NEOS TECHNOLOGIES
A Gooch & Housego Company

OPERATING MANUAL

ACOUSTO-OPTIC MODE LOCKER

MODEL NUMBERS:

12XXX-Y-TE

12XXX-Y-BR-TE

DOCUMENT NUMBER: **51A02804D**

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SECTION I
INSPECTION PROCEDURE

Examine the shipping carton for damage. If the shipping carton or packing material is damaged it should be kept for the carrier's inspection. Notify the carrier and NEOS Technologies. Check the contents of the shipment for completeness, mechanical damage, and then test the equipment electronically. Operating procedures are contained in Section V. If the contents are incomplete, or the equipment does not pass the electrical testing please notify NEOS Technologies.

If there is any problem with the use of this equipment, or if the equipment fails to function as expected, contact NEOS Technologies. Do not try to trouble shoot or repair this equipment. Consult with a NEOS service engineer. If the equipment needs repair or replacement, contact NEOS Technologies for a Return Authorization Number.

SECTION II
DESCRIPTION

The NEOS 12XXX-Y-TE, with AR coated windows and the 12XXX-Y-BR-TE, with a Brewster (BR) window configuration are standing-wave mode locker modulators consisting of a fused Quartz optic with a Lithium Niobate transducer. The "XXX" in the model number designates the frequency of operation, which is typically 38, 41, 50, or 80 MHz. The "Y" designates the active aperture height, which is typically 2 or 3 millimeters.

A laser is mode locked when the longitudinal cavity modes of the laser are forced to maintain a fixed phase relationship with each other. This can be made to occur by modulating the cavity losses at a frequency equal to the frequency difference between adjacent longitudinal modes. These modes are separated by a frequency F = C/2L. L = laser cavity length. C = speed of light. When the mode locker modulator is driven at one half the cavity resonant frequency F, an acoustical standing wave can be set up in the mode locker, corresponding to a frequency of C/2L, and the mode locker will act as a shutter that opens and closes during each round trip transit time of the laser light.

The NEOS mode locker transducer operates at a precise frequency with a very narrow bandwidth. This demands that the laser cavity length be adjusted to match the mode locker resonant frequency, and it is highly recommended that a precision cavity length adjustment (micron resolution) be used to adjust the cavity length to twice the acoustical drive frequency at resonance. The laser resonator cavity should be temperature stable as any change in length will effect the mode locked pulse output. The mode locker assembly includes a thermoelectric (TE) heat pump to fine tune the resonant mode locker frequency which is adjusted to match the precise driver frequency. A thermistor is attached near the optic to indicate it's temperature and is used to control the TE heat pump to maintain temperature. The modulator assembly should be mounted on a heatsinked base with sufficient mechanical adjustment to peak the modulator efficiency (cavity length and height, to align the acoustic beam to the laser beam; and angle, to adjust bragg angle). It is recommended that a NEOS 11XXX-1CL/MLAS driver be used to drive this modulator as it generates the stable precise RF frequency needed to drive the mode locker and controls the thermoelectric cooler to achieve optimum performance

The distance from the back cavity mirror to the mode locker also needs to be adjusted for maximum destructive interface between the first order incident and reflective beams. This creates the most efficient intensity shuttering possible and will produce the narrowest output laser mode locked pulse. See page 10 for mirror to device spacing requirement.

SECTION III

DEVICE SPECIFICATIONS
MODEL NUMBERS: 12XXX-Y-TE or 12XXX-Y-BR-TE

PARAMETER	**SPECIFICATION**
Interactive Material	SiO_2
Acoustic Mode	Longitudinal
Operating Wavelength	Used at Various Wavelengths Specified @1.06μm
Window Configurations	AR "V" Coated -BR = Brewster Window
Optical Transmission	>99%
Acoustic Operating Frequency F_a	"XXX" = 38, 41, 50, or 80 MHz ± 150 KHz or customer specified frequency.
Mode spacing	300 KHz for model -TE Typical 364 KHz for model -3-BR-TE Typical 596 KHz for model -2-BR-TE Typical
Average Loss Modulation	6.5 % Typical for models (50, 80 MHz)-BR 10 % Typical for models (50, 80 MHz) and models (38, 41 MHz)-BR 15 % Typical for models (38, 41 MHz)
Light Polarization	Linear, Perpendicular to Acoustic Propagation
Acoustic Aperture Size	"Y" = 2 or 3 mm
Deflection Angle = $2\theta_b$ in air	6.75 mrad @ 38 MHz @ 1.06μm 7.3 mrad @ 41 MHz 8.9 mrad @ 50 MHz 14.2 mrad @ 80 MHz
RF Power Level	< 1 Watt
Impedance	50 Ohms @ Resonate Frequency
VSWR	< 1.5:1 @ Resonate Frequency
Thermistor Resistance vs. Temperature:	See Table 1

