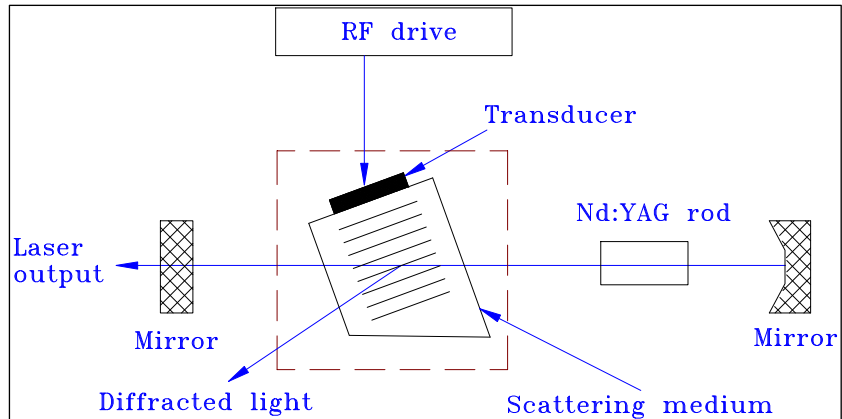


Acousto-Optical Q-switch

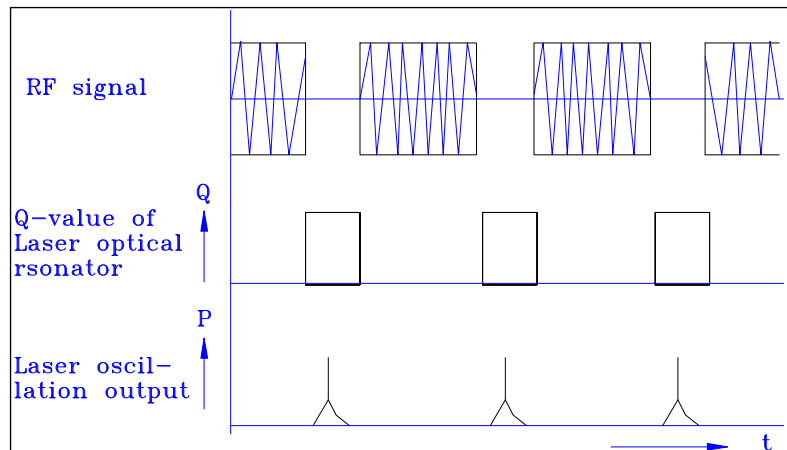
The acousto-optical Q-switch often used in the laser marking makes use of mutual interaction between an ultrasonic wave and a light beam in a scattering medium. The light beam that enters in a direction forming a Bragg angle to the wave surface of the acoustic wave in the scattering medium is diffracted 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 μ s) 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

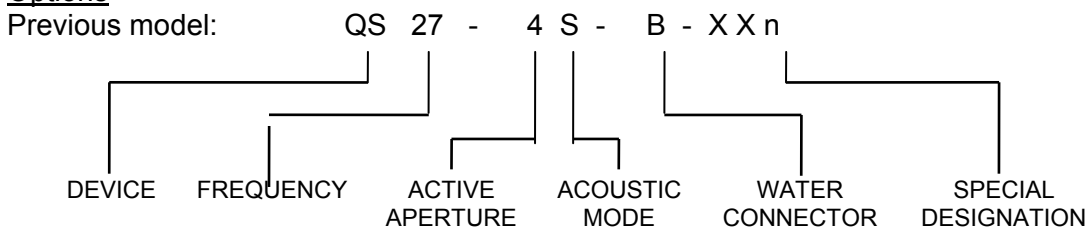
Model no:	See "Options" below
Interaction medium:	Fused silica
Operational wavelength:	1064nm
Anti reflection coating:	Hard multi-layer dielectric
- Reflectivity:	$\leq 0.2\%$ / surface ($< 0.1\%$ typical)
- Damage threshold:	$> 500\text{MW cm}^{-2}$
Insertion loss:	$\leq 10\%$ ($< 5\%$ typical)
Active aperture:	See "Options" below
Diffraction (separation) angle	~ 4.8 mrad
VSWR:	$\leq 1.2:1$
Maximum CW drive power:	100W
Thermal interlock:	+50°C



