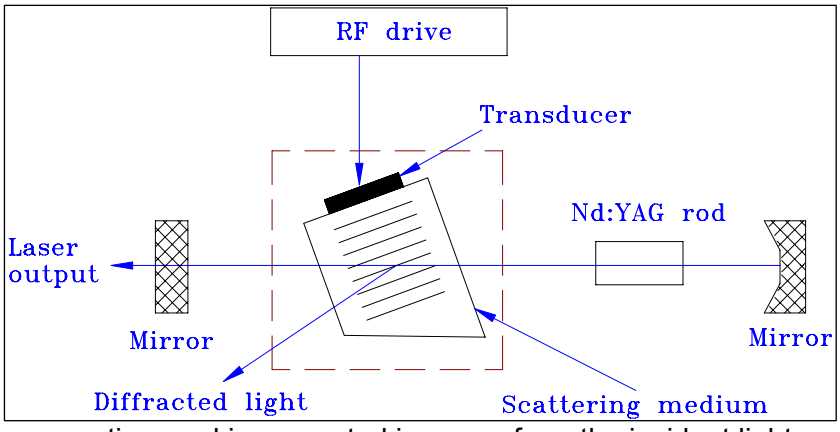
Acousto-Optical Q-switch

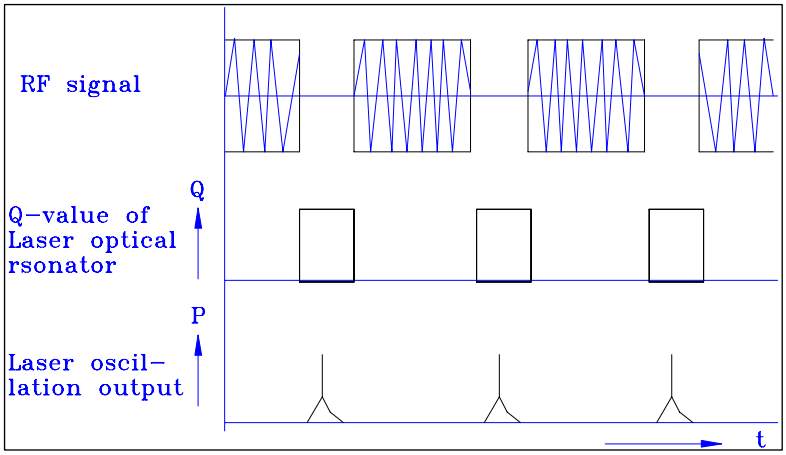
The acousto-optical Q-switch often used in the laser marking makes use of mutual interaction between an ultrasonic wave and a light beam in a scattering medium. The light beam that enters in a direction forming a Bragg angle to the wave surface of the acoustic wave in the scattering medium is diffracted in accordance with periodic changes in the diffraction rate produced by the acoustic wave.

The situation is briefly explained. First of all, an RF signal is impressed to the transducer adhered to the molten quartz and thickness extensional vibration is produced. Ultrasonic shear waves are caused to advance in the molten quartz by this vibration, and phase grating formed by acoustic waves is produced. The laser beam is diffracted when it satisfies the Bragg angle with respect to this phase grating, and is separated in space from the incident light.



If the laser optical resonator is constructed against 0-dimensional diffracted light (undiffracted light), the diffracted light deviates from the laser optical resonator axis when a RF signal is impressed. As a result, loss occurs in the laser optical resonator and laser oscillation is suppressed. To make use of this phenomenon, an RF signal is impressed for a certain length of time only (status of low Q-value) to suspend laser oscillation. In the meantime, the population inversion of the Nd:YAG rod is accumulated by continuous pumping. When the RF signal is reduced to zero (status of high Q-value) and the loss to the laser optical resonator is removed, the accumulated energy is activated as laser oscillation in a pulse form within an extremely short length of time. They are Q-switch pulses.

This situation is briefly explained. When an RF signal is subjected to pulse modulation, it is possible to periodically take out a Q-switch pulse. When the period of Q-switch pulses becomes shorter than the life (about 200 μs) of the higher order of the Nd:YAG rod, however, the population inversion decreases and the peak value of Q-switch pulses decreases.



1. QS Series Q-switch Element

1) Standard QS24/27 Series Industrial Q-switches

A water-cooled acousto-optic Q-Switch for use in high-power Nd:YAG laser systems. Combining top grade fused silica with high quality optical finishing and in-house anti-reflection coatings, this Q-Switch exhibits very low insertion loss and high damage threshold. Through an innovative design and manufacturing process, RF powers up to 100W may be applied.

Standard options include a choice of frequencies (24 to 68MHz), active apertures (1 to 8mm), acoustic modes (compressional for linear polarisation, shear for unpolarised) and water connectors. Customised housings are available for OEM's.

Specifications

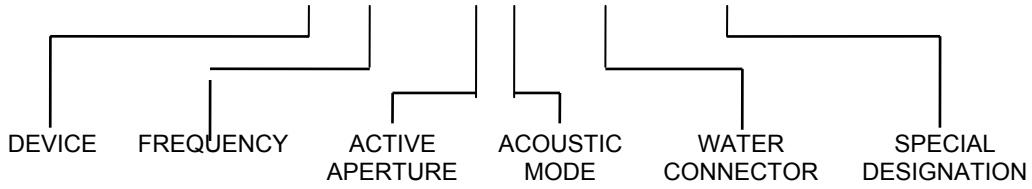
Model no:	See "Options" below
Interaction medium:	Fused silica
Operational wavelength:	1064nm
Anti reflection coating:	Hard multi-layer dielectric
- Reflectivity:	≤ 0·2% / surface (< 0·1% typical)
- Damage threshold:	> 500MW cm^{-2}
Insertion loss:	≤ 10% (< 5% typical)
Active aperture:	See "Options" below
Diffraction (separation) angle	~4.8 mrad
VSWR:	≤ 1·2:1
Maximum CW drive power:	100W
Thermal interlock:	+50ºC

Water Cooling

Flow rate:	190cc / min (minimum)
Water Temperature:	
- Recommended operating:	32ºC
- Recommended maximum:	40ºC
Water Connectors:	See "Options" below

Options

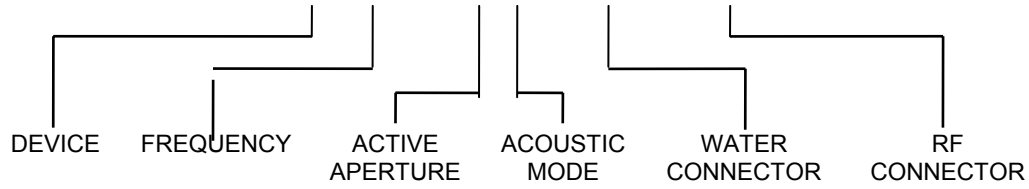
Previous model: QS 27 - 4 S - B - X X n



Device:	QS	- Q-Switch
Frequency:	24, 27, 41, 68, 80	- Value in MHz
Aperture:	1.6, 2, 3, 4, 5, 6·5, 8	- Value in mm (In general, the aperture of Q-switch is equal to or larger than the diameter of laser beam or YAG rod.
Acoustic Mode:	C	- Compressional
	S	- Shear
Water Connector:	S	- Screw-on (Swagelok etc.)
	B	- Barbed Push-on
Special Designation:		- For non-standard Q-switch models identification characters which define the configuration may be allocated.

Available models are QS27-3C-B, QS27-4S-S etc.

New model: I-QS 27 - 4 S 4G - B 5



Device:	I-QS	- Q-Switch
Frequency:	24, 27, 41, 68, 80	- Value in MHz
Aperture:	1.6, 2, 3, 4, 5, 6·5, 8	- Value in mm (In general, the aperture of Q-switch is equal to or larger than the diameter of laser beam or YAG rod.
Acoustic Mode:	C	- Compressional
	S	- Shear
	4G	- Fused silica, operation at 1064nm
Water Connector:	S	- Screw-on (Swagelok etc.)
	B	- Barbed Push-on
RF connector:	5	- BNC Fm BH RF connector
Special Designation:		- For non-standard Q-switch models identification characters which define the configuration may be allocated.

Available models are I-QS27-3C4G-B5, I-QS27-4S4G-S5 etc.

2) Stallion Series 'Industry Standard' Acousto-Optic Q-Switches

A 'Stallion' version of our industry standard water cooled Acousto-optic Q-Switch, for use in high power lamp or diode pumped Nd:YAG lasers.

The patent pending 'Stallion' manufacturing technique provides superior corrosion resistance whilst maintaining optimum performance and RF power handling capabilities up to 100W.

Combining top grade fused silica with high quality optical finishing and in-house anti-reflection coatings, this Q-Switch exhibits very low insertion loss and high damage threshold.

In addition to the standard product shown, custom configurations are available for specialized applications. These include alternative housing options, wavelengths and RF frequencies.

Key Features:
- Industry standard for Nd:YAG lasers
- Superior corrosion resistance
- Stainless steel cooling channels
- High damage threshold
- Push fit water-connectors
- Up to 100W RF power handling
- Custom configurations available

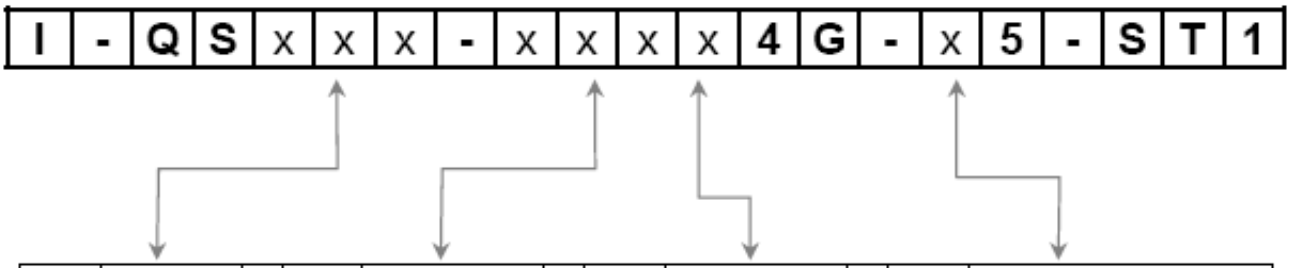
Applications:
- Material processing:
- Laser marking
- Laser engraving
- Laser cutting
- Laser drilling
- Medical (surgery)
- Lithography

General Specifications:

Interaction material:	Fused Silica
Wavelength:	1064nm

AR coating reflectivity: Damage threshold:	< 0.2% per surface > 1GWcm-2
Transmission (single pass):	> 99.6%
Static insertion loss:	≤ 6% at 50W laser power
VSWR:	< 1.2:1 (<1.4:1 at 50W RF power)
RF power rating:	100W CW (max)
Water flow rate:	> 190cc / minute
Water-cooling channel material:	Stainless steel 316
Recommended water temperature:	+22°C to +32°C
Thermal switch cut-off:	+55°C +/- 5°C

Ordering Codes
Example: I-QS027-4S4G-N5-ST1 (Q-Switch, 27.12MHz, 4mm active aperture, shear mode, fused silica, 1064nm, 4mm OD straight push fit water-connectors, BNC, Stallion housing with M3 mounting holes)



Code	Frequency		Code	Active aperture		Code	Acoustic mode		Code	Water connector
024	24.00MHz		1.6	1.6mm		C	Compressional		N	4mmOD straight push fit
027	27.12MHz		2	2.0mm		S	Shear		P	6mmOD straight push fit
041	40.68MHz		3	3.0mm					Q	4mmOD right angle push fit
068	68.00MHz		4	4.0mm					U	6mmOD right angle push fit
			5	5.0mm						
			6.5	6.5mm						
			8	8.0mm						

How to Find the Replacement of the Used/damaged Q-switch

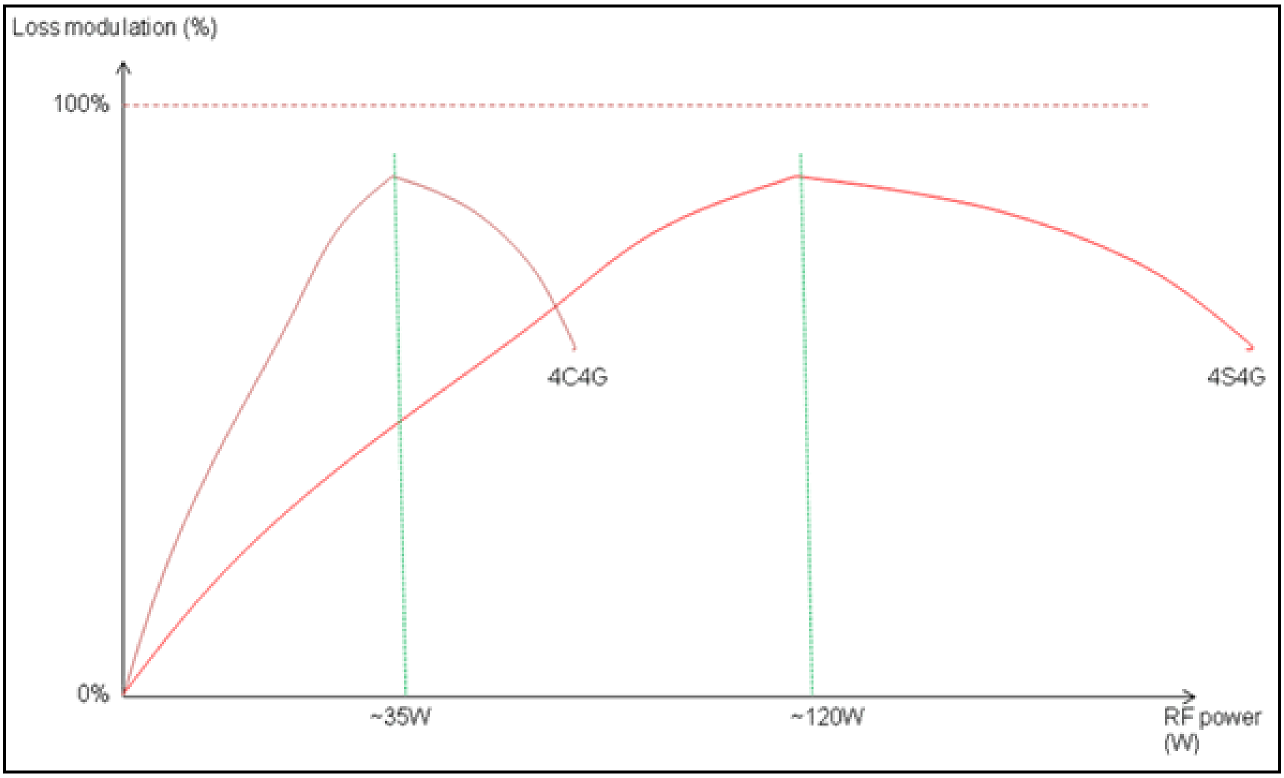
1. To find the frequency of the RF driver (Q-switch driver).
2. To find the diameter of the YAG rod or laser beam diameter from the laser head. In general, the aperture of the Q-switch is 1mm larger than the YAG rod diameter.
3. If there is no polariser inside the laser resonator and the laser beam is non-polarised, acoustic mode S should be used. Otherwise, acoustic mode C is used in polarised laser beam. (Remark: the above recommendation is not 100% true. We have found that acoustic mode S is also used in polarised lasers and it operates well. Acoustic mode C is also used in non-polarised lasers and it operates well too.)
4. Then to select a suitable water connector. Please note that you can use your own water connector to replace/change the connector since the connector is screwed. For example, if the damaged Q-switch has B-connector and you have a new Q-switch with S-connector, you can take away B-connector from the damaged Q-switch and then install this B-connector into your new Q-switch replacing its S-connector.

RF Power for Q-switches:

The following table shows the RF powers required at the theoretical peak loss modulations for Q-switches:

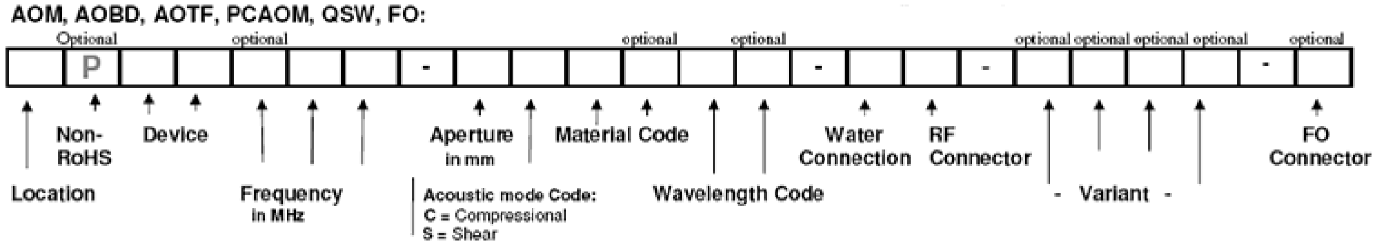
Aperture size	Compressional peak RF power	Shear peak RF power
2mm	~20W	~60W
3mm	~25W	~90W
4mm	~35W	~100W
5mm	~50W	~100W

Remark: the maximum allowed RF input is 100W only.



