Instruction Manual

Model 065/085/090
Optical Module

*Note: Models 065, 085, and 090 are identical except as following:

Model 065: Wavelength 650 nm, power output 2mW, Class II
Model 085: Wavelength 850 nm, power output 2mW, Class IIIb
Model 090: Wavelength 904 nm, power output 1mW, Class IIIb

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WARRANTY

Berkeley Nucleonics Corporation warrants all instruments, including component parts, to be free from defects in material and workmanship, under normal use and service for a period of one year. If repairs are required during the warranty period, contact the factory for component replacement or shipping instructions. Include serial number of the instrument. This warranty is void if the unit is repaired or altered by others than those authorized by Berkeley Nucleonics Corporation.

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SAFETY PRECAUTIONS

The following warnings, which appear both here and in the main body of the text, are to alert the user of potential safety hazards and to encourage safe operating practices.

WARNING: *Laser light emitted from the end of a connected light fiber is invisible. Fibers should be terminated in a system which will not allow human exposure to this radiation. Do not stare into the beam or into a beam from a reflecting surface. Caution-use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous exposure. Safety labels attached to the modules are shown in Figure 2-1.*

WARNING: *Do not attempt to defeat the safety interlock, and keep the LIGHT OUT connector covered with the dust cap when a fiber is not attached. Light produced by this instrument is invisible and may be an eye hazard.*

The following cautions, which appear both here and in the main body of the text, are to prevent equipment damage that could result from improper operation.

CAUTION: *The module must be installed with mainframe power off. A module can be damaged or have its memory corrupted if inserted or removed from the mainframe with the power on.*

CAUTION: *Keep sharp, hard or abrasive objects away from the fiber ends. Do not, for example, use a metal instrument when cleaning the connector, even if a cloth or tissue is wrapped around it. Damage to the fiber's light coupling capacity can result.*

850 NM OPTICAL MODULE

MODEL 085

Graphic (Model 065/085)

The Model 085 is one in a series of output plug-in modules that provide electrical and optical pulses when installed in the Model 6040 mainframe.

This particular module provides optical pulses of 850 nm wavelength at peak levels to 2mW at rates to 100 MHz.

SECTION 1

SPECIFICATIONS

MODEL 085 CHARACTERISTICS

Timing Characteristics

Rep Rate:	0 Hz-100 MHz.
Delay:	0 ns - 640 s.
Width:	5 ns - 640 s (Pulse Mode); 3 ns (min.) at reduced amplitude. Impulses, fixed 400 ps fwhm (typical).
Duty Factor:	0-100%.
Minimum Pulse Separation:	5 ns (for both Width and Delay < 160 ns) or 50 ns (for either Width or Delay ≥ 160 ns), trailing to leading edges.

Input Characteristics

EXTERNAL DRIVE

Range:	dc - 300 MHz (200 MHz for zero Baseline level): Specifications apply dc - 100 MHz.
Input Impedance:	50 ohms.
Minimum Signal Amplitude:	300 mV.
Maximum Signal Amplitude:	±7 V dc or 7 V ac rms.
Minimum Width:	5 ns:3 ns at reduced amplitude
Threshold Range:	±2.5 V.
Threshold Resolution:	10 mV.
Insertion Delay:	5 ns, typical (between EXT DR and LIGHT OUT).
Jitter:	30 ps rms (between EXT DR and LIGHT OUT).
Connector:	SMA.

EXTERNAL MODE

Range:	100 Hz to 700 MHz (-3 dB).
Input Impedance:	50 ohms.
Sensitivity:	100 mV rms/mW, typical
Maximum Signal Amplitude:	±2 V dc or 2 V ac rms.
Total Harmonic Distortion:	< 20 dB below fundamental (1 mW avg. Level with1 mW rms modulation).
Insertion Delay:	5 ns, typical (between EXT MOD and LIGHT OUT)
Connector:	SMA.

SPECIFICATIONS

Output Characteristics

LIGHTOUT

Source:	Temperature stabilized laser diode.
Wavelength:	830 nm ± 30nm.
Spectral Width:	2 run typical.
Power Level:	0 to 2 mW (Peak or Baseline). Specifications apply above 100 µW (laser threshold) Impulse is fixed at 100 (µW Baseline and 1.3 mW Peak (typical).
Power Level Resolution:	10 µ.W.
Extinction Ratio:	00 (zero Baseline), or 20.0 to 1.01.
Mesial Level:	50 µW to 1.995 mW (105 µW min. for nonzero Baseline).
Dynamic Range:	20 dB (nonzero Baseline, CW, External Modulation), 13 dB (zero Baseline).
Accuracy, Absolute:	±ldB.
Accuracy, Relative:	±0.5 dB (±10 %) from 200 µW to 2 mW (Pulse Mode). ±0.05 dB (±0.5 %) CW .External Modulation
Temperature Coefficient:	0.05 dB/° C.
Transition Times (20 to 80%):	0.5 ns rise time, 1.5 ns fall time (zero Baseline). 1ns rise time, 1 ns fall time (nonzero Baseline).
Module Delay:	10 ns. typical (between mainframe PULSE OUT and LIGHT OUT; see Figure 1-1.)
Insertion Delay:	55 us, typical (between mainframe TRIG IN and LIGHT OUT; see Figure 1-1).
Jitter:	100 ps rms (between mainframe TRIG OUT and LIGHTOUT).
Fiber:	Multimode 50/125 Um graded-index; 0.21 NA.
Connector:	ST, with safety interlock switch.

MODULE DISABLE	The optical output of the module can be remotely disabled, using the mainframe MODULE DISABLE jack.
Laser Inhibit:	4 V - 5 V. 5 mA sourcing current (into the 6040) or contact opening.
Laser Enable:	0-300 mV, 5 mA sinking current (from the 6040), contact closure, or plug removed from jack.

Modes

PULSE

Single Pulse:	Conventional pulse generator with rate, delay and width controlled by the 6040 mainframe.
Double Pulse:	A pair of identical pulses of the selected width with leading edges separated by the selected delay.
External Drive:	Produces pulses corresponding in rate and duty cycle to an external pulse train.

SPECIFICATIONS

EXTERNAL MODULATION	Converts digital and analog electrical signals into their optical equivalent.
IMPULSE	
Single Impulse:	A sub nanosecond pulse of fixed width and amplitude, with rate and delay controlled by the 6040 mainframe.
Double Impulse:	A pair of identical impulses separated by the selected delay.
CW	Provides a steady-state, adjustable power level.

Module Memory

PERMANENT MEMORY	A ROM in the module determines the instrument's allowable operating conditions and display units.
STORE	Ten complete instrument settings can be stored in the module's nonvolatile RAM. The module may be removed without loss of these settings.
RECALL	Stored settings can be manually recalled or bus transferred to the mainframe. The setting in memory 0 is activated automatically upon power-up or reset.

General

DIMENSIONS	3.75" W × 4.9 " H × 10" D (95 mm × 124 mm × 254mm).
WEIGHT	2 lbs, net (0.9 kg); 7 lbs, shipping (3.2 kg).
AMBIENT TEMPERATURE	Operating Range : 0° - 50° C (32° -122° F). Specifications apply : 10° - 40° C (50° -104° F).

Module Status Byte Summary

Table 1-1. 085 Module Status Byte

Bit	Description
7	Always zero
6	Always zero
5	Always zero
4	Always zero
3	Always zero
2	Laser Disabled
1	Laser Active
0	Laser Guard

SECTION 2

OPERATING INFORMATION

DESCRIPTION

The Model 085 plug-in module provides an 830 nm optical output source for the Model 6040 Universal Pulse Generator. The 085 operates in all four Modes of the 6040 mainframe: Pulse, External Modulation, Impulse, and CW.

In Pulse Mode operation, the 085 supplies flat-topped pulses with fast rise and fall times and independently adjustable Peak and Baseline levels. The timing for these pulses may be supplied in a number of ways.

A delayed pulse of adjustable width may be generated by the mainframe. This delay can be specified with respect to an internal trigger occurring at a selected repetition rate or with respect to an externally supplied trigger signal (TRIG IN). In addition, Single Cycle operation allows the user to trigger the instrument manually, using a pushbutton (or using remote programming). In each case a trigger out signal (TRIG OUT) is provided by the 6040 for reference (see Figure 1-1). Double Pulse operation, producing both an initial and delayed pulse out of the same jack, may be selected for any trigger choice. For all of these timing options, the mainframe supplies +5 V output pulses (PULSE OUT) approximately coincident with the module's LIGHT OUT output (see Figure 1-1).

External Drive operation is also available in the Pulse Mode. This allows a drive signal, supplied by the user to the module's front panel (EXT DR), to generate the optical pulses directly. The occurrence and duration of each light pulse will correspond to that of each pulse in the external drive signal : when the EXT DR pulse goes high, the light pulse goes to the Peak value. Peak and Baseline output levels remain specified by the mainframe (as well as the threshold level for the external drive signal). With External Drive, the mainframe's pulse and trigger outputs are disabled.

In External Modulation Mode, an electrical signal supplied to the module's front panel (EXT MOD) by the user will be converted into its optical analog. The quiescent optical level, corresponding to the average level of the input signal, is selected by the mainframe (External Modulation Level), but no other parameters can be altered.

