Optical Clock Module

HTM-077-B
CRAY T90™ Series
Last Modified: March 1998

Figures

Tables

Record of Revision

March 1995

Original printing.

Revision A: April 1997

Modified Figure 4 and made other minor changes.

Revision B: March 1998

Modified Figure 2, added Figure 3, and added information for the clock module block diagram description (Figure 6). Made numerous minor changes throughout the document.

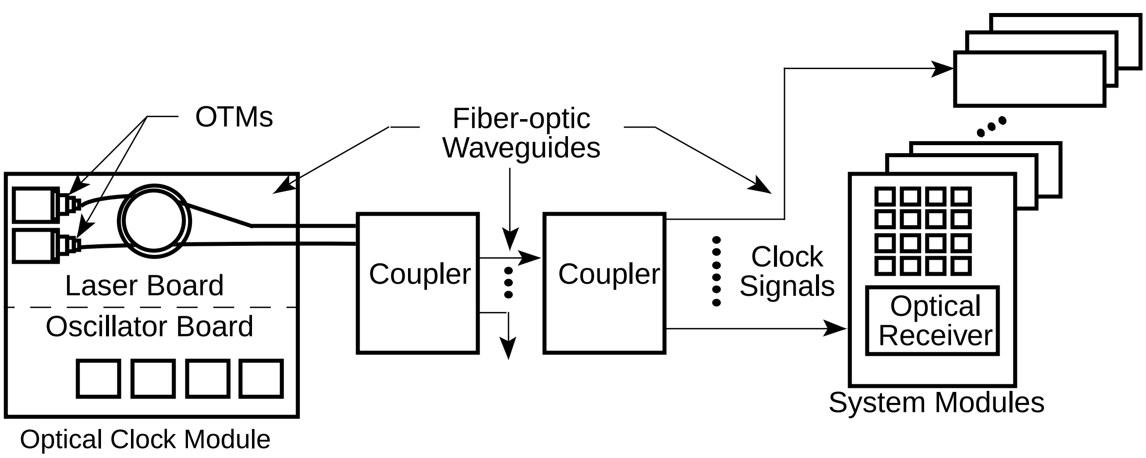
Optical Clock Module Overview

The optical clock module generates an optical clock signal and sends it to all system modules. Each CRAY T90 series system has one optical clock module. In CRAY T94 systems, the optical clock module is mounted on a clock deck located on the top of the card cage which is submersed in Fluorinert. In CRAY T916 and CRAY T932 systems, the optical clock module is located between memory module stack D and memory module stack H and is labeled Clock Box; it is not submersed in Fluorinert. The optical clock module has its own power supply. Refer to the appropriate CRAY T90 series power, cooling, and control system document for more information on the clock module power supply.

The optical clock module consists of two 4 in. X 9 in. printed circuit boards: an oscillator board and a laser board. The oscillator board contains the oscillators and integrated circuits. The laser board contains the optical transmitter modules (OTMs) that house the lasers. Two types of laser boards are available: CRAY T94 systems use the LP01 type, and CRAY T916 and CRAY T932 systems use the HP01 type.

Figure 1 shows the path of the optical clock signal. The oscillators generate an electronic clock signal and send it to the OTMs. The OTMs convert the electronic clock signal to an optical signal and send it through the fiber-optic waveguides to an optical receiver on each system module. The optical receiver converts the signal back to an electronic signal and distributes it to a TZ option, which, in turn, distributes it to each option on the system module.

Figure 1. Optical Clock Signal Path



Module Components

An optical clock module consists of a laser board and an oscillator board. The laser board contains the OTMs and connectors. The oscillator board contains the oscillators, integrated circuits (ICs), and connectors. Figure 2 illustrates the components on an LP01 optical clock module for the CRAY T94 and Figure 3 illustrates the HP01 optical clock module for the CRAY T916 and CRAY T932 systems.

Oscillators

The oscillators create a differential electronic clock signal (emitter crystal logic level) to drive the OTMs. Four oscillators on the module allow for three different clock frequency levels: the U4 and U5 oscillators provide a 450-MHz clock signal, the high-frequency oscillator provides a 460-MHz frequency signal, and the low-frequency oscillator provides a 440-MHz frequency signal. Oscillators U4 and U5 are the normal clock-frequency oscillators that provide the CRAY T90 series systems with a 2.2-ns clock. Two normal-frequency oscillators are available for redundancy purposes; if one oscillator fails, the second oscillator generates the clock signal. The second oscillator is selected by the control system. The system stops instantly if the clock is lost.