Reference: Model Number Designation Guide:

AOM, AOBD, AOTF, PCAOM, QSW, FO:



Acoustic mode Code:
C = Compressional
S = Shear

Location Code:
I: Ilminster
M: Melbourne
N: Norderstedt
T: Torquay

Device Code:
CD: Cavity Dumper
FS: Frequency Shifter
ML: Mode Locker
TF: Tunable Filter
D: AO Beam Deflectors
M: Modulator
QS: Q-Switch
QD: Integrated Q-Sw / Driver
MS: Bragg Mount
FA: Focusing Assembly Optics / Mount
ZR: Zero order re-combiner

Material Code:

1 $PbMoO_4$	10 Crystal Quartz
2 TeO_2	11 Germanium
3 SF6	12 Lithium Niobate
4 Fused Silica	13 F2
5 SF10	14 Potassium Yttrium Tungstate
6 SF57	15 KDP
7 SF2	16 Si
8 Amtir-1	17 GaP
9 SF8	18 GLS

Wavelength Code:

A 442 nm	W 780 nm	BA 250 – 400 nm	BS 1000 – 1500 nm
B 488 nm	X 850 nm	BB 300 – 400 nm	BT 1064 – 1300 nm
C 532 nm	Y 946 nm	BC 400 – 700 nm	BU 1064 – 1550 nm-
D 543 nm	Z 1230 nm	BD 450 – 850 nm	BV 1064 – 2100 nm
E 633 nm	V1 1342 nm	BE 450 – 950 nm	BW 1300 – 1600 nm-
F 800 nm	V2 1640 nm	BF 470 – 850 nm	BX 1800 – 2200 nm
G 1064 nm	V3 1940 nm	BG 600 – 1200 nm	BY 1800 – 4000 nm
H 1319 nm	V4 1990 nm	BH 670 – 900 nm	BZ 1850 – 2500 nm
J 1550 nm	V5 2000 nm	BJ 700 – 900 nm	B1 1900 – 2200 nm
K 532 / 1064 nm	V6 2022 nm	BK 700 – 1200 nm	B2 2000 – 3000 nm
L 1660 nm	V7 2090 nm	BL 725 – 825 nm	B3 2400 – 2600 nm-
M 2130 nm	V8 2100 nm	BM 800 – 1100 nm	B4 2650 – 2900 nm
N 488 - 633 nm	V9 1030 nm	BN 900 – 1500 nm	B5 3000 – 4000 nm
P 2.5 µm – 3.5 µm		BP 900 – 2000 nm	B6
Q 10.6 µm		BQ 950 – 1700 nm	B7
R Brewster	R1* 244-260nm	BR 950 – 1850 nm	B8
S 930 nm	R2* 300-550nm		B9
T 355 nm	R3*		
U 244 nm			WA 400 / 800 nm
V 405 nm	* Brewster - Limited by Design		WB 355 / 440 nm

Water Connection Code:
None Air Cooled (No Water Connection)
B: Barbed Push on
F: Festo CN-M-5-PK-4-59
J: Screw on with Jaco nylon nuts
K: KQH 04-M5 SMC Push on
L: Landwehr connector
M: MS-5H-6 SMC
N: 4mm OD Straight Legris 3106 04 00
P: 6mm OD Straight Legris 3106 04 06
Q: 4mm OD Right Angle Legris 3102 04 00
U: 6mm OD Right Angle Legris 3102 04 06
R: Right angle
S: Swagelok Screw on
T: Heater / Cooler (TE)
W:3.2 mm SMC Push in

RF Connector Code:
1: SMB Fm BH
2: SMC Fm BH
3: SMA Fm BH
4: SMA Fm Pig Tail
5: BNC Fm BH
6: Right Angle SMA Fm BH
7: Right Angle BNC Fm BH
8: SMA Male Pig Tail
9: BNC Male Pig Tail
C: BNC Female Pig Tail
Fm = Female
BH = Bulk Head

Variant 1 Customer Code and a Number = xxn
Variant 2 Fiber Coupled = **F** and a number (ports) followed by:
S = Single Mode Fiber **M** = Multi- Mode Fiber
P = Polarization maintaining Fiber **H** = High Power Option
L = Large Area Single Mode Fiber

Variant 3 FA / MS Focusing Assembly Optics / Bragg Mount
WP = Weather Proof

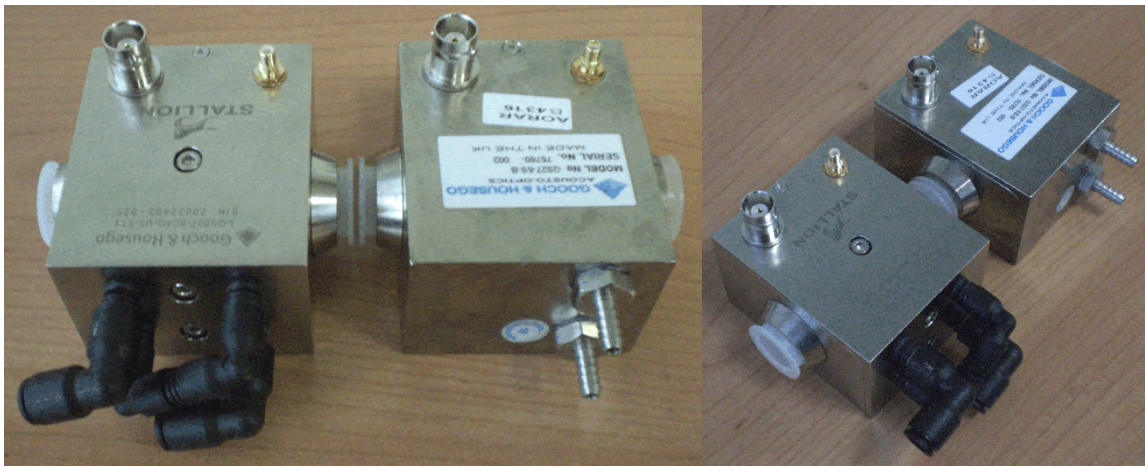
FO Connector Code:
A: FC/APC
B: FC/PC
C: SC/PC
D: SC/APC

Comparison between Standard QS Series Q-switches and Stallion Q-switches

Stallion, I-QS27 series	Old QS27-xx-x series
Water-cooling pad still made of Aluminum to avoid corrosion (prevent oxidation)	Water-cooling pad is made of Aluminum, no coating. This is very easy to cause corrosion.
Inner water-duct is having 3.5mm diameter by coating with stainless steel	Inner water-duct is having 2.5mm diameter
Same dimension and screw hole position as QS27 series	
Screw is using international standard, M3	Screw is using old UK standard
Water-connector is having choice of right-angle and straight through	Only straight through version
Water-connector is having 4mm or 6mm diameter selection	
Using laser marking for the serial number on the housing (un-erasable)	Using sticker to label part number and serial number that is very easy to erase even by hand (erasable of the device's information)

New part number of Stallion versus the older model：

Stallion Q-switch series	Old Q-switch series
I-QS27-5S4G-U5-ST1	QS27-5S-x
I-QS27-3S4G-U5-ST1	QS27-3S-x
I-QS27-5C4G-U5-ST1	QS27-5C-x
I-QS27-4S4G-U5-ST1	QS27-4S-x



Comparison between Stallion and old Q-switches. The main difference of the outlooks is water connector.

AO Q-Switch at Other Wavelengths

Model No.	QS027-4J-xxx	I-QS027-5S4Y-x5-ST1
Interaction material	Fused Silica (Infrasil, water-free)	Fused Silica (Infrasil, water-free)
Wavelength	1550nm	946nm
AR coating reflectivity	< 0.2% per surface at 1550nm	< 0.2% per surface at 1550nm
Damage threshold	> 500MWcm-2	> 1GWcm-2
Polarisation	Random	Random
Interaction length	46.0mm	46.0mm
RF frequency	27.12MHz	27.12MHz
VSWR	< 1.2 1	< 1.2 1
Acoustic Mode	Shear	Shear
Active aperture	1.6mm	5.0mm
Clear aperture	8.0mm	8.0mm
Loss modulation	> 70% at 50W; > 85% at 100W	> 75%
Housing	Standard QS27-xx-xxx	Stallion
Water connectors	Barbed or Screw fit	Push fit

Model No.	I-QS041-3C4H-x5-ST1	QS027-4H-xxx
Interaction material	Fused Silica(Infrasil, water-free)	Infrasil (water-free fused silica)
Wavelength	1319 - 1342nm	1319-1342nm
AR coating reflectivity	< 0.2% per surface at 1319-1342nm	< 0.2% per surface
Damage threshold	> 1000MWcm-2	> 1000MWcm-2
Polarisation	Linear (vertical to base))	Linear (vertical to base)
Interaction length	46.0mm	46.0mm
RF frequency	40.68MHz	27.12MHz
VSWR	< 1.2 1	< 1.2 1
Acoustic Mode	Compressional	Compressional
Active aperture	3.0mm	5.0mm
Clear aperture	8.0mm	
Loss modulation	~ 85% at 40W RF power	> 80% at 50W RF power
Housing	Stallion	Standard QS24/27-xx-xxx
Water connectors	Push-fit	Barbed

Model No.	QS027-4G/M-xxx	QS027-4C/G-xxx
Interaction material	Infrasil (water-free fused silica)	Fused Silica
Wavelength	1064nm / 2128nm	532/1064nm
AR coating reflectivity	< 0.2% per surface at 1064nm < 0.3% per surface at 2128nm	< 0.2% per surface
Transmission:	> 99.6% at 1064nm > 99.4% at 2128nm	> 99.6%
Damage threshold	> 500MW/cm2	> 500M W/cm^2
Polarisation	Linear, vertical to base	Linear, vertical to base
Active Aperture:	5.0mm	4.0mm
Interaction length	46.0mm	46.0mm
RF frequency	27.12MHz	27.12MHz
VSWR	< 1.2 1	< 1.2 1
Acoustic Mode	Compressional	Compressional
Active aperture	5.0mm	
Loss modulation	> 85% at 45W (1064nm) > 75% at 100W (2128nm)	> 80% at 35W
Rise-time (10-90%):	109ns/mm	109ns/mm
Housing	Standard QS27-xx-xxx	Standard QS27-xx-xxx
Water connectors	Barbed or Screw fit	Barbed or Screw fit

Model No.	QS027-4M-AP1	QS027-4H-xxx
Interaction material	Fused Silica (Infrasil, water-free)	Fused Silica (Infrasil, water-free)
Wavelength	1980 - 2050nm	1342 / 1550nm
AR coating reflectivity	< 0.2% per surface at 1980 - 2050nm	< 0.2% per surface at 1342nm < 0.5% per surface at 1550nm
Damage threshold	> 500MW/cm2	> 500M W/cm^2
Polarisation	Linear (vertical to base)	Any
Active Aperture:	4·0mm	1.6mm
Interaction length	46·0mm	
RF frequency	27.12MHz	27.12MHz
VSWR	< 1.2 1	< 1.2 1
Acoustic Mode	Compressional	Compressional
Loss modulation	~ 55% at 50W (3mm beam diameter)	70% at 50W RF power > 85% at 75W RF power
Rise-time (10-90%):	109ns/mm	109ns/mm
Housing	Standard QS27-xx-xxx	Standard QS27-xx-xxx
Water connectors	Barbed or Screw fit	Barbed or Screw fit

Model No.	QS027-10M-NL5	QS041-10M-HI8
Interaction material	Crystal Quartz	Crystal Quartz
Wavelength	2054nm	2053nm
AR coating reflectivity	< 0.2% per surface	< 0.2% per surface
Polarisation	Linear (vertical to base)	Linear (vertical to base)
Active Aperture:	5mm	2mm
Interaction length	46·0mm	
RF frequency	27.12MHz	40.68MHz
VSWR	< 1.2 1	< 1.2 1
Acoustic Mode	Compressional	Compressional
Loss modulation	~ 80% at 100W	> 85% at 50W RF power
Rise-time (10-90%):	109ns/mm	109ns/mm
Housing	Standard QS27-xx-B	Standard QS27-xx-B
Water connectors	Barbed	Barbed

Model No.	I-QS050-1.4V10M-U5-HI10	I-QS027-5C4G-x5-SOx
Interaction material	Crystal Quartz	Fused Silica
Wavelength	2053nm	1060-1125nm
AR coating reflectivity	< 0.2% per surface	< 0.3% per surface
Polarisation	Linear (vertical to base)	Linear, vertical to base
Active Aperture:	1.4mm	5mm
Interaction length	46·0mm	
RF frequency	50MHz	27MHz
VSWR	< 1.2 1	
Acoustic Mode	Very High Efficiency (VHE)	
Loss modulation	>95%	> 80%
Housing	Stallion	Stallion
Water connectors	Push in	Push in

Model No.	I-QS027-4C10V5(BR)-x5-IS6	
Interaction material	Crystal Quartz	
Wavelength	2000-2100nm	
AR coating reflectivity	< 0.2% per surface	
Optical faces	Brewster angled (parallel)	
Polarisation	Linear (vertical to base)	
Active Aperture:	4mm	
Interaction length	46·0mm	
RF frequency	27MHz	
VSWR	< 1.2 1	

Loss modulation	>80%	
Housing	Stallion	
Water connectors	Push in	

Application Notes:

- The surface of the crystal inside Q-switch should be kept clean and dry. If the surface is contaminated, the surface will easily be burnt due to high power laser beam.
- The cooling water should be de-ionised water or distilled water for QS series Q-switches. Please do not use city water as cooling water. Otherwise, the cooling channels will be corrupted and then the Q-switch will be damaged.
- The damage caused by non-proper use is not within the warranty.

2. Super Q-Switch (SQS)

- High efficiency
- For unpolarised, high power, high gain lasers
- 2 x 50W RF power handling

A new compressional mode, water-cooled, AO Q-Switch designed for use in high power unpolarised lasers giving faster switching, better pulse-to-pulse stability and higher power densities. Enhance your systems performance with greater punch and increased power, specifically for laser processing applications.

Before the Super Q-Switch, some customers were using 2 x Compressional mode Q-Switches (like the QS27-4C-S) in the same cavity. One of the Q-Switches is rotated 90degrees to the other. Because the Compressional mode Q-Switch is more efficient for polarised light, the first Q-Switch would block one polarisation & the second Q-Switch blocks the other. This is a good solution, but takes a large space in the cavity. The Super Q-Switch gives the same performance as using 2 x Compressional Q-Switch, but they are incorporated into 1 device.

This Q-switch uses a dual channel driver to operate two orthogonal compressional mode transducers bonded to a single monolithic optical cell and mounted in one convenient housing. Our proprietary bonding techniques and power handling technology allows this device to operate up to 50W per channel giving an efficient, compact, single device for the next generation of high power, high gain, solid state lasers.

(1) QS2x-xD-x-xxx

Interaction Material	Fused Silica
Wavelength	1047 to 1064nm
Anti-Reflection Coating	< 0.2% per surface
Damage Threshold	> 500MWcm-2 (1GWcm-2 typical)
Transmission (single pass)	> 99.6%
Frequency	24.00 or 27.12MHz
VSWR	< 1.2:1 (50. input impedance)
Active Aperture	1.6, 2, 3, 4, 5 or 6.5mm2
Clear Aperture	9 x 9mm
Acoustic Mode	Compressional (Orthogonal)
Rise-Time / Fall-Time	109ns/mm
RF Power Rating	2 x 50W CW
Water Flow Rate	190cc / minute, minimum
Maximum Water Temperature	+40°C (recommended, 22°C to 32°C)
Water Connectors	Screw-fit or Barbed (push-on)
Thermal Switch Cut-Off	+55°C ± 5°C
Housing / Flow Chamber Material	Aluminium HE30TF

(2) I-QS027-6.5D10G-B5

Model No:	I-QS027-6.5D10G-B5
Device:	AO Q-Switch
Interaction material:	Crystal Quartz
Wavelength: Damage threshold:	1064nm > 1GW/cm2
AR coating reflectivity:	< 0·2% per surface
Transmission:	> 99·6%
Frequency:	27.12MHz
VSWR:	< 1.3:1 at 0dBm
Optical polarisation:	Random
Active aperture:	6.5mm
Acoustic mode:	Compressional, dual
Rise-time (10-90%):	113ns/mm
Loss Modulation:	> 90% at 40W RF / Channel
Maximum RF power:	50W per channel
Cooling:	Water
Thermal switch cut-off:	65ºC ± 5%
Water connectors:	Barbed
Housing material:	Aluminium
Temperature range:	-20ºC to +70ºC

Driver Selection

N390xx-yyDMzzz-2CH

- Aperture size 1.6D, 2D or 3D, use 25W dual channel driver
- Aperture size 4D, 5D or 6.5D, use 50W dual channel driver

RF Power for Super QS & VHE QS :

The following table shows the RF powers required at the theoretical peak loss modulations for FS (Fused Silica) and CQ (Crystal Quartz) SQS (24/27MHz) and VHE devices (68MHz).

Aperture size / mm	Approximate ϕ / mm	FS SQS / W	CQ SQS / W	FS VHE / W	CQ VHE / W
1.6	1	~15	~10	~55	~40
2	1.5	~20	~15	~70	~50
3	2	~25	~20	~100 (max)	~70
4	2.5	~35	~25	-	~90
5	3.5	~45	~30	-	~100 (max)
6.5	5	~50 (max)	~40	-	-

All values are for 1064nm, SQS (super Q-switch) values stated are per channel.

3. VHE Q-Switch

I-QS068-xxxV10G-x5-ST3 (*QS68-xV-x-xxx)*

• Very High Efficiency > 95%
• Unique patent-pending acousto-optic design
• Includes 'Sure-Flow' technology
• For linearly polarised lasers

The VHE acousto-optic Q-Switch is ideal for use in high-gain, high-power, linearly polarized Nd:YAG & Nd:YVO4 lasers. Thanks to a special design it provides up to 96% single-pass loss modulation (compared to ~85% from conventional designs).

This astonishing performance is achieved inside the industry-standard package, allowing simple integration into existing cavity configurations.

Incorporating our special 'Sure-Flow' corrosion resistant treatment, which allows confident, efficient

water-cooling, the VHE Q-Switch can handle up to 100W of RF power.

