AUTOMATIC TESTING OF CABLE TELEVISION DECODERS

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ABSTRACT

Many types of test equipment are available which use the GPIB Bus (also known as IEEE 488 and HPIB Bus) for control and access. By using a personal computer and this test equipment, it is possible to fully automate the testing of a cable television decoder with a minimum of custom made parts. By using BASIC as the control language, anyone with experience in programming a personal computer can develop their own test programs.

We have developed programs for many tests including the following: headend calibration RF, video, and audio measurements; decoder box RF, video, and audio measurements; decoder beat measurements; and tuner gain and noise figure measurements.

WHY AUTOMATIC TESTING?

A manufacturer or purchaser of cable televison decoders must test a portion of the units to insure they meet design requirements. For any measurements, test equipment must be purchased and employees trained to measure units and document results. The steadily declining cost of computers coupled with the widespread availability of GPIB Bus-compatible equipment and an increasing number of people with BASIC language programming skills, makes it now feasible to develop automatic measuring systems at a reasonable cost. There are many advantages in doing this, including: rapid testing time, improved accuracy and repeatability, lower skilled personnel required for day-to-day testing, automatic graphics generation for clear reports, and automatic report generation. The disadvantages are higher equipment cost (offset by time and labor savings as well as better accuracy) and programming required. With the use of a personal computer, it is possible to write programs in BASIC which will do testing and write reports in a minimum of time. With a minimal amount of experience, it is possible to quickly convert a manual test procedure to an automatic test procedure. A logically structured sequential test program written in BASIC is also self documenting. This makes it a permanent record of the way a test was done, allowing another person, familiar with BASIC, to analyze the test procedure used. Once the program is debugged, the testing can be done by unskilled personnel, allowing engineers and technicians time for analysis of the data. Because of the speed and ease of automatic testing, many more units are tested and more parameters are measured, making statistical analysis more meaningful and allowing for tracking of trends.

There are two types of automatic testing, one for rapid production testing and the other for detailed engineering measurements used for checking engineering design and for calibration of production testing. The system described here is primarily designed for engineering type testing. This means using general purpose test equipment as much as possible for the following reasons: guaranteed performance specifications, elimination of design and cost of custom designs, and flexibility in adding or changing tests. This last feature is very important as all types of products, modules, and prototypes can be tested on one station.

HARDWARE CONFIGURATION

The block diagram in Figure 1 shows the computer interface of equipment used for decoder measurements.

Whenever possible, we have selected equipment which can be operated and read using GPIB Bus (GPIB is a handshaking parallel bus which is defined as IEEE-488 and also known as HPIB). This is a fast, easy-to-use (from a high level programming point of view, however, the hardware is fairly complex) method to control and read data from various test instruments. The instruments and primary uses are as follows:

1. Digital Multimeter - Used primarily to measure internal decoder parameters for drift or the effect of different input parameters. With a switcher, a number of measurements can be made by multiplexing the input.

2. Audio Analyzer - Generates signals and monitors results for frequency response, distortion, volume adjust range, output audio level, audio carrier deviation, and signal-to-noise ratio. With the use of a switcher, analog, digital, and digital stereo audio parameters can be measured.

3. Spectrum Analyzer - This is the most expensive instrument listed but also the most useful. It can be used for measuring RF and audio levels and frequencies. All controls can be set