Integrated Circuits (ICs)

The optical clock module uses three types of integrated circuits: multiplexers, differential amplifiers, and divide-by-4 ICs. The multiplexer ICs select one of four paths, based on the input they receive from the control system. The paths are the high-frequency oscillator, low-frequency oscillator, the normal clock frequency oscillator, and the external generator. The differential amplifier ICs amplify the signals that are sent to the OTMs and those sent from the control system. The divide-by-4 ICs direct the signal to the trigger source for the respective multiplexer IC. The trigger source ensures an accurate clock signal reference point.

Optical Transmitter Modules (OTMs)

The OTMs contain the lasers that send the optical signals through the fiber-optic waveguides to the optical receiver on the system modules. The specifications for the lasers are different for the various models of CRAY T90 series systems. Table 1 lists the laser specifications for the OTMs in CRAY T932, CRAY T916, and CRAY T94 systems.

Table 1. CRAY T90 Series OTM Specifications

Specification	CRAY T932 and CRAY T916 (OH01) System	CRAY T94 (OL01) System
Rated power	12.229 milliwatt (mW)	2 milliwatt (mW)
Operating peak power	10 mW	1 mW
Operating average power	5 mW	0.5 mW
Wavelength	1310 nm	1310 nm
Pulse frequency	450 MHz nominal, range 50 MHz to 30 MHz	450MHz nominal, range 50 MHz to 30 MHz

Couplers

A coupler splits a clock signal that comes from the OTM and sends it to the system modules. Two levels of couplers are associated with each optical clock module. In CRAY T94 systems, the coupler on the clock deck is a 2-by-2 coupler: two inputs (from the two OTMs) and two outputs (however, only one output is used). This coupler sends the optical clock signal to a 1-by-8 coupler. The 1-by-8 coupler splits the signal and sends it to 8 different system modules.

In CRAY T916 and CRAY T932 systems, the coupler is a 4-by-4 coupler in which only two inputs are used (one from each OTM). Only two outputs are used in CRAY T916 systems, and all four outputs are used in CRAY T932 systems (refer to Figure 5). This coupler sends the optical clock signal to a 1-by-24 coupler, which splits the signal and sends it to a maximum of 24 system modules.

Connectors

The optical clock module has two types of connectors: right-angle head connectors and SMA jacks. Table 2 describes the functions of the five different right-angle head connectors. The SMA jacks are the connectors for the external generator source and the trigger source.

Table 2. Right-angle Head Connectors

Connector Description	Connector Name	Connector Function
3-pin	Power	Powers on the optical clock module
4-pin	Laser Enable	Enables one of two lasers
5-pin	Laser Alarm	Indicates whether the laser is in an operational or non-operational state
6-pin	Oscillator Path Select	Selects one of four paths: low frequency, high frequency, normal frequency, or external generator
7-pin	Oscillator Power Select	Powers on the selected oscillator

Cooling Devices

The CRAY T916 and the CRAY T932 optical clock modules contain a heat sink on the OTMs and a chiller (in the middle of the fibre optic cable). An illuminated green LED indicates that the cooling devices are operating normally. Refer to Figure 3.