Interaction Material	Fused Silica
Wavelength	1047 to 1064nm
Polarisation	Linear, vertical to base
Anti-Reflection Coating	< 0.2% per surface
Damage Threshold	> 1GWcm-2 (2GWcm-2 typical)
Transmission (single pass)	> 99.6%
Frequency	68MHz
VSWR	< 1.21 (50Ω input impedance)
Active Aperture	1.6, 2, 3, or 4mm
Rise-Time / Fall-Time	109ns/mm
Loss Modulation	> 95% (single pass)
Beam Separation	12mrad
Acceptance Angle	5mrad
RF Power Rating	100W CW
Water Flow Rate	190cc / minute, minimum
Maximum Water Temperature	+40°C (recommended, 22°C to 32°C)
Water Connectors	Screw-fit or Barbed (push-on)
Thermal Switch Cut-Off	+55°C ±5°C
Housing Material	Aluminium, with 'Sure-Flow' technology
Driver Model	A253-yy or A253-zz

The VHE Q-Switch: Pushing the boundaries further
Q-Switching is a method frequently used to obtain short laser pulses of enhanced power. However, improvements in laser technology have lead to the situation where the maximum loss modulation provided by conventional Q-Switches is insufficient to hold off the laser output.

That was then: Alignment of two Q-Switches
For high-gain unpolarised systems, the Gooch & Housego Super Q-Switch is available but until now, there was only one way to provide the loss modulation needed to successfully Q-Switch high-gain linearly-polarised systems. This was to fit two Q-Switches in series to provide sequential depletion of the zeroth order beam. Orientation of these two devices is crucial since any rediffraction of the first order rays back into the zeroth order will significantly reduce the loss modulation. Misalignment of the two Q-Switches could even result in a lower loss modulation than a single Q-Switch on its own.

Rediffraction is not the only drawback associated with using two Q-Switches. The relative phase of the acoustic modulation must also be considered if timing jitter is to be avoided. The increase in cavity length associated with fitting two Q-Switches will mean the pulse width will be increased. Two Q-Switches will place four optical faces into the laser cavity leading to increased insertion loss and multiple reflections. Each of the two Q-Switches must be carefully aligned at the Bragg angle while simultaneously avoiding rediffraction losses and of course two Q-Switches will require extra plumbing for the water cooling system and RF drivers.

This is now: A Q-Switch with >95% loss modulation
Understanding the challenges laser engineers face, Gooch & Housego has developed the VHE Q-Switch. Designed for use in high-gain, high-power, linearly-polarised Nd:YAG and Nd:YVO4 lasers, the patent-pending design provides better than 95% single-pass loss modulation, compared to ~85% from conventional designs. This outstanding performance is achieved inside the industry-standard package which allows simple integration into existing cavity configurations.

The rediffraction problem has been solved by careful alignment of the acoustics within the structure. At certain incidence angles, a laser beam will not be diffracted by an acoustic beam. These angles are built into the VHE Q-Switch which ensures that light cannot be diffracted back into the zeroth order.

This design greatly simplifies the alignment procedure and simultaneously achieves >95% loss modulation. The VHE Q-Switch uses a single RF driver so timing jitter from a phase mismatch

between two Q-Switches is eliminated.

The VHE Q-Switch from Gooch & Housego has been designed to allow laser engineers to push the boundaries that little bit further.

4. Q-Switch used in DPSS lasers

4.1 QS041-10G-xxyy series Q-switches

- DPSS Nd:YAG / Nd:YVO4, linearly polarized
- Compact conduction cooled, crystal quartz
- 2mm active aperture

A compact, conduction-cooled, acousto-optic Q-Switch for use in DPSS Nd:YAG & Nd:YVO4 lasers. Utilising the same manufacturing technology as our industry standard, high power QS24/27 series, these compact devices offer unrivalled reliability through superior optical quality and coatings.

Optimised for use with linearly polarised beams of up to 1.6mm diameter, offering loss modulation figures exceeding 85%. Utilising Crystal Quartz as the interaction material to give increased efficiency and high thermal transfer properties allowing use at RF powers of up to 15W, conduction-cooled.

This Q-Switch can also be customised to feature alternative frequencies, active apertures and housing designs, our team of scientists will be pleased to discuss variations with you.

Model Number	QS041-10G-SO3	QS041-10G-IN2
Interaction Material	Crystal Quartz	
Wavelength	1047 to 1064nm	
Polarisation	Linear, vertical to base	Linear, vertical to base
Anti-Reflection Coating	< 0.2% per surface	
Damage Threshold	> 1GWcm^2	
Transmission (single pass)	> 99.6%	
Frequency	40.68MHz	
VSWR	< 1.2:1 (50 Ω input impedance)	
Active Aperture	1.6mm	1.8mm
Acoustic Mode	Compressional	
Rise-Time / Fall-Time	109ns/mm	113ns/mm
Loss Modulation	> 85%	> 85%
Beam Separation	7.3mrad	
Acceptance Angle (full)	6.1mrad	
RF Power Rating	20W CW	
Cooling	Conduction through base	
Dimension	35x35x24mm	39.5x35x22mm
Q-switch driver	R39041-20DMFPS-SC	

Model No	I-QS041-1.8C10G-4-GH21 (QS041-10G-GH21)	I-QS041-1.6C10G-4-SO6
Device	AO Q-Switch	AO Q-Switch
Interaction material	Crystal Quartz	Crystal Quartz
Wavelength	1047 to 1064nm	1064nm
Damage threshold	> 1GW/cm^2	> 1GW/cm^2
AR coating reflectivity	< 0·2% per surface	< 0·2% per surface
Transmission	> 99·6%	> 99·6%
Frequency	40.68MHz	40.68MHz
Optical polarisation	Linear, vertical to base	Linear, vertical to base
Active aperture	1.8mm	1.6mm
Acoustic mode	Compressional	Compressional

Rise-time (10-90%)	113ns/mm	113ns/mm
Loss Modulation	≥ 85%	≥ 85%
RF Power	20W (Max)	20W (Max)

Remark: The main difference of the above Q-switches is the dimensions.

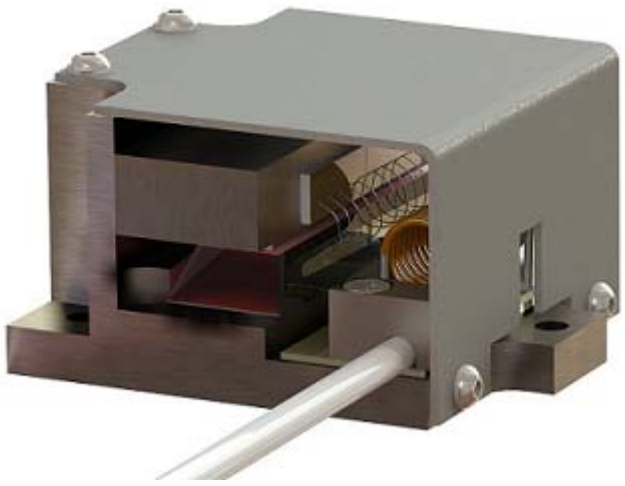
Model No	QS041-10M(BR)-HI5	
Device	AO Q-Switch	
Interaction material	Crystal Quartz	
Wavelength	2090 nm	
Damage threshold	> 1GW/cm^2	
Optical faces	Brewster angled	
Transmission	> 99.6%	
Frequency	40.68MHz	
Optical polarisation	Linear, vertical to base	
Active aperture	1.8mm	
Interaction length	28mm	
Acoustic mode	Compressional	
Beam separation	14.9mrad	
Rise-time (10-90%)	113ns/mm	
Loss Modulation	≥ 45%	
RF Power	20W (Max)	

4.2 Air-cooled Q-switch QS068-4J-xxx

Device	AO Q-Switch
Model No	QS068-4J-xxx
Interaction material	Fused Silica
Wavelength	1540nm
Damage threshold	>500MW/cm^2
AR coating reflectivity	< 0.2% per surface
Transmission	> 99.6%
Frequency	68MHz
Optical polarisation	Random
Active aperture	1.0mm
Acoustic mode	Shear
Rise-time	120ns
Modulation Bandwidth (3dB)	4.2MHz
Separation Angle	28mrad
Diffraction Efficiency	>10% @ 6W
Maximum recommended RF Power	10W
Cooling	Conduction cooled through base
Q-switch driver	N39068-10DSA05

4.3 Air-cooled Q-switch QS080-2G-3D1

- DPSS systems, polarisation insensitive
- Miniature size, conduction-cooled
- 1.0mm active aperture



We present probably the smallest, conduction-cooled, acousto-optic Q-Switch currently in production anywhere in the world. Specifically designed for use in miniature, short-pulse, low power, DPSS lasers, the tiny size of this device facilitates Q-Switching of the shortest cavities.

Utilising a highly efficient crystalline interaction material, greater than 85% loss modulation can be achieved without the need for active cooling - just bolt the Q-Switch to the laser rail and switch

on!

Operating at 80MHz carrier frequency, the diffracted beams are sufficiently separated for most short cavities and pulse repetition rates of 100kHz or more are possible.

Interaction Material	Tellurium Dioxide
Wavelength	1047 to 1064nm
Polarisation	Insensitive
Anti-Reflection Coating	<0.2% per surface
Damage Threshold	>10MWcm-2
Transmission (single pass)	>99.5%
Frequency	80MHz
VSWR	<1.2:1 (50Ω input impedance)
Active Aperture	1.0mm
Clear Aperture	1.4mm
Acoustic Mode	Compressional
Rise-Time / Fall-Time	153ns/mm
Loss Modulation	>85% at 3W (typical)
Beam Separation	20mrad
Acceptance Angle (full)	12mrad
RF Power Rating	3W, CW
Cooling	Conduction through base
RF Driver	R39080-3DMzzz-SC

Frequently Asked Questions

Which parameters do I need to specify if I want to order a Q-Switch?
You will need to specify the frequency, aperture, acoustic mode and the type of water connector.

Which frequency should I use?
The answer depends on your location. There are various regulatory bodies (for example the ITU) that stipulate the maximum levels of RF radiation that can be emitted in certain frequency bands. The Q-Switch drive frequency is usually chosen to be within one of the permitted bands for the country in which it will operate. Historically, 24.0MHz has been the chosen frequency in the USA and Japan and 27.12MHz in Europe and elsewhere. However, this has been less rigidly observed in recent years and 27.12MHz is now used widely in the USA.

What is the difference between clear aperture and active aperture? ,
The clear aperture of a Q-Switch is defined by the size of the block of silica in which the light and sound interact. For the QS24/27 Series the minimum clear aperture is 9mm. The active aperture is defined by the height of the acoustic beam inside the silica block. This is the dimension that matters when specifying a Q-Switch.

How do I select the appropriate aperture for my application?
As a rule of thumb, the active aperture of the Q-Switch should be the same as the beam diameter of the laser at the point where the Q-Switch will be located. If the gain of the laser is modest it may be possible to use a Q-Switch with an active aperture one size smaller than the actual beam diameter (e.g. a 3mm active aperture Q-Switch in a laser with a 4mm diameter rod). This has the advantage of requiring lower RF drive power (drive power scales linearly with active aperture), which means less heat input and consequently greater efficiency and improved beam quality. It may even mean a lower cost driver can be used. On the downside, alignment of the Q-Switch in the cavity may be more critical.

Which acoustic mode would suit me best?
The choice is between shear (S) mode and compressional (C) mode (also known as longitudinal mode). If your laser is unpolarised you should choose shear mode. For polarised systems better results (less RF power = lower cost driver, less heat = better beam quality) will be obtained by using a compressional mode Q-Switch.

Which water connector should I choose?
The choice is between screw-on (S) connectors with a nut and olives which grip the outside of the flexible tubing, and barbed (B) push-on connectors, which grip the inside of the flexible tubing. There is little to choose between the two and it usually depends what type of pipe fitting is used as standard in the laser system. Overall the push-on fittings are probably best because there is no danger of them restricting the water flow. (The olives in the screw-on type can constrict the soft-wall tubing usually used in laser systems.)

How do I know that the Q-Switch is not over-heating?
The Q-Switch is fitted with a thermal interlock. If, for example, the cooling water fails it will shut down the driver when the temperature reaches 50 degrees C, preventing damage to the Q-Switch.

What is the optimum operating temperature of the Q-Switch?
The temperature should be set slightly above ambient to prevent the possibility of condensation forming on the optical surfaces of the Q-Switch. Around 32 degrees C is typical. For optimum performance and lifetime we do not recommend operating the Q-Switch at temperatures above 40 degrees C.

How do I know that the QS24/27 Series Q-Switch is the best choice for my application?
Please call one of our engineers if you are in any doubt about which Q-Switch to use. The QS24/27 Series Q-Switches are 'industry standard' devices that have been developed and refined over many years. As a result they are very reliable and because they are manufactured in large quantities they are lower cost than some of the more specialised products we can offer. Basically, if you have a lamp-pumped industrial or medical Nd:YAG laser this is probably the Q-Switch for you. It is also suitable for the latest generation of high-power industrial diode-pumped lasers.

I am designing a compact laser and the QS24/27 Series Q-Switch is too large. What should I do?
G&H manufacture a range of standard compact Q-Switches that may be suitable for your application. If not, we have considerable experience of designing application-specific Q-Switches. We supply Q-switches to many of the leading diode-pumped laser manufacturers and it is likely that we will have a design that can easily be adapted to suit your requirements.

I have a single-mode polarised laser. Will the QS24/27 Series Q-Switch be suitable? ,
Yes. You can use a compressional mode version with a small active aperture (3mm or less). However, you may find that the integrated Q-switch, with its integral RF driver is a more cost effective solution that also offers performance advantages in terms of higher average Q-Switched output power.

How much laser power can I hold off? ,
It depends on the design of your laser cavity, where the Q-Switch is placed in it and so on. Hold-off is not a parameter of the Q-Switch alone, but of the Q-Switch/laser combination. We can however determine the extra-cavity loss modulation of the Q-Switch, which is a direct measure of its effectiveness at blocking the laser beam.

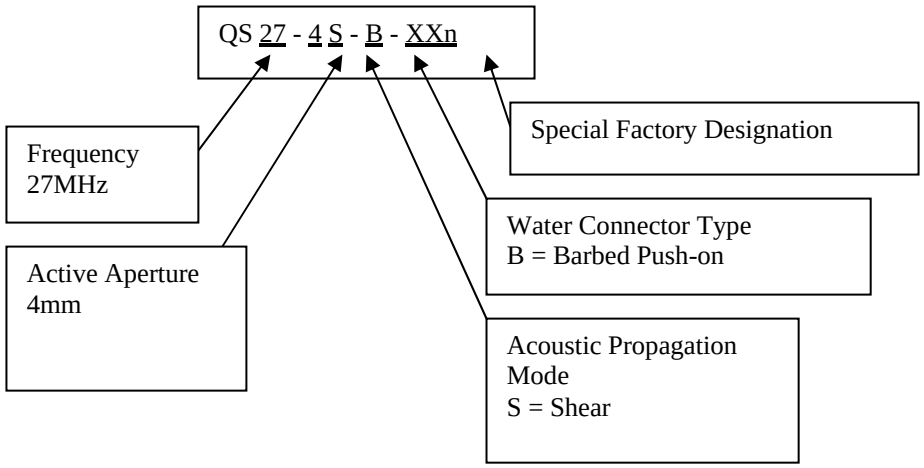
I have a high gain laser and need the maximum possible loss modulation. How do I achieve this? ,
There are two ways; by using two compressional mode Q-Switches in series and orientated such that the acoustic beams are orthogonal to each other you can obtain a high, polarisation insensitive, loss modulation with minimum RF drive power. Also available is a newly developed Q-Switch incorporating two orthogonal compressional mode transducers in a single monolithic cell and mounted in one convenient housing. A dual channel RF driver is available for both applications.

Can I trust the damage threshold quoted in the data sheet?
Yes. We periodically send a sample Q-Switch to a NIST certified test house to have the optical damage threshold verified. G&H take the utmost care in the polishing of the optical surfaces and in their preparation and coating. All these operations are carried out in-house in order to have total control of the process.

Acousto-Optic Q-Switch Selection Guide

When choosing a Q-switch there are a number of user definable parameters which can be selected in order to give the optimum performance in a specific laser system.

Here is an example part number for an industry standard type Q-switches.



- **Operating Frequency** QS**27**-4S-B-XXn

24MHz and 27MHz have historically been the standard frequencies for A-O Q-switching in lamp-pumped 30W to 100W Nd:YAG (1064nm) laser systems.

For the shorter cavities employed in DPSS Nd:YAG systems higher RF frequencies, such as 41MHz and 68MHz, have been introduced because they are more effective than the lower frequencies in shorter cavities. This is because the larger acousto-optic deflection angles at the higher drive frequencies are more efficient in dumping optical energy from a shorter cavity.

- **Active Aperture** QS27-**4**S-B-XXn

This number defines the effective vertical height (in mm) of the acoustic beam which causes the Q-switch to operate. Standard apertures are 1, 1.6, 2, 3, 4, 5, 6.5 and 8mm.

Only that part of the optical beam passing through this region will be modulated.

There are a number of important factors when selecting the active aperture.

1. For high efficiency (defined as maximum loss modulation at lowest possible RF power) you should choose an active aperture as close as possible to the size of your optical beam. Acoustic energy which does not flow through the region of the Q-switch carrying the optical beam is not effective in modulating the laser. This acoustic power is wasted making the device less efficient.

