Aug 12

Acousto-Optic Modulator / Deflector Driver

Including: Basic AOM650-H / M1199-G50 Alignment

Instruction Manual

RFA4060-2

Models -

RFA4060-2	: 40/60MHz, 100W output, dual frequency, phase controlled Digital Modulation
RFA4060-2A	: 40/60MHz, 100W output, dual frequency, phase controlled Analog Modulation
RFA4060-2ZP	: 40/60MHz, 100W output, dual frequency, zero phase

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1. GENERAL

The Model RFA4060-2 is a class A amplifier designed to drive the AOM650 / M1199 series of Isomet High Power Germanium Acousto-Optic Modulator/Deflectors with up to 180Watts power at 40/ 60 MHz. The RFA4060-2 exhibits phase shifting between the two RF output channels. Phase shifting is the basis of the beam-steering technique used in Isomet wideband AO deflectors and ensures optimum efficiency across the bandwidth of the deflector. [Note: Model RFA4060-2ZP has a zero phase shift between the RF output channels].

The driver accepts a modulating input signal and provides a double-sideband amplitude modulated RF output to the acousto-optic modulator. A second input selects the carrier (centre) frequency.
A summary of the driver specification is shown in the following table:

Model	Application	Center Frequency	Total Output Power
RFA4060-2	Dual spot Mode Digital Modulation	40MHz and 60MHz. Generates 2 active 1st orders (Not simultaneously)	> 180.0 Watt
RFA4060-2A	As above Analog modulation/power control		
RFA4060-2ZP	Single spot Mode. Allows continuous RF to be applied to AOM for thermal stability.	40MHz or 60MHz One freq' is selected to generate the active 1st order (Other beam dumped)	> 180.0 Watt

Figure 2 is a block diagram of the driver. The two center frequencies are determined by free-running quartz-crystal oscillators. The frequency is accurate to within $\pm$ 0.003% and the stability is better than $\pm$ 0.003%; the oscillator is not temperature stabilized.

A high-frequency, diode ring modulator is used to amplitude-modulate the RF carriers. Single turn potentiometers provide gain control for adjusting the maximum r-f power for both outputs of the Driver at each frequency.

A solid state switched delay unit generates the correct phase control between the outputs depending on the selected spot frequency (i.e. 40 or 60 MHz). A MMIC r-f pre-amplifier stage isolates the low level modulation and phase control circuitry from the power amplifier stages.

The two power amplifier stages function in parallel and are designed to operate at full rated power into a 50Ω load with 100% duty cycle.

There are two control inputs,

1: Frequency Select TTL input for switching the RF Output frequency.
Note: This input is internally pulled low.
A TTL low level will select 60MHz.
A TTL high level will select 40MHz.

2: Amplitude Modulation input.
This one input controls both RF outputs simultaneously and there are two options depending on the driver model:

- RFA4060-2, Digital Modulation, TTL equivalent ON:OFF control.

An input swing of > 2.7V volt (positive with respect to ground) will drive the RF On.
An input voltage of less than 0.8V will drive the RF Off.

- RFA4060-2A, Analog Modulation, Continuous RF amplitude control.

The response is pseudo linear.
An input of 0.0V volt will generate the minimum RF (OFF).
An input voltage of 10V will generate the maximum RF output.

The RF switching rise and fall time for the amplifier is approx 200nsec.
The maximum RF output at each frequency is set by the power adjust potentiometers PWR ADJ1 (40MHz) and PWR ADJ2 (60MHz)

NOTE : Maximum RF power = fully clockwise
The digital input levels must not exceed 7 volts
The analog input levels must not exceed 15 volts
<u>Water cooling is mandatory. The heatsink temperature must not exceed 70°C.</u>

SERIOUS DAMAGE TO THE AMPLIFIER MAY RESULT IF THE TEMPERATURE EXCEEDS 70°C.
SERIOUS DAMAGE TO THE AMPLIFIER MAY ALSO RESULT IF THE RF OUTPUT CONNECTOR IS OPERATED OPEN-CIRCUITED OR SHORT-CIRCUITED.

A low impedance d-c power source is required. The operating voltage is +24V or +28Vdc at a current drain of approximately 15A. The external power source should be regulated to ± 2% and the power supply ripple voltage should be less than 200mV for best results.
Higher RF output power is achieved at 28Vdc.

2.0 DIGITAL MODULATION

The RF POWER ADJUST control sets the peak driver output for the ON condition (TTL=1). A low level input (TTL=0) will turn the RF output OFF.

Figure 3 illustrate the modulation waveforms

2.1 LED INDICATOR

The front panel bi-colour LED indicator serves to indicate a number of possible operating states.
(Note: early versions fitted with single colour LED. This indicates Interlocks are valid only)
The LED will illuminate RED or GREEN, when the DC power is applied and the Interlocks are valid.
One or both RF outputs may be live if the LED is illuminated.