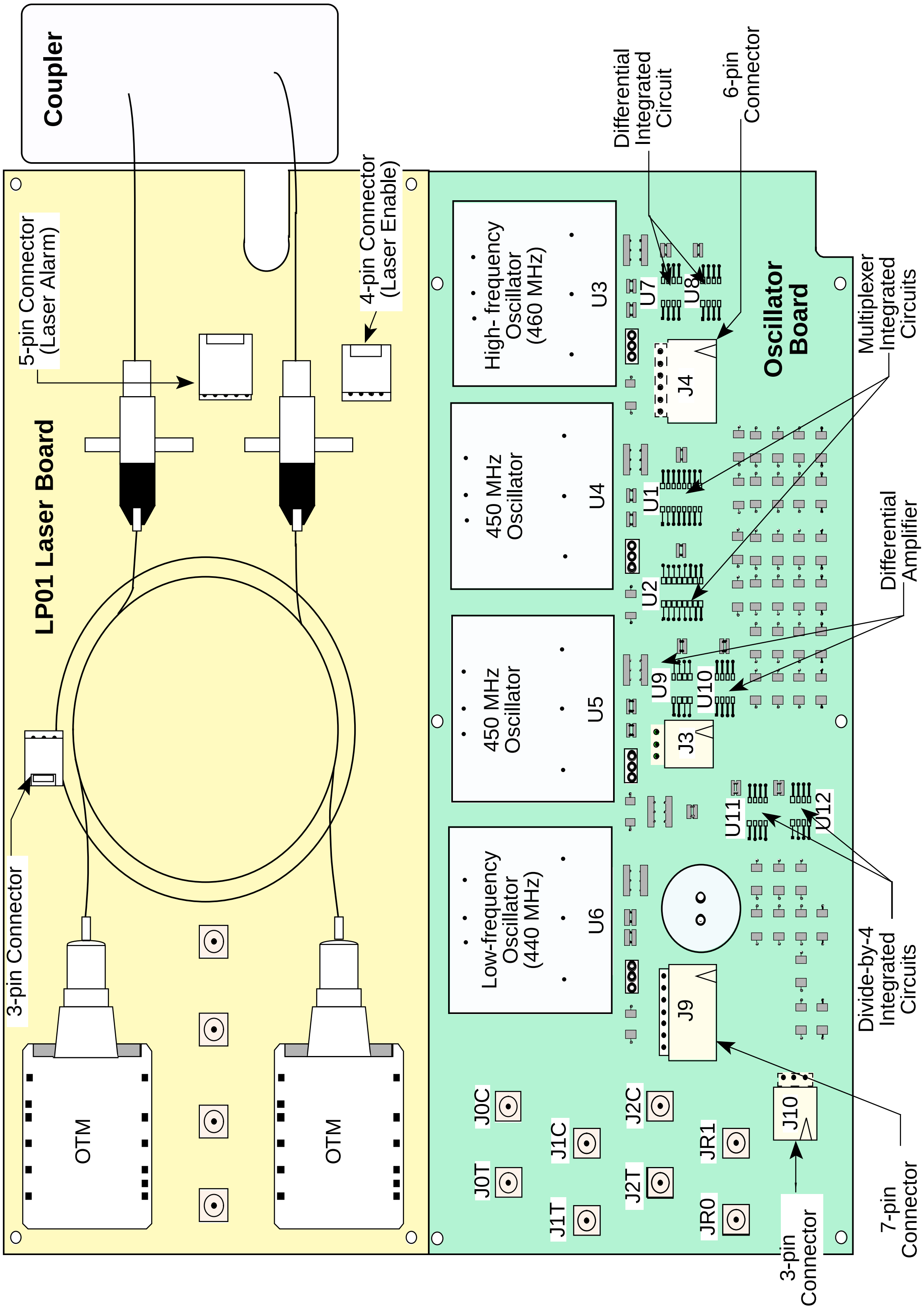


Figure 2. CRAY T94 Optical Clock Module