In the Impulse Mode, a narrow optical pulse of fixed width and amplitude is produced at the module output (LIGHT OUT) with a corresponding pulse (of 5 ns duration) appearing at the mainframe (PULSE OUT). As with the Pulse Mode, the trigger source may be internal, external or from manual (or remote programming) control. Either a single delayed impulse or a pair of impulses separated by a delay may be obtained. In Impulse Mode, External Drive operation is disabled and Peak and Baseline Level settings have no effect.

CW Mode results in a steady-state optical output. The output power level in this Mode may be adjusted by the mainframe (CW Level).

For more detailed information on the characteristics of each Mode and how to control the module from the mainframe, see the Specifications section and the 6040 manual.

OPERATING INFORMATION

General

WARNING: *Laser light emitted from the end of a connected light fiber is invisible. Fibers should be terminated in a system which will not allow human exposure to this radiation. Do not stare into the beam or into a beam from a reflecting surface. Caution-use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous exposure. Safety labels attached to the module are shown in Figure 2-1.*

POWER UP

When power is applied to the 6040 mainframe with an 08 module installed, the instrument settings from the module's memory 0 are activated. The mainframe automatically checks what type of plug-in module is in place and loads the appropriate parameters. The LCD, after showing the mainframe's software version number and performing a memory check, will display "085 Ver. x.x" where "x.x" is the version number of the module.

Module Installation

CAUTION: *The module must be installed with mainframe power off. A module can be damaged or have its memory corrupted if inserted or removed from the mainframe with the power on.*

To install the module, simply slide it in and tighten the mount screw knob.

Warm Up Requirements

The instrument should be allowed to warm up for 30 minutes before high precision measurements are made. Less critical tests can be performed immediately after turn-on.

MODULE DISABLE

The MODULE DISABLE jack, located on the mainframe rear panel, is active with the 085 module. As described in the 6040 manual, the jack leads are normally closed, but they open when a plug is inserted. When these leads are opened, the module disable circuitry shuts off the laser (and turns off both front panel LEDs). Placing a switch between the leads of the plug allows the user to remotely enable and disable the module's laser output.

Alternately a signal having characteristics comparable to HCMOS type outputs may be used, with the high level (4 V - 5 V, 5 mA sourcing current into the 6040) inhibiting the laser and the low level (0-300 mV, 5 mA sinking current from the 6040) enabling it.

Graphic (Safety Labels)

Fig. 2-1. Safety labels for Models 065, 085, and 090

TROUBLESHOOTING

Follow the procedure in the Troubleshooting section of the 6040 manual. Make sure that the module is seated correctly in the mainframe.

Cold Boot

If the instrument turns on, but is completely unresponsive to the keyboard or displays the error message "Invalid Function," then the module's memory may have been corrupted causing the instrument to "hang up." To correct this, turn the unit off, then hold down the (ENTER) key, and turn the power back on. This will initialize the module's memory to its default settings (see Table 2-1).

Table 2-1. 085 Module Default Settings

MODE:	Pulse
TRIG:	Single Cycle (with other values set as follows) Internal Trigger Rate = 1 kHz. External Trigger Threshold = 0 V Trigger Slope + External Drive Threshold = 0 V
TIMING:	Delay -1 us Width = 1 us Single Pulse
LEVEL:	Peak = 2 mW Baseline = 0 mW External Modulation = 0mW CW=0mW
GPIB/RS232:	GPIB Address = 6 Baud Rate = 1200 Full Duplex Remote Enabled

Quick Test

The Quick Test procedure for the mainframe may be applied to the 085 by selecting the Pulse Mode and following the test sequence described in the 6040 manual using the module's LIGHT OUT connector and an optical detector in place of the mainframe's PULSE OUT. After Pulse Mode operation has been verified, the Impulse Mode can be tested. This will require an oscilloscope with a 1 GHz bandwidth. The impulse should appear as a narrow pulse (approximately 400 ps). Its amplitude is roughly equal to that of a 1.5 mW, 5 ns pulse generated in the Pulse Mode. The CW and External Modulation Modes are similar. These should produce continuous outputs. The output under External Modulation should follow any waveform presented to the module's EZT MOD connector.

Front Panel Description

LED INDICATORS

The 085 module has two LED indicators on the front panel.

LASER ACTIVE will light when the instrument is in a state that can produce a light output,

LASER GUARD will light if the laser is being protected from an unsafe power output level, whenever the Mode is changed and when the unit is first turned on. LASER GUARD will remain on if any unsafe circuit conditions exist (e.g., excessive current driving the laser),

CONNECTORS

Three connectors appear on the 085 module front panel.

LIGHT OUT provides the optical output from the module. A multimode 50/125 um fiber with an ST connector is required. To protect the user, the optical output is provided with a safety interlock that prevents light from being transmitted unless a connector is attached. A cap is provided to keep dust out of the connector when not being used. For proper handling and cleaning procedures, consult the Maintenance and Calibration section.

> **WARNING :** *Do not attempt to defeat the safety interlock, and keep the LIGHT OUT connector covered with the dust cap when a fiber is not attached. Light produced by this instrument is invisible and may be an eye hazard.*

EXT DR (External Drive) is an SMA connector for accepting drive signal inputs to the module.

EXT MOD (External Modulation) is an SMA connector that accepts external signals to modulate the instantaneous light output power level.

Rear Panel Description

The rear panel of the 85 module has a mounting screw (for installation into the mainframe), one 40-pin edge connector, and one ConheX (slide-on type) coaxial connector. The 40-pin connector allows the 6040 mainframe to control and communicate with the module and also supplies the power to the module. The ConheX connector receives the high speed pulse generator DRIVE signal from the mainframe. This signal is an ECL version of the mainframe's front panel PULSE OUT.

OPERATING INFORMATION

Mainframe Operation

This section presents information on how to operate the Model 6040 Universal Pulse Generator with the Model OS optical module installed. Only the details that are specific to the module are described. For an overall description of how to use the mainframe with plug-in modules, please refer to the 6040 manual.

Front Panel Programming

When operating the instrument from the front panel, certain control keys have module dependent action, as indicated in the 6040 manual. The aspects of these keys, and the menus they control, that are not general to the mainframe will be listed here.

An overall chart of the menu keys, showing which menu selections have control in each Mode, is given in Table 2-2. An x in the column for a given Mode indicates that the menu selection operates in that Mode.

{MODE}

The Mode menu for the 085 has all four selections available: Pulse, Impulse, CW, and External Modulation.

Pulse Mode can operate over the entire timing range of the 6040, producing flat-topped delayed pulses. The Delay interval, Peak level, Baseline level, and Pulse Width are all adjustable.

External Drive operation is available in this Mode, allowing the module to be digitally modulated at rates from zero to 300 MHz (for nonzero Baseline levels) or 200 MHz (for zero Baseline level).

Impulse Mode produces pulses of fixed 400 ps -width with fixed 100 μW baseline and 1.3 mW peak levels (typical).

CW Mode provides continuous wave optical output.

External Modulation Mode allows a user-provided analog or digital signal to be linearly converted to its optical equivalent. Inputs ranging from 100 Hz to 700 MHz are converted with 100 mV rms/mW sensitivity {typical).

OPERATING INFORMATION

{TRIG} The Trigger source and parameter menu, which operates in the Pulse and Impulse Modes, has all five menu items : Single Cycle, Internal Trigger (and Rate), External Trigger (and Threshold), External Trigger Slope, and External Drive (and Threshold).

Internal Trigger Rate and External Trigger Threshold are adjustable over the 6040's entire range.

External Drive is valid only in Pulse Mode (and has no effect in Impulse Mode). The External Drive Threshold for the discriminator on the EXT DR input to the module is adjustable from -2.3 V to +2.3 V with 10 mV resolution.

{TIMING} This module places no constraints on timing settings selected with the Timing parameter menu.

{LEVEL} All four Level parameter menu selections are available for this module: Peak Level, Baseline Level, External Modulation Level and CW Level.

Peak and Baseline Levels select the high and low power levels in Pulse Mode operation. These levels may be set to zero or they may be adjusted between 100 µW and 2 mW in 10 µW steps (note that accuracy specs apply only over 200 µW). Peak Level and Baseline Level may be set independently, but if Peak is set below Baseline the output will be a constant CW at the Baseline Level.

External Modulation Level sets the quiescent optical power level. This may be selected over the range of 100 µW to 2 mW in 10 µW steps.

CW Level may also be adjusted to any power level between 100 µW and 2 mW with 10 µW resolution.

For all four Level parameters, levels between zero and 100 µW may be selected but output characteristics are not guaranteed.

{UNITS} This key is not used with the 085 module (and has no effect).

FUNCTION KEYS {A}, {B}, {C} These keys are not used with the 085 module (and have no effect).

Table 2-2. Menu Keys for the 085 Module.

	MODE Menu			
	Pulse	**Impulse**	**CW**	**External Modulation**
TRIG Menu				
Single Cycle	X	X		
Internal Trigger (and Rate)	X	X		
External Trigger (and Threshold)	X	X		
External Trigger Slope	X	X		
External Drive (and Threshold)	X			
TIMING Menu				
Delay	X	X		
Width	X			
Single/Double Pulse	X	X		
LEVEL Menu				
Peak	X			
Baseline	X			
CW			X	
External Modulation				X

Remote Programming

The remote programming commands that are specific to this module correspond to the module dependent front panel commands, as described in the previous section. Consult the 6040 manual and the above section for details on controlling the instrument with remote programming. The Module Status command, the only command that is specific to the 085 module, will be described here.