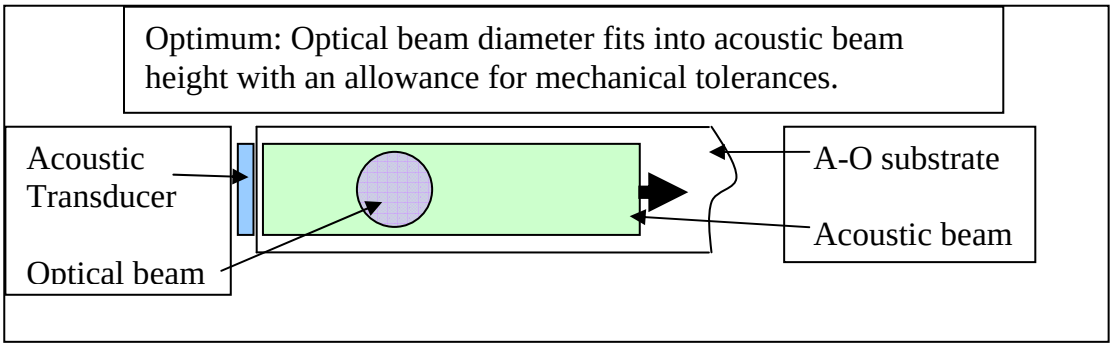
2. If the optical beam is larger than the active aperture the regions of the optical beam falling outside of the active aperture will not be modulated.

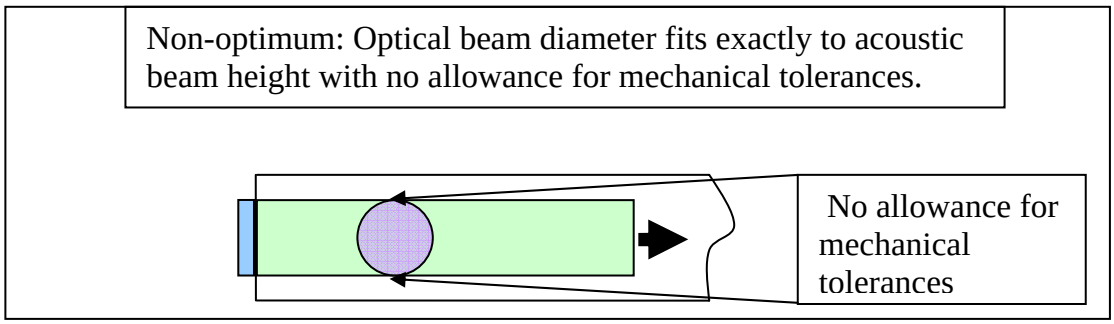
3. For ease of alignment of the Q-switch in the laser the active aperture should be slightly larger than the optical beam. This allows for mechanical tolerances in the laser assembly.

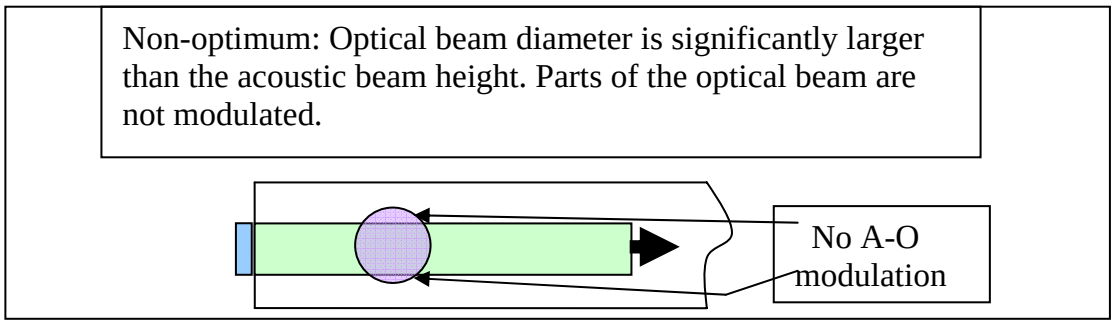
For example if you have a 1.7mm diameter laser then a -2 Q-switch would be appropriate (2mm active aperture, just a little larger than the optical beam diameter).

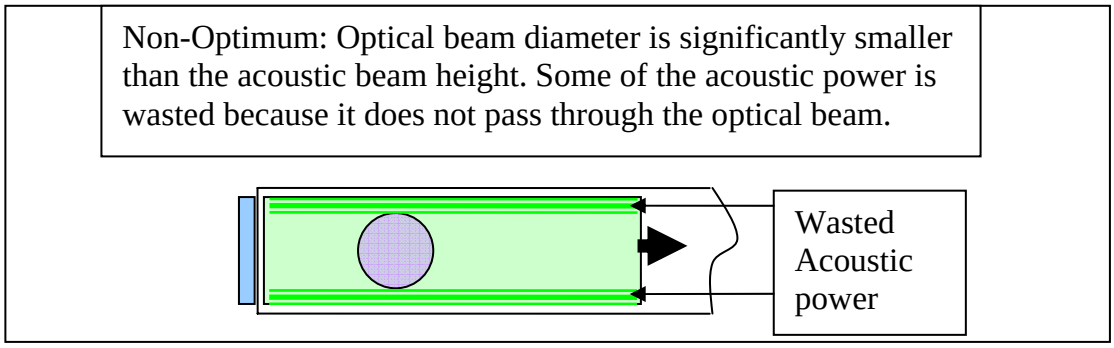
The following diagrams illustrate this in more detail, showing the effect of changing the active acoustic aperture for a fixed optical beam height. In most applications the laser system designer knows the optical beam properties and should select a Q-Switch with suitable active aperture dimensions as shown below.

The active acoustic aperture is defined in the Q-Switch part number.
The optical beam must pass through the acousto-optic cell in the region that carries the acoustic beam. The optical beam diameter shown in the diagrams represents the $1/e^2$ diameter.
All diagrams show the relationship between the optical and acoustic beams when viewed in the direction of propagation of the optical beam. The acoustic wave originates at the transducer shown on the left and travels to the right as indicated by the arrow.









- **Acoustic Mode** QS27-4**S**-B-XXn

There are three different configurations of acoustic wave which can be launched into the Acousto-Optic device to effect optical beam modulation.

1. **Shear waves** have the advantage of effecting all polarisations of light equally and are recommended for use in un-polarised lasers. Q-switches using this acoustic mode are defined by the letter S after the active aperture. (see **Note a.** below)

2. **Compressional waves** (defined by the letter C after the active aperture) exhibit higher efficiency than shear waves when the laser is linearly polarised (optical polarisation perpendicular to the base of the Q-switch). As such compressional wave devices are preferred for polarised lasers and will require less RF drive power than the equivalent shear wave device. (see **Note** a. below)

3. **Two orthogonal compressional waves.** For high power un-polarised lasers, this acoustic configuration can be used for more efficient modulation than an equivalent shear wave device. Such a dual acoustic channel device is defined by the letter D after the active aperture.

Note a: Although the compressional acoustic wave (defined by –C) does not effect all optical polarisations equally, some QS users have found that they can use a compressional mode device in some specific un-polarised laser application. This is very dependant on the laser design and the end user should determine the usefulness of this mode by trial and error.

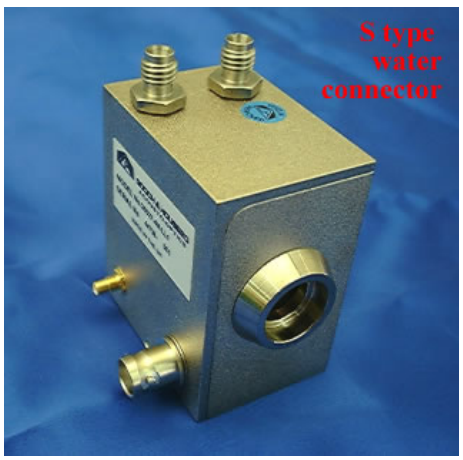
Note b: Devices using Crystal Quartz as the A-O interaction medium are only offered as compressional (-C) mode devices. (NOT –S or –D)
The optimum optical polarisation for the crystal Quartz devices is perpendicular to the acoustic propagation direction. These devices have found some application in un-polarised systems. The users should determine the usefulness of this mode in an un-polarised laser by trial and error.

- **Water Cooling** QS27-4S-**B**-XXn

Q-switches requiring lower RF drive power can often be supplied without water cooling (conduction cooled).

Water cooling is used in devices where the RF power input is significant and it is not possible to extract the resulting thermal load by conduction alone.

The water supply is attached to the Q-switch via a pair of water connectors on the end bulkhead and the user can specify his preferred connector type as part of the Q-switch part number as follows:



S = Screw-on (‘Swagelok’)

B = Barbed Push-on

Examples

QS24-5S-S

Operating frequency is 24MHz for use in lamp-pumped Nd:YAG lasers with longer cavities.
Active aperture is 5.0mm for use with an optical beam diameter of ~ 4.0mm.
Acoustic mode is shear for use with unpolarised laser systems.
Water connectors are the 'Swagelok' screw-on type.
No special factory designation indicates the G&H industry standard design pictured above (i.e. with no specific custom modifications).

Problem Report Form

Please fill the form and email it to us if there is any problem on using Q-switches. Thank you!

Report date	
User's name	
Model of Q-switch	
S/N	
Purchase date	
Description of problem (hold-off capability, surface situation, VSWR, water leakage, electrode wires etc)	
Description of usage: mainly including 1. water (de-ionised, drinking, mineral, pure or distilled); 2. over-temp and no water protection; 3. laser parameters (wavelength, average power, peak power, beam diameter; 4. Q-switch driver (maker, model, RF power) and 5. others	
Check report by maker	

Fibre-Q: Fibre-Coupled Acousto-Optic Modulator
T-M150-0.4C2G-3-F2S

Gooch & Housego specialises in providing optical components for high power fibre laser and amplifier systems. In-house control of critical manufacturing processes, from crystalline material selection and orientation, cutting, polishing and AR coating through to fibre coupling, ensure our components are of the highest optical quality.

The 'Fibre-Q' Acousto-Optic Modulator is designed for use in pulsed fibre laser amplifier systems. In addition to the standard product shown, custom configurations are available for specialized applications.

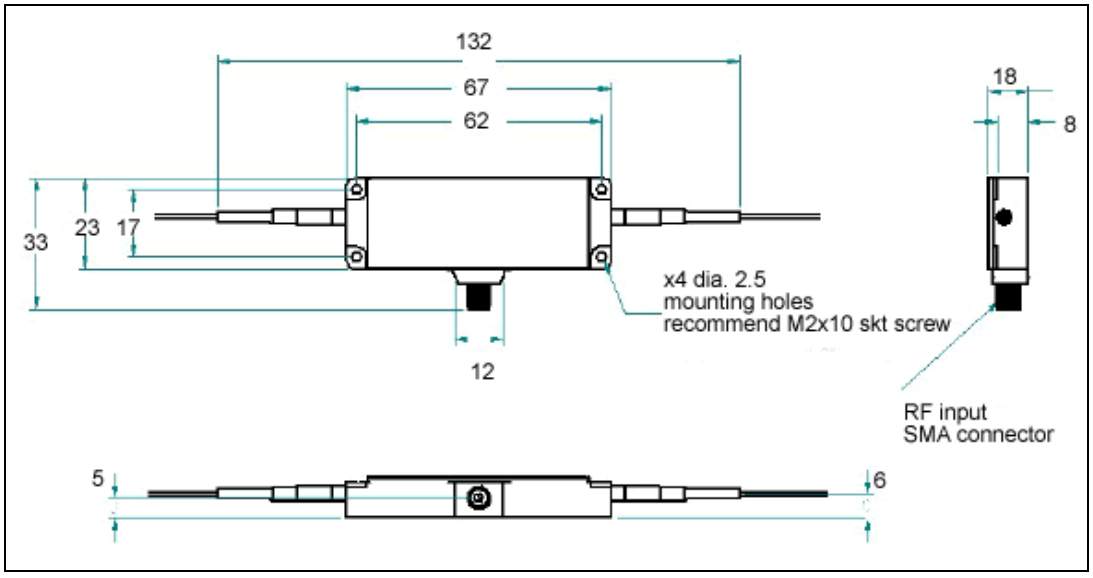
Key Features:
_ Low insertion loss
_ Compact, low profile package
_ Rugged hermetic design
_ Stable performance
_ Custom configurations available

Applications:
_ Fibre laser
_ Fibre amplifier
_ Pulse picker

General Specifications

Interaction material:	Tellurium Dioxide
Wavelength:	1060 - 1090nm (other wavelengths available on request)
Average optical power handling:	5W
Peak (pulse) optical power handling:	30kW typical (dependent on pulse width)
Insertion loss:	< 2dB
Return loss: Extinction ratio (1st order on / off)	> 40dB (>50dB version available on request) > 50dB
Rise-time / fall-time:	30ns
Frequency:	150MHz
VSWR:	< 1.2:1
Input impedance:	50Ω
RF power:	< 2.0W
Frequency shift:	150MHz (up-shift)
Fibre type:	Hi1060 (900µm sleeving, 1.5m length)
Fibre termination:	Bare fibre
Recommended RF driver:	A35150

Ordering Code:
Explanation: T-M150-0.4C2G-3-F2S (Modulator, 150MHz, 0.4mm active aperture, compressional mode, Tellurium Dioxide, 1064nm, SMA female bulk head connector, 2 fibre, single mode (Hi1060)



Other Q-Switches

The Q-Switches are for use in both industrial and laboratory applications. Q-Switching is used principally on high peak power solid state Nd:YAG lasers at 1.06 micrometer wavelength. The Q-Switches are divided into three categories: for use with multi-mode, un-polarized lasers, with beam sizes 5mm and larger; for use with miniature, polarized or un-polarized, solid state diode pumped lasers; and single mode, polarized, low divergence solid state lasers, with beam size of 1 to 2 mm.

High Power Q-Switches for random polarized lasers:

Spectral Range (nm)	Q-Switch Model	Recommended Driver Model Number	Loss Modulation (%@Watts) @1064nm Polarization	Active Aperture (mm)	Center Frequency (MHz)	Rise Time (ns / mm beam dia.)	Optical Power Density /(cm2) Ave./Pk	Interaction Material
10.6um	37027-3	39027-30DSA05	85 @ 30	3	27.12	120	500	Ge
10.6um	37027-5	39027-30DSA05	75 @ 30	5	27.12	120	500	Ge
1064	32024-50-4	39024-50DS 39024-50DM	55 @ 50 Random	4 x 13	24	175	50KW/500MW	Fused Silica
1064	32027-50-4	39027-50DS 39027-50DM	55 @ 50 Random	4 x 13	27.12	175	50KW/500MW	Fused Silica
1064	33024-50-5-I-HGM-W	39024-50DS 39024-50DM	70 @ 50 Random	5 x 10	24	115	50KW/500MW	Crystal Quartz
1064	33027-50-5-I-HGM-W	39027-50DS 39027-50DM	70 @ 50 Random	5 x 10	27.12	115	50KW/500MW	Crystal Quartz
1064	33041-50-3-I-HGM	39041-50DS 39041-50DM						
1064	32024-70-7	39024-70DS 39024-70DM	55 @ 70 Random	7 x 13	24	175	50KW/500MW	Fused Silica
1064	32027-70-7	39027-70DS 39027-70DM	55 @ 70 Random	7 x 13	27.12	175	50KW/500MW	Fused Silica
1064	33024-70-7-I-HGM-W	39024-70DS 39024-70DM	85 @ 70 Random	7 x 10	24	115	50KW/500MW	Crystal Quartz
1064	33027-70-7-I-HGM-W	39027-70DS 39027-70DM	85@ 70 Random	7 x 10	27.12	115	50KW/500MW	Crystal Quartz
1064	32024-100-4-HGM-W	39024-100DS 39024-100DM	90 @ 50 Random	4 x 13	24	175	50KW/500MW	Fused Silica
1064	32027-100-4-HGM-W	39027-100DS 39027-100DM	90 @ 50 Random	4 x 13	27.12	175	50KW/500MW	Fused Silica

Dual Axis Q-Switches for random polarized lasers:

1064	33027-40-4-XY	39027-40DS-2CH 39027-40DM (2)	90 @ 40 per channel Random	4 x 4	27.12	175	50KW/500MW	Fused Silica

Low Power Q-Switches for polarized or random polarized lasers:

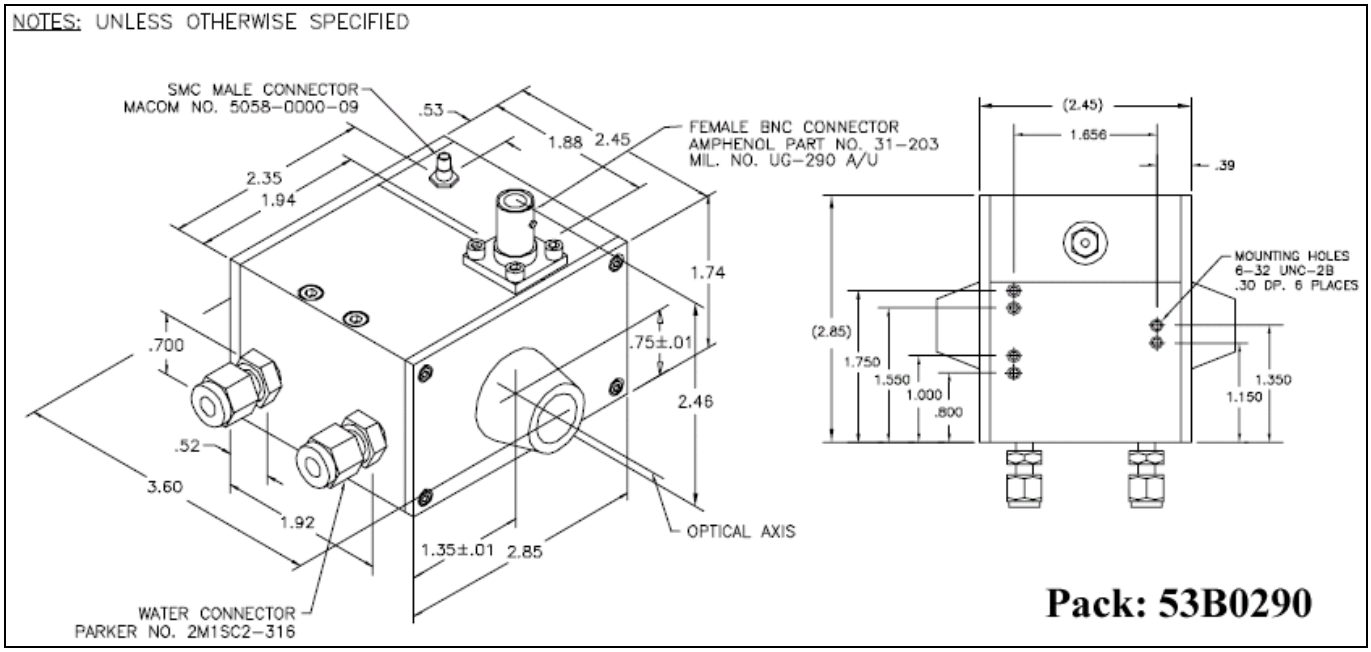
Spectral Range (nm)	Q-Switch Mode	Recommended Driver Model Number	Loss Modulation (% @ Watts) @1064nm Polarization	Active Aperture (mm)	Center Frequency (MHz)	Rise Time (ns/ mm beam dia.)	Optical Power Density/ (cm2) Ave./Pk	Interaction Material
1064	33027-10-1.5-I	39027-10DS 39027-10DM	80 @ 10 Linear Perpendicular 65 @ 10 Random	1.5	27.12	115	50KW/500MW	Crystal Quartz
1064	33041-10-1.5-I	39041-10DS 39041-10DM	72 @ 10 Linear Perpendicular 45 @10 Random	1.5	40.68	115	50KW/500MW	Crystal Quartz
1064	33041-20-1.5-I-TB	39041-20DMFPS-SC	90 @ 20 Linear Perpendicular 80 @20 Random	1.5	40.68	115	50KW/500MW	Crystal Quartz
1064	33080-10-1-I	39080-10DS 39080-10DM	80 @ 10 Linear Perpendicular 60 @ 10 Random	1	80	115	50KW/500MW	Crystal Quartz
1064	33027-25-3-BR	39027-30DSA05 39027-30DMA05	75 @ 25 Linear Perpendicular	2	27.12	175	50KW/500MW	Fused Silica

