1.0

1.1

1.25

1.4

1.6

2.8

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3.2

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4.0

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1.8

1 of 1

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Autocharacterization Feasibility System On Hunters Trophy Event

Richard A. Mills

**Instrumentation Development Department 9321
Sandia National Laboratories
Albuquerque, NM 87185**

Abstract

An automated system to characterize cable systems at NTS has been developed to test the feasibility of such a system. A rack of electronic equipment including a fast pulse generator, digital sampling scope, coaxial switch matrix and GPIB controller was installed downhole at NTS for the Hunters Trophy event. It was used to test automated characterization. Recorded measurements of simulation and other instrument data were gathered to determine if a full scale automated system would be practical in full scale underground nuclear effects tests. The benefits of such a full scale system would be fewer personnel required downhole; more instrument control in the uphole recording room; faster acquisition of cable parameter data.

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Abbreviations

COM	COMmon
GEN	GENerator
GPIB	General Purpose Interface Bus
NS	NanoSecond
NTS	Nevada Test Site
PPL	Picosecond Pulse Lab
PS	PicoSecond
SW	SWitch
TEK	TEKtronix
UGT	UnderGround Test
UHC	UpHole Cable

1.0 INTRODUCTION

This report describes an automated full recording system and cable characterization system for use on full scale nuclear weapons effects tests conducted in tunnels at the Nevada Test Site (NTS). Signals from high frequency diagnostics are routed from underground gauges to an aboveground data recording facility at NTS in area 12, Bldg. 12-909, via short copper coax cables and a 7 km analog fiber optic link. A small feasibility system was developed and tested on the Hunters Trophy event during August and September, 1992.

The process of characterizing cable systems at NTS for UGT experiments requires technical personnel in the recording room at Area 12 and downhole in the area of the experiment in a coordinated effort. To characterize a single cable, technicians must manually connect a fast rise time pulse generator to the correct cable, cycle the signal, monitor the pulse uphole and make necessary adjustments, configure recording equipment and then single shot the pulse generator to record the signal. Hunters Trophy required two people downhole and two people uphole and each cable took an estimated half hour to 45 minutes to complete.

During the dry run period, the signal simulation system simultaneously pulses all cables. After initial setup, the configuration is kept in place until actual connection to a gauge. Periodic characterization of simulation is desired to monitor drift of fiber optic lasers and other system components. This requires disconnecting the cable from the simulation generator and reconnecting the generator to a sampling scope to accurately record the input signal. Simulation monitoring gives information on drift of the fiber optic lasers and tracks k factors.

Autocharacterization is an attempt to automate the process of characterization and combine simulation as well. By automating and combining the two processes, less personnel would be required, the time downhole would be reduced, wear on cable connectors would be reduced, the probability of error in connecting cables would be reduced and simulation pulser outputs could be characterized more often, possibly daily.

A fully automated system to characterize and simulate cable systems would eventually run on a workstation with multiwindow capability under control of an operator.

2.0 EXPERIMENT OVERVIEW

A pilot system was used on Hunters Trophy to characterize cables and simulate test pulses for cables on a limited basis to test the feasibility of such an automated system. Nine high speed data channels were selected for the test. A rack of equipment containing a fast pulse generator, digital sampling scope, coaxial switch matrix and switch control unit was designed, built and tested in Albuquerque then shipped to NTS and installed next to the simulation rack in the air scatter station. Jumper cables were installed to connect simulation signals to the switch matrix and then the matrix was connected to the nine selected uphole signal cables. (See Autocharacterization System Block Diagram Fig. 1.) In simulation or power down mode, simulation pulse generators were connected to uphole cables. Other options were to connect the fast pulse generator to the uphole cables individually, connect simulation generator channels to the sampling scope individually, or connect the fast pulse generator to the sampling scope. The characterization rack and simulation rack were under computer control uphole from Bldg 12 909. Fortran software was written to control all components remotely.

