BEST TELEMETRY SOURCE SELECTOR/ANALYZER SYSTEM

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ABSTRACT

This paper describes a microprocessor based multi-channel signal analyzer system for use with telemetry system pre- and post detected video signals. In the application described here, the system software is configured to simultaneously analyze up to 16 telemetry signals, compute an estimate of the SNR for each, and then select the best for output to real time recording equipment. The SNR is estimated by comparing the total signal energy with the signal power observed in an unused portion of the signal spectrum. The signal analysis filters are fully programmable over a range of 10 KHz to 2 MHz and may be set up to analyze a wide variety of telemetry formats. The microprocessor system also supports printed output of signal status and remote programming.

INTRODUCTION

This paper discusses the specifications and development of a best telemetry signal selector system to aid in the recording and interpretation of test data from training exercises. In any one exercise, telemetry from a missile or other weapon system will be monitored by both ground and airborne tracking systems. Typically, the same telemetry video signal will be available from as many as forty different sources. Difficulties with interpretation of the results arise because seldom does any one telemetry source have a high quality signal over the entire time of the test. Complete, continuous data from a missile test must be laboriously pieced together from the data recordings of all the signal sources involved. In order to speed the preliminary analysis of the flight data, a Best Source Selector (BSS) system was developed at Fleet Analysis Center (FLTAC), by Alday and Herring. This system, implemented with analog filters and multiplexers with a simple digital logic state machine, evaluated up to eight video sources and selected the best one for display on “real time” high speed oscillographs. This original system has proved a very valuable tool in preparing preliminary flight analysis reports.

Advances in technology and the growing complexity of new weapons telemetry packages has prompted reevaluation of the problem of best source selection. The instrument described in this paper is an attempt to develop an advanced BSS system which will meet both current and future needs.

SIGNAL QUALITY MEASUREMENT

A telemetry system is a chain with many links. A voltage measurement in a missile guidance system will change forms many times before it finally appears as a wiggly line on a chart recorder. The quality of a particular telemetry system depends on how closely the output data matches the original input data. For analog signals the quality is usually specified as a signal power to noise, power ratio (SNR). Digital signal quality is better described in terms of a bit errorrate (BER).

Some of the telemetry chain parameters that have possible merit for estimating the relative quality of redundant telemetry signal paths are:

TELEMETRY PARAMETER	CRITERIA
Tracking Quality	Shortest unobstructured distance from antenna to target.
Receiver Quality	Highest received signal strength.
Video Quality	Highest estimated video signal SNR.
Data Character Quality	Least amplitude and timing jitter on individual dual characters.
Data Frame Quality	Least number of synchronizing or framing errors.
Data Output Quality	Most stable data in the decomutated output.

After an extensive evaluation of these quality measurement estimates, the Video Quality approach appeared to be the most practical solution. The key to this approach is the estimation of the SNR from the video signal alone.

One way to estimate the SNR from the video signal is to measure the signal energy in an unused portion of the video spectrum. In this technique the guard band between the base-band signal and the sub-carrier is examined. The signal energy measured in the empty band is assumed to be representative of the noise over the rest of the video bandwidth. The empty band energy is then compared with the total energy measured in the video channel. The video data channel with the highest ratio of total energy to empty band energy is considered the best source. The present FLTAC BSS system is based on this method of quality evaluation.

The main difficulty with this method is that the availability of an empty channel of sufficient bandwidth is not always guaranteed among the variety of telemetry data formats now coming into common use. It is typical, however, that the receiver bandwidth will exceed the actual transmitted signal by enough bandwidth to make an empty channel measurement just above the highest frequency in the transmitted spectrum.

USER INTERFACE

The primary feature of this implementation of a BSS system is the programmability of the signal evaluation parameters. A major challenge, therefore, is to make the instrument easy to use yet maintain the versatility which the fully programmable signal analysis modules allow.

The approach taken with this instrument is to provide the user with a complete set of parameter menus and status displays which allow viewing and editing of all the system parameters. A set of 6 dynamically labeled soft keys allow the user to quickly move through all the menus and status displays. Once a set of parameters have been determined and entered, they can be stored as a group and given a particular label. These groups of parameters are referred to as configurations. As many as 10 configurations may be entered and saved in the current implementation. The operator may re-configure the instrument simply by calling up one of the previously stored configurations.