- Shows GREEN when the RF outputs are live and provided that :
  - a) the modulation duty cycle is more than 20% (approx).
  - b) the RF CW power is > 20% (approx) of the driver maximum power

- Shows RED when one or both RF outputs have low average power
  e.g. a) Modulation OFF
  b) RF power set to less than approximately 20% of the maximum driver RF power
  c) Modulation duty cycle is less than approximately 20%

LED Off

The LED will not illuminate if :

a) the internal driver thermal interlock switch is open (Over temperature fault)
b) the AOM thermal interlocks switch is open (Over temperature fault)
c) the AOM thermal interlock is not connected to the driver interlock input
d) the DC supply is off.

The thermal interlocks will reset once the AO device and / or RF driver are cooled below the switching temperature.

- The driver thermal switch over temperature is 50deg C
- The AOM650 thermal switch over temperature is 32deg C

The hysterisis of the thermal switches is 7-10deg C.
Once in a fault state the coolant temperature may need to be reduced to reset the thermal switches.

3 INSTALLATION AND ADJUSTMENT

3.1 Connect cooling water to the RFA4060-2. Refer to Figure 1.

Connect cooling water to the AO device. (see appendix A for dual port cooling)

Due to the high RF power dissipated in the AO modulator, it is paramount that the device is operated only when water cooling is circulating.

For optimum AO performance ensure the flow rate is more than 2 litre / minute at < 20 deg.C

3.2 Connect the positive input of the +24V (or +28V) DC power to the solder feed-thru terminal and the supply 0V (GND) to the adjacent M4 tag. DO NOT APPLY POWER.

3.3 Align the deflector head to insure that the incident light beam is centred in the active aperture of the deflector.

3.4 Connect the (2) RF output BNC jacks to the (2) SMA RF inputs of the acousto-optic deflector (or a 50 ohm RF load, if it is desired to measure the modulator RF output power). **The order of connection is important. This depends on the Bragg orientation. Figure 4 illustrates the options.**

The deflector will not be damaged if the order is incorrect but the amplifier outputs must be terminated. If the RF cable connections are incorrect, it will not be possible to achieve high efficiency at both frequencies / spot positions.

The cable lengths from the amplifier to the two RF connections of the deflector should be equal.

3.5 Connect the Interlock of the acousto-optic modulator (mini 3-pin snap connector) to the enable inputs on the 15-pin D-type connector of the RFA4060-2. Connect pin 1 of 'D' to the centre pin 1 and pin 9 of 'D' to the outer pin 2. (See Figure 5)

If the temperature of the modulator exceeds 32ºC or the internal driver temperature exceeds 70ºC, then the interlock connection becomes open circuit, disabling the RF output. An LED indicator illuminates when the Interlocks are closed and the RF is enabled. In addition, a open drain 'interlock valid' signal output is provided on pin 2 of the D-type connector for remote monitoring purposes.

3.6 Adjustment of the RF output power is best done with amplifier connected to the acousto-optic modulator. The Amplifier maximum output power is factory preset to approx 70W per output (140W total).

The optimum RF power level required for the modulator to produce maximum first order intensity will be different at various laser wavelengths and/or frequencies. Applying RF power in excess of this optimum level will cause a decrease in first order intensity (a false indication of insufficient RF power) and makes accurate Bragg alignment difficult. It is therefore recommended that initial alignment be performed at a relatively low RF power level.

3.6 Locate the PWR ADJ access holes on the driver end plate.

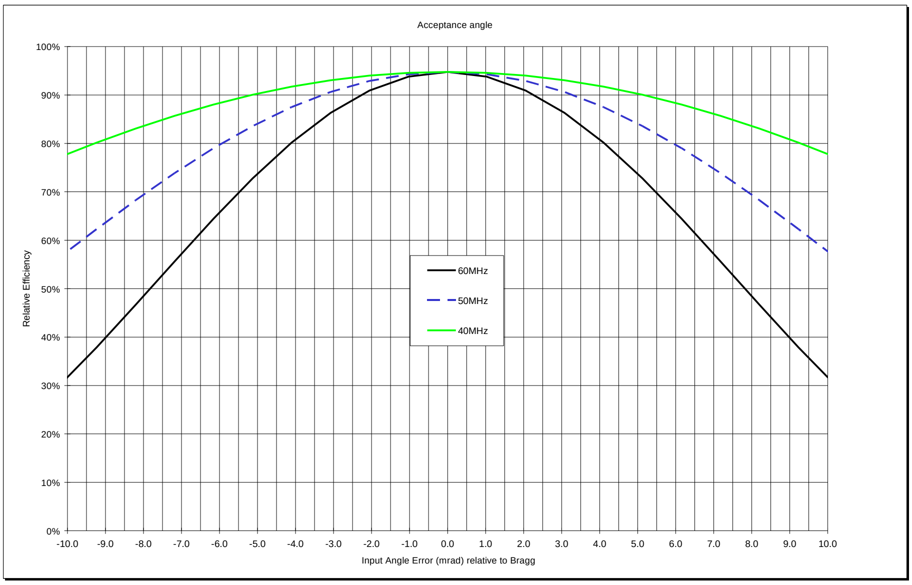
3.7 With an insulated alignment tool or screwdriver rotate both PWR ADJ 1 (40MHz) and PWR ADJ 2 (60MHz) potentiometers fully anti-clockwise (CCW) i.e.OFF, then clockwise (CW) approx 1/2 turn.

