable lengths of 50, 100, 200 and 400 feet are used to generate delays of 58.4, 116.8, 233.6 and 467.2 nS, respectively. The cables are trimmed to produce phase coherent delays at the combined output of the delayed and undelayed signals. Delay paths may be selected individually or in combination to produce single or multiple reflections. Fixed attenuators in each delay path are

used to set equal signal levels through each delay path. A single amplifier and programmable attenuator are used to control the level of the delayed signals relative to the undelayed signal.

After combination, the delayed signals are fed through a variable delay network consisting of short pieces of cable which are cut to provide delays of 1/8, 1/4, 1/2 and 1 wavelength at the reference channel. This unit serves as a "digital trombone" to permit generation of in-phase and out-of-phase delays. The system will generate micro-reflections up to 0 dB relative to the level of the main signal.

CONTROL AND DATA ACQUISITION

All critical system functions are automated. An IBM compatible PC is used as the system controller. The computer is equipped with a National Instruments xxxxx IEEE-488 interface for instrument control. A Hewlett-Packard HP3497 Control and Data Acquisition unit serves as the interface between the IEEE-488 bus and the programmable attenuators and switches. These elements are controlled by contact closures from a series of HP44428A Relay Actuator cards in the HP3497 controller. Manual control of the system is also provided via a switch panel as shown in Fig. 5. An example of the control circuitry is shown in schematic form in Fig. 6.

The system control elements are Alan Industries Model 75MDA127 programmable attenuators and Tri-Lithic 7002F coax switches. The attenuators are programmable in 1 dB increments up to 127 dB. Insertion loss is about 3 dB and frequency response is within ± 0.7 dB over a frequency range of 0 - 1 GHz. The switches have a maximum insertion loss of 0.2 dB up to 650 MHz.

An H8568B Spectrum Analyzer serves as the principal instrument for RF measurements. The analyzer interfaces directly to the IEEE-488 bus.

The system is also capable of automated recording of viewer opinions of picture quality. This is done via a handheld device, known as the Subjective Quality Input Device (SQUID) which interfaces to the system via the HP3497. A photograph of the SQUID is shown in Fig. 7 and a schematic of the device is shown in Fig. 8. A linear potentiometer, biased to read from 1-5V in order to correspond to an impairment scale of 1-5, is set by each viewer to reflect his/her opinion of the picture quality. After a selection is made, the ENTER button is depressed, causing the SQUID's sense output to change state. The computer polls the sense line of each SQUID and, if the sense output of a particular device is high, that device's data output (i.e. - the voltage corresponding to the pot setting) is read by the computer.

Each SQUID interfaces to the computer via connections to an HP44421A Analog Multiplexer card in the HP3497. The SQUID outputs are read by the internal DVM in the HP3497 and the viewer assessment data are stored in the computer data base.

SYSTEM SOFTWARE

All of the control and data acquisition software for the system is written in the C language. The operator interface to the system control functions is menu driven. The operator interface menu is shown in Fig. 9. Selection of a particular test is made via the PC's function keys (F1 - F10).

Once a test has been selected, the program automatically steps through the test sequence. The system control functions include laser disk frame selection (via an RS-232 interface), setting of attenuators and switches and polling of viewer responses. These functions are repeated several times for each test sequence.

Test sequence control is accomplished via a series of test scripts which are called by the program. These test scripts are ASCII files which can be modified using a text editor to facilitate addition and/or changes to test sequences as required. A sample test script is shown in Fig. 10.

System re-calibration is also accomplished via a series of ASCII files. These files are simply lookup tables which relate attenuator settings to corresponding impairment values.

SYSTEM CONFIGURATION

A photograph of the impairment test system is shown in Fig. 11. The impairment generation circuitry is housed in two racks. The left hand rack contains the manual control panel, the video and RF circuitry and the system power supplies. The right hand rack houses the delay cables, the HP3497 controller, the spectrum analyzer and a 13" TV receiver which is used by the system operator to monitor picture quality and impairment levels.

RECEIVER MEASUREMENTS

27" cable ready receivers are used for all subjective tests. The receivers were purchased from local distributors and, presumably, exhibit typical product performance characteristics.