The status displays provide a constant read out of the signal level and SNR estimates for all incoming signals. Other diagnostic displays are provided to help verify proper operation and calibration of each of the signal evaluator modules.

The programmable narrowband filters in the signal evaluator modules allows for special diagnostic mode which simulates the action of a spectrum analyzer. The narrowband filter is swept across the entire frequency band and the signal strength is plotted on the display screen. This diagnostic mode aids in setting up parameters for new signal formats.

HARDWARE IMPLEMENTATION

The general hardware architecture used to implement the BSS system is shown in Figure 1. The three main building blocks of the system are the Signal Evaluator modules, the Signal Output module, and the Control Computer. The Control Computer communicates with the signal modules over a common digital control bus. Signal modules also send analog signals between themselves over a special common analog signal bus. This structure allows for a variety of new types of signal processing modules to be developed and incorporated into the system without modifying the existing hardware. For example, a PCM jitter evaluation module could be developed and easily incorporated into the system. Also the capability to provide multiple independent signal outputs could easily be provided.

Signal Evaluator Module

The BSS system requires one signal evaluator module for each signal to be processed. The current chassis implementation allows for up to 16 of these modules. Each of these will accept and evaluate a single telemetry video signal. The internal functions of this module is shown in the block diagram of Figure 2. The input signal is buffered and then fed to three separate circuits. The first circuit estimates the total (wideband) signal energy. This is converted to digital form and made available on the digital control bus. Next the signal is filtered by a programmable narrowband filter. The energy in the output of this filtered signal is also digitized and made available on the control bus. The narrowband filter is programmable over a range of 10KHz to 2 MHz by a set of control registers accessible from the digital control bus. The final circuit that receives the video signal is the output switch which can direct the signal to the analog signal bus for output via the Output Module.

Note that the Signal Evaluator Modules all operate in parallel. This allows a response time of no more than 10 ms to detect a change in the incoming signals. This, however, complicates the calibration procedure. Extensive automatic software calibration procedures keep all of the modules properly aligned.

Output Module

This module provides the required buffering to drive the signal output. Only one output module is required. It receives the best signal from one of the Signal Evaluator Modules as selected by the control computer and outputs it via a low impedance driver. A block diagram of the Output module is shown in Figure 3. The output module also contains a programmable test signal generator which is used to automatically calibrate the Signal Evaluator Modules.

Control Computer

The control computer block diagram is shown in Figure 4. The control computer is based on the IBM PC bus and includes an 8086 CPU with 256KB RAM, 512KB ROM, and 2KB NVRAM. The user interface is implemented by a 512x256 pixel E.L. graphics display and 22 keys arranged as a 4x4 key pad and 6 special function keys. An RS-232 port is also provided for communication with a terminal, printer or other computer. Most all of the elements of the control computer are built up from “off-the-shelf”, IBM PC compatible function cards. In this way, other features such as IEEE 488, expanded RAM, or a hard disk may be easily integrated into the system.

SOFTWARE IMPLEMENTATION

The software to drive the BSS system is divided into two sections, the foreground and the background. The foreground section of the software is written predominately in FORTRAN and is responsible for the following functions:

1) Interacting with operator by updating displays, menus, and reading keyboard.

2) Keeping track of system parameters, storing and editing configuration information.

3) Diagnostics and calibration procedures.

4) Maintaining contact with external devices such as a printer or terminal.

The background routine is written entirely in assembly language. Every 10ms a system timer generates an interrupt which starts execution of the background routines. The background routine must then perform the following functions:

1) Scan all active signal evaulators and collect raw data.

2) Apply calibration correction factors to adjust raw data.

3) Calculate SNR for each channel and select best source.

4) Direct the best signal to the output module.

5) Make SNR data available to the foreground FORTRAN routine for display and output.

The foreground and background routines communicate by a set of common arrays containing data items and semaphores.