3.8 Apply DC to the amplifier.

3.9 Apply a TTL High (or 5.0V) constant modulation signal to the Modulation input on the 15way D-type connector of the RFA4060-2.
Connect the modulation signal to pin 7 of ‘D’ type and signal return to pin 14.
(For the RFA4060-2A, apply a constant 10V analog modulation signal)

3.9.1 Select a spot frequency.
Connect the Freq Select signal to pin 8 of ‘D’ type and signal return to pin 15.
For 40MHz diffracted spot, apply a constant TTL high level (or 5.0V) to the Frequency Select input on the 15way D-type connector.
For 60MHz output, apply a TTL low level (or leave unconnected).

Bragg angle sensitivity increases with frequency, therefore it is recommended that the initial Bragg angle adjustment be made at 60MHz. See figure below.
This graph shows the AOM650 sensitivity to Bragg angle error.
This plot also gives an estimate of the DE reduction due to Input Beam Divergence or Convergence.



Alignment

Input the laser beam toward the centre of either aperture of the AOM. Ensure the polarization is horizontal with respect to the base and the beam height does not exceed the active aperture height of the AOM.

Start with the laser beam normal to the input optical face of the AOM and very slowly rotate the AOM (direction related to the RF connection order). See Figure 5 for one possible configuration.

3.10 Observe the diffracted first-order output from the acousto-optic modulator and the undeflected zeroth order beam. Adjust the Bragg angle (rotate the modulator) to maximise first order beam intensity.

3.11 After Bragg angle has been optimized for 60MHz (Freq Select signal = Low), slowly increase the RF power. Rotate PWR ADJ2 for 60MHz until the maximum first order intensity is obtained.

3.12 Change the selected Frequency to 40MHz (Freq Select signal = High).
Increase the RF power for this frequency. Rotate PWR ADJ1 for 40MHz until the maximum first order intensity is obtained at this spot.

To equalise deflection efficiency, alternate between the two frequencies and carefully re-adjust Bragg angle and RF powers to give the same efficiency for both. (Note: the power meter may require repositioning for the two angles.)

PLEASE NOTE

3.13 If high efficiency cannot be achieved at both frequencies, it is probable that the RF connections to the AOM are incorrect. In this case the phase delayed output of the RFA4060-2 is connected to the incorrect input of the AO deflector. See Fig 4 for guidance.

Turn off the DC power to the RFA4060-2 and exchange RF connections at the Driver.
Repeat the above alignment procedure.

3.14 The driver and deflector are now ready for use.

4. MAINTENANCE

4.1 Cleaning

It is of utmost importance that the optical apertures of the deflector optical head be kept clean and free of contamination. When the device is not in use, the apertures may be protected by a covering of masking tape. When in use, frequently clean the apertures with a pressurized jet of filtered, dry air.

It will probably be necessary in time to wipe the coated window surfaces of atmospherically deposited films. Although the coatings are hard and durable, care must be taken to avoid gouging of the surface and residues. It is suggested that the coatings be wiped with a soft ball of brushed (short fibres removed) cotton, slightly moistened with clean alcohol. Before the alcohol has had time to dry on the surface, wipe again with dry cotton in a smooth, continuous stroke. Examine the surface for residue and, if necessary, repeat the cleaning.

4.2 Troubleshooting

No troubleshooting procedures are proposed other than a check of alignment and operating procedure. If difficulties arise, take note of the symptoms and contact the manufacturer.

4.3 Repairs

In the event of deflector malfunction, discontinue operation and immediately contact the manufacturer or his representative. Due to the high sensitive of tuning procedures and the possible damage which may result, no user repairs are allowed. Evidence that an attempt has been made to open the optical head will void the manufacturer's warranty.