Water Cooling

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

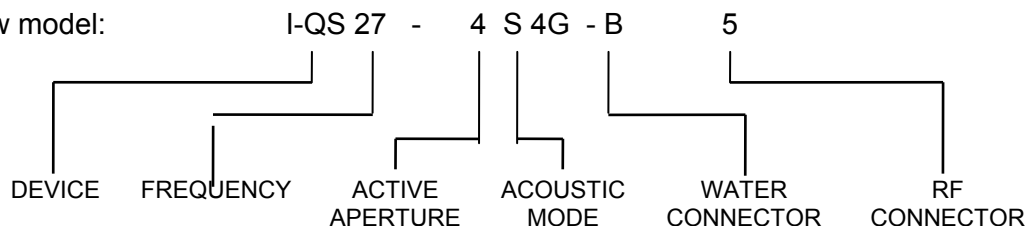
Options



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:



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

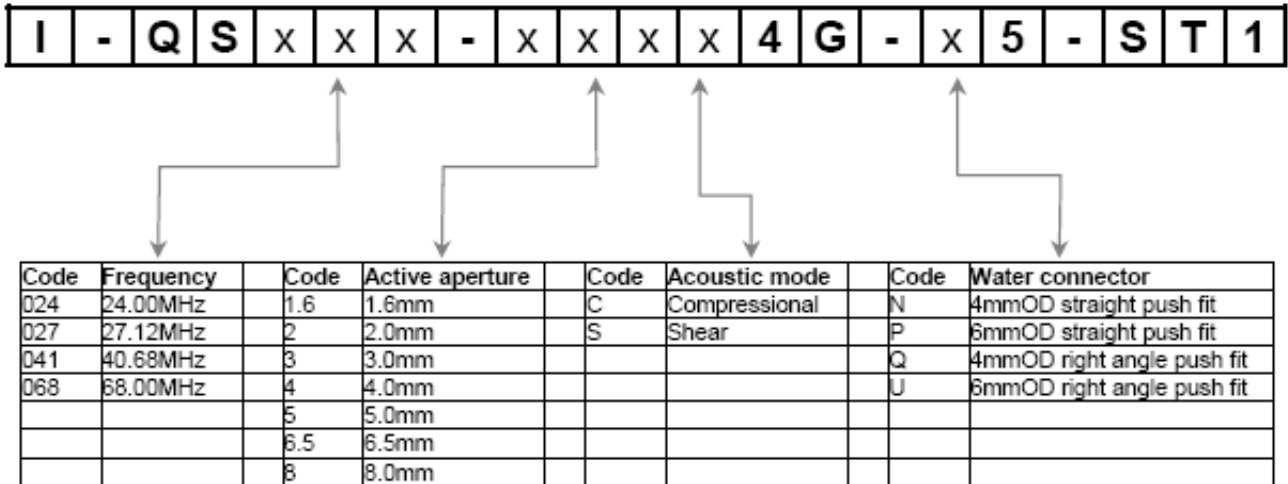
Wavelength:

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)



