PROGRAMMABLE MASTER-TIMER SYSTEM

Jerry M. Potter, Michael L. Barnes, and Eric A. Bjorklund, MP-1, MS-H828
Los Alamos National Laboratory, Los Alamos, NM 87545

ABSTRACT

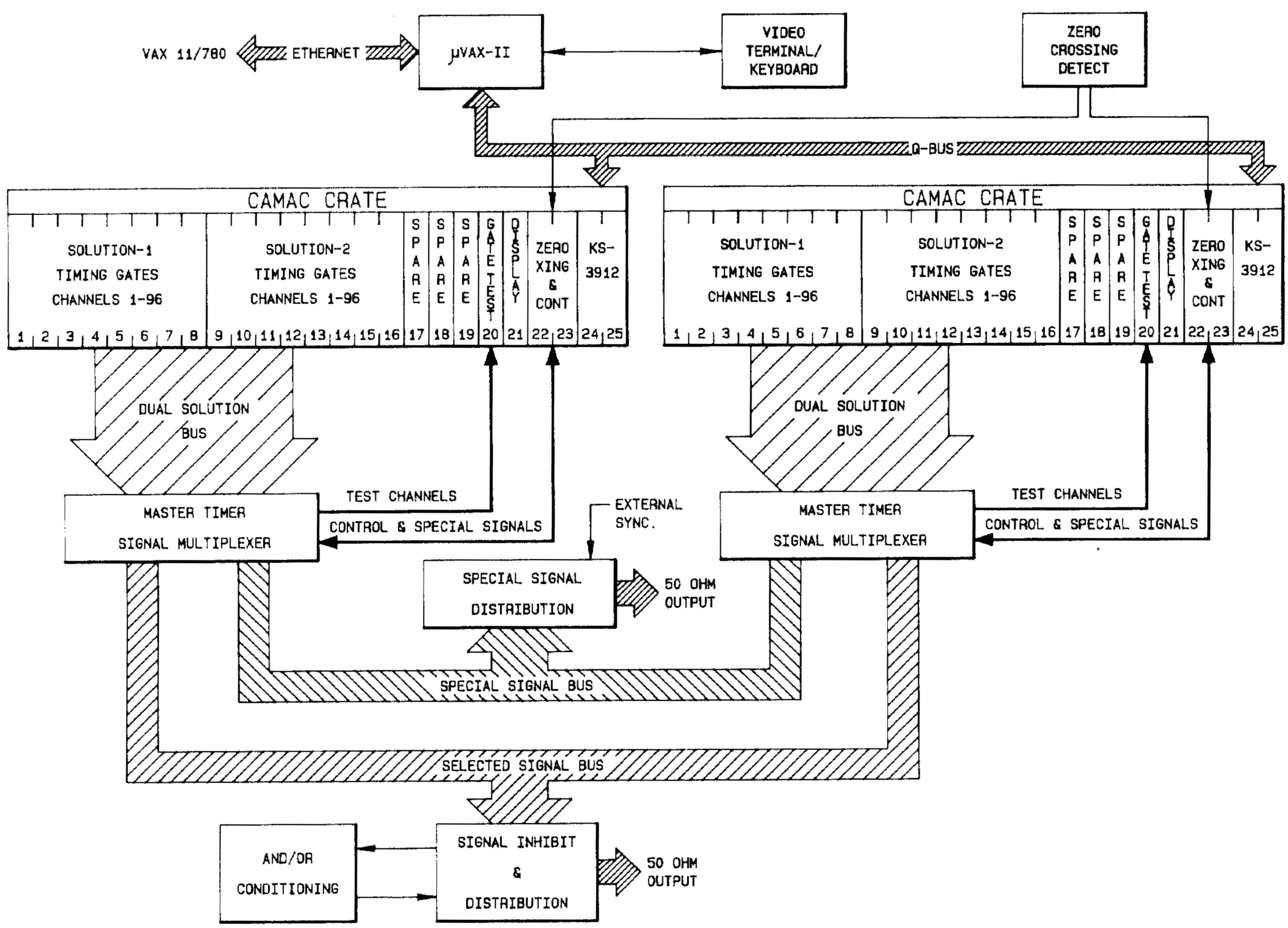
The Clinton P. Anderson Meson Physics Facility (LAMPF) master-timer system provides a 96-channel timing solution of programmable signals and eight predefined system signals required for accelerator operation. Each signal may differ in delay, length, and rate of repetition. Timing solutions are calculated in the LAMPF central control computer, a VAX 11/780, and down-loaded to the master-timer computer, a μVAX-II. The one second timing solution consists of 120 macropulses synchronized to the zero crossing of the ac line. The output signal resolution is one microsecond. This CAMAC-based system is implemented in a dual configuration to ensure versatility and reliability. Each subsystem provides two, 96-channel timing solutions. Any of the four master-timer solutions can be loaded, verified, and then synchronously selected. If the μVAX-II discovers a timing error during self-testing, it automatically switches to a valid solution. Once loaded, the system will continue to run without computer intervention. The master-timer system has the capability of local control and of displaying current status information. Adaptability, reliability, and self-testing assure that the LAMPF master-timer system will keep pace with future requirements.