PS Module Status: This command returns the Module Status byte for the 085

Module Status Byte:

Bit	**Description**
7	Always zero
6	Always zero
5	Always zero
4	Always zero
3	Always zero
2	Laser Disabled
1	Laser Active
0	Laser Guard

Bits 3-7: These bits are always zero and are reserved for future use.

Bit 2: This bit is set if the LIGHT OUT interlock or the MODULE DISABLE input jack has disabled the laser.

Bit 1: This bit is set if the LASER ACTIVE LED is lit.

Bit 0: This bit is set if the LASER GUARD LED is lit.

SECTION 3

THEORY OF OPERATION

GENERAL

Module Interface

Figure 3-1 shows a simplified block diagram of the Module Interface board. The path for communication between mainframe and module is via the 40-pin edge connector (P8). The eight QAD lines and five QA lines are internal bus interface lines, and a MOD DIS line is used for disabling the Output board. Power is also delivered by the edge connector.

The address demultiplexer and select logic circuitry decodes the bus signals and selects one of the other blocks.

The I.D. ROM contains information necessary for operation specific to the Output board. This includes boundaries for parameters, values used to initialize the nonvolatile RAM (NVRAM), and the version number of the I.D. ROM.

The nonvolatile RAM is used for saving and retrieving ten panel settings. It also holds the GPIB/RS232 bus settings.

The digital control circuits are used to monitor and set the operating state of the Output board. The DACs and amplifiers provide four analog values that can be used for level control. All of the control, status, and analog signals are delivered to the Output board by two 20-pin connectors (Jl and J2).

Laser Driver Output

Figure 3-2 shows a simplified block diagram of the Laser Output board. The connection to the Module Interface board is shown in the lower left hand corner. There are three analog lines used to set the output levels and the threshold of the External Drive discriminator. The control lines select which Mode the Laser Output will operate in.

The selection of the digital drive source is controlled by four digital control lines, EXT DRIVE EN, IMPULSE, CW and EXT MOD. These determine which of the two drive sources will be controlling the state of SI, a high speed transistor switch. A discriminator, whose threshold is set by the analog voltage EXT DRIVE LEVEL, is connected to the drive source from the front panel EXT DR connector. The other signal source is the rear panel DRIVE connector which delivers the mainframe's pulse generator output.

The level control circuitry sets levels on one or both of the current sources as determined by the analog inputs, PEAK LEVEL and BASELINE LEVEL, and by the digital Mode control lines. During the Impulse, CW and External Modulation Modes, it uses the PIN detector in the laser module to monitor and stabilize the laser's output. When LASER GUARD is active, both current sources are set for zero output.

Graphic (Module Interface)

Figure 3-1. Module Interface Block Diagram

Graphic (Laser Output)

Figure 3-2. Laser Output Block Diagram

The two current sources are used for different Modes. The current source on the left is used during Pulse and Impulse Modes (to supply the Peak level), and during the External Modulation Mode. This current source can be modulated from a wideband preamp which is driven by the front panel SMA connector EXT MOD. The current is switched to the laser by S1, as determined by the digital drive select circuitry and the drive signals. The current source on the right is used in Pulse Mode when a nonzero Baseline level is selected, in Impulse Mode, and in the CW Mode.

The Laser Protection circuitry monitors the laser output and circuit conditions. If the laser output exceeds a preset level, S2 will be closed and all laser drive current will be shunted to ground. The current is then monitored until it is reduced below another preset value before S2 is allowed to reopen. This block also drives the front panel LEDs, LASER ACTIVE and LASER GUARD, which allow the user to monitor the state of these circuits. The DAC EN signal is used to notify the Module Interface board of a potential problem and disable its DACs, thus setting all level control voltages to zero. The MOD DIS signal is used to remotely disable the module's output. The interlock switch disables the output when an optical connector is not attached.

The Laser Module is a single package that contains the laser diode, a PIN monitor diode, a thermoelectric cooler (TEC), and a temperature sensing device. A 50/125 um multimode fiber is connected to the front panel (LIGHT OUT). The TEC and thermister are used in conjunction with an op amp and transistor to regulate the temperature of the laser diode, thus improving power and wavelength stability.

CIRCUIT DESCRIPTION

Module Interface Board (Schematic 6040-35)

The Module Interface board contains all the necessary circuits to allow the 6040 mainframe to control the module. Interfacing between the module and the mainframe is realized via the 40-pin edge connector, P8. This delivers eight data bits (QADO-QAD7) and 13 address bits (QADO-QAD7, multiplexed, and QA8-QA12, nonmultiplexed). P8 also delivers power to the Interface board and the Output board.

Z2 is an eight bit latch that demultiplexes QADO-QAD7 to produce the lower eight address bits QAO-QA7. This allows up to 8K bytes to be addressed within the Interface board, though not all of this is utilized at the present time. Table 3-1 gives the memory map for the module.

Zl is a dual quad selector. ZlA is used to select between one of four 2K byte segments. These four segments are used for: 1) Z3, the I.D. ROM; 2) Z4, the nonvolatile RAM; 3) reserved for expansion; 4) Z5, Z6 and Z7, the digital and analog control of the output board. Z1B selects which 1C in the fourth segment is accessed.

THEORY OF OPERATION

Table 3-1. Plug-In Module Memory Map

Memory Range	
COOO-C777	Z3.I.D. ROM
C800-CFFF	Unused
DOOO-D7FF	Z4. Nonvolatile RAM (NVRAM)
D800-DFFF	I/O
D800-D9FF	Z5.82C55 PPI
D800	Port A
D801	PortB
D802	PortC
D803	Control
DAOO-DBFF	Unused
DCOO-DDFF	Z6,7528; Dual DAC
DCOO-DC03	PEAK LEVEL
DC04-DC07	BASELINE LEVEL
DEOO-DFFF	BZ7,7528; Dual DAC
DEOO-DE03	SPARE
DE04-DE07	EXT DRIVE LEVEL

Z3 is the I.D, ROM. It is an 8K byte ROM (only the lower 2K is used) that contains the module dependent information necessary for the 6040 to operate correctly. This includes the Modes that are valid, parameter boundaries, and the type of output that the module has (optical or electrical). It also contains the values for initializing the nonvolatile RAM.

Z4 is a 2K byte nonvolatile RAM (NVRAM). It is used to save instrument settings and power-on conditions.

Z5 is a configurable Parallel Peripheral Interface IC set up to allow 16 bits of output and eight bits of input. The outputs are used to select the operating state of the Output board while the inputs monitor the board's status.

DACs Z6 and Z*7,* in conjunction with op amps Z8 and Z9, generate analog signals that set the value of the Peak, Baseline, and quiescent level of the output. They are also used to set the threshold level for the External Drive discriminator. The variable resistors, R3-R6, are used to compensate for slight differences in the DACs.

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The voltage reference for the analog signals is CR1, a 6.2 V temperature compensated zener diode. Q1 is used to disable CR1 if the signal DAC EN is allowed to go up to +12 V. The Output board asserts this in the event of a Mode change or if any unusual condition is detected.

The MOD DIS line allows the Output board to be disabled via the 6040 rear panel MODULE DISABLE connector.

The Module Interface board has two grounds, digital and analog. The analog ground is used exclusively by the DAC and op amp circuitry (Z6, Z7, Z8, Z9, etc.), while all other circuitry is connected to digital ground. These are separated to prevent any noise or dc offsets by power supply return currents from affecting the analog control voltages.

The 20-pin connectors J1 and J2 deliver the digital and analog control signals to the Output board, while the 16-pin connector J11 delivers the power supply voltages. J3 is an expansion connector to be used in conjunction with future modules.

Laser Output Board (Schematic 155-32)

Inputs and Control Signals (Schematic Sheets 1 and 2)

The Laser Output board receives three types of inputs : digital control signals from the Interface board via P1, analog control signals from the Interface board via P2, and drive and external modulation inputs via front or rear panel coax connectors. Four of the digital control signals, IMPULSE. EXT MOD, CY, and BIAS, are used to control analog switches, Z14 and Z11 (sheet 1). These switches are in their low impedance (closed) state when the control input, the terminal with inversion circle, is low (near ground).

Table 3-2 shows how these digital control signals affect the condition of the analog switches in each Mode. The switches are identified by their control terminals (e.g., Z14-9); "L" and "H" indicate low and high logic/voltage levels. By turning on and off these switches, these digital signals provide proper routing for BASELINE LEVEL and PEAK LEVEL, the analog signals that control the amplitude at the laser output. As an example, in the Pulse Mode with a nonzero Baseline (and not using External Drive), the only high input to Z9 is BIAS (Z9-5). Thus Z9-10 and Z9-12 are both high and Z9-6 is low. Z14-1 is low and this connects the BASELINE LEVEL amplitude control to Z8-3 via Z13-7 and Z14-3. Other Modes may be similarly analyzed using this table.