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

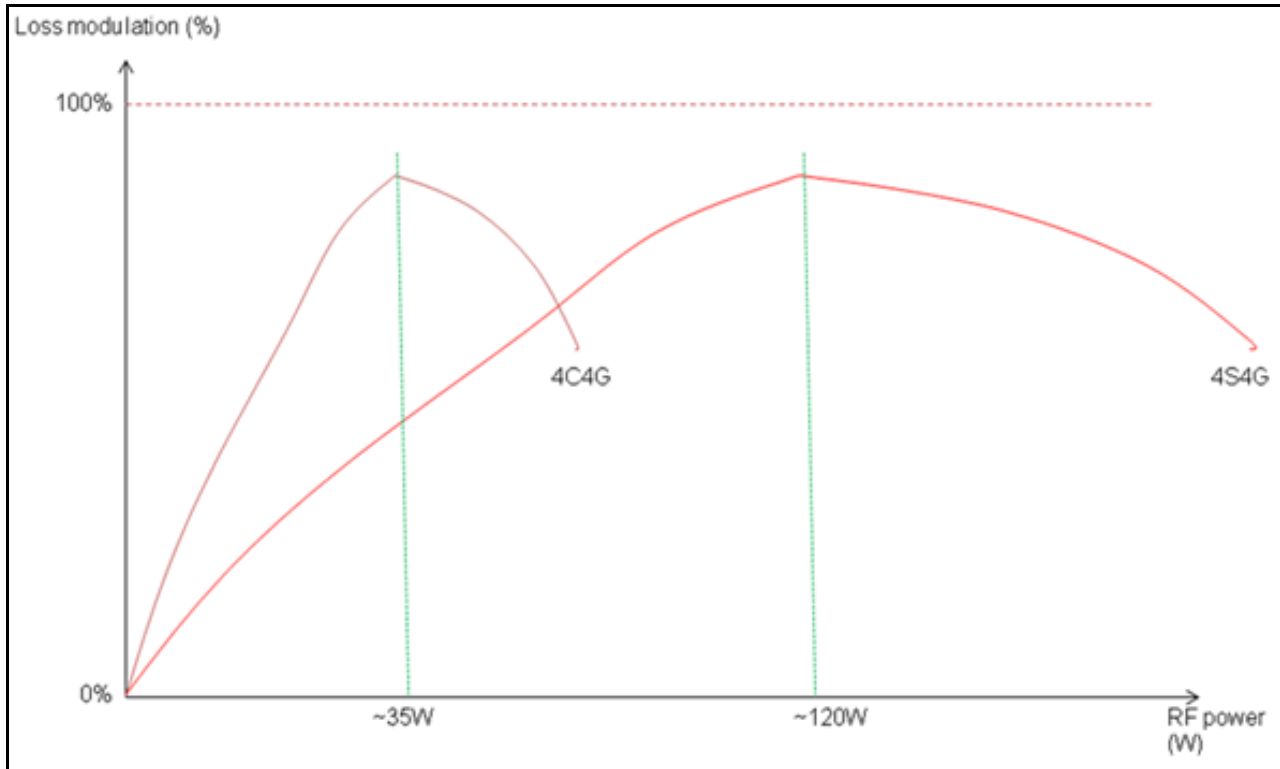
1. To find the frequency of the RF driver (Q-switch driver).
2. To find the diameter of the YAG rod or laser beam diameter from the laser head. In general, the aperture of the Q-switch is 1mm larger than the YAG rod diameter.
3. If there is no polariser inside the laser resonator and the laser beam is 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:																	
Optional	optional						optional	optional					optional	optional	optional	optional	optional
P																	
↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
Non-RoHS	Device				Aperture in mm		Material Code			Water Connection	RF Connector						FO Connector
Location	Frequency in MHz				Acoustic mode Code: C = Compressional S = Shear		Wavelength Code										
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 2 TeO ₂ 3 SF6 4 Fused Silica 5 SF10 6 SF57 7 SF2 8 Antir-1 9 SF8 10 Crystal Quartz 11 Germanium 12 Lithium Niobate 13 F2 14 Potassium Ytrium Tungstate 15 KDP 16 Si 17 GaP 18 GLS	Wavelength Code: A 442 nm B 488 nm C 532 nm D 543 nm E 633 nm F 800 nm G 1064 nm H 1319 nm J 1550 nm K 532 / 1064 nm L 1660 nm M 2130 nm N 488 - 633 nm P 2.5 μm - 3.5 μm Q 10.6 μm R Brewster S 930 nm T 355 nm U 244 nm V 405 nm W 780 nm X 850 nm Y 946 nm Z 1230 nm V1 1342 nm V2 1640 nm V3 1940 nm V4 1990 nm V5 2000 nm V6 2022 nm V7 2090 nm V8 2100 nm V9 1030 nm R1* 244-260nm R2* 300-550nm R3* * Brewster - Limited by Design	Variant BA 250 - 400 nm BB 300 - 400 nm BC 400 - 700 nm BD 450 - 850 nm BE 450 - 950 nm BF 470 - 850 nm BG 600 - 1200 nm BH 670 - 900 nm BJ 700 - 900 nm BK 700 - 1200 nm BL 725 - 825 nm BM 800 - 1100 nm BN 900 - 1500 nm BP 900 - 2000 nm BQ 950 - 1700 nm BR 950 - 1850 nm	BS 1000 - 1500 nm BT 1064 - 1300 nm BU 1064 - 1550 nm BV 1064 - 2100 nm BW 1300 - 1600 nm BX 1800 - 2200 nm BY 1800 - 4000 nm BZ 1850 - 2500 nm B1 1900 - 2200 nm B2 2000 - 3000 nm B3 2400 - 2600 nm B4 2650 - 2900 nm B5 3000 - 4000 nm B6 B7 B8 B9 WA 400 / 800 nm 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: KOH 04-MS 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 Models for 1064nm (Conduction cooled)