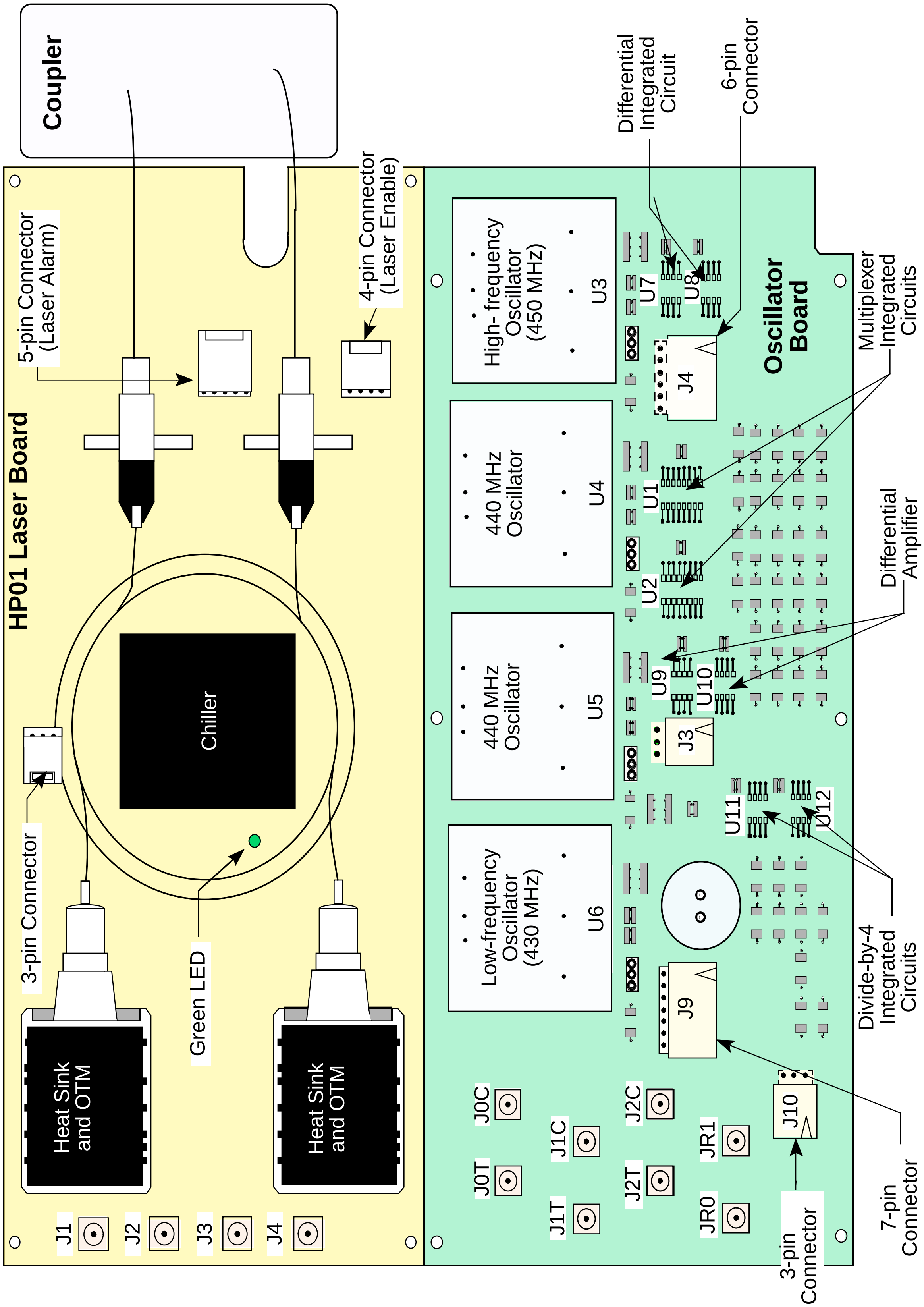
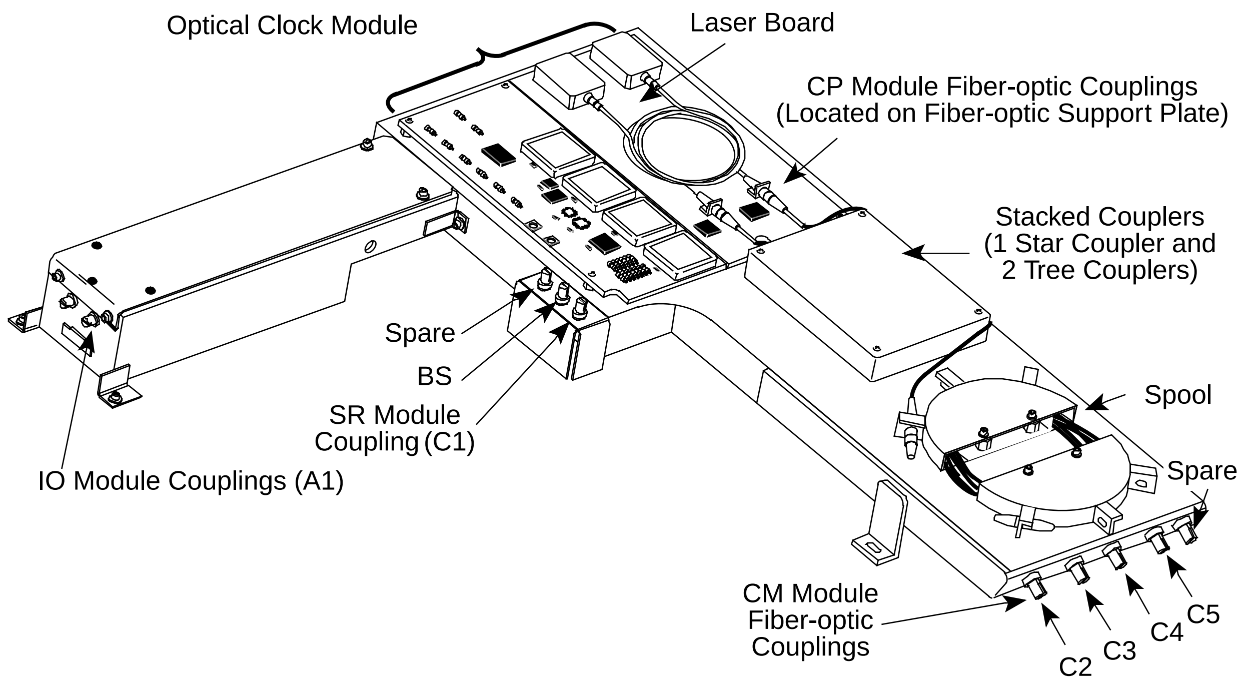