Three digital control signals, EXT MOD, CY (sheet 1) and EXT DRIVE EN (sheet 2), select which drive source is presented at the output of the ECL multiplexer, *24.* In Pulse Mode either the DRIVE signal from the mainframe or the EXT DR signal from the module front panel can be selected. This signal, after passing through Z3 and R162, becomes PREDRIVE, which determines when the laser is switched between Peak and Baseline levels. In External Modulation Mode, EXT MOD selects X4 (Z4-11), which is tied high, for the multiplexer output, causing PREDRIVE to be held high. In CY Mode, X2 is selected, causing PREDRIVE to be held low.

THEORY OF OPERATION

Laser Module (Schematic Sheet 3)

The Laser Module is shown enclosed by dashed lines within which are four components. The laser itself is the lower diode whose anode is connected to ground at pin 5. The diode shown between pins 7 and 8 is a built in monitor (detector) that is used for controlling the laser's output in the CY, External Modulation, and Impulse Modes and is also used to detect excessive optical power. A thermoelectric cooler (TEC) is incorporated in the module and is
shown connected between pins 1 and 14, Its associated thermistor is connected between pins 10 and 11, The temperature is maintained at approximately 23° C by means of a feedback loop consisting of Z1 and Q10. This loop supplies enough cooling current to bring the thermistor resistance to 23 k. R104 limits the maximum current during start-up to a safe level (approximately 2 A). A 170 μH inductor (L3) prevents Q2's collector capacitance from attenuating high frequencies, R170 helps terminate the drive signal from 06.

CW models (Schematic Sheets 1 and 3)

CW operation utilizes the dc current source, Ql and Z7*,* The voltage from Z8-1 (labeled CW OR BASELINE LEVEL) is applied to one arm of the resistor bridge, R36, R37, R63 and R66. This same voltage is forced to appear across R82 and R83. A typical calibration is for R82 and R83 to be 50 ohms so that 20 mA/V is produced by Q1. This current flows (via R81, L1, and L3) through the laser to ground. Since PREDRIVE is held low the path for current through Q6 will be cut off. Once the threshold current of the laser is exceeded, the relationship between the current in the laser and *its* optical output is linear.

The path of the CW OR BASELINE LEVEL signal may be followed on schematic sheet 1. First, we note that the PEAK LEVEL control voltage is inverted by Z13-1 and delivered to Z16-3 via R20. Second, we determine the status of the switches that affect the CW OR BASELINE LEVEL signal. Zll-3. for example, is connected to three such switches. From Table 3-2 it is seen that its control signal is IMPULSE from Z9-2, and that it is high in the CW Mode. Thus, Z9-3 is not conducting. Z14-16 is similarly found to be low so this switch is conducting. Also, Z14-1 is high which renders this switch open. Since Z14-9 is low. the EXT MOD OR CW FEEDBACK signal from Z16-7 is applied to Z16-2. The output from Z13-1 is also applied to Z16-3 The output from Z13-1 is not influenced by R22 because Z14-6 is open and no voltage is applied to R22.

In summary, the PEAK LEVEL control voltage is inverted about ground by Z13-1 and also undergoes a gain reduction of six (-6 V from PEAK LEVEL becomes +1 V at Z13-D. The current from the monitor diode is converted at Z16-7 to approximately 1 V for a 2 mW optical output and is applied to Z16-2 where it will almost cancel the signal from Z13-1. If this does not happen, a large error signal appears at Z16-1 where it passes via Z14-4 and Z8-1 to the current generator, Z7 and Ql (sheet 3).

External Modulation Mode (Schematic Sheets 1 and 3)

We have traced in detail, for CW Mode, the manner in which the PEAK LEVEL control voltage causes a predictable current to be applied to the laser, Similar considerations show how the quiescent light level for the External Modulation Mode is derived. The PEAK LEVEL control voltage is still used to set the desired optical level (around which the modulation will occur). Feedback via Z16-7 is used as with CW. Zll-1 is high (as for CW) but now Z14-16 is also high. This has the effect of routing the error signal (Z16-1) through Z8-7 (a precision rectifier).

THEORY OF OPERATION

It is then applied (sheet 3) as the EXT MOD OR PULSE AMPLITUDE signal to Zl-5 (a x2 attenuator followed by an adjustable x3 gain stage). Since PREDRIVE is held high, the laser's dc bias is now provided by 09 (via 06). R108 samples the current which is compared

Table 3-2. Control Signals

Mode					**Source**	**Destination**	**Signal Label**
Pulse		**CW EXT MOD Impulse**					
Zero Bsln Nonzero Bsln							
L	L	L	L	H	P1-18	Z9-1	IMPULSE
H	H	H	H	L	Z9-2	Z3-12 (Sheet 2),	IMPULSE
						Z11-1	
L	L	L	H	L	P1-12	Z4-10 (Sheet 2)	EXTMOD
						Z9-11	
H	H	H	L	H	Z9-10	Z10-5	EM
L	L	H	L	L	P1-9	Z4-9(Sheet 2)	CW
						Z9-13	
H	H	L	H	H	Z9-12	Z10-4, Z14-6	CW
L	H	L	L	L	P1-10	Z9-5	BIAS
H	L	H	H	H	Z9-6	Z14-1	BIAS
L	L	H	H	L	Z10-6	Z10-1, Z14-8	CW + EM
H	H	L	L	H	Z10-3	Z14-9	CW + EM
						Analog	
						Switches	
H	L	H	H	H	Z9-6	Z14-1	BIAS
L	L	H	H	L	Z10-6	Z14-8	CW + EM
H	H	L	L	H	Z10-3	Z14-9	CW + EM
H	H	L	H	H	Z9-12	Z14-16	CW
H	H	H	H	L	Z9-2	Z11-1	IMPULSE

THEORY OF OPERATION

To the voltage from Z1-7 by a bridge arrangement (R72, R73, R74, R95). Z2-7 generates the error signal applied to Q8 and then the Q9.

The actual modulation is applied from J801, via FET current amplifier Oil, to 08 There it generates a base voltage for Q9 which (via R112) generates a predictable signal current through R108 and Q6 that finally drives the laser. Although this circuit appears to be direct coupled from J801, it acts as if it were ac coupled due to the action of *Z*2. which monitors the total laser current (flowing through R108). The low frequency cut off is approximately 100 Hz.

Pulse Mode

In Pulse Mode, two conditions exist : the circuitry involved when the Baseline level is set to zero is different from the circuits used with a nonzero Baseline. In Pulse Mode with zero Baseline, there is no optical output between pulses (during a logical "zero" there is zero light output). The upper level is set by the PEAK LEVEL control voltage which, in turn, determines the amount of current switched into the laser. In Pulse Mode with a nonzero Baseline, both the upper ("one") and lower ("zero") logic levels must be adjustable according to the Peak and Baseline settings.

Pulse Mode (Nonzero Baseline)

Pulse Mode with nonzero Baseline requires 1) producing a current that determines the optical power radiated between pulses (the Baseline), and 2) calculating the difference between the desired Peak power and the Baseline power, and then generating a pulse of corresponding amplitude. This pulse is added to the already present Baseline level to produce the desired Peak level. The Baseline current is generated and applied to the laser in the same manner as for CW operation, except that optical feedback is not used and the BASELINE LEVEL signal determines the level.

When the digital control signal BIAS is asserted, the path from the BASELINE LEVEL control voltage is through Z13-7*.* Z14-3 (conducting), past Z14-14 and Z11-3 (both open), to Z8-1 (unity gain) and finally to Z7 (sheet 3). As stated above, Z7 and Q1 form a current source, and this is what supplies the Baseline current to the laser.

The path from the PEAK LEVEL control voltage is through Z13-1 (sheet 1), Z16-1, past Z14-15 (open), to Z8-7, through CR7, Zl-7 (sheet 3). and finally to Z2-7. As stated above, Z2-7, Q8 and Q9 form a current source which also drives the laser. Pulse Mode differs from External Modulation in that the current is switched by Q6 and Q7 (as defined by the level of the PREDRIVE signal) and there is no optical feedback.

The pulse current (through Q6 and Q7) is determined for PEAK LEVEL by the precision rectifier formed by Z8 and CR7 and the two resistor dividers R31/R40 and R32/R39 (sheet 1). This circuit produces a voltage which is the difference between the voltages at Z16-1 (the scaled version of the PEAK LEVEL control voltage) and Z8-1 (the scaled version of the BASELINE LEVEL control voltage), yet not less than zero. The output, at the cathode of CR7, is applied to Z1-5 (sheet 3) which provides an adjustable gain of from x0.5 to x2. At this point, a 3 V difference between the control voltages has become 500 mV at Z1-7. Z2-7 and R108 (47 ohm) convert this to approximately 10 mA, which is the value needed for a 1.0 mW optical power change. Thus a 3 V difference between the PEAK LEVEL and BASELINE LEVEL control voltages is converted to a 1.0 mW optical step. Since this step is added to the Baseline level already present (via Z7, Q1) the Peak and Baseline levels are determined by their respective control voltages, provided that the "gains" (voltage to current conversion factors) of the two channels are set to be equal.