Model No.	I-QS080-0.5C10G-8-GH48	I-QS080-1C10G-8-GH28
Device		
Interaction material	Crystal Quartz	Crystal Quartz
Wavelength	1064nm	1030 to 1064nm
AR coating reflectivity	< 0.2% per surface	< 0.2% per surface
Damage threshold	> 1GW/cm ²	> 1GW/cm ²
Transmission	> 99.6%	> 99.6%
Frequency	80MHz	80MHz
Polarisation	Linear, vertical to base	Linear, vertical to base
Active Aperture	0.5mm	1.0mm
Acoustic Mode	Compressional	Compressional
Separation angle	14.9mrad	14.9mrad
Rise time	113ns/mm	113ns/mm
Loss Modulation	>=85%	>=85%
Max RF Power	10W (max)	10W (max)
Storage Temperature	-20 to +70degC	-20 to +70degC

Model No.	I-QS041-1.8C10G-4-GH21	I-QS080-1C10G-4-GH25
Device		
Interaction material	Crystal Quartz	Crystal Quartz
Wavelength	1064nm	1030 to 1064nm
AR coating reflectivity	< 0.2% per surface	< 0.2% per surface
Damage threshold	> 1GW/cm ²	> 1GW/cm ²
Transmission	> 99.6%	> 99.6%
Frequency	40.68MHz	80MHz
VSWR	< 1.2:1	< 1.2:1
Polarisation		Linear, vertical to base
Active Aperture	1.8mm	1.0mm
Rise time	113ns/mm	113ns/mm
Loss Modulation	>=85%	>=85%
Max RF Power	20W (max)	15W (max)
Storage Temperature	-20 to +70degC	-20 to +70degC

Model No.	I-QS027-4S4V2-x5-ST1	I-QS080-1C10G-4-GH25
Device		
Interaction material	Crystal Quartz	Crystal Quartz
Wavelength	1064nm	1030 to 1064nm
AR coating reflectivity	< 0.2% per surface	< 0.2% per surface
Damage threshold	> 1GW/cm ²	> 1GW/cm ²
Transmission	> 99.6%	> 99.6%
Frequency	40.68MHz	80MHz
VSWR	< 1.2:1	< 1.2:1
Polarisation		Linear, vertical to base
Active Aperture	1.8mm	1.0mm
Rise time	113ns/mm	113ns/mm
Loss Modulation	>=85%	>=85%
Max RF Power	20W (max)	15W (max)
Storage Temperature	-20 to +70degC	-20 to +70degC

AO Q-Switch Models for 1064nm (Water cooled)

Model No.	I-QS027-4C10G-x5-ST7	
Device	AO Q-Switch	
Interaction material	Crystal Quartz	
Wavelength	1064nm	
AR coating reflectivity	< 0.2% per surface	
Damage threshold	> 1GW/cm ²	
Transmission	> 99.6%	
Frequency	27.12MHz	
Polarisation	Linear, vertical to base	
Active Aperture	4.0mm	
Acoustic Mode	Compressional	
Loss Modulation	> 80%	
Max RF Power	75W	
Water flow rate	> 0.2l / minute	
Recommended water temperature	22°C to 32°C	
Thermal switch cut-off	65°C ± 5%	
Housing	Stallion, St/St 316 water channels	
Water connectors	To be specified	

AO Q-Switch at Other Wavelengths (Conduction Cooled)

Model No.	I-QS027-4S4V2-x5-ST1	I-QS041-2C10V5-4-HC1
Device		
Interaction material	Infrasil (water-free fused silica)	Crystal Quartz
Wavelength	1550nm	1900 to 2100nm
Polarisation	Any	Linear, vertical to base
AR coating reflectivity	< 0.2% per surface	< 0.5% per surface
Damage threshold	> 500MWcm ⁻²	> 500MWcm ⁻²
Transmission	> 99.6%	> 99.0%
Frequency	27.12MHz	40.68MHz
Active Aperture	4.0mm	2.0mm
Acoustic Mode	Shear	
VSWR	< 1.2:1 (<1.4:1 at 50W RF power)	< 1.2:1
Rise time		113ns/mm
Loss Modulation	> 60%	> 45%
Max RF Power	100W	20W (max)
Storage temperature		-20 to +70degC

AO Q-Switch at Other Wavelengths (Water Cooled)