RFA 4060-2 Standard Version

Connection Summary

1.0 15 way 'D' Type Control Connection

Signal	Type	Pin out connection
Frequency Select, TTL High = 40MHz, Low = 60MHz	Input	Signal pin 8 Return pin 15
Digital Modulation TTL * < 0.8V(off) , >2.7V(on)	Input	Signal pin 7 Return pin 14
Interlock (connect to AO modulator 'INT, normally closed)	Input	Signal pin 1 Return pin 9
'Interlock Valid' monitor (Open Drain logic, Low = OK) **Maximum applied voltage (via external pull up resistor) = 5.5V** **Maximum current = 10mA**	Output	Signal pin 2 Return pin 10

*Optional Analog Modulation < 0.4V(off) to 10.0V(on) : Model RFA4060-2A

2.0 Mounting Holes

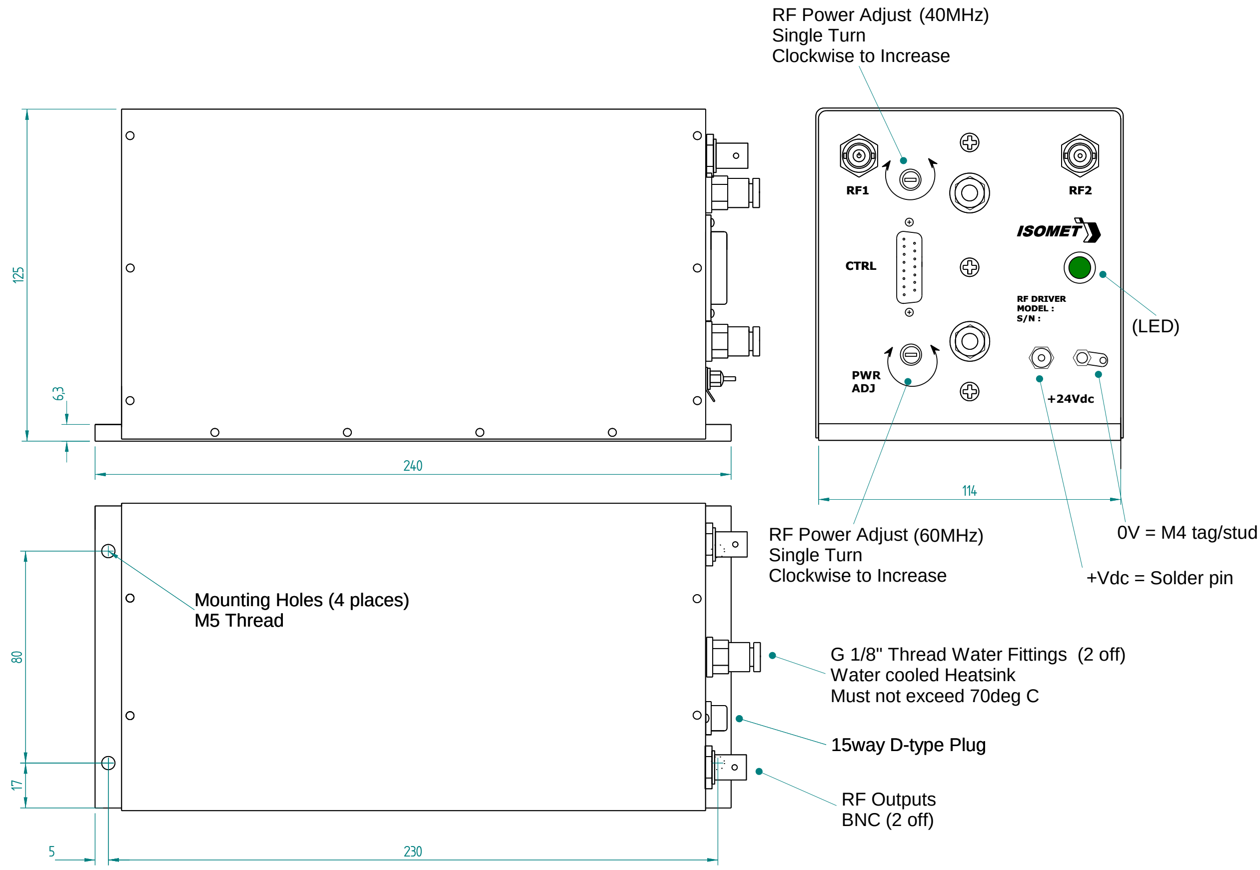
4 x M5

Notes:

The modulation input signal (pin 7) needs to be applied

The interlock signal must be connected. Contacts closed for normal operation.