RELATED DOCUMENTS:

Model #s	Outline Drawing:	Acceptance Test Procedure:	Acceptance Test Results Form:
12XXX-3-TE:	53A02198	42A14128	52A02807
12XXX-3-BR-TE:	53A03890	42A14128	52A04976
12XXX-2-BR-TE:	53A04807	42A12275	52A04975

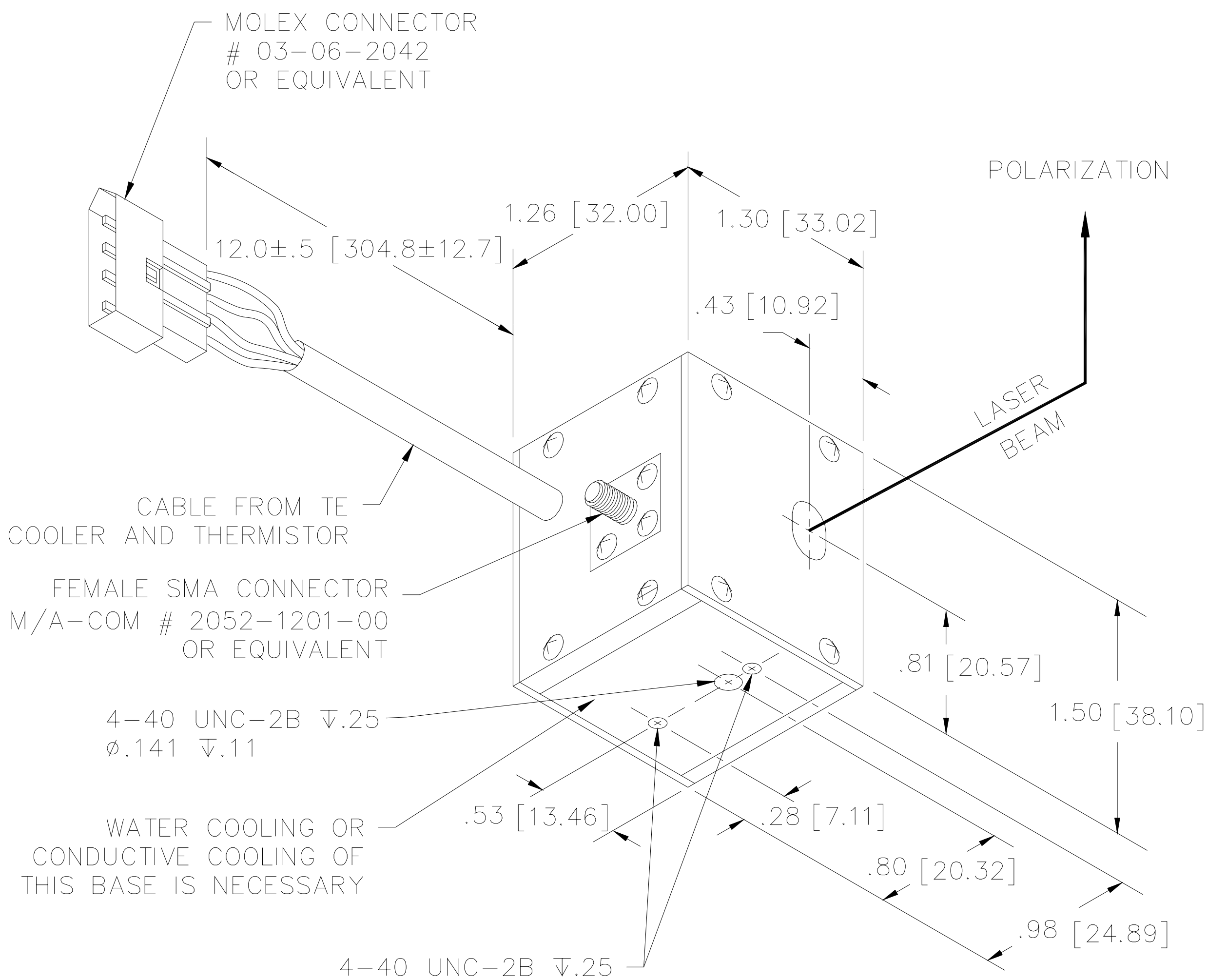
RECOMMENDED DRIVER: 11XXX-1C/MLAS

TABLE 1

TEMPERATURE INDICATED VS. THERMISTOR RESISTANCE