Figure 3. CRAY T916 and CRAY T932 Optical Clock Module

CRAY T94 Clock Deck

In CRAY T94 systems, the optical clock module is mounted on a clock deck. The clock deck is on the top of the card cage. The clock deck is a field replaceable unit (FRU) if the coupler fails; however, if the laser board or the oscillator board fails, then the failing board (not the entire clock deck) becomes the FRU. Refer to Figure 4 for an illustration of the CRAY T94 clock deck. Refer to *Field Replacement Procedures*, publication number HMM-111-0, for information on how to replace the clock deck, the oscillator board, or the laser board.

Figure 4. CRAY T94 Clock Deck



Optical Clock Path

Figure 5 shows the optical clock path for CRAY T94, CRAY T916, and CRAY T932 systems. In CRAY T94 systems, the optical clock module is capable of sending the clock signal to 16 system modules. In CRAY T916 and CRAY T932 systems, the optical clock module is capable of sending the clock signal to 96 different system modules. In CRAY T932 systems, each output of the 1-by-24 coupler can connect to any of the four mainframe quadrants.

Figure 5. Optical Clock Path

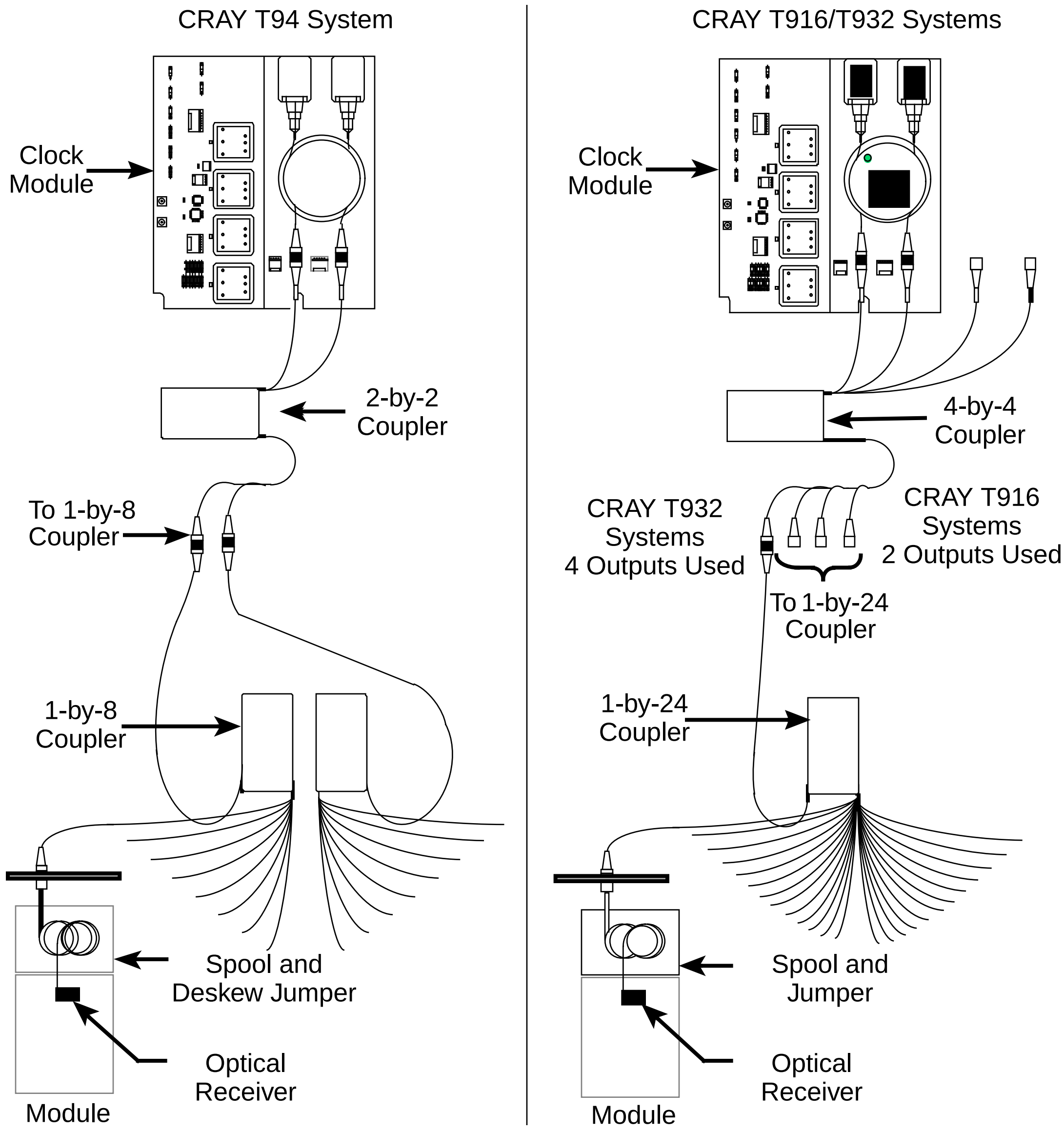
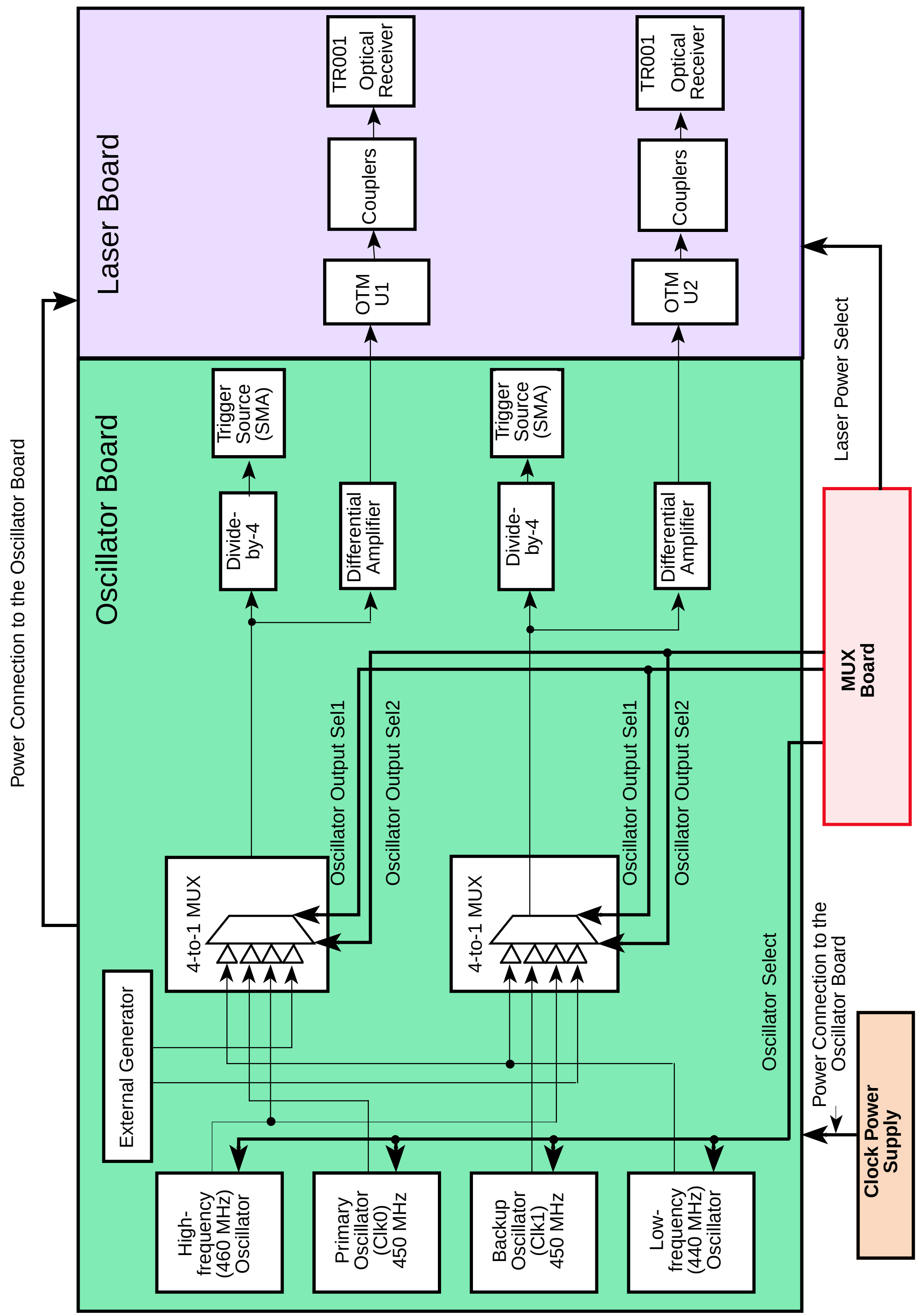


Figure 6 is a block diagram of the optical clock path. The control system sends three signals simultaneously to the optical clock module. One signal selects a path to enable the multiplexer; another signal powers on the specified oscillator or external generator; and a third signal powers on the associated OTM.