3.0 RF Power Adjustment
PWR ADJ 1 sets 40MHz RF maximum power
PWR ADJ 2 sets 60MHz RF maximum power



Dimensions : mm
1" = 25.4mm

Recommended coolant flow
(see appendix A
for dual port AOM cooling)

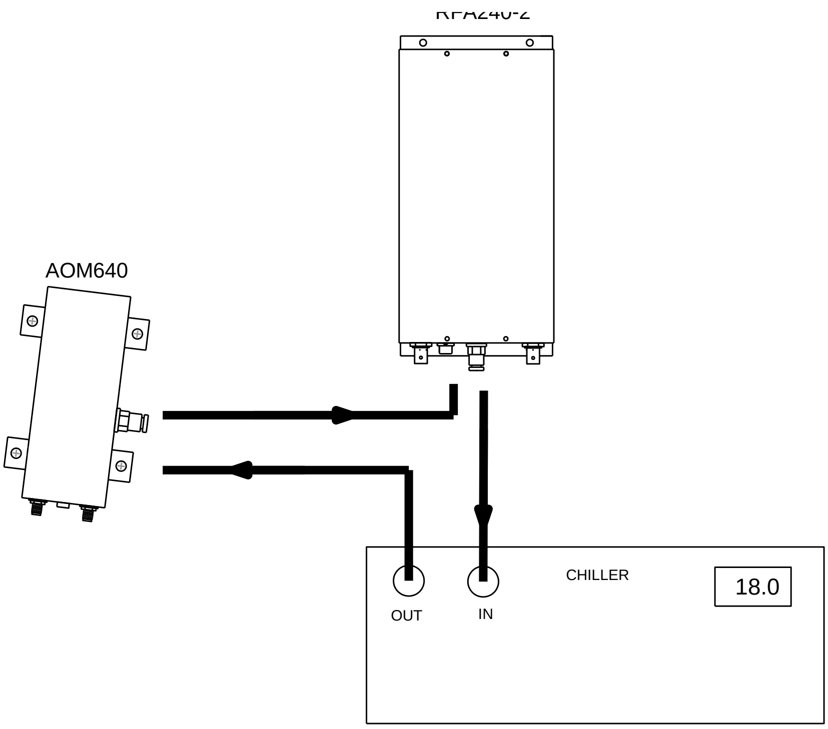


Figure 1: Driver Installation

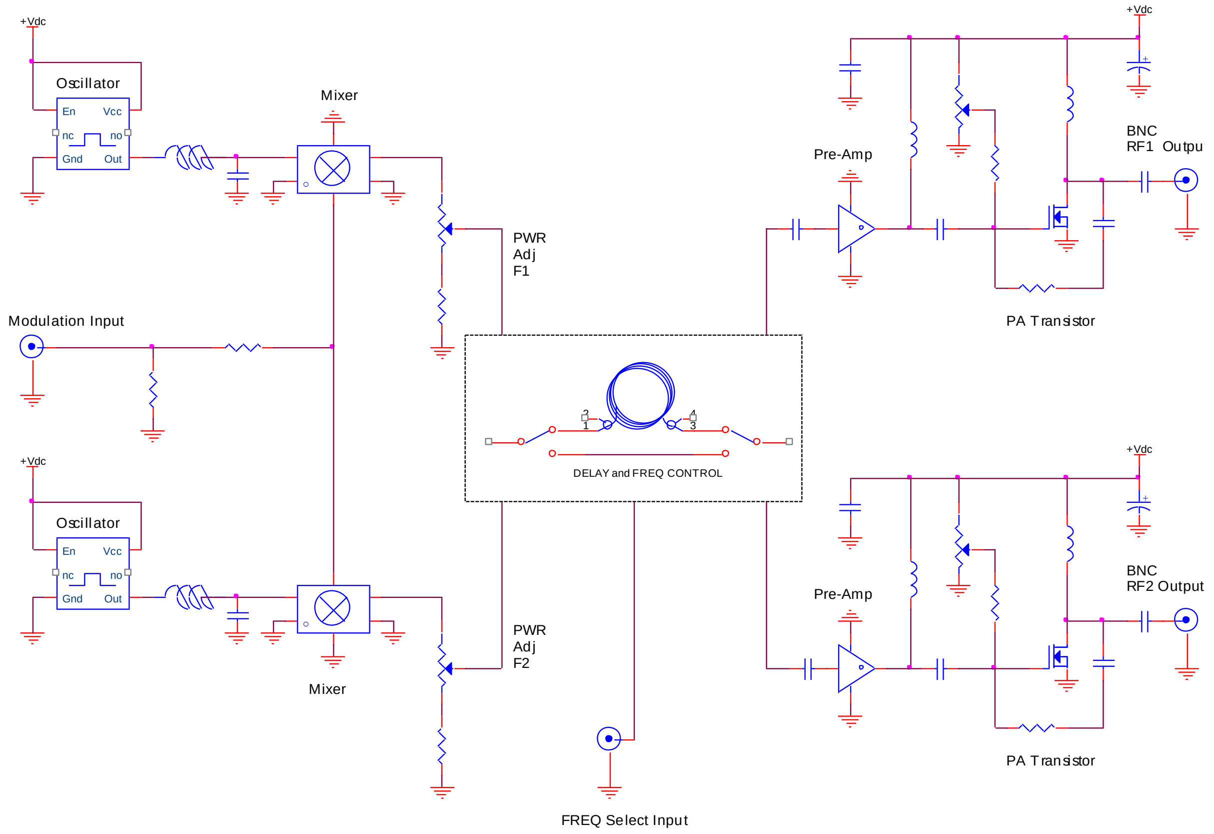


Figure 2: Driver Block Diagram

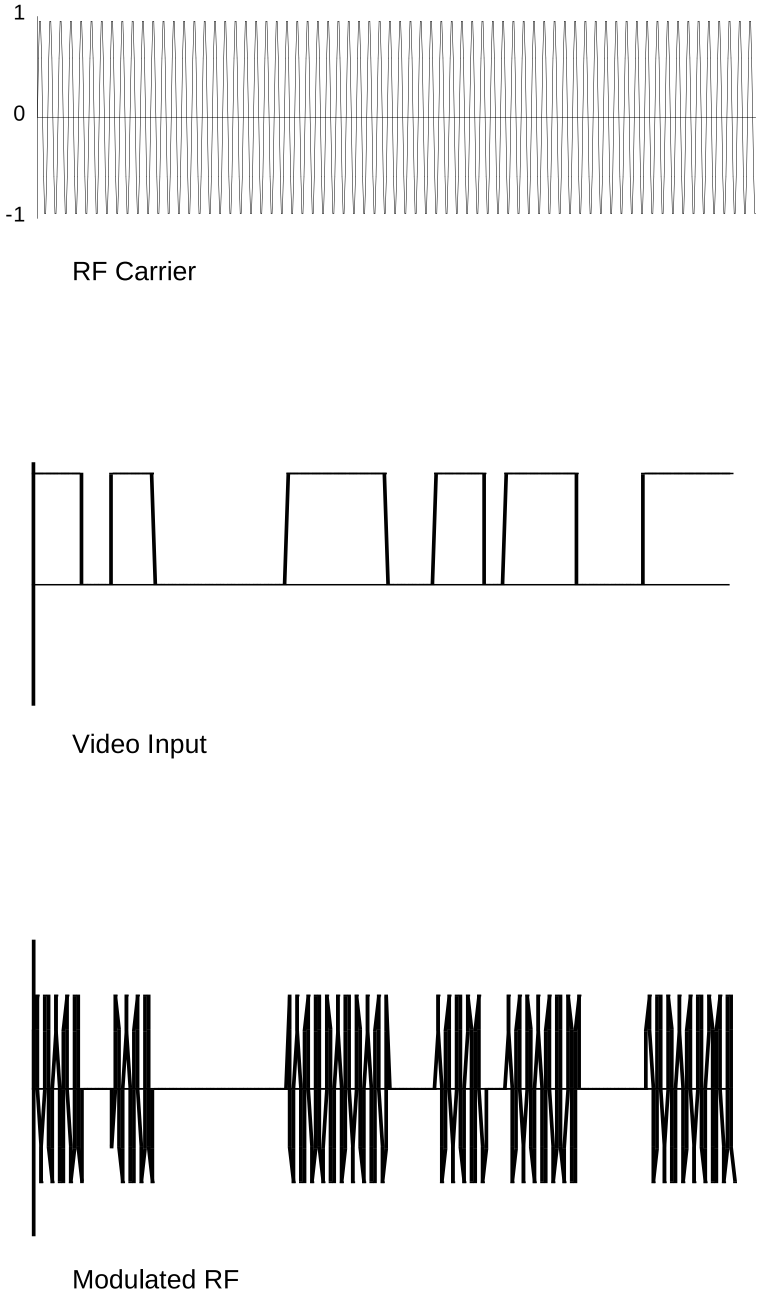
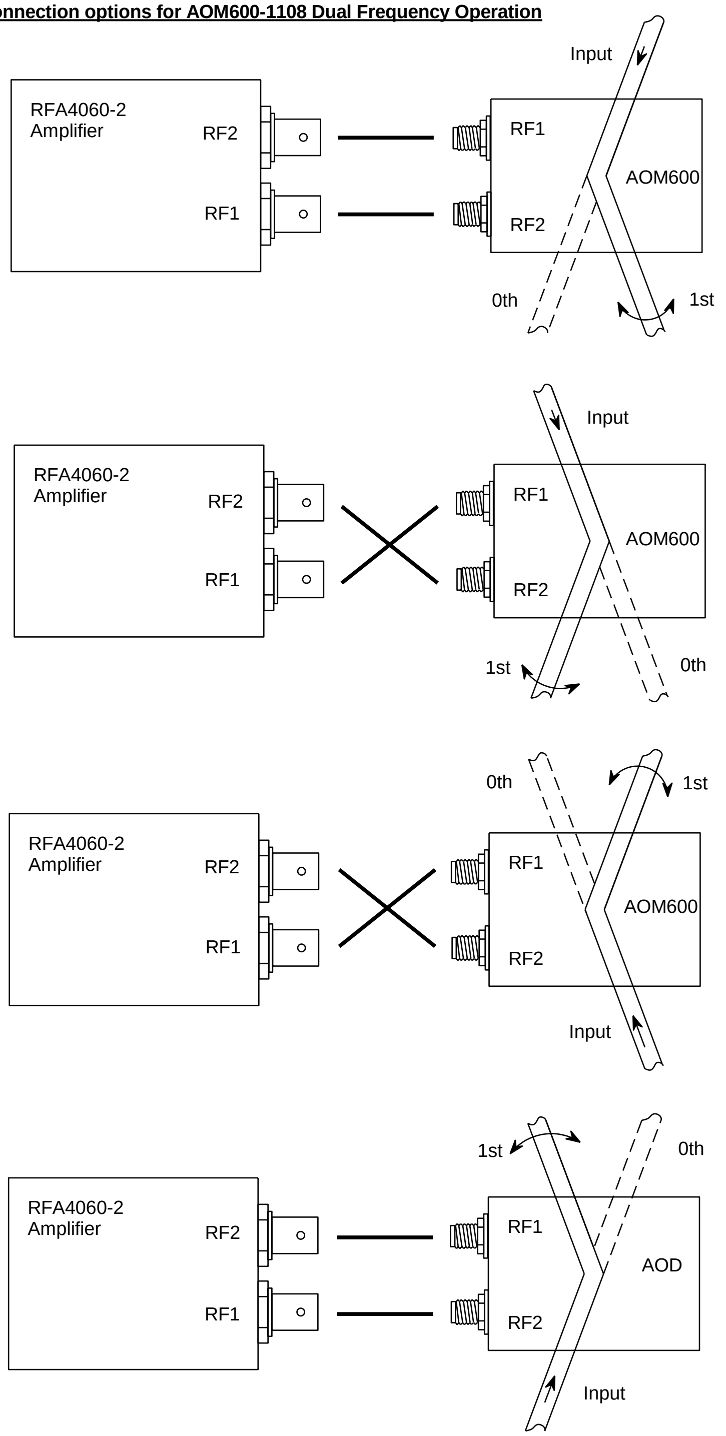