Simulation or power down are modes where the coaxial switches are in a position to pass simulation pulses uphole. This is considered a failsafe default because, in case of power failure or some other system failure, dry run simulation could still occur. Connecting the fast pulse generator to uphole cables configures the system to characterize cable frequency response. The pulse generator is cycled at a slow rate (typically 1 Hz) for view on uphole recording equipment (Tektronix Model 7912HB).

The simulation generator channels can be switched to the sampling scope and, by triggering the simulation, a precision digitized record of the channel can be obtained. This gives an operator a picture of each simulation channel close to the source so that computer comparisons can be made with downhole generated characterization data vs. uphole dry run data. An operator can also switch the sampling scope to record the output of the fast pulse generator. This data is used with uphole data in the 7912s to compute software compensation functions.

Control of the autocharacterization equipment was designed to use two graphics terminals. One terminal is used to control the switch matrix and other instruments and the other is used to control the 7912s and record data for characterization. Both terminals would be placed side by side for ease of use. A more mature system would use a workstation capable of multiple windows which would allow a single operator to control all functions at one location. In practice during Hunters Trophy, one terminal was used in the recording room and one used in the programmer's area because of tight calibration and dry run scheduling.

Fig 1.

Autocharacterization system block diagram. Hunters Trophy used two terminals instead of the workstation shown.

3.0 HARDWARE DESCRIPTION

The block diagram of the Autocharacterization System (Fig. 1) shows how the major components are connected together. The components after the Terminal Server and except the simulation block, were located in the short characterization rack next to the simulation rack in the scatter station. After characterization and simulation were complete, the whole system was disconnected and sent uphole. The gauges in the diagram were then connected to the uphole cables (UHC 1 UHC 9) for actual event recording.

The Autocharacterization Switch Matrix Schematic (Fig. 2,3) details the coaxial switches for routing fast pulses. In the simulation or power down mode, the switches are as shown in the schematic drawing. The diodes in the switch matrix control circuit form OR functions that allow grouping of the coaxial switches. For example, when HAR6 is connected to common, SW1-Y3, SW2-Y6 and SW14 are closed. This signal path sends the pulse generator signal to uphole cable UHC 6 and requires only one HP3488A relay closure and one computer instruction. This economizes the use of the HP3488A and simplifies the software. SIMSIG1-SIMSIG9 are simulation signals from the simulation rack and UHC1-UHC9 are uphole cables. HAR0-HER9 control relay closures and come from the HP3488A. The HP3488A configuration schematic (Fig. 4) details how the HP3488A is set up and connected to the switch matrix for control.

The Pulse Generator Signal Path Schematic (Fig. 5) shows the path from the fast pulse generator to the Tektronix 11801 sampling scope. This is critical in verifying the pulses sent uphole are correct in amplitude and duration. The schematic shows how many and what kind of coaxial switches are used. Fig. 6 is a plot of a one volt, 50 ns pulse through this path that was observed in the lab before the system was installed. After installation, similar signal plots were recorded to verify connections. The pathway in the Characterization Schematic (Fig. 7) shows the fast pulse generator connected to an uphole cable. This mode is used in acquiring data for calculating k factors.

The Simulation Generator schematic (Fig. 8) shows the path from a simulation generator to an uphole cable.

Fig. 9a through Fig. 9i are plots comparing recorded data from the simulation generator as shown in Fig. 8 with recorded data of the 11801 manually connected to the UHC output. The objective is to see the difference in the signal between SW27, SW9 and SW27, SW6, SW5, SW45. The result gives a pictorial display of the accuracy of the plots taken downhole of simulation.

Fig. 2

4.0 SIMULATION MEASUREMENTS RESULTS

There are two areas of interest in automating a simulation measurement. First is the signal integrity at the output of the switch. How much delay, attenuation and distortion can be expected and tolerated when routing a fast pulse through coaxial switches. The second is the ability to get a precision digitized record of each simulation signal channel on demand and not disturb cable connections downhole and chance a cable mixup or accidental destruction of a connector.