CONCLUSION

A microprocessor based instrument for analyzing and selecting the best telemetry source from a set of redundant signals has been presented. The system performs an SNR estimate on up to 16 signals at once by comparing total signal energy with an empty channel noise measurement. The system performs full parallel measurement to achieve a 10 ms response time. All parameters for the signal analysis are user programmable. The hardware and software architecture allows for easy expansion and modification as new features are required.

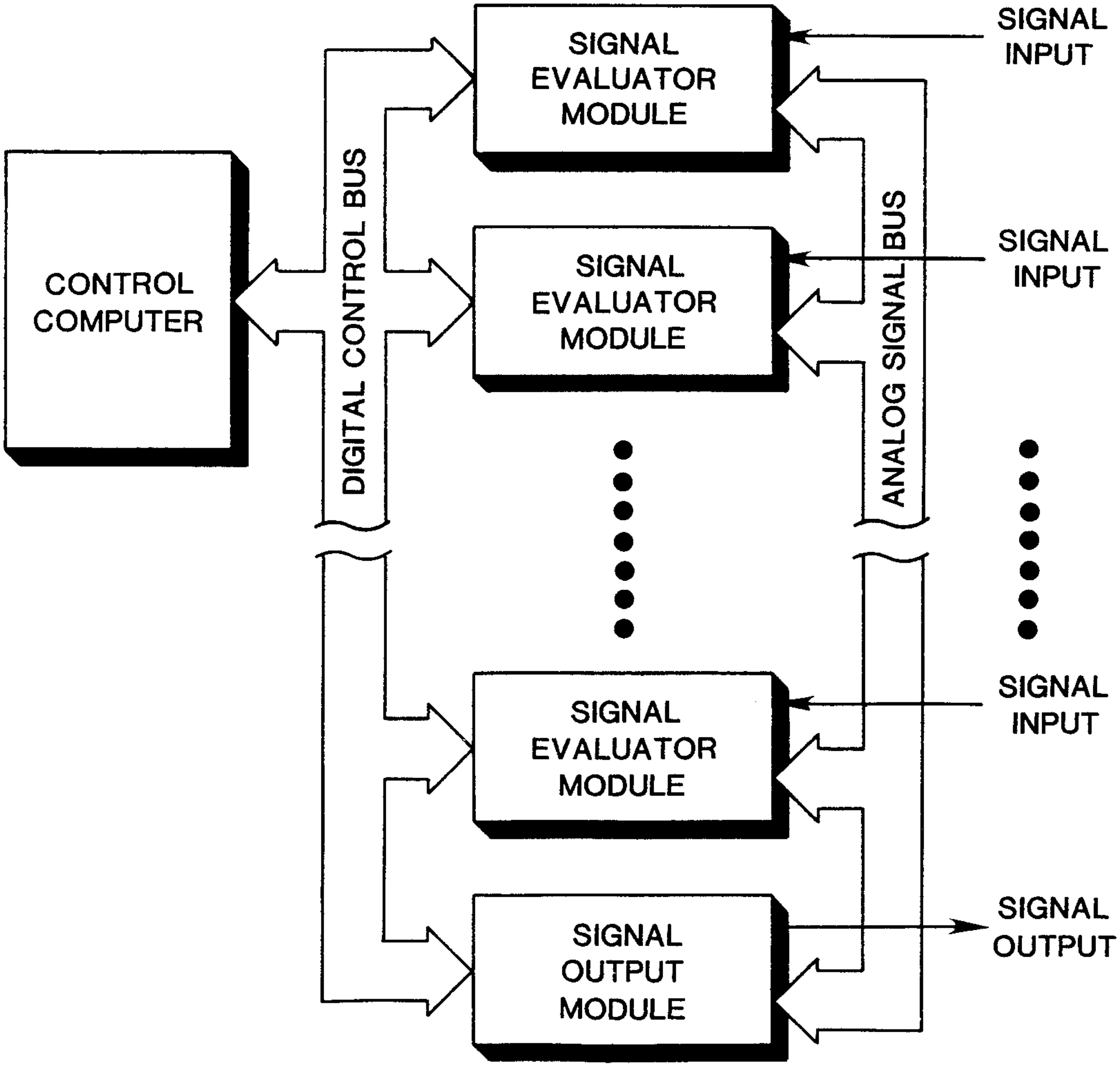