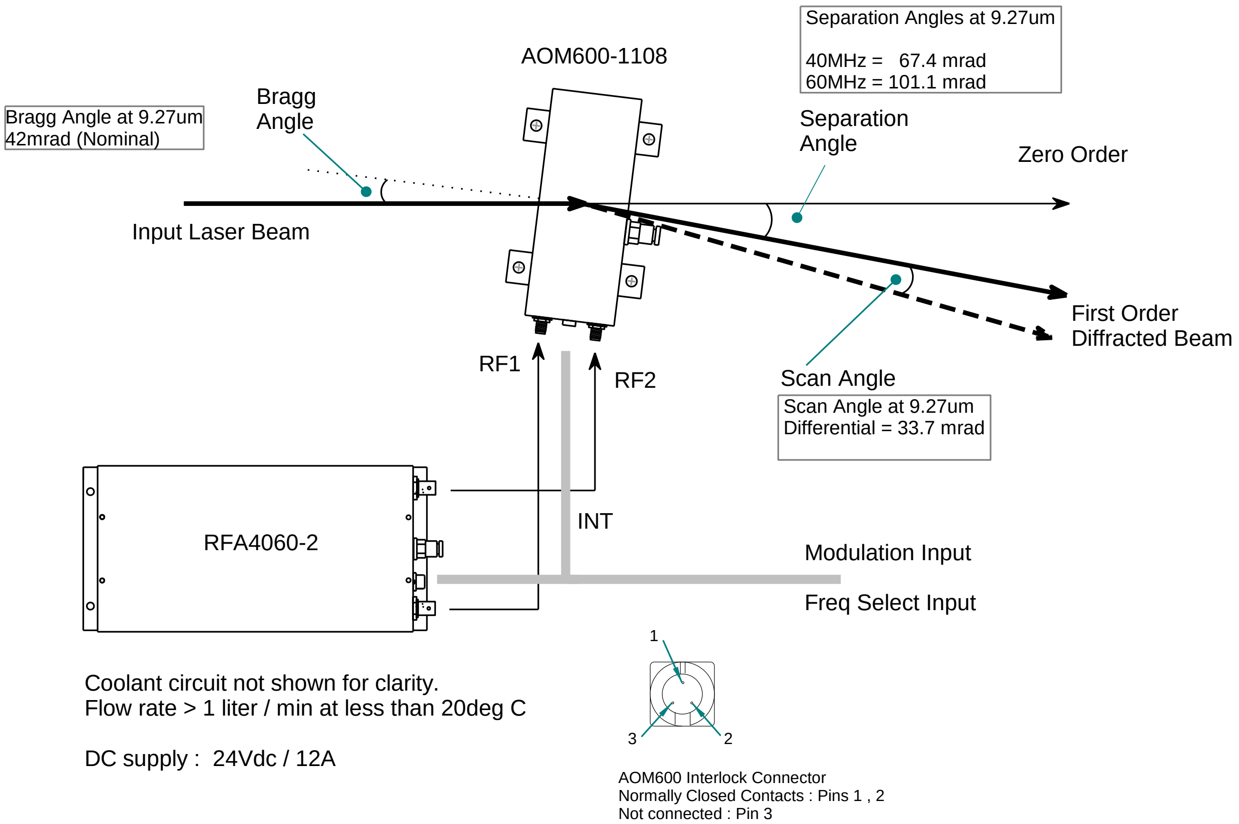
Figure 3: Typical Digital Modulation Waveforms