Delay measurements were made in the lab using a Tektronix 11801 sampling scope and a Picosecond Pulse Lab Model 10000A fast pulse generator on all channels of the switch matrix. An average delay of 7.9 ns $\pm$ 0.2 ns was observed. This was very repeatable and eventually each channel can be brought within a closer tolerance by changing jumper lengths within the switch matrix. Attenuation was measured at 1.7% on each channel and rise and fall times were within 50 ps.

Individual records of each simulation channel were obtained by two methods: a) remotely switching the input to the sampling scope to each individual simulation generator output and triggering the simulator and b) manually connecting the sampling scope to the output of each switch matrix channel. The capability of remote switching simulation allows the operator to view the simulation signal records from uphole without disturbing cable connections. The switch matrix switches from straight simulation to viewing individual simulation channels. The results are given in Fig. 9a Fig 9i. As one can observe, the two records of each simulation channel are quite similar. This indicates that records of each simulation, obtained on the sampling scope through the switch matrix, are a good estimation of actual simulation input to each cable. These records of simulation downhole can be a useful troubleshooting tool for operators.

Fig. 5

Fast Pulse Generator signal path to Tektronix 11801 sampling scope.

Test: Hunters Trophy
Date: 29-JUL-1992 10:29

Experiment: AUTOCHARACTE RMILLS
Channel: A022-222-4

BL = -12.0635 HT = 994.2099 ST = 12.9657 R = 0.5380 W = 50.1492 F = 1.0905

Fig. 6

Fast Pulse Generator output recorded through switch matrix.

Fast Pulse Generator switched to an uphole cable (UHC). This signal path is used to characterize each uphole cable system.

Fig. 8

Signal path for recording simulation generator data from uphole.

Fig. 9a.

Simulation channel 1 recorded through the switch matrix. Dotted waveform represents automated measurement. Solid waveform represents manual measurement taken at UHC ports.

Fig. 9b.

Simulation channel 2.

Fig. 9c.

Simulation channel 3.

Fig. 9d.

Simulation channel 4.

Fig. 9e.

Simulation channel 5.

Fig. 9f.

Simulation channel 6.

Fig. 9g.

Simulation channel 7.

Fig. 9h.

Simulation channel 8.

Fig. 9i.

Simulation channel 9.

5.0 SOFTWARE DESCRIPTION

Control of the Autocharacterization System is normally done uphole in Bldg. 12-909 or on any graphic terminal that has terminal server ethernet access to the computer network. MAIN_AUTOCHAR.EXE is the object file used to run on the terminal. Running MAIN_AUTOCHAR.EXE will bring up a series of menus to initialize the system. System operation is located in the CHAN_SEL subroutine which comes up automatically.

- 1 = SIMULATION
- 2 = CHARACTERIZATION
- 3 = SCOPE PPLGEN
- 4 = SCOPE SIMULATION CHANNEL
- 5 = LOG 11801 MANUAL CONTROL
- 6 = GPIB MANUAL CONTROL
- 7 = SETUP AND TRIG DG535
- 8 = EXIT CHANNEL SELECT POWER DOWN
- 9 = EXIT CHANNEL SELECT

Table 1.

Autocharacterization control menu for Hunters Trophy.

The control menu allows the operator to select and execute a function with minimum keystrokes rather than running separate programs. Selection 1 resets all coaxial switches except for the AC power control. This allows all simulation signals to pass through the switch matrix. Selection 2 queries the operator for a channel number and then routes the fast pulse generator signal to the requested channel (uphole cable). Selection 3 connects the fast pulse generator signal and trigger to the sampling scope. Selection 4 queries the operator for a simulation channel number and connects the sampling scope to the appropriate simulator channel. Selection 5 records data from the sampling scope and files the data. This data file can be plotted using DSP¹. Selection 6 enables the operator to manually remote control any GPIB function. For example, if the operator wanted to know the status of the AC power control switch, a command could be sent directly on the bus and the reply read on the terminal. Selection 7 was intended to control the triggering of the simulation and characterization via the DG535. This selection was not ready for Hunters Trophy because the process of operating the system was not clearly defined. The DG535 was controlled manually using manual GPIB control (selection 6). Selection 8 opens all switches in the switch matrix

¹DSP is a program developed to plot data

including the AC power control thus turning off the pulse generator, sampling scope and DC power to the switches.