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/cm ²	> 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.	I-QS027-4S4V2-x5-ST1	I-QS041-5C10V5-x5-ST3
Device		
Interaction material	Infrasil (water-free fused silica)	Crystal Quartz
Wavelength	1550nm	1900 - 2100nm
Polarisation	Any	
AR coating reflectivity	< 0.2% per surface	< 0.5% per surface
Damage threshold	> 500MWcm ⁻²	> 500MWcm ⁻²
Transmission	> 99.6%	> 99.0%
Frequency	27.12MHz	40.68MHz
Active Aperture	4.0mm	5.0mm
Acoustic Mode	Shear	Compressional
VSWR	< 1.2:1 (<1.4:1 at 50W RF power)	< 1.2:1 (<1.4:1 at 50W RF power)
Loss Modulation	> 60%	70%
Max RF Power	100W	50W
Water flow rate	> 0.2l / minute	> 0.2l / minute
Water cooling channel material	Stainless steel 316	Stainless steel 316
Recommended water temperature	+22oC to +32oC	+22oC to +32oC
Thermal switch cut-off	+55oC +/- 5oC	+65oC +/- 5oC
Storage temperature	0 to +50degC	-20 to +70degC

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/cm ²	> 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.	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.	QS027-10M-NL5	I-QS027-4C10V5(BR)-x5-IS6
Interaction material	Crystal Quartz	Crystal Quartz
Wavelength	2054nm	2000-2100nm
AR coating reflectivity	< 0.2% per surface	< 0.2% per surface
Polarisation	Linear (vertical to base)	Linear (vertical to base)
Active Aperture:	5mm	4mm
Interaction length	46.0mm	46.0mm
RF frequency	27.12MHz	27MHz
VSWR	< 1.2 1	< 1.2 1
Acoustic Mode	Compressional	Compressional
Loss modulation	~ 80% at 100W	>80%
Rise-time (10-90%):	109ns/mm	109ns/mm
Housing	Standard QS27-xx-B	Stallion
Water connectors	Barbed	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.

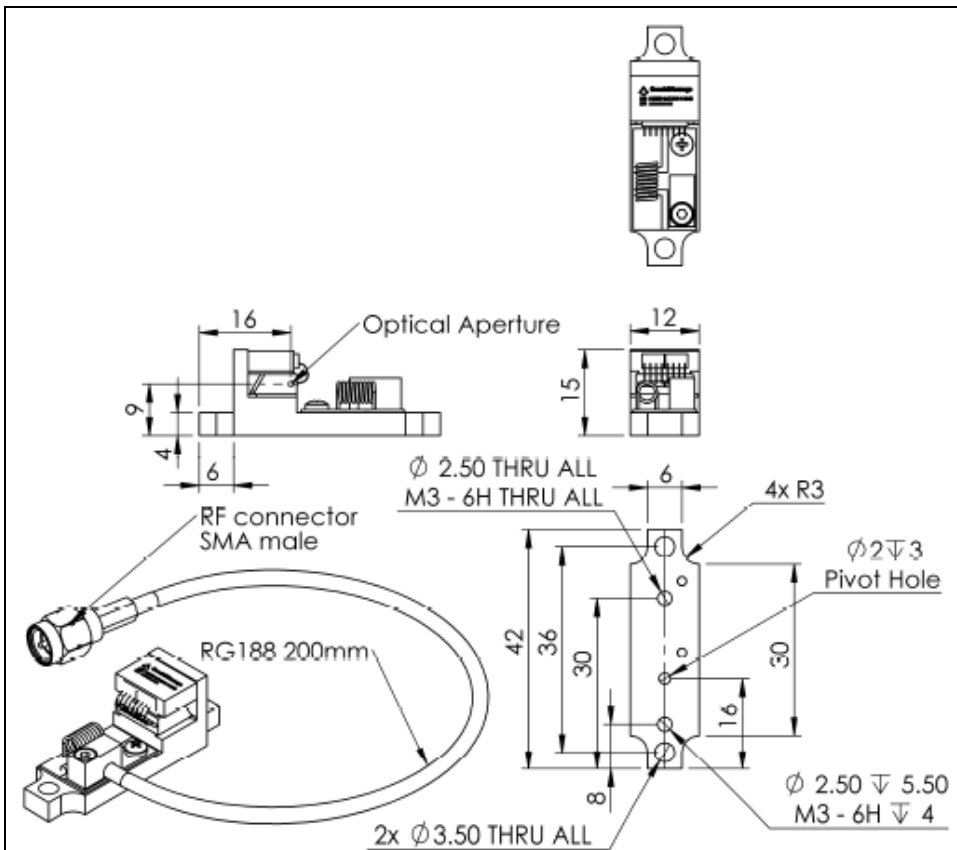
I-QS080-0.5C10G-8-GH48

- Compact package
- Conduction cooled
- High damage threshold
- High efficiency
- Custom configurations available