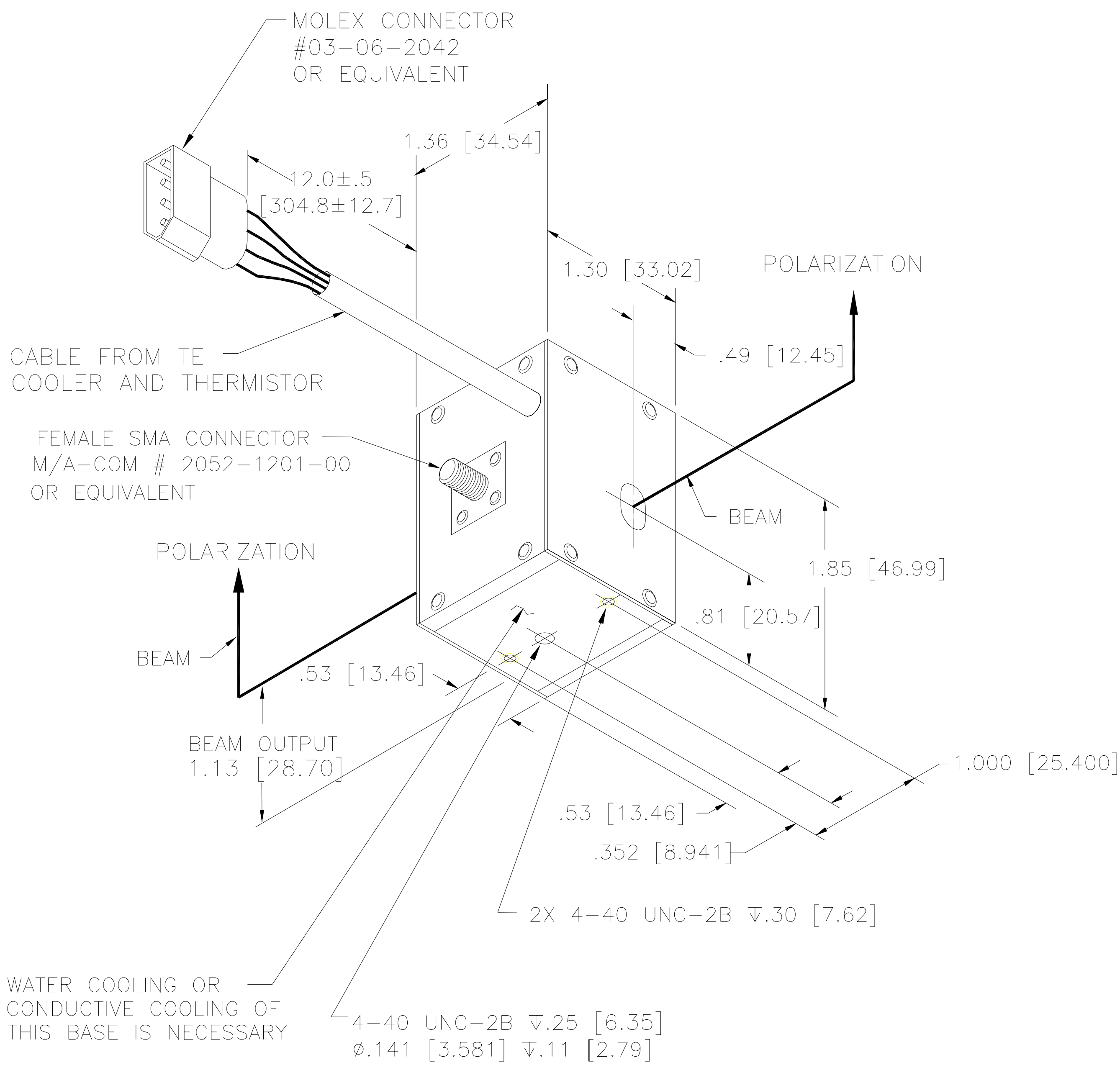
TEMP ^{O}C	RESISTANCE Ω
+10	18.79K
11	17.98K
12	17.22K
13	16.49K
14	15.79K
15	15.13K
16	14.50K
17	13.90K
18	13.33K
19	12.79K
20	12.26K
21	11.77K
22	11.29K
23	10.84K
24	10.41K
25	10.00K
26	9605
27	9227
28	8867
29	8523
30	8194
31	7880
32	7579
33	7291
34	7016
35	6752
36	6500
37	6258
38	6026
39	5805
40	5592
41	5389
42	5193
43	5006
44	4827
45	4655

