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Summary

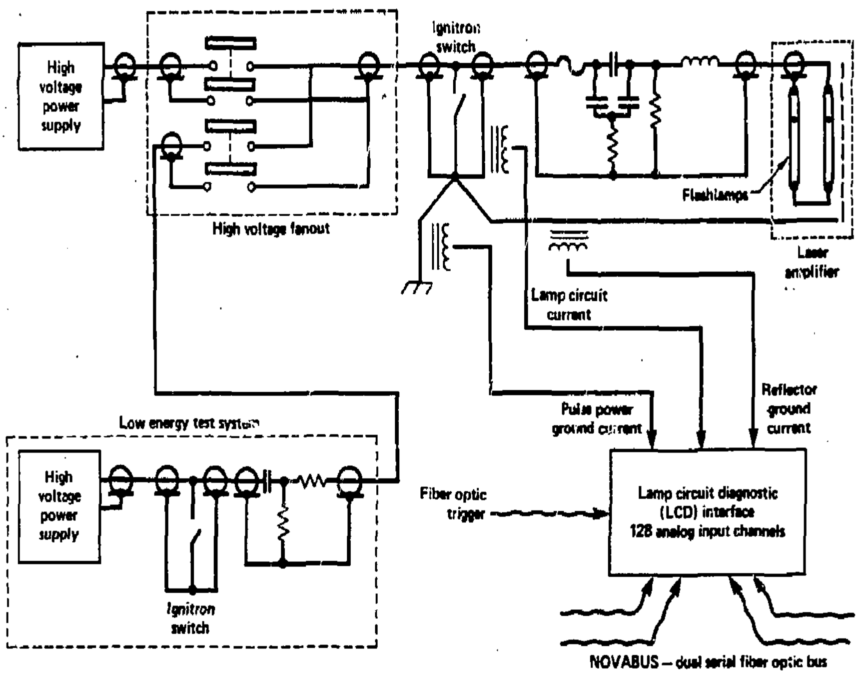
The Nova laser will have a large pulse power system for driving laser amplifiers, incorporating approximately 1,600 flashlamp circuits. An automated system has been designed for diagnosing the condition of these flashlamp circuits. It records digitized circuit current waveforms and detects current excursions above a given threshold. In addition, it is able to fire flashlamps at a low energy to ascertain the health of the system.

Data from this sytem can be plotted for inspection by the operator, analyzed by the computer system and archived for future reference.

Pulse Power System

The pulse power system is composed of about 1,600 circuits, several high voltage power supplies, ignitron switches and necessary control electronics and computer interfaces.

During normal operation, a capacitor is charged through a resistor by the high voltage power supply. The top supply in Figure 1 would be selected by the high voltage fanout in this case. At shot time, the capacitor is discharged into the flashlamps in the laser amplifier through an inductor. In a system of this size occasional failures are inevitable. These include a lamp that does not fire, a lamp which



PULSE POWER SYSTEM CONFIGURATION

FIGURE 1

*This work was performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract No. W-7405-ENG-48.

breaks while firing, an arc from the flashlamps or their leads to the reflector, or an arc from the pulse power system to building ground. Because of the many failure modes, the pulse power circuitry has been instrumented to detect these kinds of failures. The current from building ground to the ignitron switch commons, the current from the amplifier reflectors to the switch commons, and the current in the return leg of the pulse power circuits are all monitored with current transformers.

The current transformers are physically located in the switch assembly. Data from the current transformers is recorded by the Lamp Circuit Diagnostics (LCD) interface. The LCD interface also has analog latches for determining whether the current exceeded a given level.

In addition to the normal firing circuitry, provision has been made for testing the pulse power system by firing the flashlamps at a very low energy. The bottom power supply in Figure 1 is used for this purpose. It charges a capacitor through a resistor. This capacitor is connected to the pulse power circuitry through the high voltage fanout (Figure 1) and the top power supply is disconnected. The switch fires, sending a pulse of approximately the same initial voltage but much lower energy to the laser amplifiers through the pulse power circuitry. Again, the current waveforms are monitored by the LCD interface to detect faults. This allows detection of ground faults, pulse power circuit failures, and broken or bad flashlamps before firing them at full energy. Firing into a bad flashlamp at full energy can result in a profoundly damaged laser amplifier, so testing flashlamps at low energy saves money and time by preventing unnecessary damage.