Signal to noise measurements were made on four receivers. The video source for these measurements was a Tektronix 1910 signal generator having a weighted video SNR of about 61 dB. The signal was modulated using the Commander V (SNR \approx 58 dB) and fed to the receiver RF input. An attenuator in the receiver input line was used to adjust input signal levels. The input level was measured using the spectrum analyzer. Signal/noise ratios were measured at each receiver's baseband output using a Rhode & Schwartz UPSF2 video noise meter.

Fig. 12 presents the results of the SNR measurements. The knee for most of the curves occurs at about +5 dBmV with a spread of about 6dB in the individual receiver SNR's at this point.

CONCLUSIONS

An automated test system, capable of generating typical cable system impairments, has been developed for CableLabs' program of NTSC subjective testing. It is expected that this system will see increasing use for both subjective and objective testing in a simulated cable environment.

REFERENCES

- [1] M. Jeffers, "Controlled Subjective Testing of Cable System Impairments to Picture Quality Using Psychophysical Methods", NCTA Technical Papers, 156--159, 1990.
- [2] R. Pidgeon, D. Pike, "Oscillator Phase Noise and its Effects in a CATV System", NCTA Technical Papers, 1988.

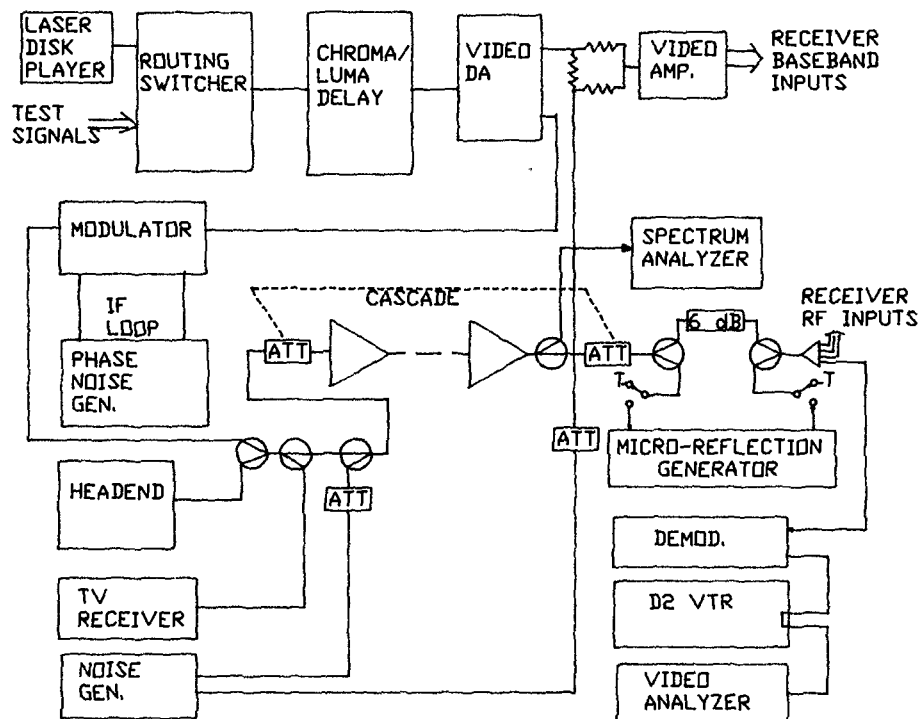
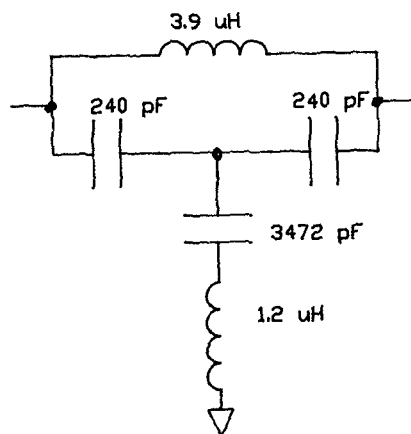
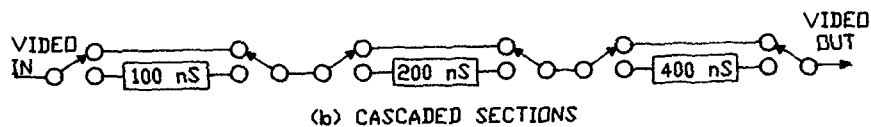