The selected oscillator (or external generator) sends an electronic clock pulse to the multiplexer. The multiplexer sends the signal through a divide-by-4 IC and a differential amplifier IC. The divide-by-4 IC sends the signal to the trigger source. The differential amplifier IC sends the spool signal to the associated OTM. The OTM converts the electrical signal to an optical signal and sends it to the optical receiver on the system modules.

Figure 6. Optical Clock Path: Block Diagram



Clock Distribution on System Modules

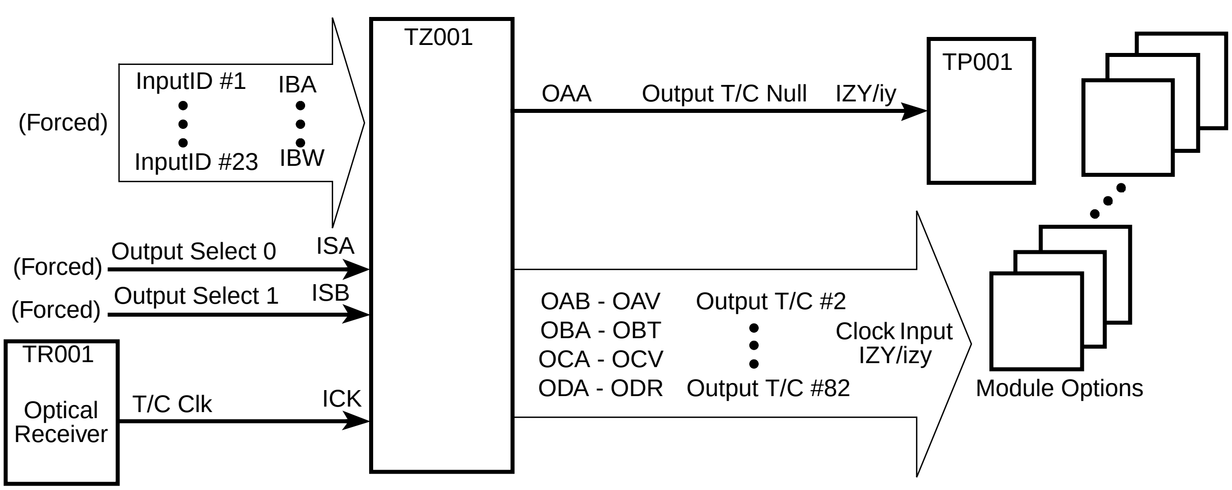
Each system module has an optical receiver (TR001) that converts the optical clock signal back to an electrical signal. The optical receiver then sends the T/C Clk signal to the TZ option. The TZ option sends a true and complement copy of this signal to each option on the module. The TP connector receives the Output T/C Null signal, which is a deskew point for probing the clock signal on the module. The other 81 TZ option outputs (OAB through ODR) go to the module options and enter the options as a Clock Input signal (Boolean term IZY).

The primary oscillator is connected to OTM1. If the primary oscillator fails, the backup can be selected using the NWACS program. When you select the backup oscillator, you are selecting OTM2 as well. The backup oscillator is connected to OTM2 and is used for redundancy.

The TZ option has forced inputs on 23 pins (IBA through IBW) for encoding module identification information, which includes the module type and module serial number. The boundary scan register (BSR) obtains this data and uses it for boundary scan functions. For more information on boundary scan and module identification, read the *Boundary Scan Module (BS02)* document, publication number HTM-005-A.

The TZ option also has two forced input signals: Output Select 0 and Output Select 1. These signals provide four TZ option output configurations, which disable unused outputs to help reduce the amount of noise on the module. Figure 7 shows the block diagram of the system module clock distribution.

Figure 7. System Module Clock Distribution Block Diagram



Note: Each differential output pair from the TZ option can drive two options on directly opposite sides of a system module.

Laser Safety: CRAY T90 Series Systems as Laser Products

The CRAY T90 series systems are considered laser products because they incorporate a laser on the optical clock module. A laser is capable of producing electromagnetic radiation; therefore, you must follow laser safety procedures when you work with the optical clock module.