Connection options for AOM600-1108 Dual Frequency Operation



Correct orientation as viewed from top of AOD
(Connector identification may differ)

Figure 4: Connection orientations (J1 = RF1 , J2 = RF2)

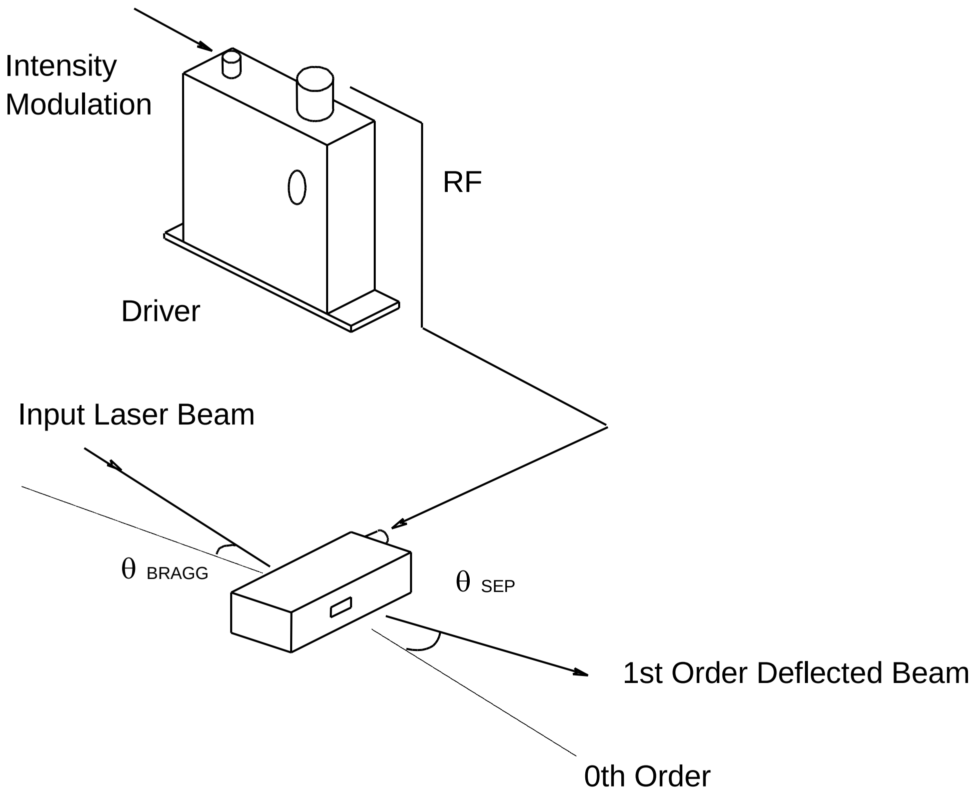


Coolant circuit not shown for clarity.
Flow rate > 1 liter / min at less than 20deg C

DC supply : 24Vdc / 12A

Figure 5: Typical Connection Configuration. See Figure 4 for alternate beam orientations

Basic AO Modulator Parameters



The input Bragg angle, relative to a normal to the optical surface and in the plane of deflection is:

$$\theta_{BRAGG} = \frac{\lambda.fc}{2.v}$$

The separation angle between the Zeroth order and the First order is:

$$\theta_{SEP} = \frac{\lambda.fc}{v}$$

Optical rise time for a Gaussian input beam is approximately:

$$t_r = \frac{0.65.d}{v}$$

where: λ = wavelength
fc = centre frequency = 40MHz / 60MHz
v = acoustic velocity of interaction material = 5.5mm/usec (Ge)

d = $1/e^2$ beam diameter

Figure 6. Modulation System

Appendix A

AOM600 / AOM700 / M1199 / DBM enhanced coolant flow

Flow rate enhancement using T-piece