PREDRIVE, the timing signal from the multiplexer (Z4), is applied (from Z3-2) to the base of predriver 04. 04 and 05 are a switching pair whose current is controlled by Z2-1 and Q3. The predrive current through Q4 and 03 increases with increasing optical output and, as the current increases, the main drivers Q6 and Q7 receive larger switching voltages. This is achieved by utilizing a current source, comprised of Z2-1 and Q3, which tracks the EXT MOD OR PULSE AMPLITUDE control voltage at Z1-7. A small offset is introduced into this current source so that at very small pulse levels there is sufficient predrive current to switch Q6 and Q7.

<u>Pulse Mode</u> (Zero Baseline)

With Zero Baseline, only the switching transistors 06 and Q7 (sheet 3) supply current to the laser. The PEAK LEVEL control voltage is processed directly through Z13-1, Z16-1 and ZS-7. Switches Z11-8, Z14-1, Z14-9 2nd Z14-6 are open and Z14-S is closed. Thus Z13-1 is a x6 attenuator while Z16-1 is a xl voltage follower. Since the switch Z14-1 is open, the BASELINE LEVEL control voltage is not presented to Z8-3, which will now be held at ground by R24. This allows Z8-7 (through CR7) to be a xl follower of the voltage at Z16-1.

This has two implications: 1) the CW OR BASELINE LEVEL current source is turned off, which prevents any quiescent light and 2) the PEAK LEVEL control voltage adjusts the pulsed current to values that produce a power level between zero and 2.0 mW (the same range that the CW OR BASELINE LEVEL current source uses with a nonzero Baseline Pulse Mode, as determined by the BASELINE LEVEL control voltage.

<u>External Drive</u> (Schematic Sheet 2)

External Drive is used in the Pulse Mode to shift the source of the drive signal from the mainframe to the front panel EXT DR connector. The circuits behave the same as under ordinary Pulse Mode operation except that the PREDRIVE signal is now obtained (via the multiplexer Z4-5) from the External Drive circuit. Two signals from P2, EXT DRIVE LEVEL and EXT DRIVE POL, select the trigger threshold magnitude and polarity for the discriminator, Z5.

<u>Impulse Mode</u>

Impulse Mode is used to generate a narrow, fixed width and fixed amplitude pulse. The digital timing is obtained from PREDRIVE (sheet 2). The leading edge of the impulse signal Z3-2 is caused by DRIVE itself. R157 and Z3-15 provide a short time delay (less than 2 ns) that produces the trailing edge. The result is a short, positive pulse delivered to the base of 04 (sheet 3).

The predrivers (Q4 and Q5) and the main drivers (Q6 and Q7) have both been programmed by PEAK LEVEL for a high (120% of full scale) current that represents the amplitude of the impulse waveform. In order to assure fast response, the laser is biased to just above its threshold current by an auxiliary feedback loop that holds the laser at this point regardless of duty factory variations. The optical output is monitored by internal detector diode DSI-7, and in Impulse Mode represents the average optical power. Both the Baseline level and the average power of the impulses themselves contribute to this signal. The latter contribution varies with rep rate (duty factor). Since it is desired to stabilize the Baseline level only, a signal proportional to the duty factor is required. This signal is obtained from Z3-2 (via R163). Both signals are sent to the auxiliary feedback loop. The IMPULSE COMPENSATION and IMPULSE FEEDBACK signals (sheet 1) are combined in Z6 along with a dc level from R37 and are sent back (via Z11-3 and Z8-1) to the Baseline current source (01, sheet 2). R37 adjusts for the small (approximately 20 μW) amount of residual light that is emitted between impulses. R42 adjusts the balance between the optical sample (from D51-7) and the digital sample (Z3-2) so that there is no change with varying rep rates.

Laser Protection (Schematic Sheets 1 and 3)

The laser is protected from excessive drive currents by a group of circuits referred to as LASER GUARD. These circuits ensure that whenever an unusual situation occurs the laser is promptly shunted by a low impedance. This action is called "crowbar." The path around the laser is from DS1-10 through L1, Q2, and R79 to ground. Even if both sets of driver transistors (Q6, Q9 and Q1) were to short circuit, the resulting current would be shunted around the laser by Q2.

If there is excessive current (20 mA or more) flowing in the crowbar transistor, 02, it is sensed by Z7. This causes a positive voltage (via CRH) to reinforce the triggering of Z12. The circuit remains in the crowbar state until the over current condition is removed. Although the control circuits generally turn on "gracefully" without excessive current transients, a time constant is provided (C39, R101) that turns 02 on when the power is initially applied.

Another input to Z12-4 is from the internal monitor diode DSI-7. This produces a voltage across R102 and R103 that is set to trigger Z12 when the optical output becomes too high.

When a change of Mode is made, the ENABLE signal (Z9-9, sheet 1) triggers the crowbar action. This is applied to a timer circuit, Z12, that acts to turn on the crowbar transistor Q2 (via Q12). It also is triggered at initial power-on by CR-23 and R130. A CROWBAR signal is sent to Z17-2 (sheet 1). This is another timer that acts to further hold off the control circuitry and permit a smooth return to normal operation.

While Z17 is in its timing cycle, the LASER ACTIVE LED is turned off and a positive level from Z17-3 via Z15-1 turns on the LASER GUARD indicator. After several seconds the Z17 timer will recover (if no over current condition is present) and allow the control circuits to recover.

Module Disable (Schematic Sheet 1)

The MOD DIS signal allows the user to remotely disable the optical output via the 6040 mainframe's rear panel connector J903. J903 is normally closed, connecting the MOD DIS signal to ground. When J903 is opened, MOD DIS is pulled to +5 V through R49 and asserts the Laser Protection circuitry.

THEORY OF OPERATION

The INTERLOCK switch is used to determine if an optical connector is attached to the module, and disables the optical output if one is not. The micro-switch SS01 is connected between the MOD DIS signal and the Laser Protection circuits. It is connected to a spring-loaded sleeve that is mounted around the LIGHT OUT connector. The sleeve is retracted when the optical connector is installed and this actuates SS01. S801 is normally open, thus disabling the laser. When an optical connector is inserted to the LIGHT OUT, S801 is closed and (given that MOD DIS is low) the laser is enabled.

The front panel LASER GUARD (DS802) and LASER ACTIVE (DS803) LEDs are not illuminated when MOD DIS or the INTERLOCK switch disable the 083 module.

Signals indicating the state of LASER GUARD, LASER ACTIVE, and MOD DIS/INTERLOCK are sent back to the Module Interface board as status bits.

SECTION 4

SERVICE, MAINTENANCE AND CALIBRATION

SERVICE- There are no user-serviceable parts in the Model 085. The unit must be returned to the factory for repair services.

MAINTENANCE

Light Output Connector

For satisfactory performance, proper care in the use of the optical components is necessary. There must be no contamination to interfere with the passage of light through the fiber end connections and the bulkhead connector. The following procedures should be observed.

1. Avoid connecting and disconnecting the optical cable as much as possible.

2. Keep the connectors absolutely clean.

3. Keep the output bulkhead connector and the user's connector capped when not in use.

Cleaning Optical Connectors

To avoid degraded performance resulting from damage to the optical fiber end polish, optical connectors should be cleaned before each mating. Dampen a lint-free cloth or tissue with reagent grade isopropyl alcohol. Wipe the center Up of both connectors, then blow dry with clean compressed air.

CAUTION : *Keep sharp, hard or abrasive objects away from the fiber ends. For example, do not use a metal instrument when cleaning the connector, even if a cloth or tissue is wrapped around it. Damage to the fiber's light coupling capacity can result.*

CALIBRATION

General

The calibration of the 085 module is in two parts: the first is for setting control voltages on the Module Interface board (PCB 6040-4); the second is for setting the Laser Output board (PCB 155-3) for the correct power output and impulse characteristics and to verify the External Modulation bandwidth.

It is recommended that the calibration of the 085 module be verified every 12 months. The instrument requires a 30 minute warm up period.

EQUIPMENT REQUIRED

- 3-1/2 digit (or better) DVM.
- BNC 6100 Optical Power Meter (or equivalent) calibrated for the appropriate wavelength,
- 1 GHz bandwidth oscilloscope (sampling or real time). A Tektronix 7000 Series with appropriate sampling plug-ins is satisfactory.
- 1 GHz bandwidth 830 nm detector (silicon). A Tektronix S-42 Optical Sampling. Head can be used with the 7000 Series Oscilloscope.
- 1 GHz variable sine wave generator. An HP 8657A Signal Generator with a Type N to SMA adapter can be used.
- Low frequency (0-1 kHz) variable sine wave generator. A Wavetek Model 188 Function Generator with a BNC to SMA adapter can be used.
- SMA terminated 30 ohm coaxial cables, 1 meter length.
- BNC terminated 50 ohm coaxial cables, 1 meter length,
- Variable dc voltage source (capable of ±3 V into 50 ohms).
- Multimode optical fiber patch cord terminated with an ST connector on one end and a connector on the other end appropriate to the detector being used.

PROCEDURE

Note: *This calibration should be carried out in the order presented.*

Before starting, verify that the power supply voltages are at their nominal levels (+12 V ±0.1 V, -12 V ±0.1 V, +5 V ±0.05 V, and -5.2 V ±0.05 V) with the module plugged in. Operate the module on extension cables.