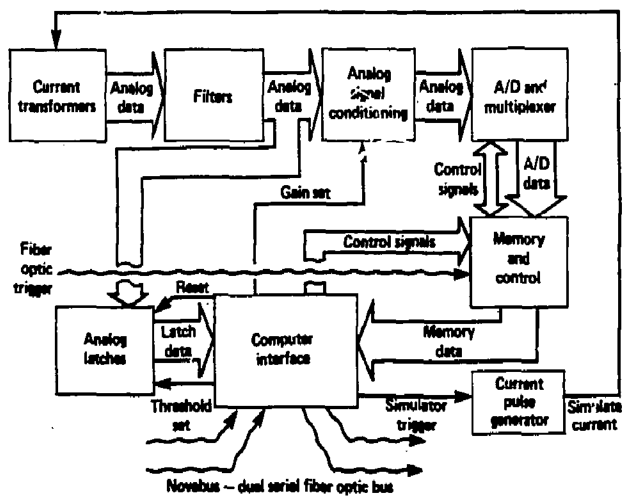
Lamp Circuit Diagnostic Interface

The LCD interface configuration is shown in Figure 2. Analog data is received from the current transformers and filtered. It is then processed in two ways. First, it is fed into analog latches which detect excursions over a given threshold. There is a high and low threshold programmable through software. Latches are set when the inputs exceed the threshold and remain set until reset by the computer interface. The latch data is read directly as discrete inputs to a computer interface.

The analog data is also amplified by the analog signal conditioning circuitry. Then the analog channels are sequentially sampled by the A/D and multiplexer. The sampling process is initiated by either the fiber optic trigger or a software generated output from the computer interface. This data is recorded in a local memory for a period of approximately four milliseconds. This data is then transferred to the central computer system through the computer interface.

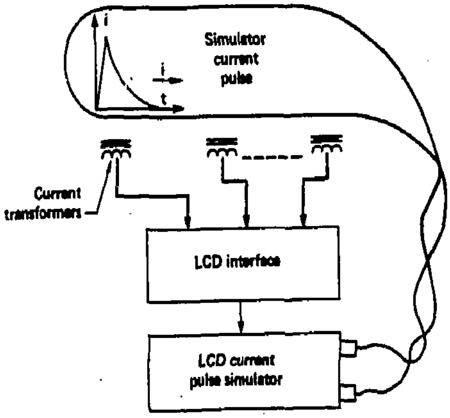
The LCD interface is composed of two identical 64 channel sections, providing a total of 128 input channels. The number of channels each of these sections samples is software programmable. The choices are 1, 8, 16, . . . 56, 64 channels. The A/D always samples at a 1 Mhz rate, so as more channels are selected, the slower the sample rate will be. For example, if one channel is sampled the rate is 1 Mhz for 8 channels the rate is 125 Khz, and for 64 channels the rate is about 15.6 Khz. The fastest natural frequency for our pulsed power circuits is on the order of 2 Khz so even the slowest sampling rate is sufficient to diagnose them.

Self diagnostic capability is provided by a current pulse generator which sends a current pulse through all of the current transformers under computer control as shown in Figure 3. This is used to check the latches on low threshold and to check the data sampling and recording circuitry. It provides a pulse of amplitude and duration similar to the low energy flashlamp circuit current pulse generated in the preshot testing of the pulse power circuitry and flashlamp.



LCD INTERFACE CONFIGURATON

Figure 2



CURRENT PULSE SIMULATOR FOR SELF DIAGNOSTICS

Figure 3

The filtering and clamping circuitry is shown in Figure 4. Its major function is to protect the LCD interface from damage due to noise. This is important because the LCD interfaces are mounted in racks next to the ignitron switches, some of which switch currents on the order of 100 kA. The series resistors provide current limiting and the steering diodes direct the current limited noise to ground through a coupling capacitor. Our testing has shown this arrangement to be effective in preventing damage to the LCD interface.

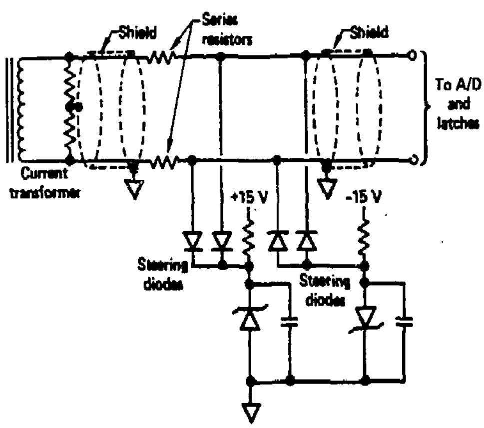
Data Processing

Data is read back from the LCD interface to the central computer system. Here data will be handled in several ways. Current waveforms can be displayed at the operator console for human inspection or analyzed by the computer. The lamp circuit current waveforms have a distinct characteristic shape, allowing an operator to easily recognize many typical problems with the pulse power system. The waveform analysis routine will determine whether the data is in limits or if it has changed since the last time it was sampled. The waveform data will also be placed in a file which can be archived if desired.

The latch data is used for a cursory inspection of the pulse power system. By reading the latches it can be determined whether the lamp circuits fired and whether there was significant current in the reflector ground or pulse power ground connection from the ignitron switch to earth ground. Waveform data will provide more detailed information if a problem is detected.

1. 1980 Laser Program Annual Report, LLNL, Nova Power Conditioning.

2. 1981 Laser Program Annual Report, LLNL, Nova Power Conditioning.



FILTERING AND CLAMPING CIRCUITRY

Figure 4