FIGURE 1. BEST SIGNAL SELECTOR SYSTEM BLOCK DIAGRAM

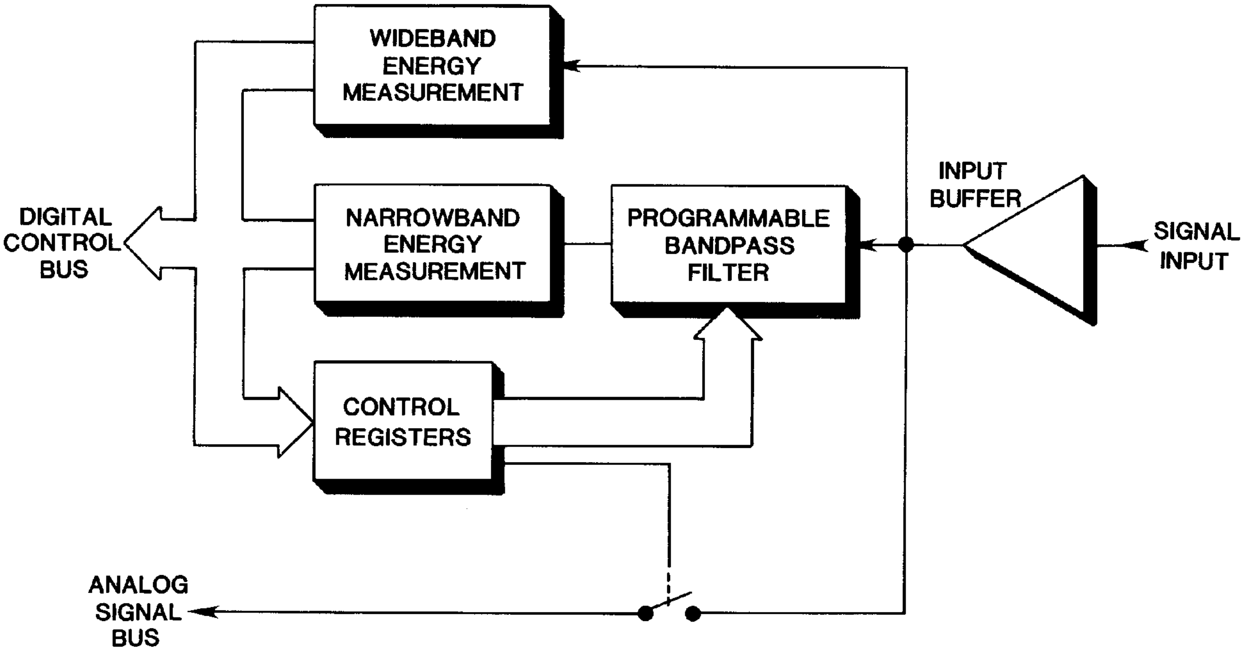

FIGURE 2. SIGNAL EVALUATOR MODULE BLOCK DIAGRAM

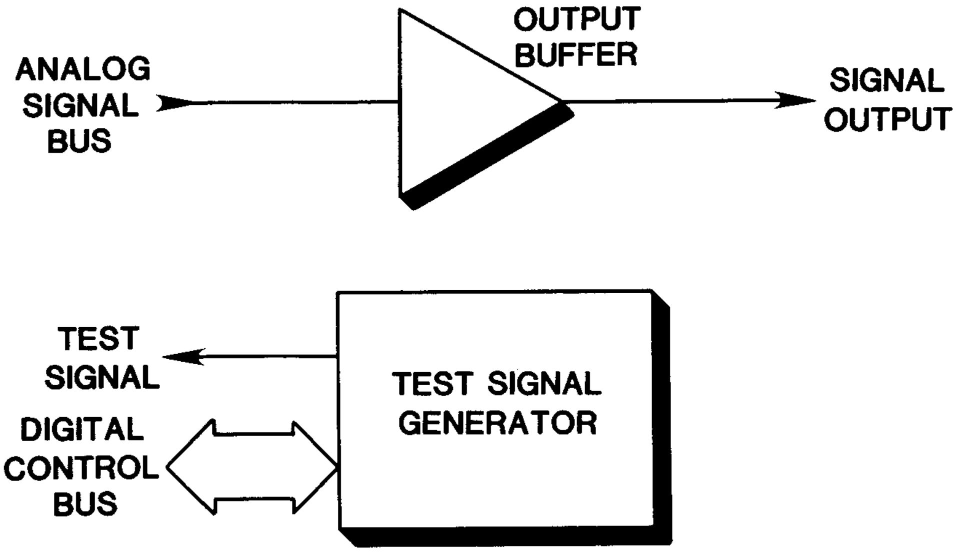

FIGURE 3. OUTPUT MODULE BLOCK DIAGRAM

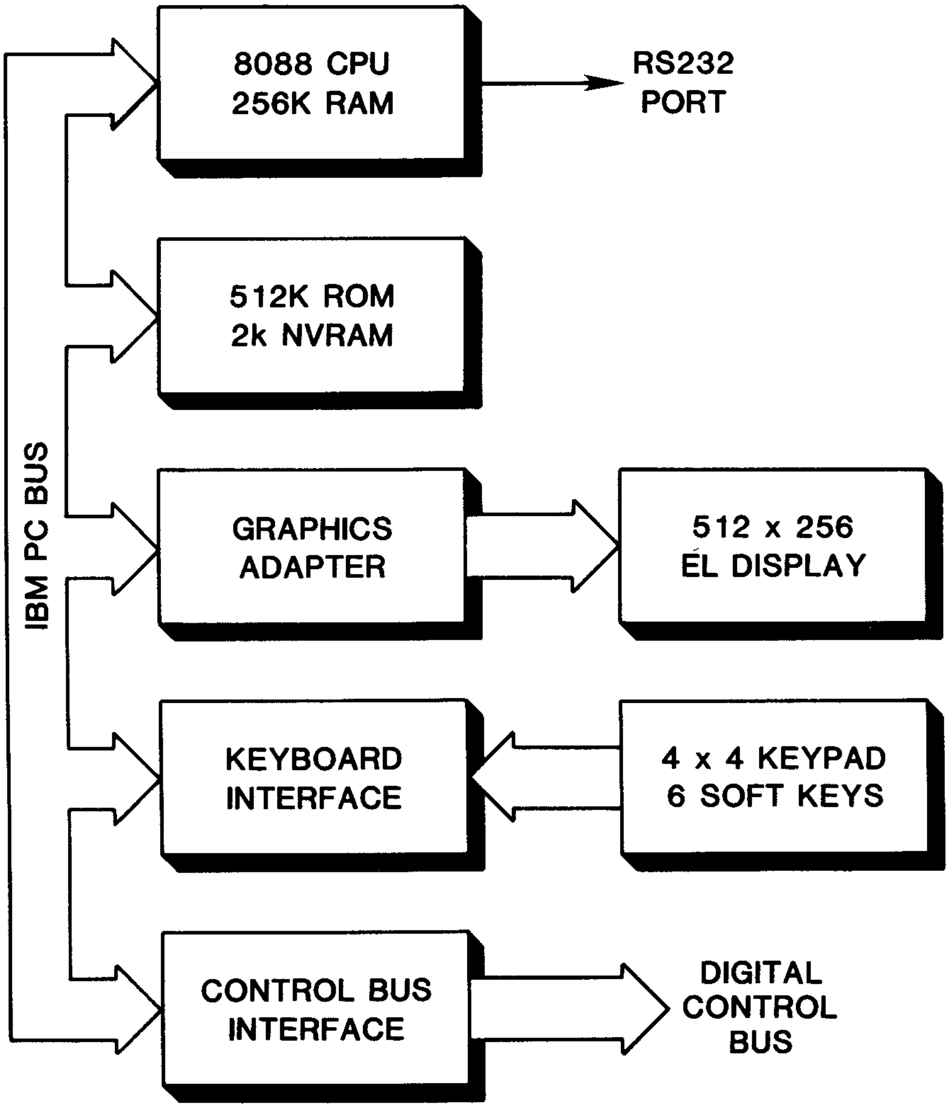

FIGURE 4. CONTROL COMPUTER BLOCK DIAGRAM