Module Interface DAC Calibration

Refer to Schematic 6040-35 (PCB 6040-4). Set the Mode to Pulse; set the Peak and Baseline levels both to 1.000 mW; set the Trigger to External Drive with a threshold of +2.50 V.

Connect the DVM between TPG (A GND) and TP-4. Adjust R3 for a voltage of -5-000 V ±2 mV.

Connect the DVM between TPG (A GND) and TP-2. Adjust R4 for a voltage of -4,000 V ±2 mV.

Connect the DVM between TPG (A GND) and TP-1. Adjust R5 for a voltage of -4.000 V ±2 mV.

Level Normalization

Refer to Schematic 6040-35 (PCB 6040-4) and Schematic 155-32, sheet 1 (PCB 155-3). Set the Mode to Pulse; set the Peak and Baseline levels both to 1.000 mW; set the Trigger to External Drive with a threshold of +2.50 V.

Connect the DVM between TPG and the cathode of CR7 (both on PCB 155-3). Adjust R5 (on PCB 6040-4) for a DVM reading of +10 mV, then back R5 down for a reading of zero ±1 mV. Change the Peak level setting to 1.010 mW and verify that the DVM reading changes by approximately 1.5 mV (and by no less than 1 mV).

External Drive Discriminator

All further measurements and adjustments refer to the Laser Output board, Schematic 155-32 (PCB 155-3).

Set the Mode to Pulse. Set Trigger to External Drive with a threshold of +0.99 V. Connect the DVM to Z1S-1 (Schematic 155-32, sheet2) and record the voltage. Now set the threshold for -0.99 V. Adjust R141 so that the DVM reading exactly complements the recorded value.

Connect a +1.00 V dc supply to the module EXT DR connector. Connect the DVM to Z5-8. Scan the TRIG External Drive threshold parameter from 0.90 V to +1.10 V and verify that Z5-8 changes from low to high (-1.7 V to -0.8 V) when the threshold voltage is set for 1.00 V ±30 mV.

CW and External Modulation Calibration

Using the patch cord, connect LIGHT OUT to the 6100 Optical Power Meter. Set the 6100 for Average power measurement and the 0 dBm range.

Set the 6040 Mode to CW and the CW level to 2.000 mW. If necessary, adjust RII (Schematic 155-32, sheet 1) to obtain a reading of 2.000 mW ±20 µW on the 6100. Set the CW level for 200 µW and verify the output to be within 20 µW.

Set the 6040 Mode to External Modulation (with no input connected to EXT MOD) and set the External Modulation level for 2.000 mW. Verify an output of 2.000 mW ±20 wW. Set the External Modulation level for 200 µW and verify the output to be within 20 µW.

Pulse Baseline Calibration

Set the 6040 Mode to Pulse, and the Trigger to Single Cycle.

A). Set the 6040 Baseline level to 2.000 mW. Adjust R83 (Schematic 155-32, sheet 3) to obtain a reading of 2.000 mW ±40 µW on the 6100.

B). Set the Baseline level to 200 µW. Adjust R22 as necessary to obtain 200 µW ±40 µW. Repeat steps A) and B) until both readings are within 40 MW of their stated values.

Pulse Peak Calibration

A). Set the Baseline level to 0.000 mW Set the Trigger to External Drive with a threshold of -50 mV. Adjust R58 (Schematic 155-32, sheet 3) for an output of 2.000 mW ±40

B). Set the Peak level to 200 µW and verify an output of 200 µW ±40

Repeat steps A) and B) until both readings are within 40 µW of their stated values.

SERVICE, MAINTENANCE AND CALIBRATION

NOTE: *The following sections require high bandwidth paths; any improperly cabled or terminated paths will yield incorrect results.*

Pulse Dynamic Characteristics

Connect the 6040 TRIG OUT to the External Trigger input of the oscilloscope (bandwidth must be at least 1 GHz). Connect the 6040 LIGHT OUT to the detector (also 1 GHz). Connect the detector's output to channel A of the oscilloscope.

With the 6040 still in Pulse Mode, set the Peak level to 2.000 mW and the Baseline level to 200 μW. Set TRIG for Internal Trigger, 100 kHz. Set Timing for a Width of 40 ns. and a Delay appropriate to view the detector output on the scope. Verify that leading and trailing edges have transition times (20-80%) <1.5 ns.

Set the Baseline level to 0.000 mW, Verify that the leading edge has a transition time (20-80%) * 0.5 ns and the trailing edge has a transition time (20-80%) < 1.5 ns.

Impulse Calibration

Set the 6040 Mode to Impulse.

A) Set TRIG to Internal Trigger, 10.00 kHz. Set the Delay to display the detector output. Adjust R37 for the maximum amplitude while maintaining a pulse width less than 500 ps (typically 400 ps).

B) Set TRIG to Internal Trigger, 10.00 MHz. Adjust R42 for the maximum amplitude while maintaining a pulse width less than 500 ps.

Repeat A) and B) until the change in amplitude between A) and B) is less than 10%. The amplitude of the impulse should be between 1 mW and 2 mW.

External Modulation Bandwidth and Sensitivity Verification

Calibrate the detector /scope channel for 400 μW per division as follows. Set the 6040 Mode to Pulse; Baseline level to 0.000 mW, Peak level to 2.000 mW; TRIG to Internal Trigger, 100 kHz; Width to 100 ns, and Delay as necessary to view output. Adjust the vertical sensitivity for a pulse height of five divisions.

Set the 6040 Mode to External Modulation, (with no input connected to EXT MOD) and set the External Modulation level to 1.0 mW. Set the sine wave generator for a 500 mV p-p signal at 1 MHz and connect it to the module EXT MOD connector.

Note the peak-to-peak modulation (depth) of the detector's output (between 800 μW and 1.6 mW peak-to-peak). Now increase the frequency to 10 MHz, verifying that the modulation depth changes less than 10%. Increase the frequency to 100 MHz, and verify that the modulation depth is within 25% of the value at 1 MHz. Continue increasing the frequency in 100 MHz steps, verifying that the modulation depth is within 25% of the value at 1 MHz, until at least 600 MHz. When 700 MHz is reached the modulation depth will be approximately 50% of the 1 MHz depth (if the depth was 800 μW at 1 MHz, it will be 400 μW at 700 MHz), this corresponds to the high frequency -3 dB response point.

Next, set the low frequency sine wave generator for a 500 mV p-p signal at 1 kHz and connect it to the module EXT MOD connector. Note the peak-to-peak modulation (depth) of the detector's output (typically between 800 MW and 1.6 mW peak-to-peak). Decrease the frequency in 100 Hz steps, verifying that the modulation depth is within 25% of the value at 1 kHz until 200 Hz. When 100 Hz is reached the modulation depth will be approximately 50% of the 1 kHz depth (if the depth was 800 μW at 1 kHz. It will be 400 μW at 100 Hz). This corresponds to the low frequency -3 dB response point. Note that this point may actually vary between 100 Hz and 50 Hz.

External Drive Dynamic Response

Connect the sine wave generator to the module EXT DR connector. Set the Mode to Pulse, set the Peak level for 2.000 mW and Baseline level for 200 μW. Set Trigger to External Drive with a threshold of 0.00 V. Verify that LIGHT OUT operates at least to 300 MHz, producing a rectangular waveform with a 50% duty cycle. Set the Baseline level for 0.000 mW and verify operation to 200 MHz (at 200 MHz the duty factor will be slightly less than 50%).

Service

There are no serviceable parts in the Model 065/085/090. Please contact the factory at 800-234-7858 for assistance.

SECTION 5

PART LISTS

Abbreviations

CER	Ceramic	**PF**	Pico farad
COMP	Composition	**SIP**	Single Inline Package
DIP	Dual Inline Package	**TAN**	Tantalum
ELEC	Electrolytic	**UH**	Microhenry
FAC SEL	Value Set at Factory	**UF**	Microfarad
K	Kilohm	**V**	Working Volts
M	Megohm	**VAR**	Variable
MF	Metal Film	**W**	Watts
MIC	Mica	**WW**	Wire wound
MONO	Monolithic Ceramic		

------------------------- NOTE -------------------------
The number in the ***second column*** *is the*
BERKELEY NUCLEONICS re-order number

MODULE INTERFACE BOARD 6040-4 649-143

C1	122-016 10µF ± 10 % 15 V TAN	**C22**	**110-033 0.1µF ± 20 % 50 V CER**
C2	122-016 10µF ± 10 % 15 V TAN		**---------------------------**
C3	122-014 33µF ± 10 % 6 V TAN	**CR1**	**412-001 1N821**
C4	122-014 33µF ± 10 % 6 V TAN		**---------------------------**
C5	110-033 0.1µF ± 20% 50 V CER MONO	**Q1**	**430-026 MPS3640**