INTRODUCTION

The LAMPF accelerator requires a complex set of timing signals for its operation. Due to the expansion of LAMPF facilities, the number and complexity of timing channels required exceeded the capacity of the former master-timer system.

It is essential for accelerator operation that the master-timer be highly reliable. It must be capable of using solutions derived by the central control computer or using predefined solutions stored in the μVAX-II, and must then continue to function without computer control. The integrity of the system must be assured by self-testing.

The new timing system requires a minimum of 60 programmable channels. Each channel must be capable of generating a pulse with a different delay, length, and rate of repetition. In addition to the programmable channels, eight predefined system signals are also required. Due to timing constraints, the master-timer must permit new solutions to be loaded and selected during a timing cycle without disturbing or losing the current cycle.

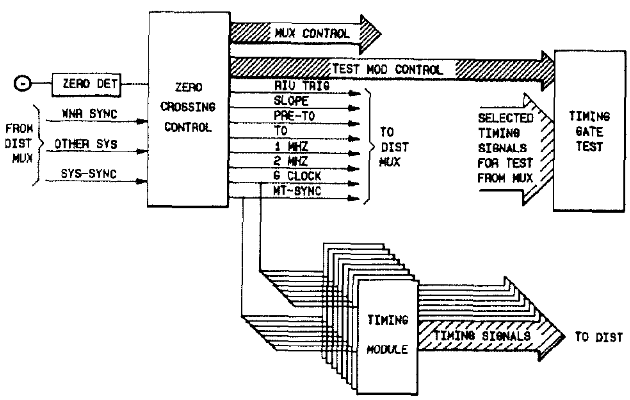


LAMPF PROGRAMMABLE MASTER-TIMER SYSTEM

SYSTEM CONFIGURATION

The master-timer system interfaces directly to the LAMPF control computer via Ethernet. The system consists of a μVAX-II computer, a video terminal, a zero-crossing detector, two CAMAC crates, several CAMAC modules, and a signal multiplexer/distribution interface. A dual configuration is implemented to ensure high reliability. Each half contains two sets of timing-gate modules that produce a two-solution, 96-channel subsystem. The remaining CAMAC slots house the zero-crossing and timing-control module, the timing-gate test module, and the display/test module.

If more than 96 timing gates are required, additional CAMAC crates and signal multiplexer/distribution segments can be added to expand the system.



MASTER-TIMER CAMAC

Zero-Crossing Detector

The zero-crossing detector is located in a separate chassis. It senses the zero-crossing of the ac power and generates an isolated square wave for use by the zero-crossing and timing-control module.

Zero-Crossing and Timing-Control Module

The zero-crossing and timing-control module is a double-width CAMAC module. This unit is synchronized by the signal from the zero-crossing detector in order to maintain a constant phase relationship to the accelerator RF power. Delay sequences are initiated on each zero crossing to provide several of the predefined system signals. This module also controls which master-timer solution is currently selected through the signal multiplexer unit, selects which channels to test, and monitors the CAMAC crate status.

Timing-Gate Modules

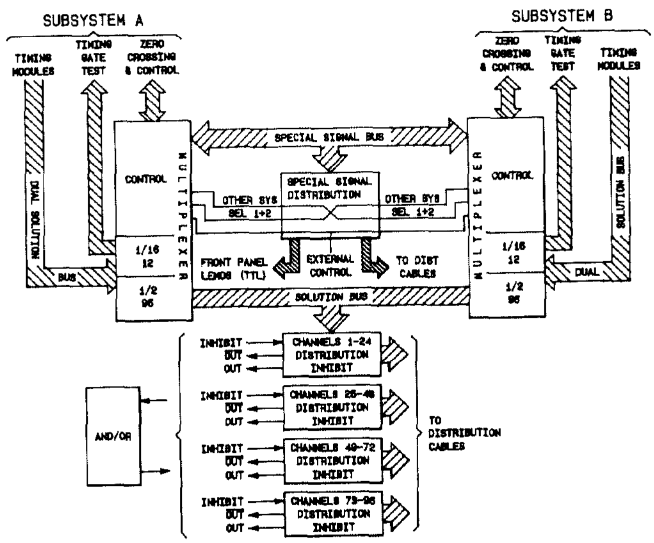
The timing-gate modules are programmable 12-channel general-purpose timing and sequence modules. The timing sequence is determined by the values set in a 4096 X 24-bit set-point memory and a 4096 X 12-bit output memory. Each channel may be programmed to change state at any set point and has a resolution of one microsecond.

Timing-Gate Test Module

The timing-gate test module is a single-width CAMAC module. This module can monitor and measure the gate outputs of one timing-gate module, 12 signals, simultaneously. For each cycle or macropulse a 16-bit counter/output register measures and stores the initial delay of a timing-gate signal. A second counter/output register measures and stores the pulse length, including the total duration if there are multiple pulses after the initial delay. These registers are read in real time by the μVAX-II and compared to a given solution before the registers are updated 8.3 ms later.