Low Power Q-Switches for random polarized lasers:

Spectral Range (nm)	Q-Switch Model	Recommended Driver Model Number	Loss Modulation (%@Watts) @1064nm Polarization	Active Aperture (mm)	Center Frequency (MHz)	Rise Time (ns / mm) beam dia.	Optical Power Density /(cm2) Ave./Pk	Interaction Material
1064	34027-1.5-SF10	38027-4DS 38027-4DM	30 @ 2 Random 60 @ 4 Random	1.5	27.12	165	120KW/500MW	SF10
1064	34041-1.5-SF10	38041-4DS 38041-4DM	20 @ 2 Random 40 @ 4 Random	1.5	40.68	165	120KW/500MW	SF10
1064	34080-1-SF10	38080-4DS 38080-4DM	20 @ 2 Random 40 @ 4 Random	1	80	165	120KW/500MW	SF10

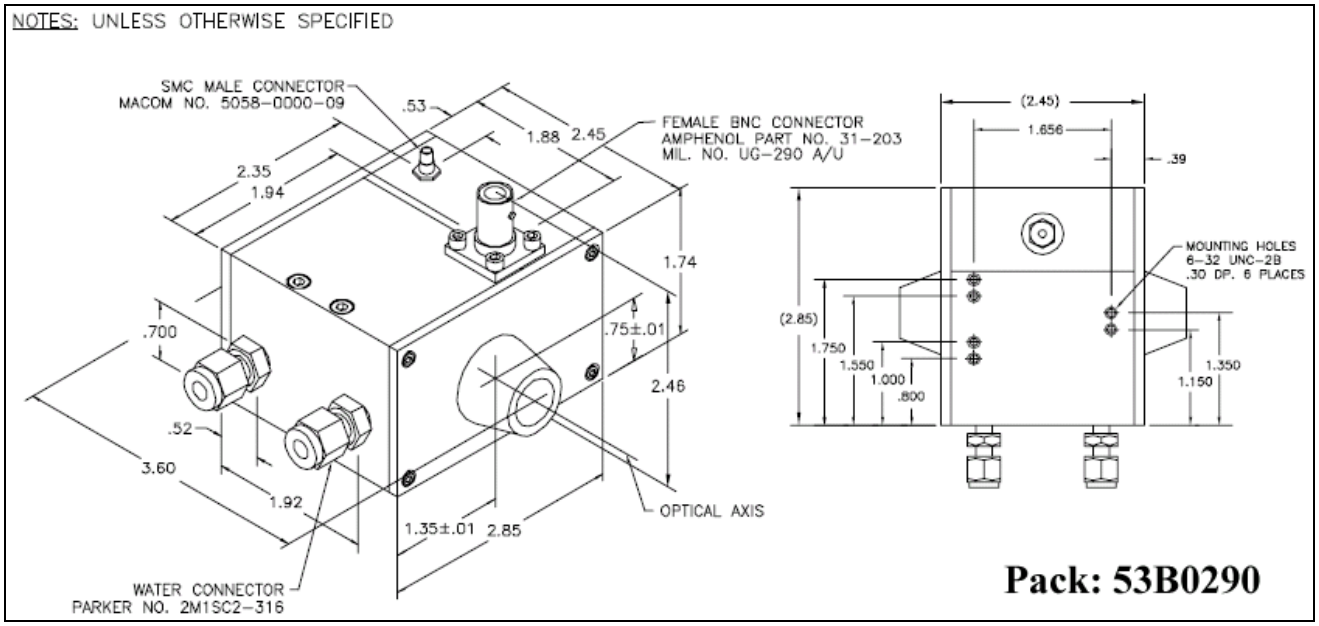
32024-50-4

PARAMETER	SPECIFICATION
Interactive Material	Fused Silica
Acoustic Mode	Shear
Operating Wavelength	1064 nm
Window Configuration	AR "V" Coated
Static Transmission	>99 %
Operating Frequency	24 MHz
Insertion Loss	<10 % @ 50 Watts
Loss Modulation	>55 % @ 1064 nm
Light Polarization	Random
Acoustic Aperture Size	4X13 mm
Rise Time	175 ns/mm Beam Diameter
Deflection Angle	6.8 mrad
RF Power Level	50 Watts
Impedance	50 Ohms
Water Cooled	0.1GPM <30°C
VSWR	1.2:1 @ 24 MHz
Package	53B00290
Recommended Drivers:	Digital Driver System: 39024-50DS***
	Digital Driver Module: 38024-50DM** or 39024-50DM***
	Options: ** = PK, PKPW *** = PPK, FPS, A05, R05



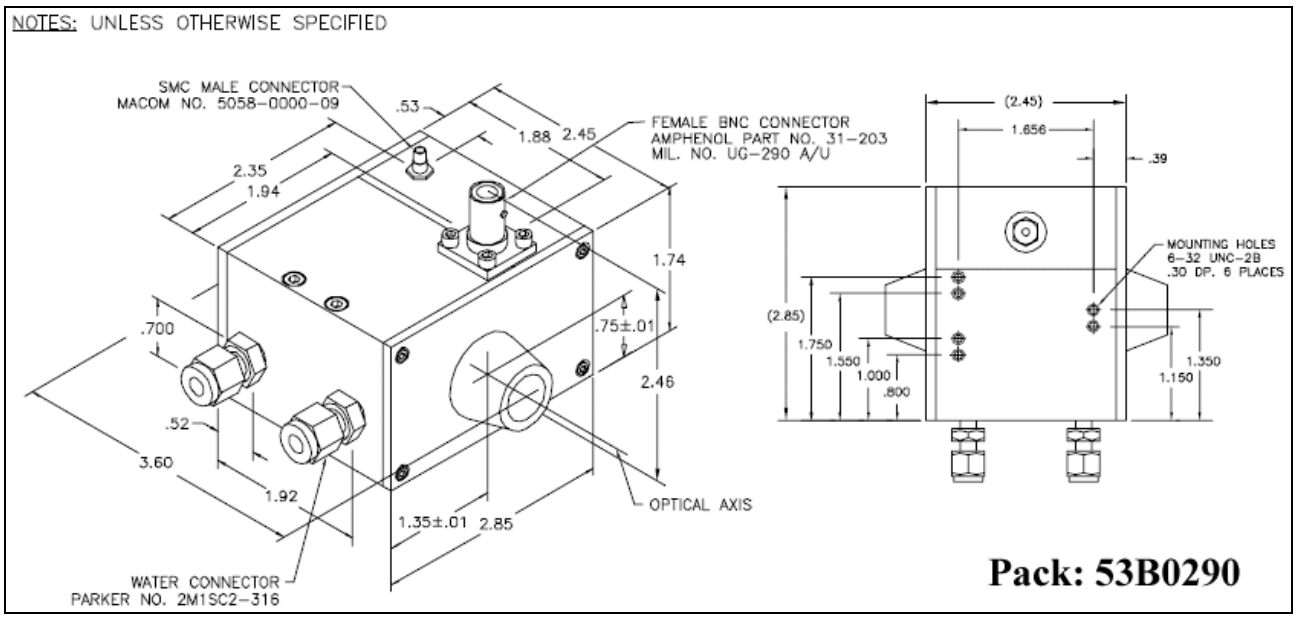
32027-50-4

PARAMETER	SPECIFICATION
Interactive Material	Fused Silica
Acoustic Mode	Shear
Operating Wavelength	1064 nm
Window Configuration	AR "V" Coated
Static Transmission	> 99 %
Operating Frequency	27.12 MHz
Insertion Loss	<10 % @ 50 Watts
Loss Modulation	>55 % @ 1064 nm
Light Polarization	Random
Acoustic Aperture Size	4 X 13 mm
Rise Time	177 ns/mm Beam Diameter
Deflection Angle	7.67 mrad
RF Power Level	50 Watts
Impedance	50 Ohms
VSWR	1.2:1 @ 27.12 MHz
Package:	53B00290
Cooling:	Water Cooled @ 0.1Gallon Per Minute With Water Temperature <300C
Recommended Drivers:	Digital Driver System: 39027-50DS*** Digital Driver Module: 38027-50DM** or 39027-50DM*** Options: ** = PK, PKPW *** = PPK, FPS, A05, R05



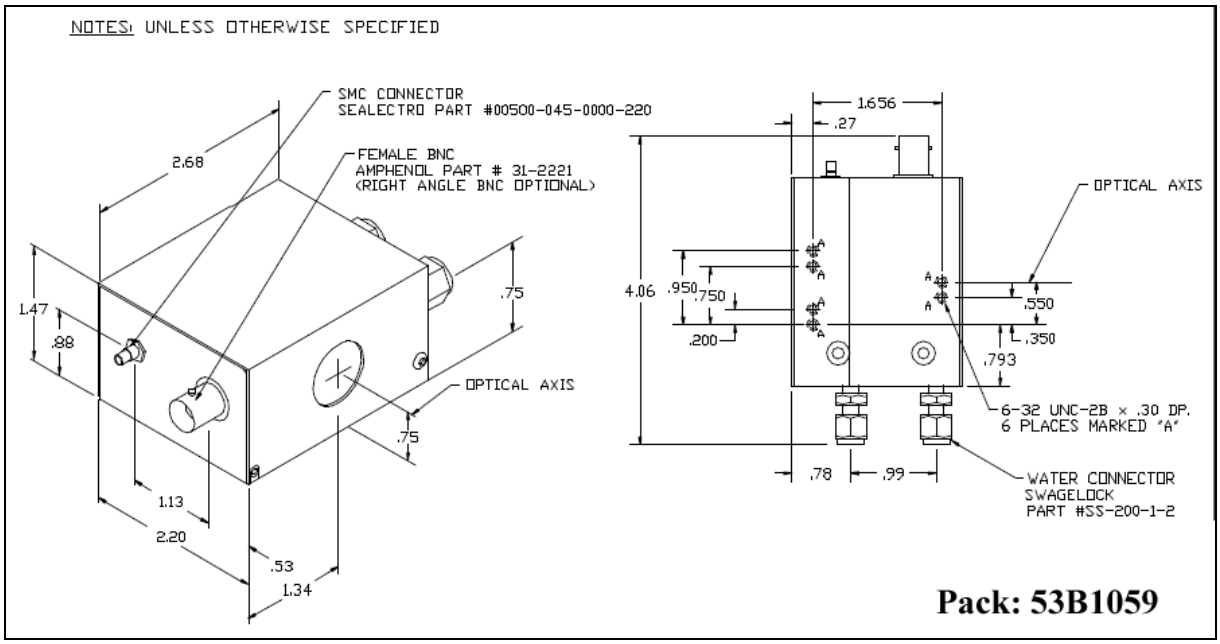
32027-70-7

PARAMETER	SPECIFICATION
Interactive Material	Fused Silica
Acoustic Mode	Shear
Operating Wavelength	1064 nm
Window Configuration	AR "V" Coated
Static Transmission	>99 %
Operating Frequency	27.12MHz
Insertion Loss	<10 % @ 50 Watts
Loss Modulation	>55 %
Light Polarization	Random
Acoustic Aperture Size	7 X 13 mm
Rise Time	175 ns / mm Beam Diameter
Deflection Angle	7.6 mrad
RF Power Level	70 Watts
Impedance	50 Ohms
VSWR	<1.2:1 @ 27.12 MHz
Package:	53B00290
Water Cooled	0.1GPM <30oC
Recommended Driver:	Digital Driver System: 39027-70DS***
	Digital Driver Module: 38027-70DM** or 39027-70DM***
	Options: ** =PK, PKPW *** = PPK, FPS, A05, R05



32027-100-4-HGM-W

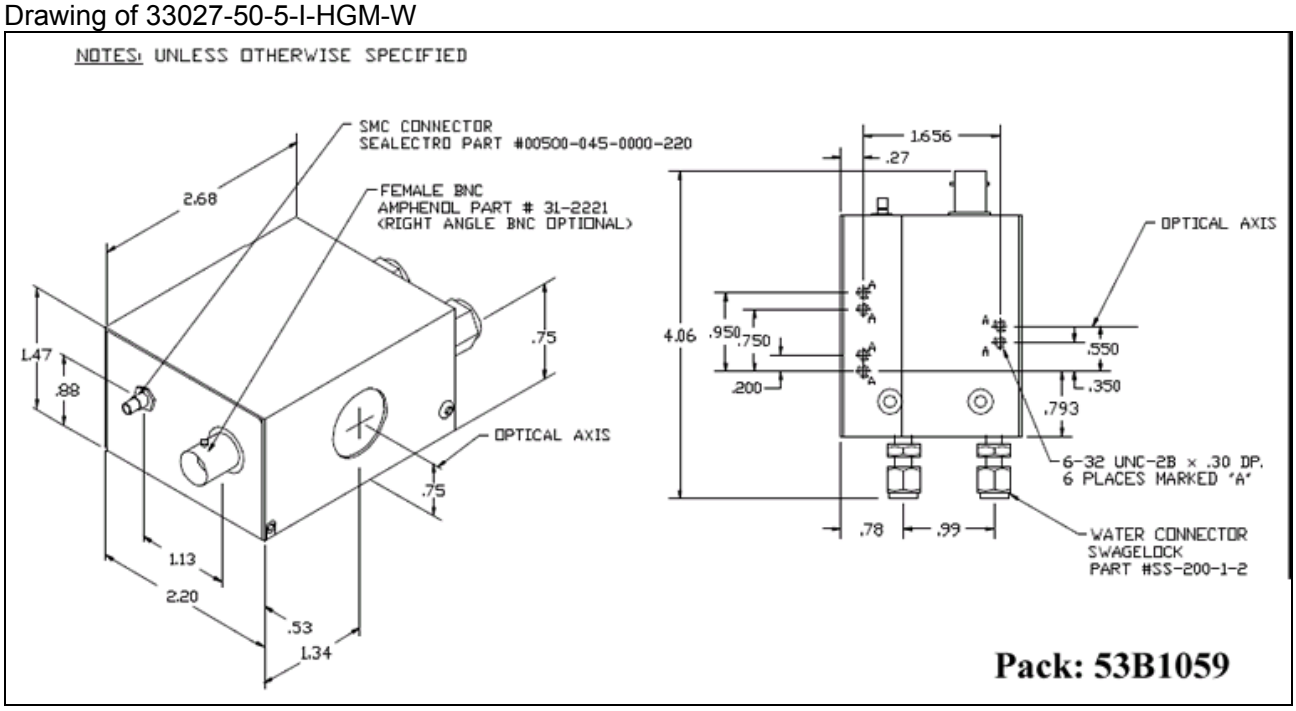
PARAMETER	SPECIFICATION
Interactive Material	Fused Silica
Acoustic Mode	Shear
Operating Wavelength	1064 nm
Window Configuration	AR "V" Coated
Static Transmission	>99 %
Operating Frequency	27.12 MHz
Insertion loss	<10 % @ 50 Watts
Loss Modulation	>90 %
Light Polarization	Random
Acoustic Aperture Size	4 X 13 mm
Rise Time	175 ns/mm Beam Diameter
Deflection Angle	7.6 mrad
RF Power Level	100 Watts
Impedance	50 Ohms
VSWR	1.2:1 @ 27.12 MHz
Package	53B1059
Water Cooled	0.1GPM <30oC
Optional Package With Cones	53B1186
Recommended Driver:	Digital Driver System: 39027-100DS***
	Digital Driver Module: 38027-100DM** or 39027-100DM***
	Options: ** =PK, PKPW *** = PPK, FPS, A05, R05