C6	110-033 0.1µF ± 20% 50 V CER MONO		
C7	110-033 0.1µF ± 20% 50 V CER MONO	**R1**	**233-016 4.7 K X 9 SIP RES NETWORK**
C8	110-033 0.1µF ± 20% 50 V CER MONO	**R2**	**233-016 4.7 K X 9 SIP RES NETWORK**
C8	110-033 0.1µF ± 20% 50 V CER MONO	**R3**	**244-047 1 K PC MT MULTITURN**
C9	110-0330.1µF ± 20% 50 V CER MONO	**R4**	**244-047 1 K PC MT MULTITURN**
C10	110-033 0.1µF ± 20% 50 V CER MONO	**R5**	**244-047 1 K PC MT MULTITURN**
C11	110-033 0.1µF ± 20% 50 V CER MONO	**R6**	**244-047 1 K PC MT MULTITURN**
C12	110-033 0.1µF ± 20% 50 V CER MONO	**R7**	**222-044 2.94 K 1 % 1/4 W MF**
C13	110-033 0.1µF ± 20% 50 V CER MONO	**R8**	**222-044 2.94 K 1 % 1/4 W MF**
C14	110-033 0.1µF ± 20% 50 V CER MONO	**R9**	**222-044 2.94 K 1 % 1/4 W MF**
C15	110-033 0.1µF ± 20% 50 V CER MONO	**R10**	**222-044 2.94 K 1 % 1/4 W MF**
C16	110-033 0.1µF ± 20% 50 V CER MONO		
C17	122-014 33µF ± 10% 6 V TAN	**R11**	**NOT USED**
C18	110-011 0.001µF ± 10% 1 KV CER	**R12**	**NOT USED**
C19	110-011 0.001µF ± 10% 1 KV CER	**R13**	**NOT USED**
C20	110-011 0.001µF ± 10% 1 KV CER	**R14**	**NOT USED**

C21 110-011 0.001µF ± 10% 1 KV CER

PART LISTS

Z1 440-212 74HC139
Z2 440-175 74HC373
Z3 441-003SE-PROM 085
Z4 440-190 MK48Z02-20
Z5 440-195 P82C55-2

Z6 440-213 AD7528
Z7 440-213 AD7528
Z8 440-168 LF412
Z9 440-168 LF412

LASER OUTPUT BOARD, 155-3, MODEL 085 649-146

C1 122-002 1µF 10 % 35 V TAN
C2 110-019 0.5µF 20% 25 V CER
C3 122-009 0.68µF 10 % 35V TAN
C4 110-021 0.01µF 20 % 16 V CER
C5 122-001 0.47µF 10 % 35 V TAN

C6 110-021 0.01µF 20 % 16 V CER
C7 NOT USED
C8 NOT USED
C9 NOT USED
C10 NOT USED

C11 122-015 33µF 10 % 35 V TAN
C12 110-033 0.1µF ± 20% 50 V CER MONO
C13 110-033 0.1µF ± 20% 50 V CER MONO
C14 110-033 0.1µF ± 20% 50 V CER MONO
C15 110-033 0.1µF ± 20% 50 V CER MONO

C16 110-033 0.1µF ± 20% 50 V CER MONO
C17 110-033 0.1µF ± 20% 50 V CER MONO
C18 110-033 0.1µF ± 20% 50 V CER MONO
C19 110-033 0.1µF ± 20% 50 V CER MONO
C20 110-033 0.1µF ± 20% 50 V CER MONO

C21 110-033 0.1µF ± 20% 50 V CER MONO
C22 110-033 0.1µF ± 20% 50 V CER MONO
C23 110-033 0.1µF ± 20% 50 V CER MONO
C24 122-015 33µF 10% 35 V TAN
C25 110-033 0.1µF ± 20% 50 V CER MONO
C26 110-033 0.1µF ± 20% 50 V CER MONO
C27 110-033 0.1µF ± 20% 50 V CER MONO
C28 110-033 0.1µF ± 20% 50 V CER MONO

R15 213-431 430 OHMS 5 % 1/4 W COMP
R16 213-103 10 K 5 % 1/4 W COMP
R17 213-103 10 K 5 % 1/4 W COMP

C33 110-033 0.1µF ± 20% 50 V CER MONO
C34 110-033 0.1µF ± 20% 50 V CER MONO
C35 110-033 0.1µF ± 20% 50 V CER MONO
C36 122-015 33µF 10 % 35 V TAN

C37 110-033 0.1µF ± 20% 50 V CER MONO
C38 110-033 0.1µF ± 20% 50 V CER MONO
C39 110-033 0.1µF ± 20% 50 V CER MONO
C40 122-015 33µF 10 % 35 V TAN
C41 110-033 0.1µF ± 20% 50 V CER MONO

C42 110-033 0.1µF ± 20% 50 V CER MONO
C43 110-033 0.1µF ± 20% 50 V CER MONO
C44 110-033 0.1µF ± 20% 50 V CER MONO

C45 110-019 0.05µF 20 % 25 V CER
C46 NOT USED

C47 NOT USED
C48 NOT USED
C49 NOT USED
C50 NOT USED
C51 NOT USED

C52 110-019 0.05µF 20 % 25 V CER
C53 110-021 0.01µF 20 % 16 V CER
C54 110-033 0.1µF ± 20% 50 V CER MONO
C55 110-021 0.01µF ± 20% 16 V CER
C56 110-011 0.001µF 10% 1 KV CER

C57 110-034 100PF ± PF 10 % 25 V CER
C58 110-019 0.05µF 20 % 25 V CER
C59 122-015 33µF 10 % 35V TAN
C60 110-034 100PF ± PF 10 % 25 V CER
C61 110-011 0.001µF 10% 1 KV CER

C62 110-021 0.01µF 20% 16 V CER
C63 110-019 0.05µF 20% 25 V CER
C64 110-011 0.001µF 10% 1 KV CER
C65 110-034 100PF ± 10% 25 V CER
C66 110-011 0.001µF 10% 1 KV CER

C67 110-019 0.05µF 20% 25 V CER
C68 122-013 3.3µF 10% 15 V TAN
C69 NOT USED
C70 NOT USED
C71 NOT USED
C72 NOT USED
C73 110-034 100PF ± 10% 25 V CER
C74 110-034 100PF ± 10% 25 V CER

<u>PART LISTS</u>

C29 110-033 0.1µF ± 20% 50 V CER MONO
C30 110-033 0.1µF ± 20% 50 V CER MONO
C31 110-033 0.1µF ± 20% 50 V CER MONO
C32 110-033 0.1µF ± 20% 50 V CER MONO
C33 110-033 0.1µF ± 20% 50 V CER MONO
C79 NOT USED
C80 112-016 10PF 5 % 500 V MICA
C81 112-003 47 PF 5 % 500 V MICA
C82 112-021 5 PF 5 % 500 V MICA

C83 112-019 15PF 5 % 500 V MICA
C84 122-074 33µF 10 % 5 V TAN
C85 NOT USED
C86 110-033 0.1µF ± 20% 50 V CER MONO
C87 110-033 0.1µF ± 20% 50 V CER MONO
C88 122-075 33µF 10 % 35 V TAN

CR1 NOT USED
CR2 NOT USED
CR3 412-009 1N5231B
CR4 411-004 1N4152
CR5 NOT USED

CR6 411-004 1N4152
CR7 411-004 1N4152
CR8 NOT USED
CR9 NOT USED
CR10 412-009 1N5231B

CR11 411-003 1N4005
CR12 411-004 1N4152
CR13 411-004 1N4152
CR14 411-004 1N4152
CR15 411-004 1N4152

CR16 411-004 1N4152
CR17 NOT USED
CR18 413-002 1N4736
CR19 411-002 1N270
CR20 411-004 1N4152

CR21 411-004 1N4152
CR22 NOT USED
CR23 411-004 1N4152
CR24 411-004 1N4152
CR25 411-004 1N4152

DS1 665-014 MODEL 085 LASER (850 NM)
527-019 HEAT SINK

C75 NOT USED
C76 NOT USED

C77 NOT USED
C78 NOT USED
Q2 430-008 2N2905
Q3 430-026 MPS3640
Q4 430-056 MM4049
Q5 430-056 MM4049

Q6 430-059 A500
Q7 430-059 A500
Q8 430-056 MM4049
Q9 430-059 A500
Q10 NOT USED

Q11 431-006 SD210
Q12 430-027 MPS3646
Q13 430-027 MPS3646
Q14 431-006 SD210
Q15 430-026 MPS3640
Q16 431-013 2N6784

R1 223-010 1K X 5 SIP RES NETWORK
R2 NOT USED
R3 NOT USED
R4 NOT USED
R5 NOT USED

R6 222-059 29.4k 1% 1/4 W MF
R7 222-059 29.4 1 % 1/4 W MF
R8 NOT USED
R9 213-301 300 OHMS 5 % 1/4 W COMP
R10 213-332 3.3K 5 % 1/4 W COMP

R11 244-035 2K MULTITURN
R12 NOT USED
R13 NOT USED
R14 NOT USED
R15 NOT USED

R16 NOT USED
R17 222-022 4.99 K 1% 1/4 W MF
R18 222-022 4.99 K 1% 1/4 W MF
R19 NOT USED
R20 213-103 10 K 5 % 1/4 W COMP

R21 213-473 47 K 5% 1/4 W COMP
R22 244-036 10 K MULTITURN
R23 NOT USED
R24 213-104 100K 5% 1/4 W COMP
R25 213-105 1M 5% 1/4 W COMP