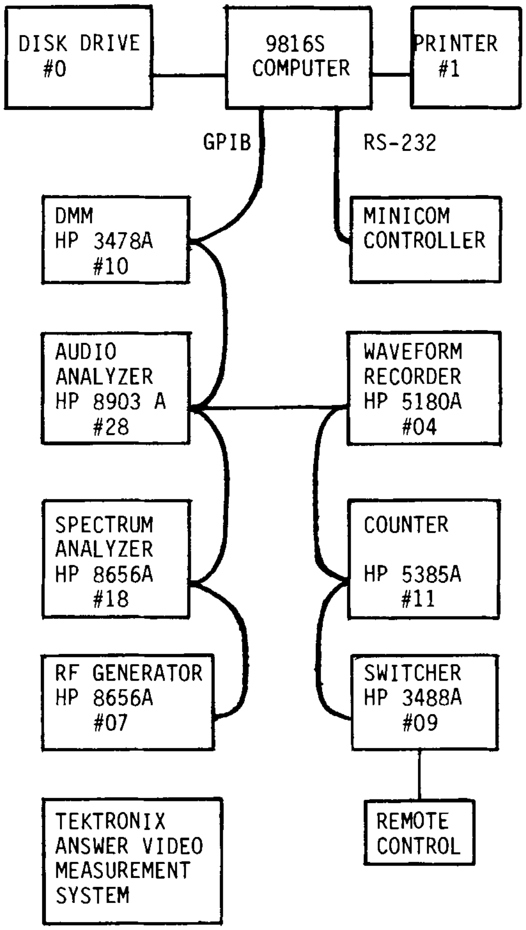

Figure 1. Computer Interface and Major Test Equipment

and the output display printed for accurate measurement and complete documentation. With a switcher, both input and output signals can be measured. It is used to measure beats, carrier levels, carrier frequencies, distortion, and bandpass response.

4. RF Generator - Generates carriers for beat test measurements on all channels. Also used with mixer and modulator output to generate any channel for special tests such as AFC range.

5. Waveform Recorder - Digitizes the video signal at a 20-MHz rate with 10 bits (one in 1024) of resolution. Hewlett-Packard is developing software to allow measurement of all video parameters with this instrument. We are currently using it for depth of modulation, Oak Sigma scrambling signal measurement, sine wave scrambling measurement, and documentation of various waveforms (abnormal audio or video responses). Anritsu Electric Co., Ltd. also makes a waveform recorder which is supplied with software and hardware for video measurements.

6. Counter - Used for measuring intercarrier frequency and for digital audio bit error rates (measured using input signal with poor video signal-to-noise ratio).

7. Switcher - This instrument is the key to maximum automation and utilization of equipment. It controls a modified IR transmitter to control the decoder being tested. It insures that input signals are correct before measuring output performance, and allows multiplexing of test equipment so only one of each type is required.

The computer, using an RS232 port, controls the Oak MiniCon Encoder/Decoder Controller. This permits changing scrambling modes as well as authorizing/deauthorizing the decoders. The Tektronix Answer automatic video measurement system is currently used to measure and document video parameters.

SYSTEM CONNECTIONS AND EQUIPMENT

The simplified block diagram in Figure 2 shows the basic signal paths of the decoder test system. The headend generates the test signals desired to check decoder parameters. The video signal, provided by the video generator, is usually a five-step staircase for adjustment and test of Sigma

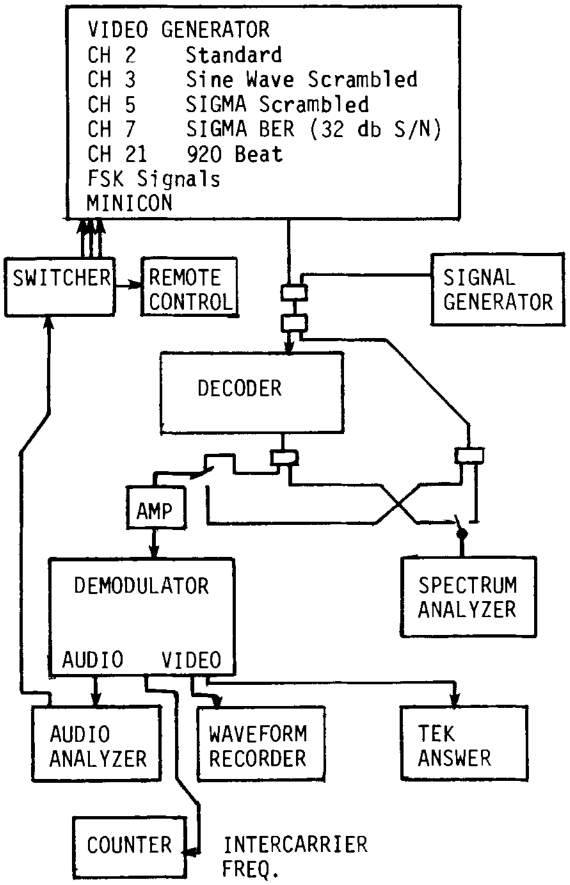

Figure 2. Test Station

scrambling, and includes VITS signals which are used by the Tektronix Answer system for video measurements. The channel 2 modulator supplies a nonscrambled signal for video and analog audio testing. Channel 3 is a sine wave scrambled signal with the switcher controlling single or double line-rate scrambling. Channel 5 is used for Sigma scrambling, with the encoder status controlled by the computer through a MiniCon controller. Channel 7 is also Sigma scrambled with a separate encoder. Noise is added in the IF signal to produce a 32-dB video SNR to test bit error rate of the digitized audio. Channel 21 has only a color signal for video and is used to measure 920-kHz beat and locate any decoder IF beats. The signal generator is used to generate upper adjacent video with 15-kHz modulation for adjacent video rejection tests with sine wave scrambling and also lower adjacent audio rejection. At this time, the input attenuator is manually adjusted for tests at +15 dBmv and -6 dBmv. Future plans are to control this with the computer.