FIG. 1 SYSTEM BLOCK DIAGRAM



(a) SINGLE DELAY SECTION (50 nS)



(b) CASCADED SECTIONS

FIG. 2 CHROMA/LUMA DELAY GENERATOR

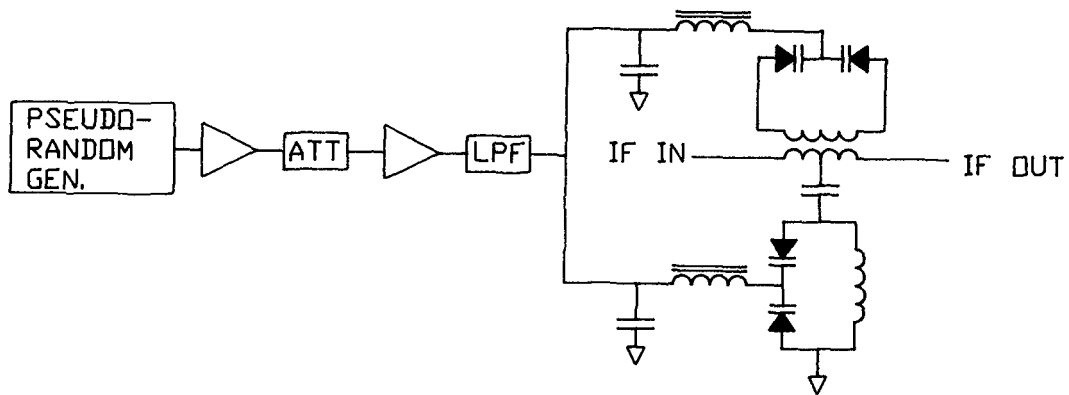


FIG. 3 PHASE NOISE GENERATOR

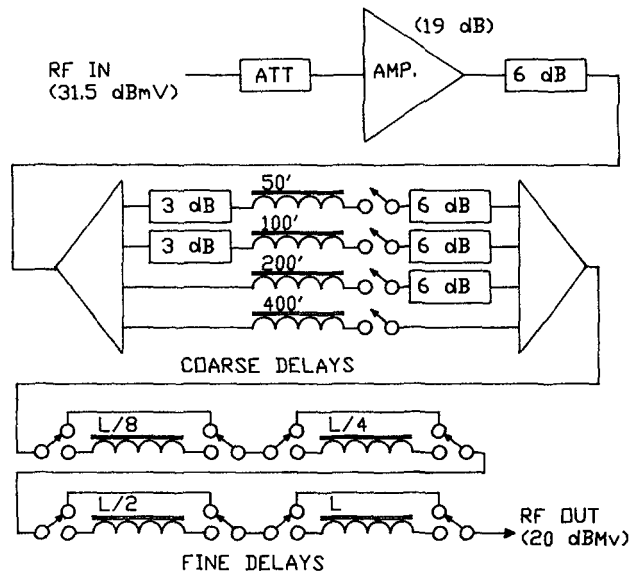


FIG. 4 MICRO-REFLECTION GENERATION

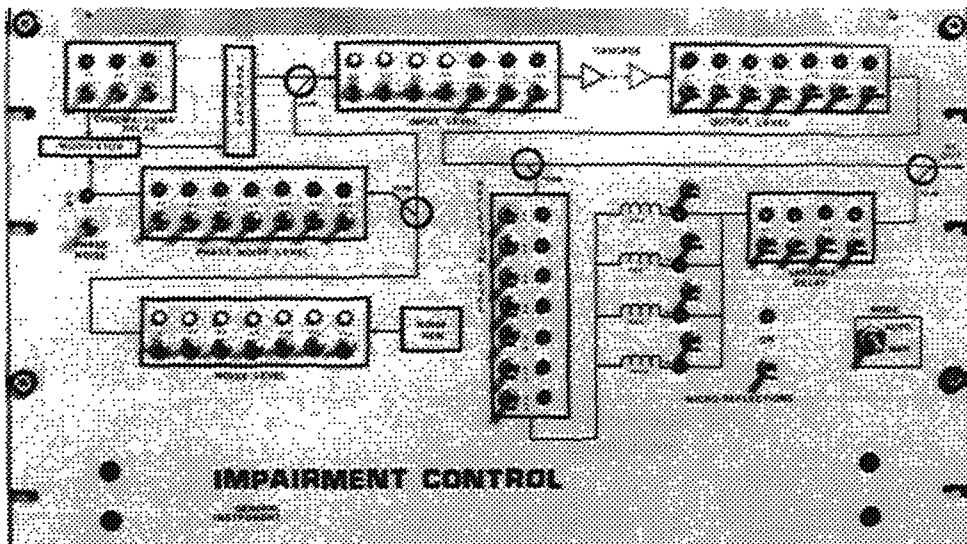


FIG.5 SYSTEM CONTROL PANEL

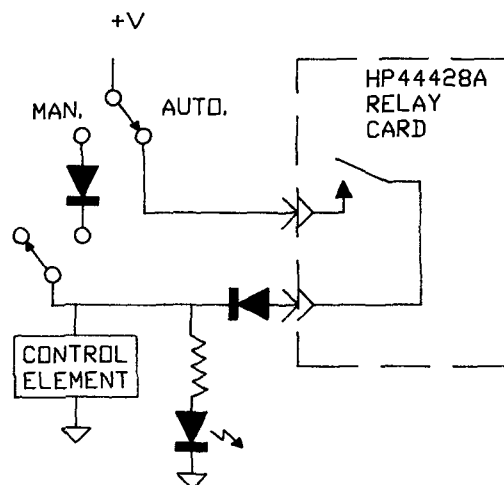


FIG. 6 CONTROL CIRCUIT SCHEMATIC

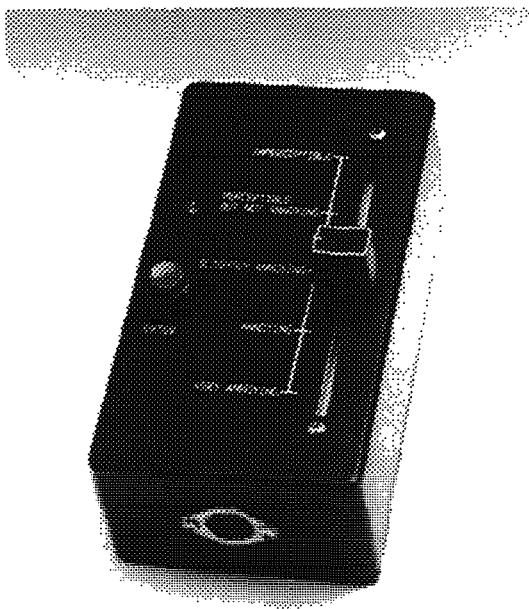


FIG. 7-SQUID

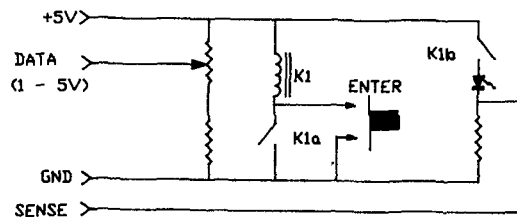


FIG. 8 SQUID SCHEMATIC

NTSC Subjective Tests Main Menu	
F1	Noise Test
F2	Phase Noise Test
F3	IM-2 Test
F4	IM-3 Test
F5	Envelope Delay Test
F6	Micro-Reflections Test
F7	Set Up
F8	
F9	
F10	Exit

FIG. 9 OPERATOR INTERFACE MENU

```

# Script file to control test setup

viewers      2      1      2      3
frames       2      35     230    3290
presentations 1
noise        7 14 20 24 26 30 36 50
phase_noise  6 15 20 25 30 35 40
lm2          7  0  2  4  6  8 10 12
lm3
env_delay    5 50 100 200 300 400
micro_refl_L 6 54 56 58 60 62 64
micro_refl_P 2  0 180
micro_refl_D 4  58 116 233 467

iballoons Shirley night_ext
iattn settings
iattn settings
iinput attn settings
i not used
ins
iattn settings
ipphase
idelays (ns)