PART LISTS

L1	318-003	FERRITE CORE
L2	311-012	15μH ± 20% PHENOLIC
L3	311-012	15μH ± 20% PHENOLIC

Q1	430-027	MPS3646
R31	222-071	1 M 1% 1/4 W MF
R32	222-071	1 M 1% 1/4 W MF
R33	213-102	1K 5% 1/4 W COMP
R34	213-105	1M 5% 1/4 W COMP
R35	213-105	1M 5% 1/4 W COMP
R36	213-104	100 K 5% 1/4 W COMP
R37	244-036	10 K MULTITURN
R38	213-820	82 OHM 5% 1/4 W COMP
R39	222-071	1M 1% 1/4 W MF
R40	222-071	1M 1% 1/4 W MF
R41	213-513	51K 5% 1/4 W COMP
R42	244-036	10K MULTITURN
R43	213-512	5.1K 5% 1/4 W COMP
R44	213-201	200 OHM 5% 1/4 W COMP
R45	213-391	390 OHM 5% 1/4 W COMP
R46	213-512	5.1K 5% 1/4 W COMP
R47	213-103	10 K 5% 1/4 W COMP
R48	213-472	4.7K 5% 1/4 W COMP
R49	213-152	1.5K 5% 1/4 W COMP
R50	222-014	499 OHM 1% 1/4 W COMP
R51	222-014	499 OHM 1% 1/4 W COMP
R52	213-471	470 OHM 5% 1/4 W COMP
R53	NOT USED	
R54	NOT USED	
R55	NOT USED	
R56	222-026	110 K 1% 1/4 W COMP
R57	222-026	110 K 1% 1/4 W COMP
R58	244-011	1 K MULTITURN
R59	NOT USED	
R60	NOT USED	
R61	NOT USED	
R62	NOT USED	
R63	NOT USED	
R64	NOT USED	
R65	222-028	110 K 1% 1/4 W MF
R66	222-028	110 K 1% 1/4 W MF
R67	213-102	1 K 5% 1/4 W COMP
R68	213-102	1 K 5% 1/4 W COMP
R69	222-026	110 K 1% 1/4 W MF
R70	222-055	102 K 1% 1/4 W MF
R71	222-070	95.3 K 1% 1/4 W MF
R72	222-026	110 K 1% 1/4 W MF
R73	222-026	110 K 1% 1/4 W MF
R74	222-026	110 K 1% 1/4 W MF

R26	**213-102**	**1K 5% 1/4 W COMP**
R27	**213-102**	**1K 5% 1/4 W COMP**
R28	**213-104**	**100 K 5% 1/4 W COMP**
R29	**213-274**	**270K 5% 1/4 W COMP**
R30	**213-131**	**130 OHMS 5% 1/4 W COMP**
R78	**222-051**	**10 K 1% 1/4 W MF**
R79	**213-150**	**15 PHMS 5% 1/4 W COMP**
R80	**222-017**	**215K 1% 1/4 W COMP**
R81	**213-820**	**82 OHMS 5% 1/4 W COMP**
R82	**213-330**	**33 OHM 5% 1/4 W COMP**
R83	**244-032**	**50 OHM 20-TURN**
R84	**244-101**	**100 OHM 5% 1/4 W COMP**
R85	**222-026**	**110 K 1% 1/4 W COMP**
R86	**213-102**	**1K 5% 1/4 W COMP**
R87	**213-301**	**300 OHM 5% 1/4 W COMP**
R88	**213-102**	**1K 5% 1/4 W COMP**
R89	**214-561**	**560 OHM 5% 1/8 W COMP**
R90	**214-680**	**68 OHM 5% 1/8 W COMP**
R91	**214-510**	**51 OHM 5% 1/8 W COMP**
R92	**214-131**	**130 OHM 5% 1/8 W COMP**
R93	**214-391**	**390 OHM 5% 1/8 W COMP**
R94	**214-510**	**51 OHM 5% 1/8 W COMP**
R95	**222-026**	**110K 1% 1/4 W COMP**
R96	**213-106**	**10 M 5% 1/4 W COMP**
R97	**213-102**	**1K 5% 1/4 W COMP**
R98	**214-510**	**51 OHM 5% 1/8 W COMP**
R99	**213-102**	**1K 5% 1/4 W COMP**
R100	**213-103**	**10K 5% 1/4 W COMP**
R101	**213-102**	**1K 5% 1/4 W COMP**
R102	**213-102**	**1K 5% 1/4 W COMP**
R103	**244-038**	**5 K MULTITURN**
R104	**NOT USED**	
R105	**NOT USED**	
R106	**NOT USED**	
R107	**214-510**	**51 OHM 5% 1/8 W COMP**
R108	**214-470**	**47 OHM 5% 1/8 W COMP**
R109	**214-470**	**47 OHM 5% 1/8 W COMP**
R110	**213-103**	**10 K 5% 1/4 W COMP**
R111	**214-820**	**82 OHM 5% 1/8 W COMP**
R112	**214-220**	**22 OHM 5% 1/8 W COMP**
R113	**214-100**	**10 OHM 5% 1/8 W COMP**
R114	**213-105**	**1 M 5% 1/4 W COMP**
R115	**213-103**	**10 K 5% 1/4 W COMP**
R116	**222-013**	**422 OHM 1% 1/4 W MF**
R117	**NOT USED**	
R118	**NOT USED**	
R119	**214-101**	**100 OHM 5% 1/8 W COMP**
R120	**214-392**	**3.9K 5% 1/8 W COMP**
R121	**214-390**	**39 OHM 5% 1/8 W COMP**

<u>PART LISTS</u>

R75 214-680 68 OHM 5% 1/8 W COMP
R76 222-051 10 K 1% 1/4 W MF
R77 222-043 2.37 K 1% 1/4 W MF
R124 213-102 1 K 5% 1/4 W COMP
R125 NOT USED
R126 NOT USED
R127 213-510 51 OHM 5% 1/4 W COMP

R128 213-105 1 M 5% 1/4 W COMP
R129 213-223 22 K 5% 1/4 W COMP
R130 213-223 22K 5% 1/4 W COMP
R131 213-102 1 K 5% 1/4 W COMP
R132 214-510 51 OHM 5% 1/8 W COMP

R133 NOT USED
R134 NOT USED
R135 NOT USED
R136 NOT USED
R137 NOT USED

R138 222-051 10 K 1% 1/4 W MF
R139 222-051 10 K 1% 1/4 W MF
R140 222-018 249 K 1% 1/4 W MF
R141 244-034 200 OHM MULTITURN
R142 222-018 249 K 1% 1/4 W MF

R143 222-018 249 K 1% 1/4 W MF
R144 222-039 1 K 1% 1/4 W MF
R145 222-069 432 K 1% 1/4 W MF
R146 213-103 10 K 5% 1/4 W COMP
R147 214-391 390 OHM 5% 1/8 W COMP

R148 214-391 390 OHM 5% 1/8 W COMP
R149 213-510 51 OHM 5% 1/4 W COMP
R150 213-510 51 OHM 5% 1/4 W COMP
R151 213-101 100 OHM 5% 1/4 W COMP
R152 213-510 51 OHM 5% 1/4 W COMP

R153 213-102 1 K 5% 1/4 W COMP
R154 213-102 1 K 5% 1/4 W COMP
R155 213-102 1 K 5% 1/4 W COMP
R156 213-102 1 K 5% 1/4 W COMP
R157 213-101 100 OHM 5% 1/4 W COMP

R158 214-131 130 OHM 5% 1/8 W COMP
R159 214-820 82 OHM 5% 1/8 W COMP
R160 214-820 82 OHM 5% 1/8 W COMP
R161 214-131 130 OHM 5% 1/8 W COMP
R162 214-560 56 OHM 5% 1/8 W COMP

R163 214-102 1 K 5% 1/8 W COMP
R164 222-081 348 OHM 1% 1/4 W MF
R165 214-820 82 OHM 5% 1/8 W COMP

R122 213-102 1 K 5% 1/4 W COMP
R123 213-222 2.2K 5% 1/4 W COMP

R166 214-131 130 OHM 5% 1/8 W COMP
R167 214-391 390 OHM 5% 1/8 W COMP
R168 214-391 390 OHM 5% 1/8 W COMP
R169 213-105 1 M 5% 1/4 W COMP
R170 214-220 22 OHM 5% 1/8 W COMP

R171 231-008 2 OHM 5 % 10 W WW
R172 213-511 510 OHM 5% 1/4 W COMP
R173 213-105 1 M 5 % 1/4 W COMP
R174 222-051 10 K 1% 1/4 W MF
R175 222-051 10 K 1% 1/4 W MF

R176 222-051 10 K 1% 1/4 W MF
R177 213-104 100 K 5% 1/4 W COMP

Z1 440-168 LF412
Z2 440-168 LF412
Z3 440-134 10H102
Z4 440-200 MC10H164P
Z5 440-149 AM6885

Z6 440-168 LF412
Z7 440-168 LF412
Z8 440-168 LF412
Z9 440-181874HC04
Z10 440-150S74HC00

Z11 440-170 DG201
Z12 440-143 NE529
Z13 440-168 LF412
Z14 440-170 DG201
Z15 440-168 LF412

Z16 440-168 LF412
Z17 440-144 555
Z18 440-168 LF412
Z19 440-168 LF412
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FRONT PANEL
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DS 802 416-001 LED YELLOW
DS 803 416-002 LED RED
DS 801 616-007 SPOT SWITCH

NOTE: *Contact Factory for Instrument Schematics*