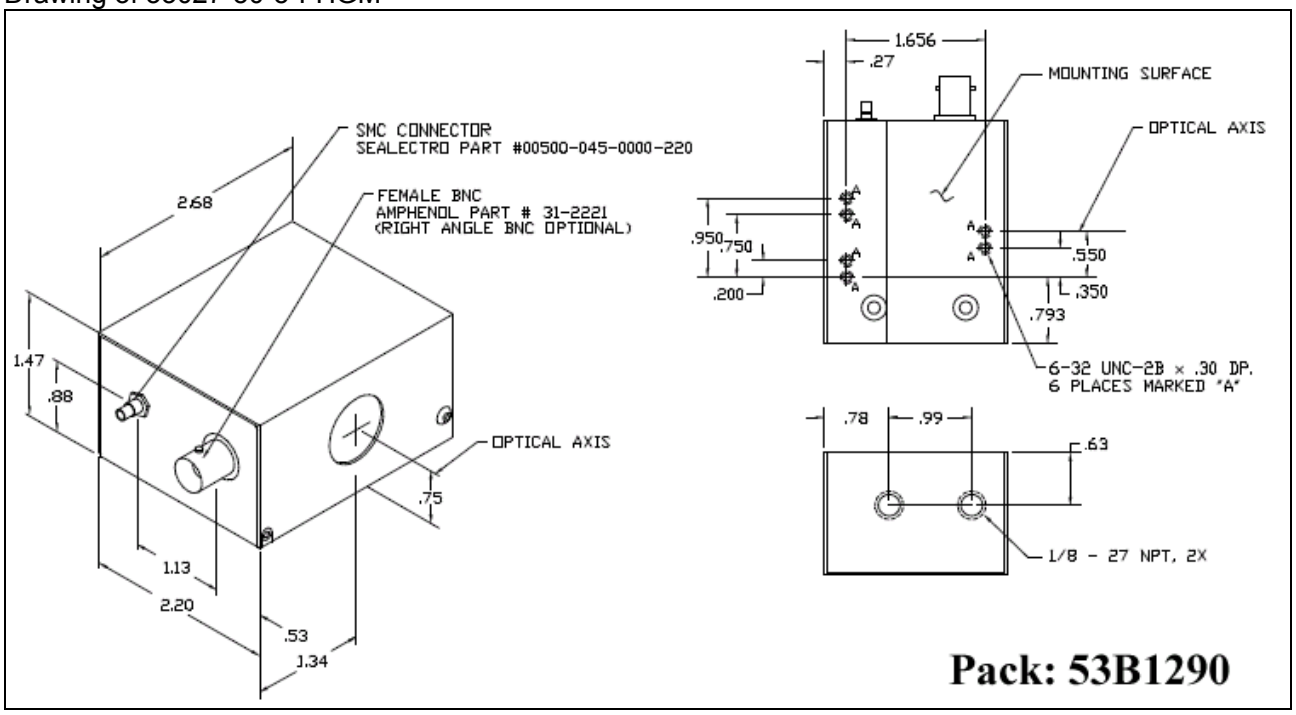
33027-50-5-I-HGM-W

PARAMETER	SPECIFICATION
Interactive Material	Crystal Quartz
Acoustic Mode	Longitudinal
Operating Wavelength	1064 nm
Window Configuration	AR "V" Coated
Static Transmission	>99 %
Operating Frequency	27.12 MHz
Loss Modulation	>85 % With Linear Polarization Perpendicular to the Acoustic Propagation >70 % With Random Polarization
Acoustic Aperture Size	5 mm x 10 mm
Rise Time	115 nsec / mm Beam Diameter
Deflection Angle	5 mrad
RF Power Level	50 Watts
Impedance	50 Ohms
VSWR	1.2:1 @ 27.12 MHz
Package	33027-50-5-I-HGM-W (With water fittings: 53B1059) 33027-50-5-I-HGM (No water fittings: 53B1290) 33027-50-5-I-HGM-CMS (With water fittings and aperture cones: 53B1186)
Cooling:	Water Cooled @ 0.1GPM <300C
Recommended Driver:	Digital Driver System: 39027-50DS*** Digital Driver Module: 38027-50DM** or 39027-50DM*** Options: ** = PK, PKPW *** = PPK, FPS, A05, R05

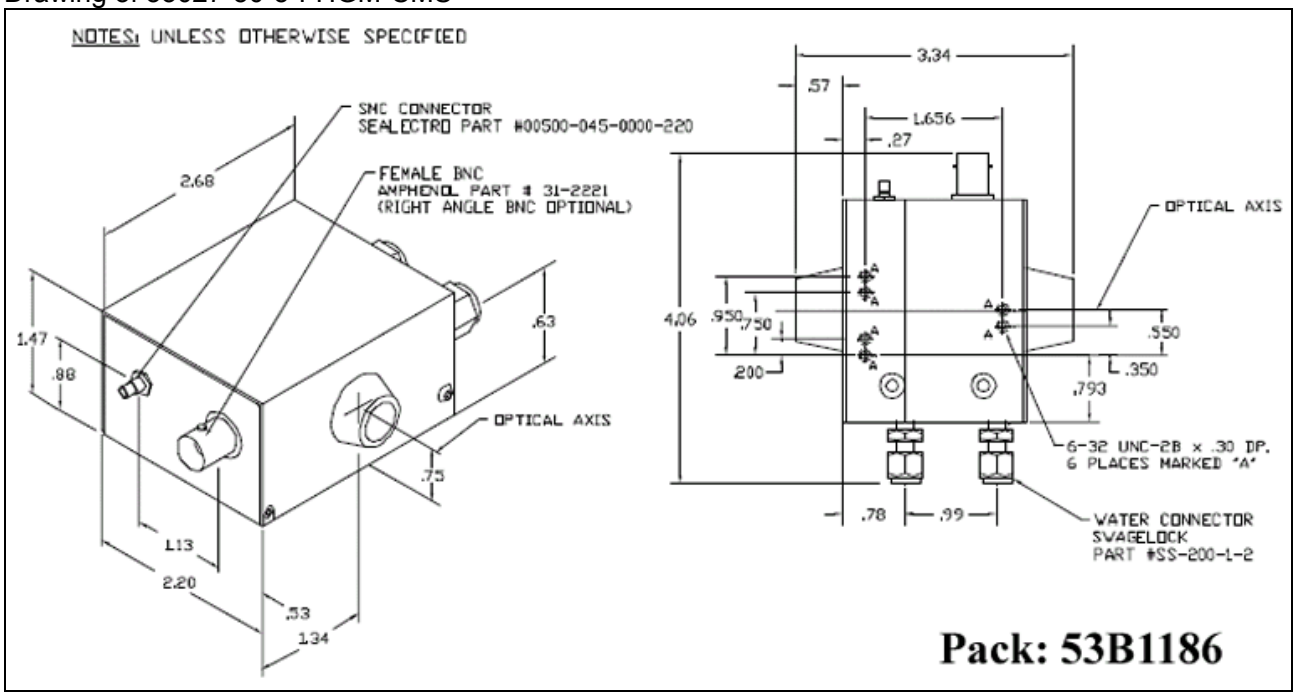
Drawing of 33027-50-5-I-HGM-W



Drawing of 33027-50-5-I-HGM



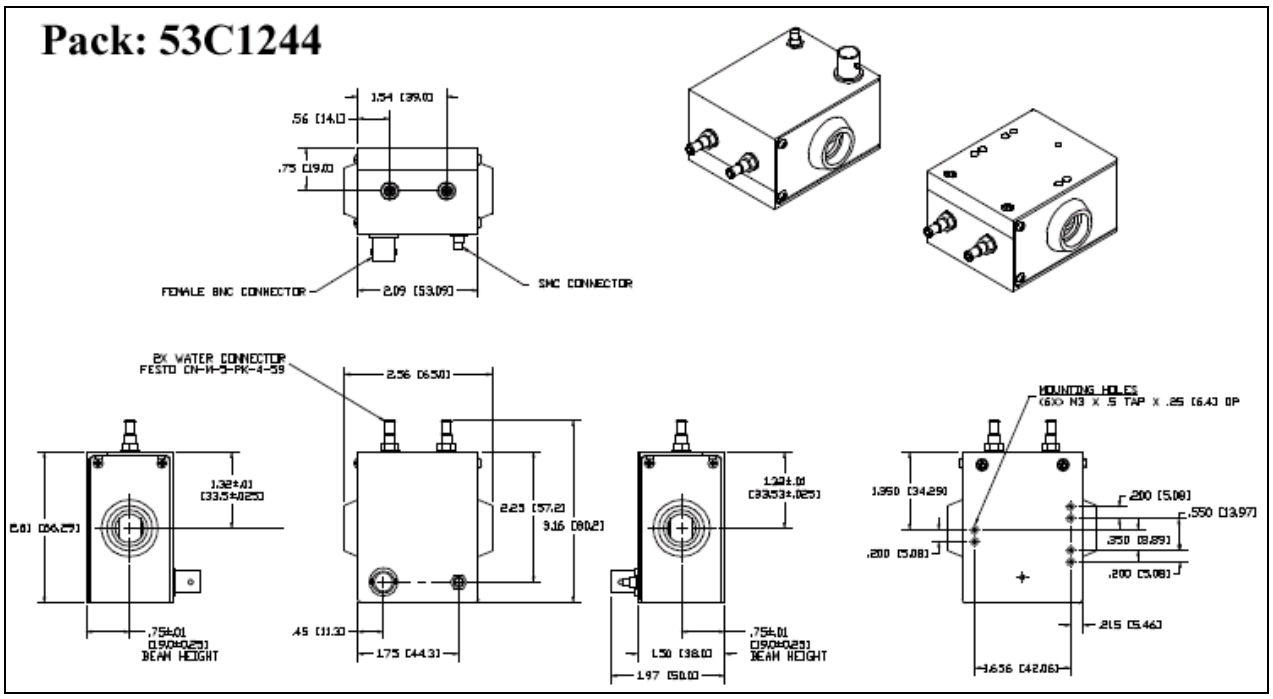
Drawing of 33027-50-5-I-HGM-CMS



Sintec Optronics

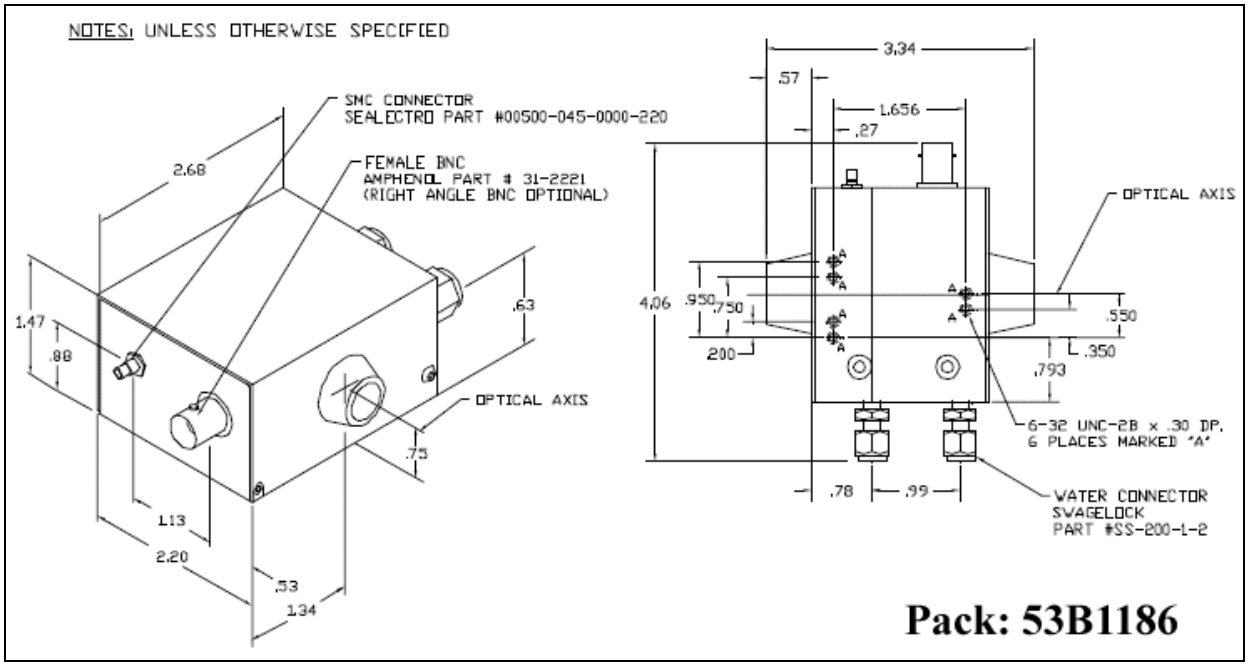
33027-50-5-I-M3

PARAMETER	SPECIFICATION
Interactive Material	Crystal Quartz
Acoustic Mode	longitudinal
Operating Wavelength	1064 nm
Window Configuration	AR "V" Coated
Static Transmission	>99 %
Operating Frequency	27.12 MHz
Loss Modulation	>85 % With Linear Polarization Perpendicular to the Acoustic Propagation >70 % With Random Polarization
Acoustic Aperture Size	5 x 10 mm
Rise Time	115 ns / mm Beam Diameter
Deflection Angle	5 mrad
RF Power Level	50 Watts
Impedance	50 Ohms
VSWR	1.2:1 @ 27.12 MHz
Package:	53C1244
Cooling:	Water Cooled @ 0.1GPM <300C
Recommended Driver:	Digital Driver System: 39027-50DS*** Digital Driver Module: 38027-50DM** or 39027-50DM*** Options: ** = PK, PKPW; *** = PPK, FPS, A05, R05



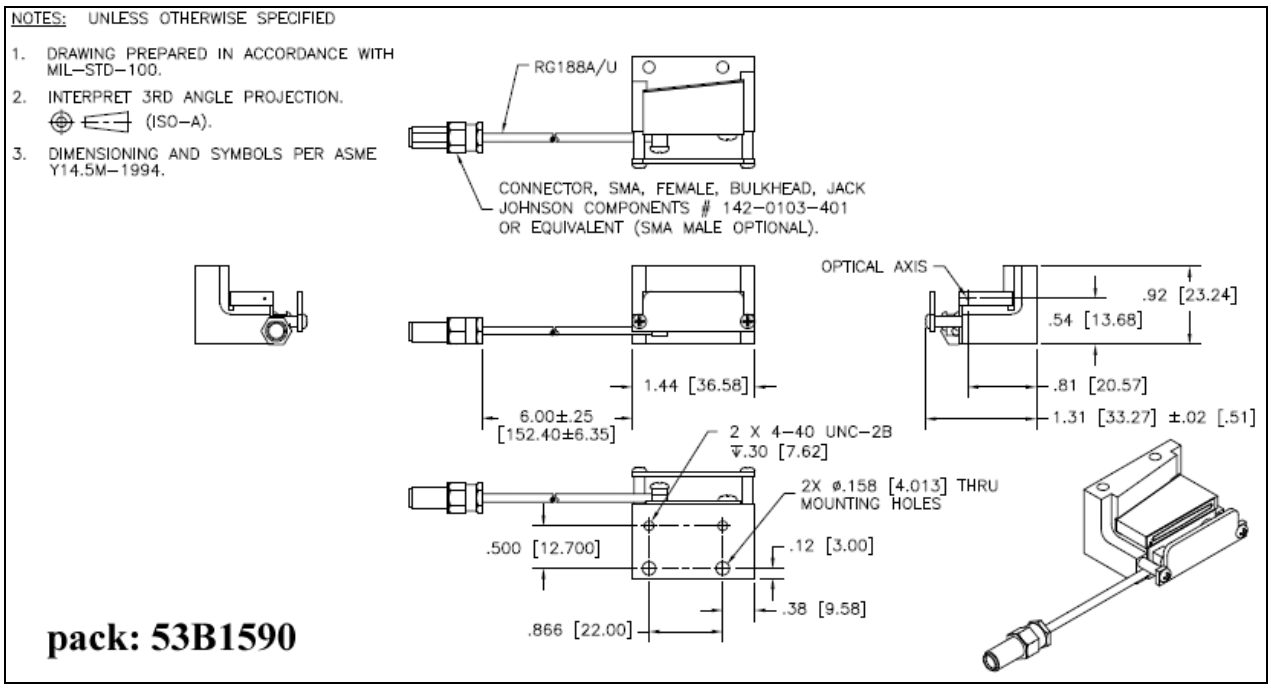
33027-70-7-I-HGM-W

PARAMETER	SPECIFICATION
Interactive Material	Crystal Quartz
Acoustic Mode	longitudinal
Operating Wavelength	1064 nm
Window Configuration	AR "V" Coated
Static Transmission	> 99 %
Operating Frequency	27.12 MHz
Loss Modulation	> 85 % With Linear Polarization, Perpendicular to Acoustic Propagation > 70 % With Random Polarization
Acoustic Aperture Size	7 X 10 mm
Rise Time	115 ns / mm Beam Diameter
Deflection Angle	5 mrad
RF Power Level	70 Watts
Impedance	50 Ohms
VSWR	1.2:1 @ 27.12 MHz
Water Cooling	0.1GPM <30oC
Package	53B1059
Optional Package With Cones	53B1186
Recommended Drivers:	Digital Driver System: 39027-70DS*** Digital Driver Module: 38027-70DM** or 39027-70DM*** Options: ** = PK, PKPW; *** = PPK, FPS, A05, R05