SECTION IV
OUTLINE DRAWINGS
FIGURE 1



53A02198	**12XXX-3-TE**
Dimensions are in inches	Tolerances: Decimal: .xx = .01 .xxx =.005
Dimensions in [ ] are in mm.	Millimeter: .xx = .25mm .xxx = .127mm
	Angle: = ± 30'

FIGURE 2



53A03890 **12XXX-3-BR-TE**

Dimensions are in inches

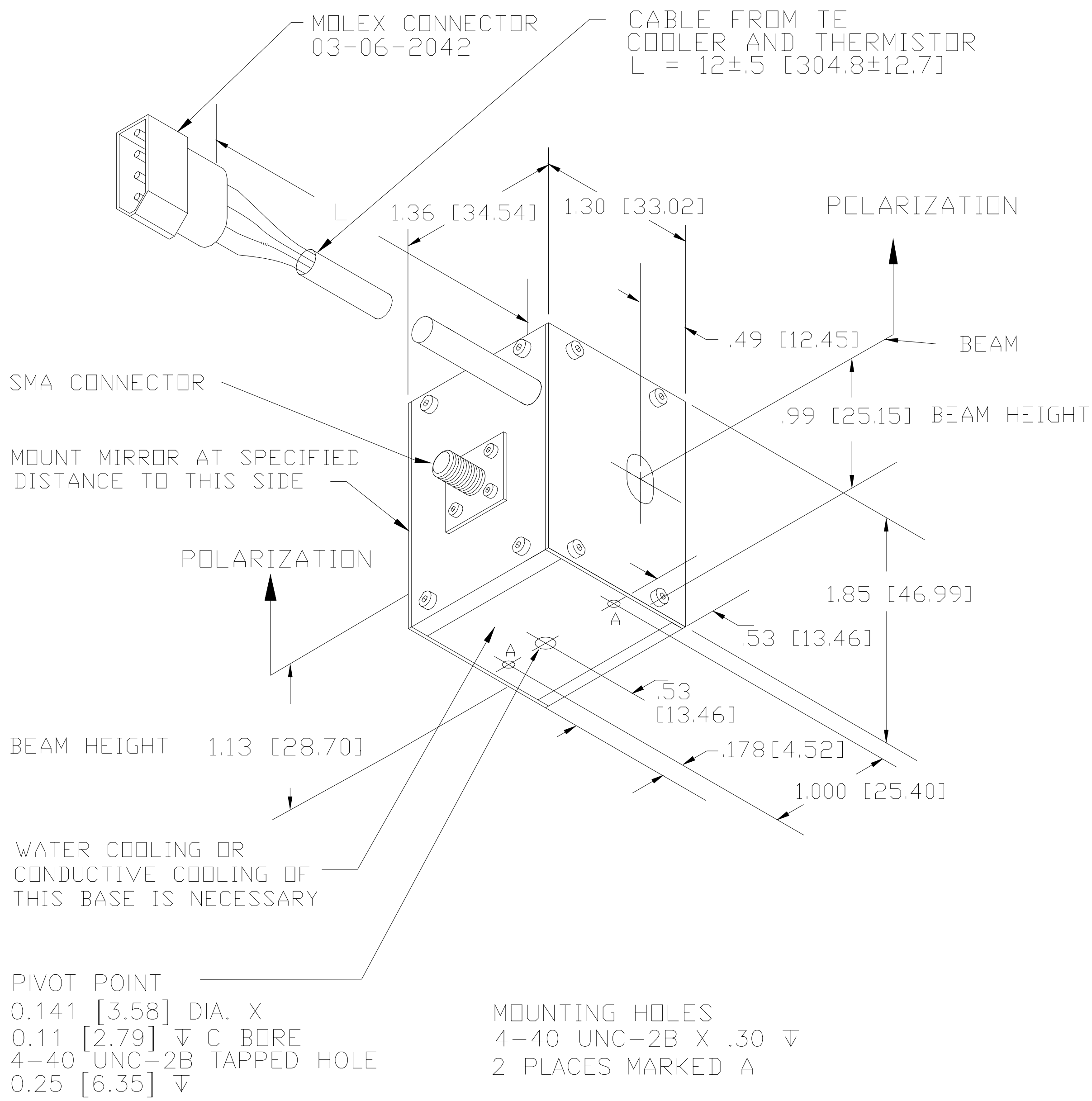
Dimensions in [ ] are in mm.