A switch (controlled by the computer through a switcher) allows the unit under test to be bypassed for testing input signals prior to test to insure they are correct. The Tektronix demodulator supplies video to the Hewlett-Packard waveform analyzer and Tektronix Answer system. The intercarrier out frequency is supplied to the counter and the audio is sent to the audio analyzer. The automatic remote control unit, run by the switcher, tunes the decoder to the correct channel and sets volume level for audio measurements.

Figure 3 shows the physical arrangement of the decoder test station. The left-most rack contains all the signal generating equipment including video generators, encoders, and modulators. The next rack contains much of the automatic and manual test equipment. The bench has the computer, spectrum analyzer, and signal generator.

Figure 3. Decoder Test Station

SOFTWARE

BASIC was chosen as the programming language for several reasons. These include wide availability in personal computers, the large number of technicians and engineers who know the language, and availability of extended BASIC's which allow structured programming. The use of the BASIC which allows merging of named subroutines saves considerable time in writing programs. The HP 9816 supports this, as does as the Commodore computer with their Simon's BASIC cartridge. With this advanced BASIC, it is possible to write and debug a program for each test before adding it to the main program. A simplified block diagram of our main decoder test program is shown in Figure 4.

This type of main program structure allows for easy addition of new tests or modification of existing tests. Each major subroutine is a complete package, i.e., it can stand alone to complete a test and print out data. Each major test subroutine may have its own subroutines to perform any repetitive tasks. By using descriptive names for subroutines, it is easy to read a listing and quickly locate a part which may need revision. The primary goal in our program structure is to have easy-to-follow procedures with no module interdependence. This may make the programs longer, but it is a very small price to pay for easy debugging and revision.

With a little practice, this method of program writing is extremely powerful. Once a library of tests is created, a very quick method of producing custom programs becomes available. To write a test subroutine, the following procedure is used. First the hardware is connected and the test is done manually to produce a test method and to insure the results are as expected. This also generates test result numbers which can be used to verify the program is working properly. In a complex test, it is important to document in detail each part of the test. Usually, the manual test procedure is used instead of a formal flow chart to write the program. If the test is a modification or extension to an existing test, the old test routine can be loaded and edited to produce the new test. If there are any special parts of the test or printout which are difficult, a small test program should be written and debugged. This is much quicker than repeatedly running a long program to improve or debug one small part. The working module can then be merged into the longer program.

Program troubleshooting techniques include adding multiple print statements to locate when bad data is collected, using single step to observe program flow and insure instruments are properly set. All modules must reinitialize test instruments to insure that all settings are at a known state before being set to the desired state.

As an illustration of an actual program, the following is a portion of the subroutine for RF measurements with comments:

```
3000 OUTPUT 718; "IP I1 CF65MZ RL20DM
     SP20MZ RM100KZ AT0DM KSB"
```

Output 718 specified the spectrum analyzer. IP is instrument preset which places all controls into a known condition. I1 specifies input 1 which is the 75-ohm input. CF65MZ sets center frequency at 65 MHz. RL20DM sets reference level at 20 dB. SP20MZ sets the frequency span to 20 MHz. RM100KZ sets the resolution bandwidth to 100 kHz. AT0DM sets the input attenuator to 0 dB. KSB is equivalent to pressing shift to dBmv. As can be seen, most instruments use some mnemonics which suggest what function is selected. The command output 718; "O3TA", tells the spectrum analyzer that the controller plans to sequentially read the complete trace. This is done using a FOR/NEXT loop to input 718; D(N) 1000 times. This data can be displayed on CRT, stored to disk, plotted, printed, or analyzed by the computer.