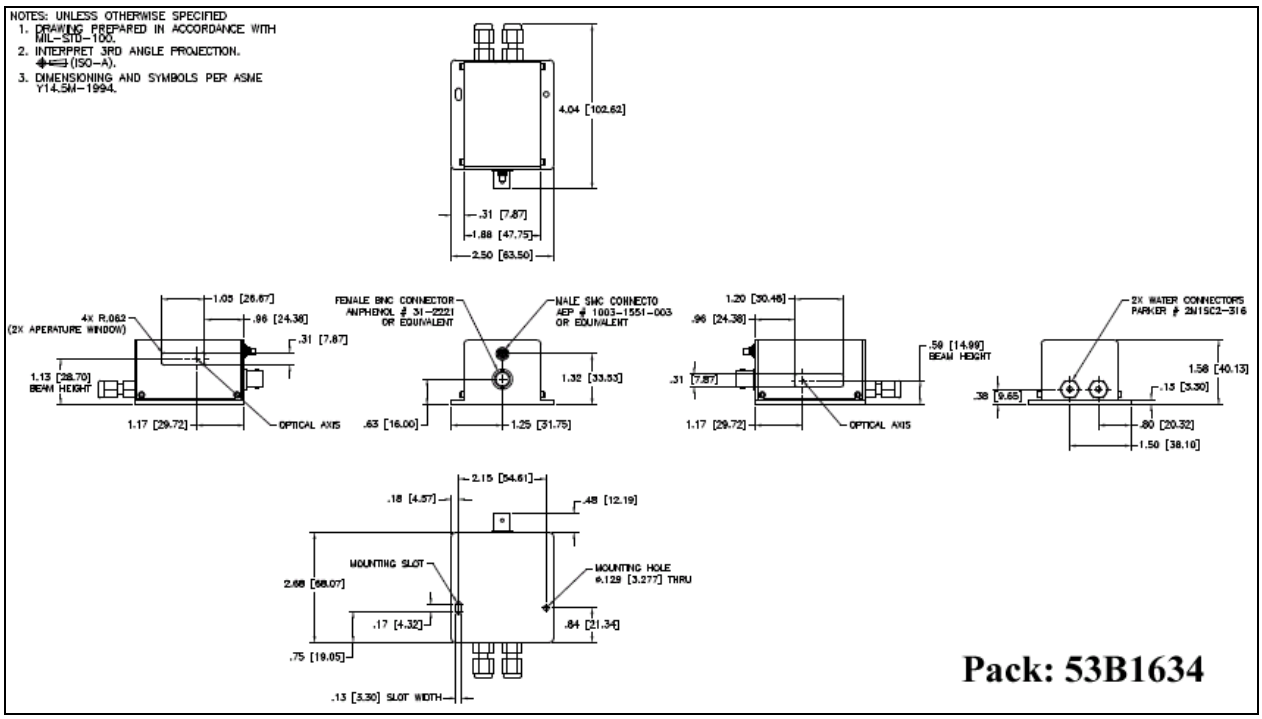
33027-10-1.5-I

PARAMETER	SPECIFICATION
Interactive Material	Crystal Quartz
Acoustic Mode	Longitudinal
Operating Wavelength	1064 nm
Window Configuration	AR "V" Coated
Static Transmission	>99 %
Operating Frequency	27.12 MHz
Loss Modulation	>80 % with light polarization Linear, perpendicular to acoustic propagation >65 % with random polarization
Acoustic Aperture Size	1.5 mm
Rise Time	115 ns/mm Beam Diameter
Deflection Angle	5 mrad
RF Power Level	10 Watts
Impedance	50 Ohms
VSWR	<1.2:1 @ 27.12 MHz
Package:	53B1590 (Package must be maintained at a temperature below 50^0C)
Recommended Drivers:	Digital Driver System: 39027-10DS*** or 38027-10DS** Digital Driver Module: 39027-10DM*** or 38027-10DM** Options: *** = PPK, FPS, A05, R05; ** = PK, PKPW



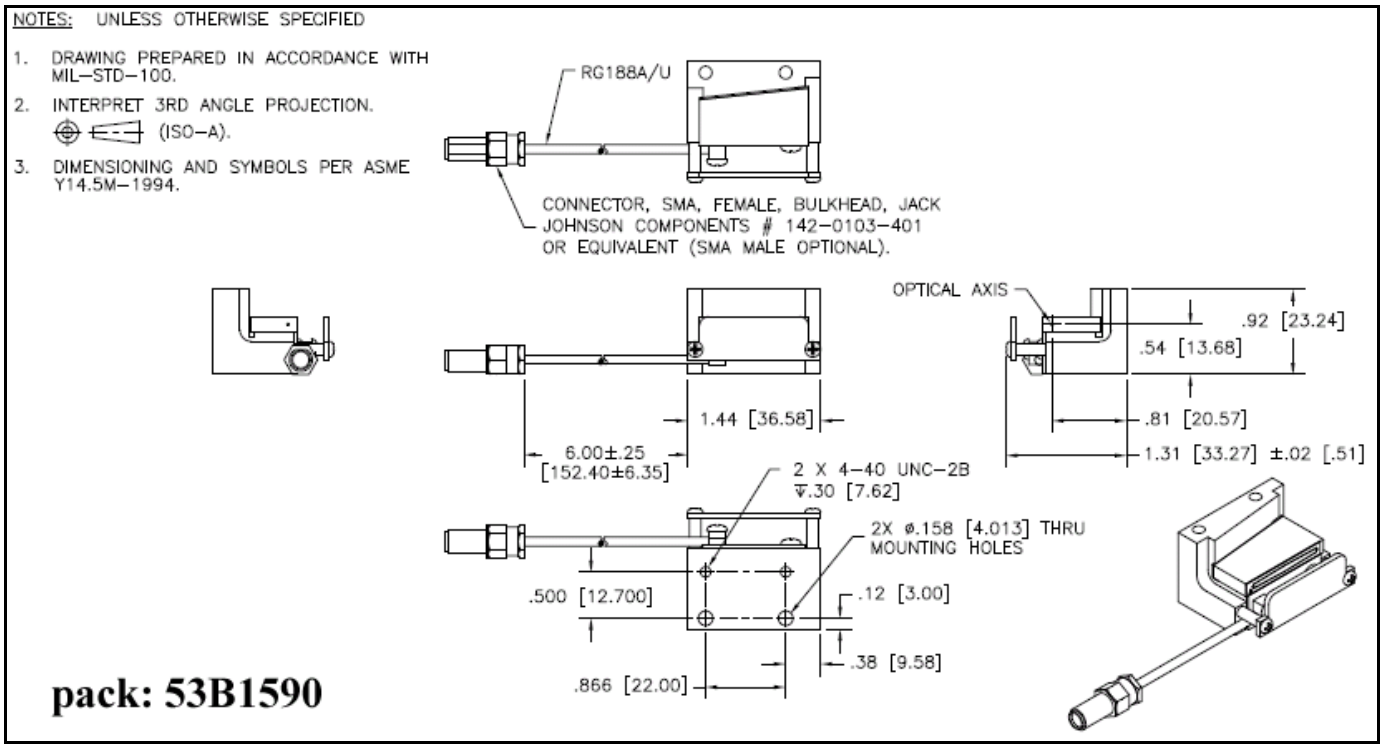
33027-25-3-BR

PARAMETER	SPECIFICATION
Interactive Material	Fused Silica
Acoustic Mode	Longitudinal
Operating Wavelength	1064 nm
Window Configuration	Brewster
Static Transmission	>99 %
Operating Frequency	27.12 MHz
Loss Modulation	>75 % With Linear Polarized light Perpendicular to Acoustic Propagation
Acoustic Aperture Size (in Air)	2 mm
Rise Time	110 ns/mm Beam Diameter
Deflection Angle	4.8 mrad
RF Power Level	< 35 Watts
Impedance	50 Ohms
VSWR	1.2:1
Package:	BNC Connector, 53D1634 SMA Connector, 53D2668
Cooling	Water cooling @ 0.1GPM @ <300C
Recommended Drivers:	Digital Driver System: 39027-35DS*** Digital Driver Module: 39027-35DM*** or 38027-35DM** Options: *** = PPK, FPS, A05, R05; ** = PK, PKPW



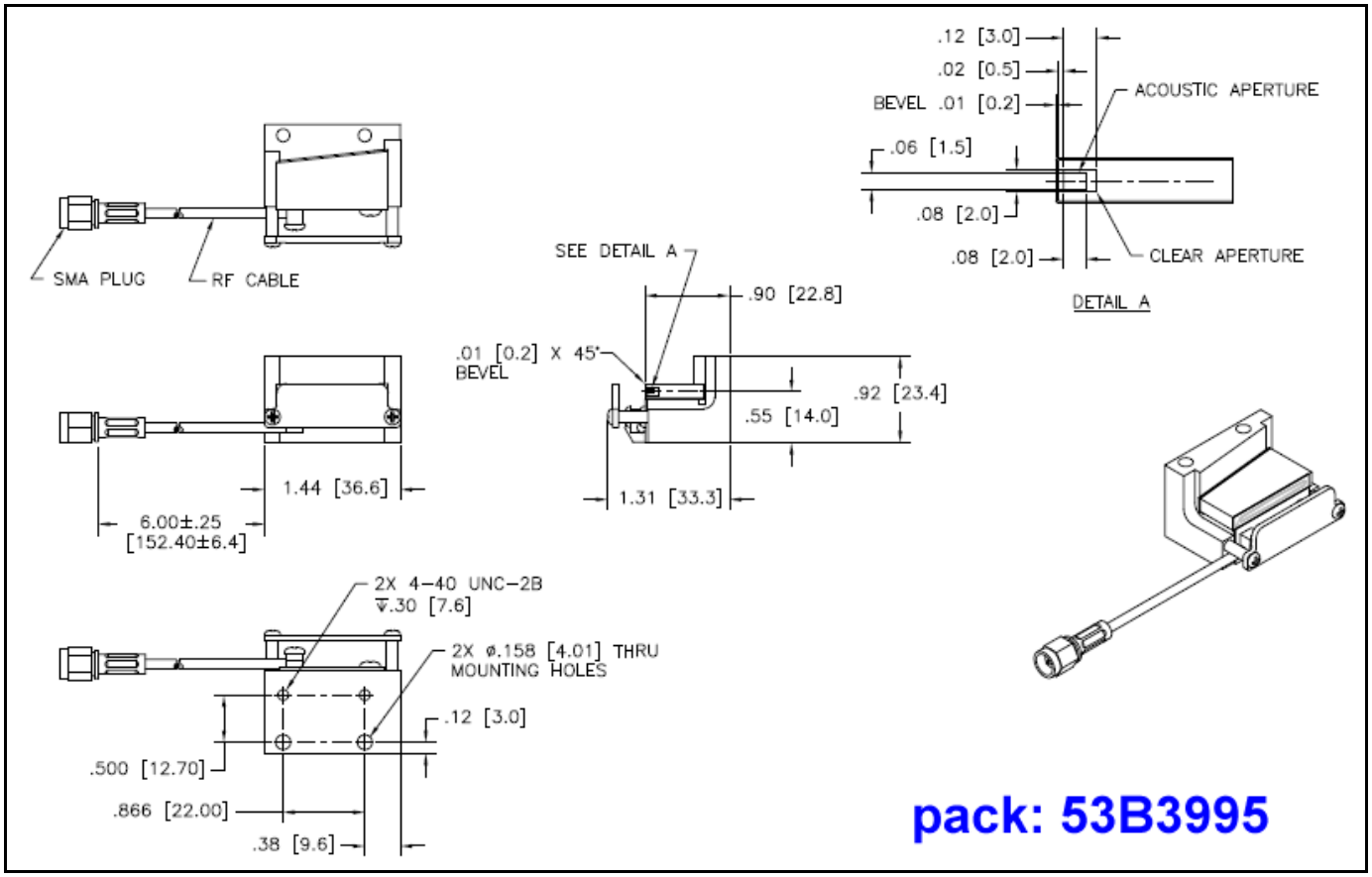
33041-10-1.5-I

PARAMETER	SPECIFICATION
Interactive Material	Crystal Quartz
Acoustic Mode	Longitudinal
Operating Wavelength	1064 nm
Window Configuration	AR "V" Coated
Static Transmission	>99 %
Operating Frequency	40.68 MHz
Loss Modulation	>72 % with Linear Polarization, Perpendicular to acoustic propagation >45 % with Random Polarization
Acoustic Aperture Size	1.5 mm
Rise Time	115 ns/mm Beam Diameter
Deflection Angle	7.5 mrad
RF Power Level	10 Watts
Impedance	50 Ohms
VSWR	<1.2:1 @ 40.68 MHz
Package:	53B1590 (Package must be maintained at a temperature below 50^{0}C.)
Recommended Drivers:	Digital Driver System: 39041-10DS*** or 38041-10DS** Digital Driver Module: 39041-10DM*** or 38041-10DM** Options: *** = PPK, FPS, A05, R05; ** = PK, PKPW



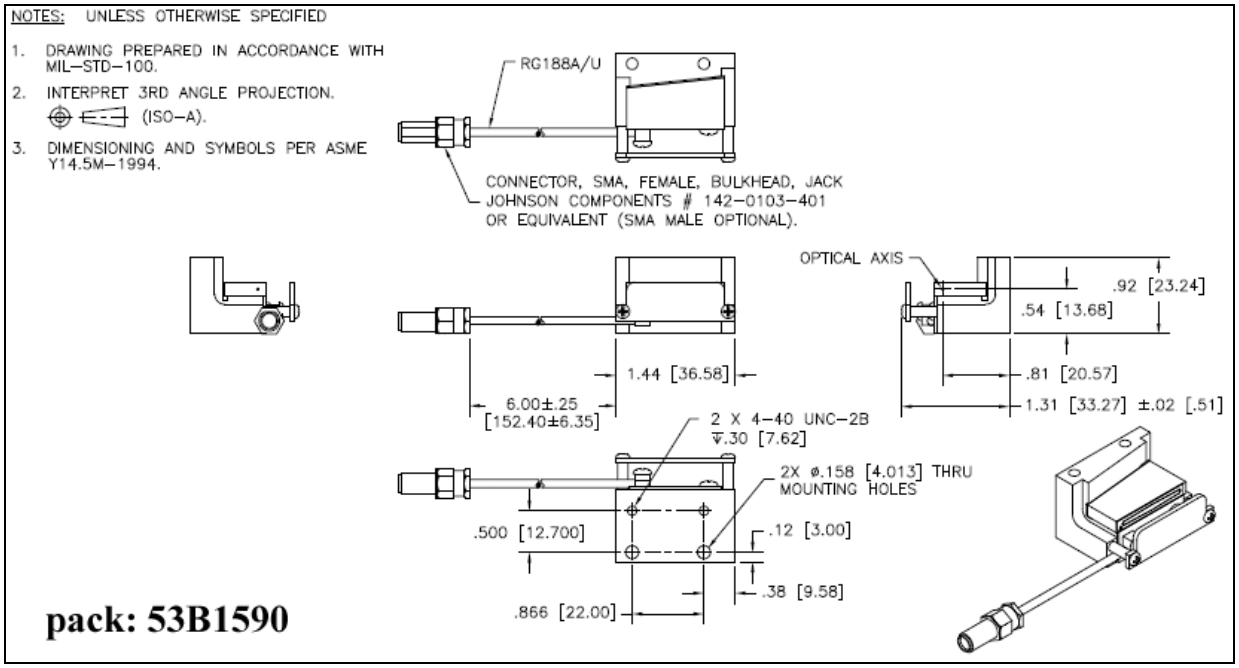
33041-20-1.5-I-TB

PARAMETER	SPECIFICATION
Interactive Material	Crystal Quartz
Acoustic Mode	Longitudinal
Operating Wavelength	1064 nm
Window Configuration	AR "V" Coated
Static Transmission	>99 %
Operating Frequency	40.68 MHz
Loss Modulation	>90 % with Linear Polarization, Perpendicular to acoustic propagation >80 % with Random Polarization
Acoustic Aperture Size	1.5 mm
Rise Time	115 ns/mm Beam Diameter
Deflection Angle	7.5 mrad
RF Power Level	20 Watts
Impedance	50 Ohms
VSWR	<1.2:1 @ 40.68 MHz
Package:	53B3995 (Package must be maintained at a temperature below 50^0C.)
Recommended Drivers:	Digital Driver System: 39041-20DS***
	Digital Driver Module: 39041-20DM***
	Options: *** = PPK, FPS, A05, R05; ** = PK, PKPW


.12 [3.0]
.02 [0.5]
BEVEL .01 [0.2]
ACOUSTIC APERTURE
.06 [1.5]
.08 [2.0]
.08 [2.0]
CLEAR APERTURE
DETAIL A
SMA PLUG
RF CABLE
SEE DETAIL A
.90 [22.8]
.01 [0.2] X 45°
BEVEL
.92 [23.4]
.55 [14.0]
1.31 [33.3]
1.44 [36.6]
6.00±.25
[152.40±6.4]
2X 4-40 UNC-2B
▽.30 [7.6]
2X ø.158 [4.01] THRU
MOUNTING HOLES
.12 [3.0]
.500 [12.70]
.866 [22.00]
.38 [9.6]
pack: 53B3995