Tolerances: Decimal: .xx = .01 .xxx =.005

Millimeter: .xx = .25mm .xxx = .127mm

Angle: = ± 30'

FIGURE 3



53A04807

12XXX-2-BR-TE

Dimensions are in inches

Dimensions in [ ] are in mm.

Tolerances: Decimal: .xx = .01 .xxx =.005

Millimeter: .xx = .25mm .xxx = .127mm

Angle: = ± 30'

SECTION V
OPERATING PROCEDURE

A. Electrical Connections

If a NEOS driver is used, connect the Molex connector of the modulator to the driver for temperature control. The black and red wires are used to supply power to the TE heat pump. A positive voltage applied to the red wire will heat the modulator causing the resonant frequency to increase. The opposite polarity will cause the resonant frequency to decrease. **Do not apply in excess of six amps at two volts to the TE heat pump**. NEOS will not warranty any failure resulting from the application of too much power to the TE heat pump. **Be sure to heat sink the base of the modulator**. **Do not allow more than approximately a ten degree Celsius difference between the temperature of the heatsink base and the optic as indicated by the thermistor**. The white wires are for the thermistor to monitor temperature. Table 1, shows the thermistor value versus temperature.

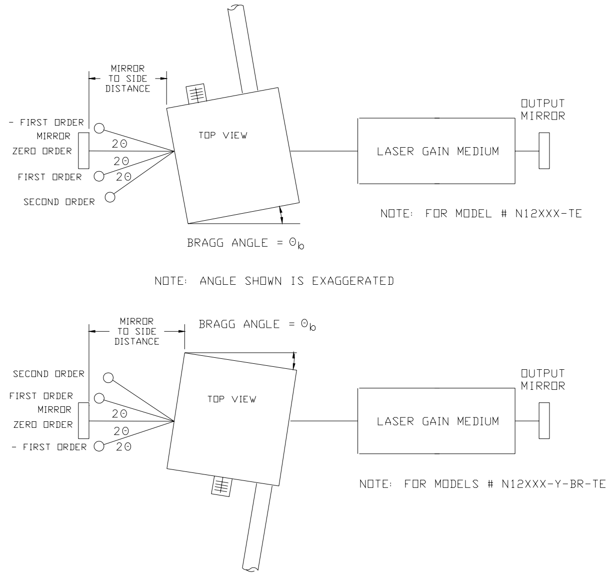
The SMA connector is the RF input. The input impedance is nominally 50 Ohms when operating in a resonance. Connect the RF output of the driver to the SMA of the modulator. The driver RF cable length is critical and is supplied with the driver system. **Do not apply more than two Watts of RF power to this modulator**. NEOS will not warranty any failure resulting from the application of too much RF power. If a NEOS driver is used, refer to its operation manual for information on temperature and RF controls and cable requirements.

B. Mounting and Required Adjustments

Mount the modulator on a stable mount, which can be adjusted for cavity length with micron resolution. This mount should be adjustable in the vertical axis so as to position the modulator's acoustic aperture to be centered on the laser beam. The mount should also have angle adjustment in the horizontal direction for Bragg angle adjustment of the modulator. Insert the modulator into the laser cavity so that the side shown in Figure 4 is closest to the cavity mirror. The distance between the modulator's side cover closest to the cavity mirror and the cavity mirror shall be as follows:

MODE LOCKER MODEL	MIRROR TO SIDE COVER DISTANCE
12038-	20 mm
12041-	16 mm
12050-	11 mm
12080-	7 mm

This distance allows for maximum destructive interface between the first order incident and reflective beams. This in turn creates the most efficient intensity shuttering possible. Make certain the light polarization is linear and oriented vertically. Make certain there is adequate heatsinking to maintain the temperature control.



45A02805 **FIGURE 4**

C. OPERATING PROCEDURE

If using a NEOS Mode Locker driver, the driver outputs an ultra-stable frequency. The temperature tuning circuit, when operated in automatic control mode, will temperature tune the modulator's crystal temperature to bring the crystal's resonance to the driver's output frequency. This causes the acoustic energy to set up a standing wave in the crystal and acts as a shutter to control the laser's longitudinal modes through loss modulation.