As an example of analysis of spectrum analyzer display, the flow chart in Figure 5 shows the method used to check a decoder for internally generated beats. With a -6 dBmv input, the decoder is cycled through all channels, with carrier generated

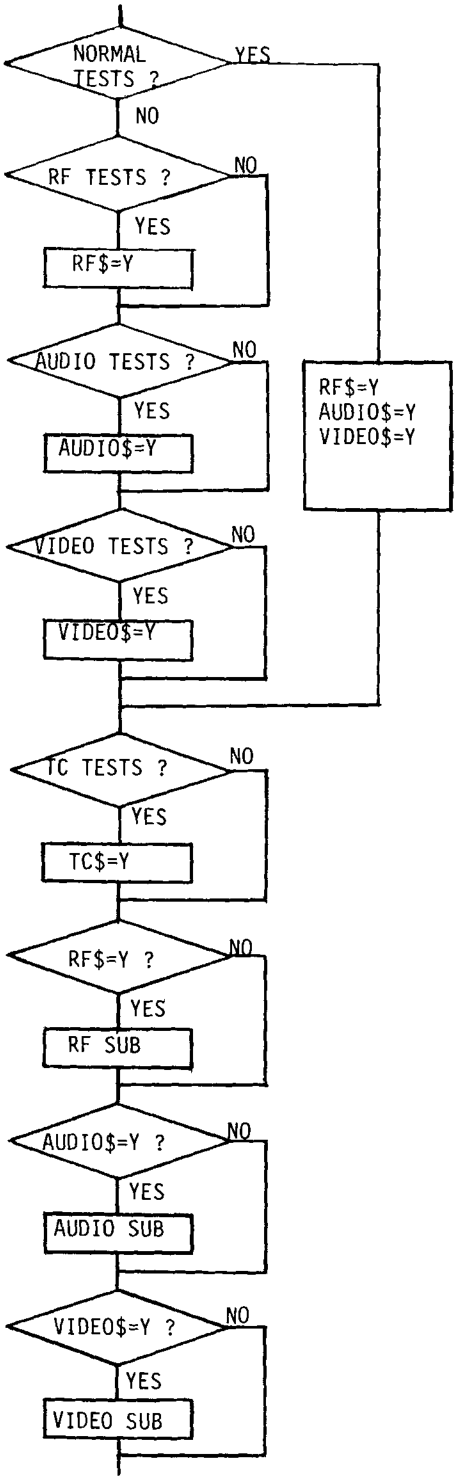

Figure 4. Overall Program Flow

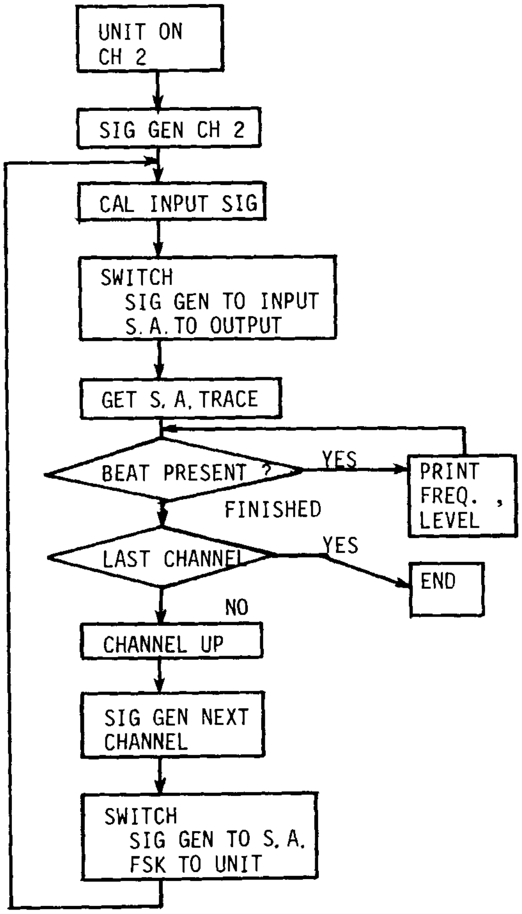

Figure 5. Beat Test Flow Chart

by signal generator. The spectrum analyzer display is loaded into an array of 1,000 points giving dB level. A portion of the program listing is shown below:

```
475  OUTPUT 718; "03 TA"
480  WAIT 1
485  FOR N = 1 TO 1001
490  ENTER 718'; A(N)
495  NEXT N
500  OUTPUT 718; "MZ E1 03 MA"
     Rem Marker Peak Search
505  ENTER 718; C1
     Rem Marker Amplitude Level
510  OUTPUT 71; "MF"
     Rem Marker Frequency
515  ENTER 718; Mf
     Rem Carrier Frequency
520  OUTPUT 718; "01 MF"
525  ENTER 718; Mpos
     Rem Display Marker Position
530  K = 1
535  FOR I = 1 to 899
540  IF A(I) > C1 -60.1 THEN GO TO 555
545  IF I <898 THEN GO TO 630
550  GO TO 640
555  FOR T = -3 to 3
560  IF A (I + T)> A(I) THEN GO TO 590
565  NEXT T
570  J(K) = A(I)
575  POS(K) = I
580  K = K + 1
585  I = I + 3
590  NEXT I
```