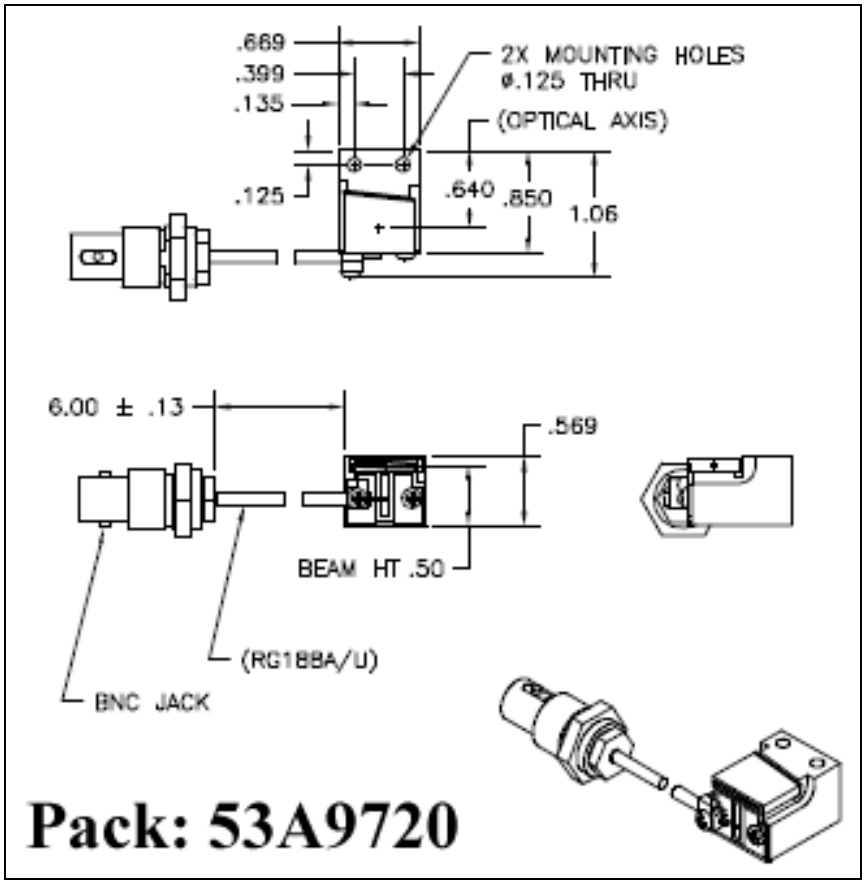
33080-10-1-I

PARAMETER	SPECIFICATION
Interactive Material	Crystal Quartz
Acoustic Mode	Longitudinal
Operating Wavelength	1064 nm
Window Configuration	AR "V" Coated
Static Transmission	>99 %
Operating Frequency	80 MHz
Loss Modulation	>80 % With Linear Polarization, Perpendicular to Acoustic Propagation >65 % With Random Polarization
Acoustic Aperture Size	1 mm
Rise Time	115 ns/mm Beam Diameter
Deflection Angle	14.7 mrad
RF Power Level	10 watts
Impedance	50 ohms
VSWR	<1.2:1 @ 80 MHz
Package:	53B1590
Recommended Drivers:	Digital Driver System: 39080-10DS*** or 38080-10DS** Digital Driver Module: 39080-10DM*** or 38080-10DM** Options: *** = PPK, FPS, A05, R05; ** = PK, PKPW



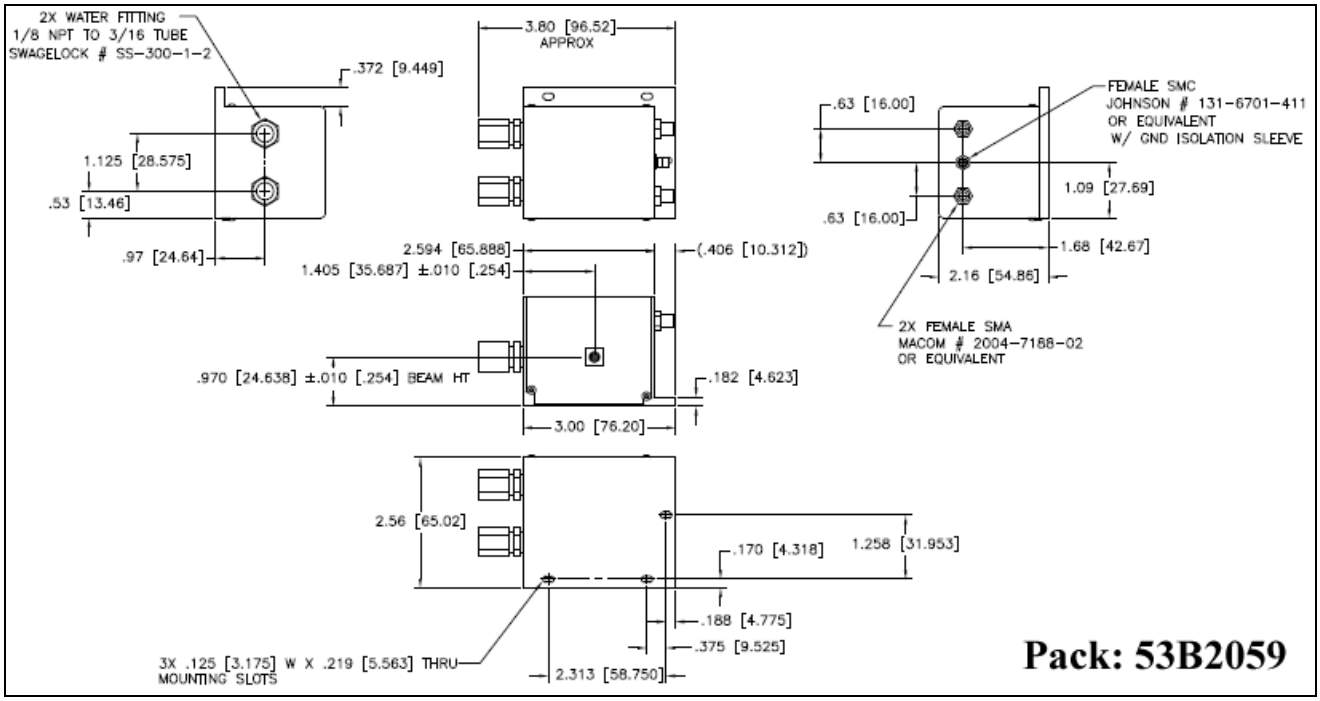
34080-1-SF10

PARAMETER	SPECIFICATION
Interaction Material	SF10
Acoustic Mode	Longitudinal
Operating Wavelength	1064 nm
Window Configuration	AR coated
Static Transmission	> 99 %
Operating Frequency	80 MHz
Loss Modulation	≥ 40 % with random polarization
Acoustic Aperture Size	1 mm
Rise Time	162 nsec/mm beam diameter
Deflection Angle	21 mrad
Max RF Power Level	3 watts
Impedance	50 ohms
VSWR	<1.2:1 at 80 MHz
Package	53A9720
Cooling	Conduction (Housing must be kept under 50°C)
Recommended Drivers	Digital Driver System: 39080-3DS*** or 38080-3DS**
	Digital Driver Module: 39080-3DM*** or 38080-3DM**
	Options: *** = PPK, FPS, A05, R05 ** = PK, PKPW



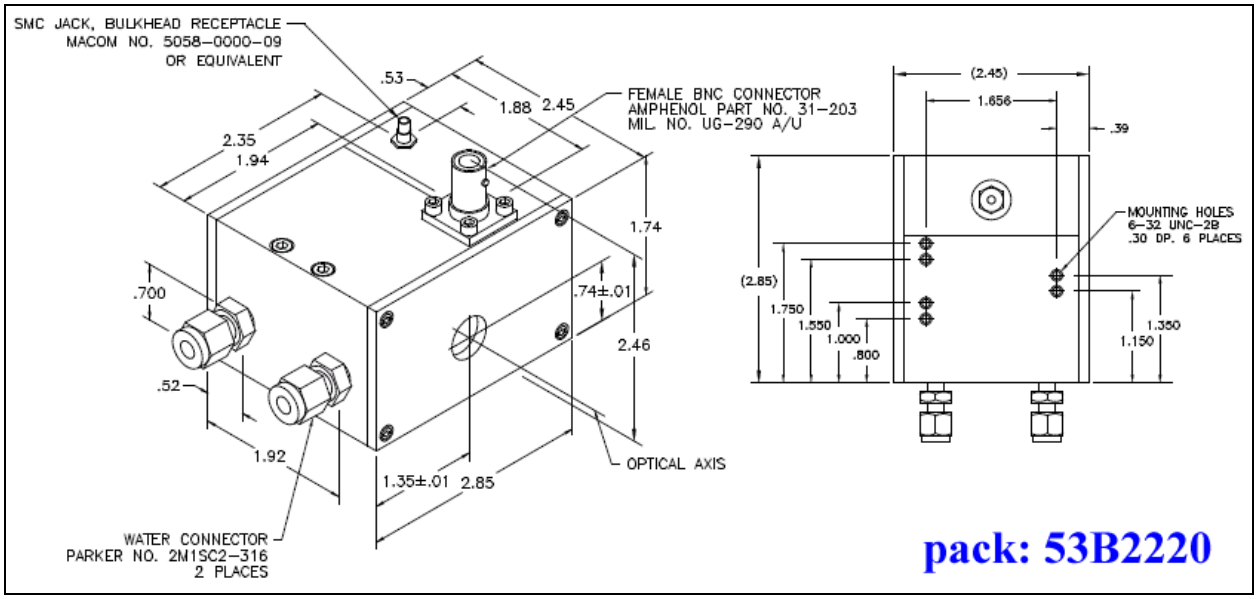
33027-40-4-XY-SMA / BNC

PARAMETER	SPECIFICATION
Interactive Material	Fused Silica
Acoustic Mode	Longitudinal, Dual Axis
Operating Wavelength	1064 nm
Window Configuration	AR "V" Coated
Static Transmission	>99 %
Operating Frequency	27.12 MHz
Loss Modulation	>90 % With Random Polarized Light
Acoustic Aperture Size	4 mm
Rise Time	120 ns/mm Beam Diameter
Acceptance Angle	+ 4 mrad
Deflection Angle	4.8 mrad
RF Power Level	40 Watts / Axis
Impedance	50 Ohms Nominal
VSWR	<1.2:1 @ 27.12 MHz
Package: SMA Connector	53B2059
BNC Connector	53B2208
Cooling	Water cooling @ 0.38GPM @ <300C
Recommended Drivers:	39027-40DS-2CH*, 39027-40DM-2CH*, 38027-40DMPK-2CH * These drivers may be ordered with operating mode options: -FPS, -PPK, A05, or R05



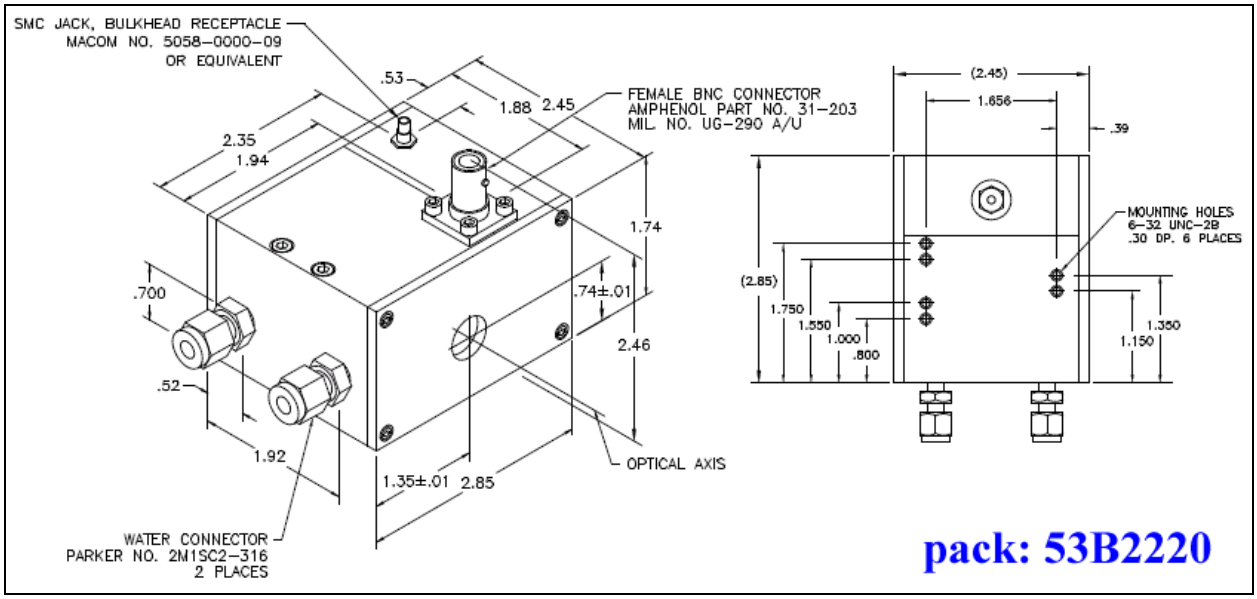
37027-3

PARAMETER	SPECIFICATION
Interactive Material	Ge
Acoustic Mode	Longitudinal
Operating Wavelength	10.6 um
Optical Power Density	5 Watt / mm2 Max
Window Configuration	AR Coated
Static Transmission	85 %
Operating Frequency	27.12 MHz
Diffraction Efficiency	>85 %
Light Polarization	Linear, Parallel to acoustic propagation
Acoustic Aperture Size	3mm
Rise Time	120ns/mm beam diameter
Deflection Angle	52 mrad @ 10.6um
RF Power Level	30 Watts
Impedance	50 Ohms
VSWR	<1.2:1 @ 27.12 MHz
Package:	53B2220
Water Cooled	0.38 litre / Minute
Recommended Driver:	39027-30DSA05



37027-5

PARAMETER	SPECIFICATION
Interactive Material	Ge
Acoustic Mode	Longitudinal
Operating Wavelength	10.6 um
Optical Power Density	5 Watt / mm2 Max
Window Configuration	AR Coated
Static Transmission	>85 %
Operating Frequency	27.12 MHz
Diffraction Efficiency	>75 %
Light Polarization	Linear, parallel to acoustic propagation
Acoustic Aperture Size	5mm
Rise Time	120 ns/mm beam diameter
Deflection Angle	52 mrad @ 10.6 um
RF Power Level	30 Watts
Impedance	50 Ohms
VSWR	<1.2:1 @ 27.12 MHz
Package:	53B2220
Water Cooled	0.38 litre/Minute
Recommended Driver:	39027-35-DSA05



Model Number Designation Guide:

Note: The prefix R in the model number Indicates compliance with the EU RoHS Directive.

1. AOM, AOBD, QSW

R □□ □□□ - □□ - □□ - □□ - □ - □□□

Series	Acoustic Center Frequency	RF Power (QSW Only)	Special Aperture Height	Special Wavelength	Number of Channels	Options

Series:

12: Mode Locker
13: Cavity Dumper
15: 50 MHz Bandwidth Modulator
17: 100 MHz Bandwidth Modulator
23: Low Cost TeO2 Modulator
24: Low Cost SF6 Modulator
25: Lead Molybdate Modulator
26: Chalcogenide Glass Modulator
32: Q-Switch Shear Wave
33: Q-Switch Longitudinal Wave
34: Flint Glass Q-Switches
35: High Power AO Modulator
36: Custom Q-Switches
37: CO2 Wavelength AO Modulator
42: 500 MHz and Greater Acoustic Frequency Modulator
43: Multi-channel Modulators
45: Slow Shear TeO2 Acoustic-Optic Beam Deflectors
46: Custom Acousto-Optic Beam Deflectors
47: Custom Acousto-Optic Modulators
48: Tunable Filter

Options:

Material: see list below
Mech. Design: LTD, TE, FOA, XY, WP
Connectors: SMA, BNC, SMB ect.
BR: Brewster Window
FO: Fiber Optic, HP
(Options are not available for some models)

Material List:

F6	SF6 Flint Glass*
F10	SF10 Flint Glass*
F57	SF57 Flint Glass*
GaP	Gallium Phosphide
Ge	Germanium Crystal
I	Crystal Quartz
L	Lithium Niobate
M	Lead Molybdate*
Q	Fused Quartz
T	TeO2

Acoustic Center Frequency: The operating frequency of the transducer of the AO device.
Aperture Height: The maximum optical aperture defined by the acoustic column in the crystal.
Wavelength: The optical Wavelength or the center Wavelength of the optical pass band.

NOTE: **Not all of the fields shown above are necessary to designate a device.**
EXAMPLES: AOM: 15210-.8-1.06 is a 210 MHz AOM with 0.8mm aperture for 1.06 um.
AOBD: 45050-6-.8 is a 50 MHz center frequency AOBD, 6mm aperture for 0.8 um.

2. AOM AND Q-Switch Drivers:

R □□ □□□ - □□ □ □ □□□ - □ - □

Series	RF Frequency	Power Output	Modulation Input	Package	Frequency Source	Number of Channels	Options

Series:

11: High Speed AOM Driver
21: Low Cost AOM Driver
31: 2nd Generation RF AOM Driver
38: 2nd Generation RF Q-Switch Driver
39: 3rd Generation RF Driver
54: Fiber Optical System
64:Custom Design

Modulation: D: Digital, A: Analog

Package: S: System, M: OEM Module

Frequency Source:
VCO: Voltage Controlled Oscillator
SYN: Phase locked Synthesizer
CL/MLAS: Close Loop/ Mode Locker Analog System

Options:
38's: PK Pulse Kill
PKPW Pulse Kill Pulse Width
39's: PPK Pre-Pulse Kill
FPS First Pulse Suppression
A05 Analog Modulation
R05 Analog Modulation Required

NOTE: Not all of the fields shown above are necessary to designate a device.
(System = rack mountable box with power supplies, controls, and fan)
EXAMPLE: Driver: 21110-.7SAS is a 110 MHz, 0.7 Watt, Self Scanning VCO, Analog Modulation driver system.

3. AOBD Drivers and Custom Drivers:

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Series	RF low Frequency	RF High Frequency	Output Power	Package	Frequency Source	Number of Channels	Custom Options

Series:

64: 64040-75-.1-8CH-16MB 8 CH PCAOM DRIVER
64020-200-2ADMDFS-A DFS AOBD DRIVER
64389.5-SYN-9.5-1 CAVITY DUMPER DRIVER
64090-150-7ASVCO-2 VCO AOBD DRIVER
64040-150-0.2ADMDFS-8X1 NEW 8 CH PCAOM DRIVER
64040-150-0.8ADMDFS-8X1 NEW 8 BEAM AOBD DRIVER

Package:
S: System
M: Module

Source:
VCO: Voltage Controlled Oscillator
DFS: Digital Frequency Synthesizer
SAS: Self Scanning Analog System
ADS: Analog Digital System
SYN: Phase locked Synthesizer

Channels:
2 Ch
2
4 Ch5,
8 Ch

Options:
2Detect
M
16,16M,16B,16MB