If applying the RF power using an ultra-stable variable frequency source, such as a frequency synthesizer, always slowly approach from the low side of the modulator's resonant frequency. As the resonance is approached and RF power is absorbed the mode locker will begin heating up. The TE heat pump can be used to control this change in temperature by cooling the modulator's crystal. The rate of frequency change versus temperature is approximately 5.7 KHz per degree Celsius. The resonant frequencies, where the standing acoustical wave is set up in optic device, occurs every 300 KHz for the standard (-TE) mode locker device, 364 KHz for the 3 mm Brewster window device (-BR-TE) and 596 KHz for the 2 mm Brewster window device (-BR-TE).

Monitor the reflected RF power when RF power is applied to the modulator**. The modulator is in a resonance when the reflected RF power is minimal.** If the resonance is accidentally passed, drop the frequency source back down in frequency to below the resonant frequency and try again. With using the NEOS driver, if the resonant frequency can not be reached under automatic control due to the temperature being too cool, turn the TE cooler controller to "manual" control and to "heat" to raise the crystal's temperature for a few minutes. Then return the switch to cool and the unit to automatic control.

Optimum operation of the modulator can be achieved when the reflected RF power is minimal and the Bragg angle, vertical position in the laser beam are adjusted properly as described below. Then adjust the cavity length to match twice the modulator acoustic frequency at resonate to achieve mode locking.

With the RF power applied to the modulator and operating at a resonance, rotate the Bragg angle of the modulator as shown in Figure 4. See the specifications for Bragg angle θ_b on page 5. Optimize the adjustments for cavity length and vertical position of the beam through the modulator's acoustic aperture until the shortest most stable optical pulses are achieved from the laser. These adjustments are the most critical, while the horizontal adjustment and Bragg angle is the least critical. Finally, adjust the RF drive power level to the modulator and laser's circulating power level to optimize pulse width and stability. View the detected laser pulses on a fast oscilloscope both to see the individual pulses for width and shape and view the "train" of laser pulses at a long time scale to see the laser cavity stability.

Notes:

Stable mode locking of a laser requires stable temperature control of the laser environment as well as temperature control the mode locker modulator's crystal. Any change in cavity length will result in unstable mode locking.

Stable mode locking of a laser requires a very clean cavity. Any dust or contaminate inside the laser cavity will influence the laser modes. Make sure all surfaces that the laser beam passes through or reflects from are clean.

Stable mode locking also requires balancing the energy pumped into the laser media and the energy removed during the transit of a mode locked laser pulse through the media. If excess energy is input to the media, spontaneous lasing may cause the mode locked pulses to be unstable. If insufficient energy is input to the media, the energy in the upper state may be depleted also resulting in unstable mode locked pulses.

Therefore, critical adjustment of the laser's input power is necessary to produce stable mode locking.

SECTION VI
OPTICAL WINDOW CLEANING

Stable mode locking requires that the optical surfaces be absolutely clean, as anything in the optical path will cause instability in the modes of the laser. If the optical window of the crystal needs cleaning to remove a build-up of dust or contamination, contact NEOS Technologies if using a Brewster window device for a return authorization as cleaning requires disassemble of the mode locker. For the AR coated mode locker follow the procedure below:

- Remove the protective cover.
- Blow off any visible dust with canned air. Do not use an air gun unless it is filtered and water and oil free!
- Fold (4 times) a new lens tissue into a triangle to make a cleaning tool.
- Dip the tip of the lens tissue into fresh acetone or spray fresh acetone from a squeeze bottle onto it. Then shake excess fluid out of the lens tissue. Do not handle the wet area of the tissue, as your finger oil will be absorbed and contaminate the optical surface of the crystal.
- Wipe (only once) across the crystal, starting at the top and drawing the tissue across the optical surface in one even motion toward the bottom. Do not damage the transducer or the bond wires! Do not reuse the tissue as it may pickup the mounting silver epoxy and damage the window.
- Repeat with a new tissue each time and for each surface that needs cleaning.
- The covers must be replaced after cleaning.

Do not touch the windows with bare fingers. The skin oil can etch into the AR coating.

Notes:

- The lens tissue must be lint free and the best grade available.
- Only use each tissue once, for only one surface. Do not reuse the tissue, as it will redistribute the removed dust.
- The acetone must be electronic grade. The acetone must be fresh from a new bottle, as the acetone will absorb water from the air and cause streaks. Discard any acetone, which has been exposed to the air for more than 4 hours. If the bottle is half- empty, do not use.