*** * * * *** **CAUTION !!!!!** *** * * * ***

SWITCHES IN THE HF44471A MODULES IN THE HP3488A CONTROLLER ARE LATCHING. THIS MEANS THAT IF THE HP3488A IS POWERED DOWN, THE SWITCHES ARE NOT RESET AND WILL NOT BE RESET UNTIL THE UNIT IS POWERED UP. UPON POWER UP, AN AUTOMATIC INITIALIZATION RESETS ALL SWITCHES.

Selection 9 exits from the CHAN_SEL subroutine and allows exiting the control program without altering switch settings. This is useful in trouble shooting software, plotting data and comparing and useful if there are computer glitches requiring program restart.

A multiwindow workstation would run DSP, ACETEST², and MAIN_AUTOCHAR simultaneously in their respective window and under control of a single operator. MAIN_AUTOCHAR controls switching and data recording, ACETEST controls the 7912's and DSP is used to plot recorded data.

6.0 PULSE GENERATOR MEASUREMENT

Fig. 10 is a plot of a 1 khz pulse from the Picosecond Pulse Lab fast pulse generator through the switch matrix and after installation downhole. The generator was set to output pulses of 50 ns at 1.0626 volts amplitude to compensate for switch attenuation. Fig. 8 shows the switch configuration for obtaining this record. The purpose of this is to view the output of the pulse generator by the operator before cable characterization starts so the operator can verify amplitude and pulse width. Each cable requires its own amplitude and pulse width which experimenters specify. More mature software will have to be developed to store preset amplitude and pulse duration settings

²ACETEST is a program developed to control 7912 recorders

Fig. 10.

Pulse from PPL fast pulse generator, recorded from uphole,
 after downhole equipment installation.

for each cable to be characterized so operators can execute this process with a minimum of data entry.

7.0 CHARACTERIZATION MEASUREMENT

Characterization on Hunters Trophy required a coordinated effort with recording room operators to operate two terminals. This effort was impossible with the compressed schedule imposed. Personnel were working many overtime hours often after 10:00 PM and, given the amount of work in necessary calibration, this experiment in characterization could not be successfully performed. However, the triggering of simulation was done uphole for simulation and this triggering is a large part of the characterizing process. Fig. 7 shows the switch configuration for characterization. The fast pulse generator would be set to trigger from the trigger input port which is initiated from the DG535. This is selection 7 of the MAIN_AUTOCHAR menu.

8.0 CONCLUSIONS

The data plotted from simulation reveal that an operator can monitor simulation and pulse generator status from uphole. Also simulation can take place through coaxial

switches with acceptable pulse degradation. The question remains about the practicality of characterization using a workstation. Given the circumstances of a compressed schedule on Hunters Trophy, and the limited number of channels it would seem that a system such as this would only be practical and cost effective in terms of money in two ways. First, the volume of channels to be characterized and simulated would have to be high to justify the system cost. And second, the process by which simulation and characterization is done needs to be changed to accommodate such a system. The old process of requiring people uphole and downhole must be completely changed and a new and thoroughly thought out process needs to be implemented to allow success. Preparation for many shots has hardened the old process for cable characterization and change will not be easy.

9.0 RECOMMENDATIONS

This system can be expanded from the initial 18 channel capability to accommodate up to 144 cables, however, the rack space requirement would increase 100%. The above system was designed with six position coaxial switches to distribute signals but twelve position switches are available with the same specifications. Any future system of this type should consider the following criteria: 1) rack space and closeness to the simulation system or integration with simulation, 2) added delay caused by cable and switch distribution, 3) system cost with twelve position switches and 4) the process by which this system is operated.

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