```

FIG. 10 TEST SCRIPT

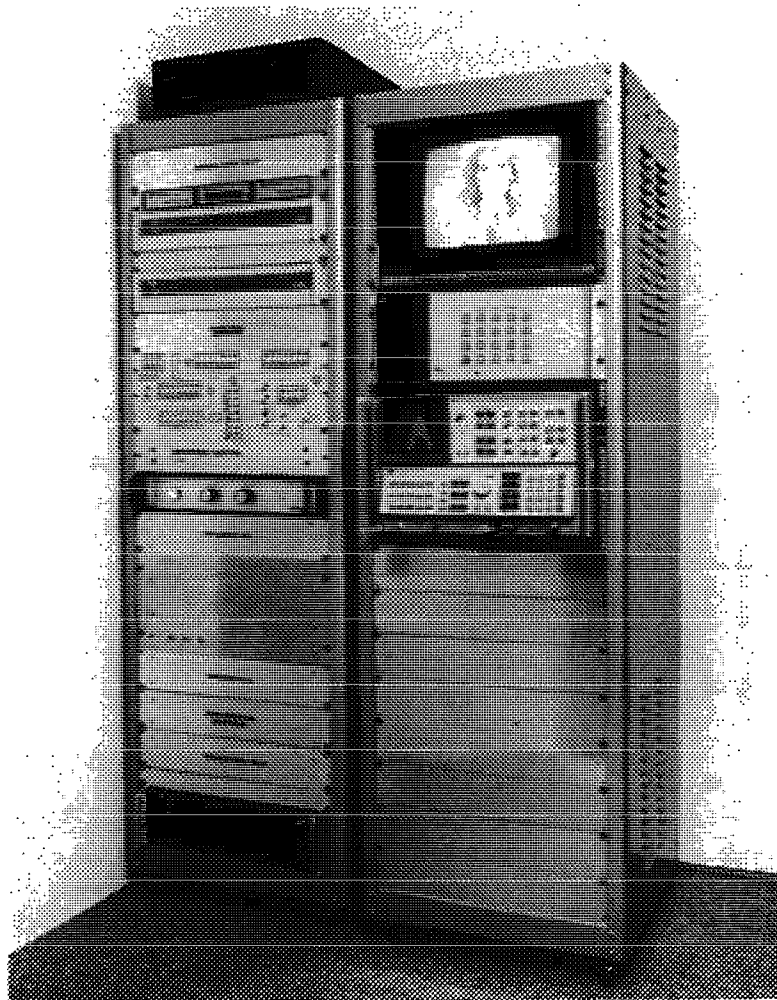


FIG.11 TEST SYSTEM CONFIGURATION

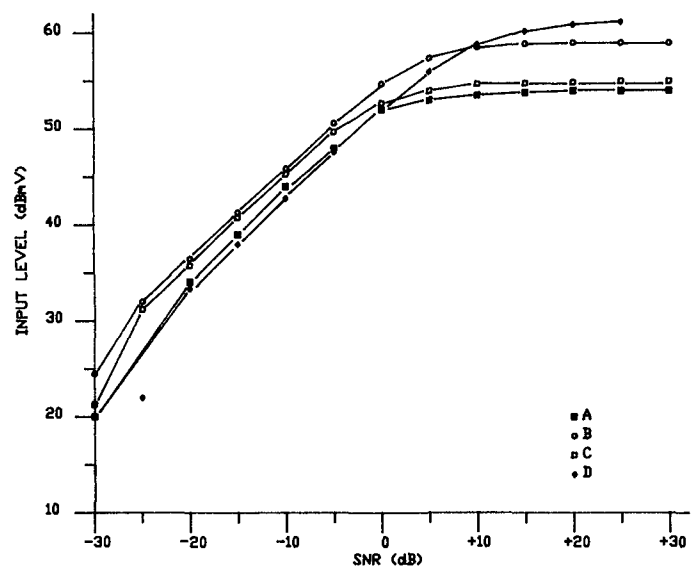


FIG. 12 RECEIVER SNR MEASUREMENTS