Lasers are classified by the level of radiation that the user can be exposed to during the operation of the laser or laser product. Table 3 lists the different laser classes and describes their wavelength range and optical power accession limits. The accession limit is the maximum rating or potential sudden burst from the specified laser class.

Note: A Class I laser is the safest type of laser or laser product.

Table 3. Laser Classes, Wavelength Range, and Accession Limits

Class	Wavelength Range	Accession Limits
I	80 nm to 106 nm	Varies with λ and exposure time
IIa	400 nm to 710 nm	$3.9 \bullet 10^{-6}$ watt (W)(3.9 microwatts)
II	400 nm to 710 nm	$1.0 \bullet 10^{-3}$ W (1.0 milliwatt)
IIIa	400 nm to 710 nm	$5.0 \bullet 10^{-3}$ W (5.0 milliwatts)
IIIb	180 nm to 400 nm	Varies with λ and exposure time
	400 nm to 10^{6} nm	0.5 watt

The lasers on the optical clock module are Class IIIb lasers; the manufacturer establishes this classification. However, when Cray Research, Inc. (CRI) incorporates these lasers into the CRAY T90 series systems, the laser product (or CRAY T90 series system) is considered a Class I laser product. This classification is determined by the amount of radiation exposure during system operation. During the operation of a CRAY T90 series system, all of the laser light is confined to the fiber-optic waveguides in the system. No laser light radiates outside of these fiber-optic waveguides; therefore, no laser light radiates outside of the mainframe cabinet.

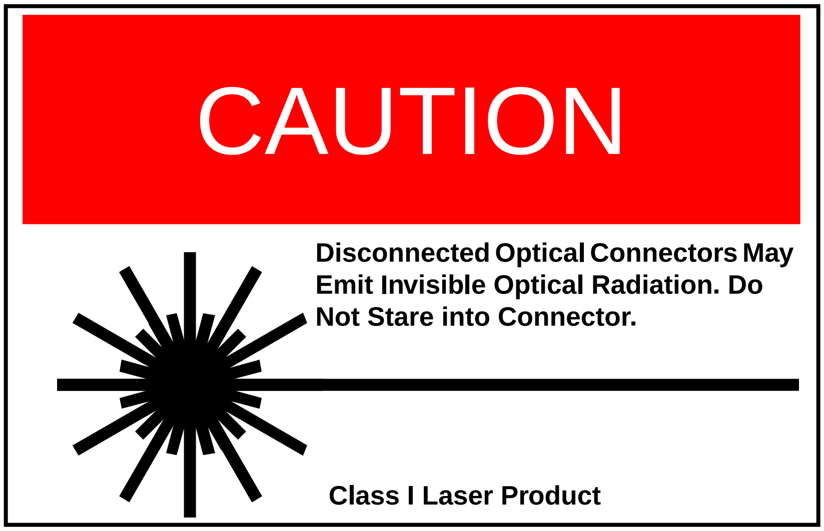
Note: If a CRAY T932 system is degraded for maintenance, the degraded portion of the system still receives the clock signal. Be sure to follow all laser safety procedures when you replace modules or perform system maintenance on a degraded CRAY T932 system.

Laser Safety Guidelines

If you apply power to the optical clock module when it is not enclosed in the mainframe cabinet (STCO and Engineering only), or if you are maintaining a degraded CRAY T932 system, be sure to follow these guidelines to ensure safety:

- Read and follow the information on all caution/warning/danger labels before you apply power to the module. Figure 8 illustrates a sample caution label for a laser product.

Figure 8. Caution Label for a Laser Product



- Always attach the connector to the fiber-optic cable before you apply power to the module. This ensures that all light is confined within the fiber-optic waveguide, practically eliminating any potential hazard.

- Never look into the end of a fiber-optic cable to confirm that light is being emitted. Most fiber-optic laser wavelengths (1300 nm and 1550 nm) are invisible to the eye and will cause permanent damage. Shorter wavelength lasers (for example 780 nm) are visible and cause significant eye damage. Always use an optical power meter to verify light output.

- Never look into the end of a fiber-optic cable on a powered device with any type of magnifying device such as a microscope, eye loupe, or magnifying glass. This will cause a permanent, irreversible burn on your retina.

- Call the manufacturer with any questions about laser safety before you apply power to the optical clock module.

If you are exposed to or injured from laser radiation, you must fill out a Health Incident Report and submit it (within 24 hours of the incident) to the Cray Research Environmental Health and Safety department in Chippewa Falls, Wisconsin.