Display/Test Module

The display/test module is a single-width CAMAC module. This module is used to check the CAMAC dataway for correct operation.



MASTER-TIMER SYSTEM DISTRIBUTION

Signal-Multiplexer/Distribution Interface

There is a signal-multiplexer/distribution segment associated with each subsystem. It directs the selected solution to the LAMPF timing distribution system and selects timing channels for verification by the timing-gate test module.

Distribution of the timing signals is accomplished with two signal-multiplexer units, one special signal-distribution unit, four timing-signal distribution/inhibit units, and one AND/OR unit.

Each subsystem has a multiplexer chassis which contains a one-of-two, 96-channel multiplexer to allow either 96-signal solution to be selected. Their outputs are on a tristate bus to allow either multiplexer to present the selected solution, effectively a one-of-four multiplexer. Tristate devices are also used to multiplex the special signal bus. Additionally, each multiplexer chassis houses a 12-channel multiplexer that allows one of 16 timing modules to be verified by the timing-gate test module.

The dual configuration ends at the distribution portion of the master-timer. The special signal distribution unit manages the eight predefined system signals. It also receives an external control signal. If this signal occurs during a 75 μs window following the ac zero crossing, the master-timer will synchronize to it. This unit also passes control signals between subsystems and keeps them synchronized.

The four signal-distribution/inhibit units each provide 24 timing signals, 50 ohm and TTL, for distribution. External signal conditioning is provided for on the front panel. Any channel can be inhibited or conditioned with the AND/OR unit at this point. Both positive and negative signals are available on the front panel.

MAINTENANCE

Prior to installation the master-timer system was tested with a personal computer using an interactive BASIC compiler.

Master-timer system diagnostics check all parameters of the output gates. If an error is detected the system switches to another pretested timing solution, displays the error on a local video terminal, and notifies the central control computer that an error has occurred. The hardware of the subsystem that caused the error can be shut down for repair without affecting the currently selected timing solution.

SOFTWARE

The software for the master-timer μVAX consists of five independent processes running under the VAXELN real-time operating system. They are the VT100 process, the monitor process, two driver/diagnostic processes, and the CAMAC-driver process. These five processes communicate with each other and with the central control computer via remote procedure calls.

The primary interface for reading and setting the master timer is via the operator consoles attached to the central control computer. A secondary interface is provided through a VT100 terminal equipped with a touch screen and connected to the master-timer μVAX. This VT100 is used mainly for diagnostic and maintenance purposes. The operator can check to see which one of the four solutions is selected and display the current values of the timing gates. He can also change to another solution, initialize a crate and load it with the current solution, run diagnostics on a selected timing module, and issue CAMAC commands to any module in the system. Eventually, operators will also be able to set the master-timer from the terminal if the central control computer is down.

The master-timer monitor process keeps track of the current state of the master-timer system. It monitors the location of the currently active solution and the status of the other solutions. Some solutions may not be usable due to errors detected by the on-line diagnostics. Requests by the VT100 or the central control computer to read or change the state of the system are directed to the master-timer monitor process.

Two driver/diagnostic processes, one for each crate, are responsible for selecting and monitoring the currently active solution. These processes handle all interaction with the zero-crossing and timing-control modules and with the timing-gate test modules. When a new solution is sent to the master timer, the master-timer monitor process loads the solution into a currently inactive set of timing modules and then requests the appropriate driver process to switch to the new solution. After the driver process selects the new solution, it begins the on-line diagnostic using the timing-gate test module.

The zero-crossing and timing-control module generates two interrupts which are used by the on-line diagnostic. One interrupt is generated every second to synchronize the diagnostic with the beginning of the one-second timing solution. The other interrupt is generated 120 times per second to let the diagnostic know that a new macropulse is about to begin. At this time the values of the gates for the previous macropulse have been stored in the timing-gate test module's registers.

The driver/diagnostic process continuously checks the currently active solution for both CAMAC errors and errors in the timing modules. When an error is detected, the diagnostic will mark the current solution off-line and the solution is switched to another location. Currently the master-timer software keeps the same values in all four solutions in order to make solution switching as quick as possible after an error is detected.

The last process is the CAMAC driver. It is used to load the timing modules and to perform CAMAC diagnostics.

CONCLUSION

The LAMPF master-timer system was designed to be a highly reliable and versatile system. A master-timer solution can be loaded via the LAMPF control computer, verified, and then synchronously selected. The μVAX-II can also be programmed for a stand-alone mode. Once loaded, the system will continue to run without the intervention of either computer. This system has the capability of local control, displaying parameters, measuring specified gate outputs, and generating or receiving error messages. System diagnostics check all parameters of the output gates, display errors on a local video terminal, and notify the central control computer when an error has occurred. Either subsystem can be shut down without affecting the overall operation, making the master timer highly reliable and allowing necessary maintenance.