This section of the program loads the array A(N) with data points from the spectrum analyzer display. After using the peak search feature of the spectrum analyzer to locate the output carrier frequency and display position, it then looks for beats greater than -60.1 dBC. Lines 555 to 565 are a peak search routine to locate each peak less than 60.1 dB below the carrier. A print routine following this section prints channel number, beat level, and beat frequency for each beat found.

TUNER TESTING

In addition to decoder testing, we have also automated the noise figure and gain measurements for tuner testing. Figure 6 is a block diagram of the setup used. The interpod IEEE-488 interface allows the Commodore computer to control GPIB Bus instruments using Print # and Input # commands. One bit of the parallel port is used to control channel up on a modified remote control. After measuring the tuner, the results are plotted giving an easy-to-read report as shown in Figure 7.

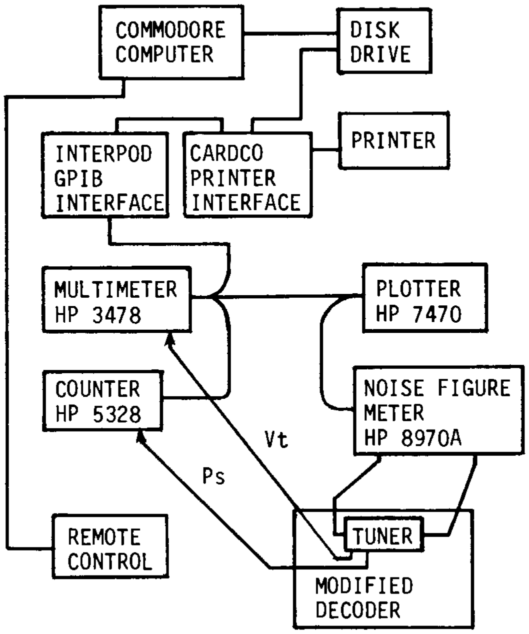

Figure 6. Tuner Noise Figure Test

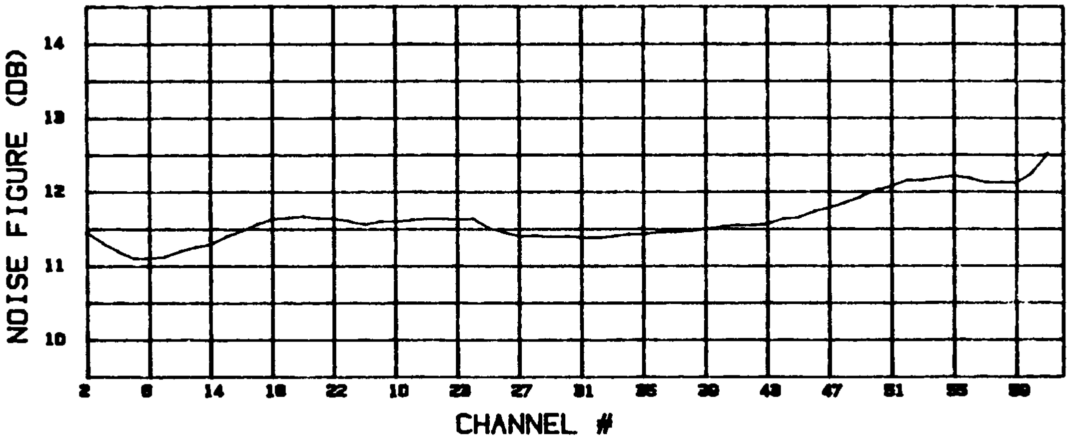

Figure 7. Sample Test Plot

FUTURE PLANS

Now that we have developed automatic methods for all the major tests, we are working on the following automation projects:

1. Automatic testing of life test units. Using A/B switches and a demultiplexer, we can isolate the output of each decoder to do tests. Eventually we expect to do testing of life test units automatically at night.

2. Use of Commodore computer and HP 853 spectrum analyzer display to measure intermodulation performance of tuners and decoders.

We have found this project very useful as not only a labor and time savings, but also an accuracy improvement due to precise setup and checking of test signals.