A ultra-compact conduction-cooled Acousto-Optic QSwitch, ideally suited to short cavity end pumped Nd:YAG & Nd:YVO4 lasers. Utilising top grade Crystal Quartz for increased efficiency & thermal stability, with high quality optical finishing & high damage threshold antireflection coatings to provide high damage threshold & low insertion loss. In addition to the specifications indicated, we also offer alternative wavelengths, RF frequencies, active apertures & an extensive range of mechanical housing configurations. We also offer full custom design & manufacturing, enabling our customers to achieve the perfect solution.

Model No.	I-QS080-0.5C10G-8-GH48
Device	
Interaction material	Crystal Quartz
Wavelength	1064nm
AR coating reflectivity	< 0.2% per surface
Damage threshold	> 1GW/cm ²
Transmission	> 99.6%
Frequency	80MHz
Polarisation	Linear, vertical to base
Active Aperture	0.5mm
Acoustic Mode	Compressional
Separation angle	14.9mrad
Rise time	113ns/mm
Loss Modulation	>=85%
Max RF Power	10W (max)
Storage Temperature	-20 to +70degC

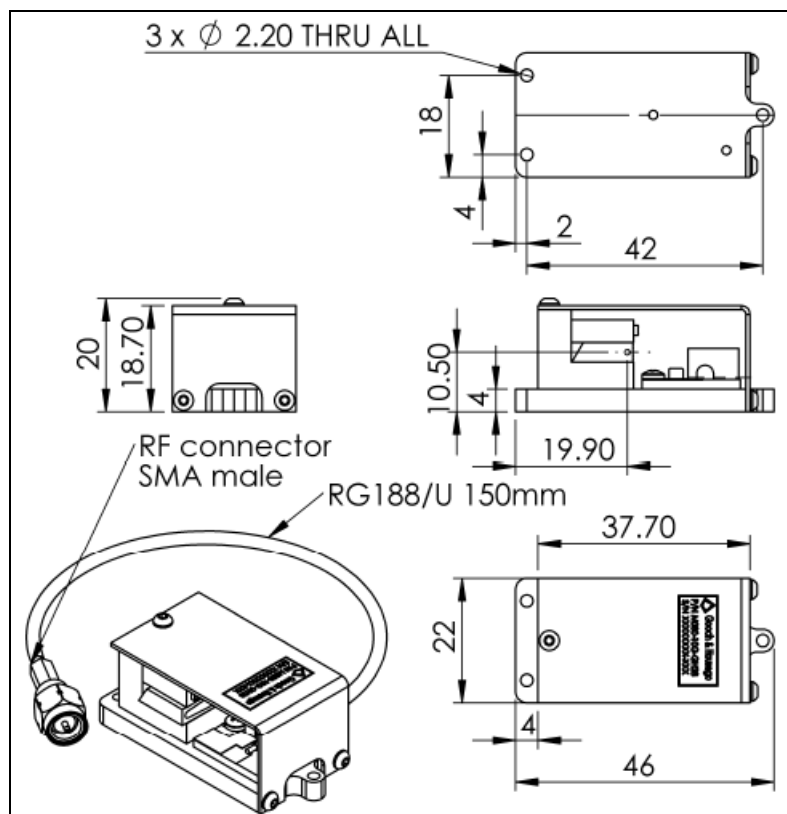


I-QS080-1C10G-8-GH28

- Compact package
- Conduction cooled
- High damage threshold
- High efficiency
- Custom configurations available

A compact conduction-cooled Acousto-Optic QSwitch, ideally suited to short cavity end pumped Nd:YAG & Nd:YVO4 lasers. Utilising top grade Crystal Quartz for increased efficiency & thermal stability, with high quality optical finishing & high damage threshold antireflection coatings to provide high damage threshold & low insertion loss. In addition to the specifications indicated, we also offer alternative wavelengths, RF frequencies, active apertures & an extensive range of mechanical housing configurations. We also offer full custom design & manufacturing, enabling our customers to achieve the perfect solution.

Model No.	I-QS080-1C10G-8-GH28
Device	
Interaction material	Crystal Quartz
Wavelength	1030 to 1064nm
AR coating reflectivity	< 0.2% per surface
Damage threshold	> 1GW/cm ²
Transmission	> 99.6%
Frequency	80MHz
Polarisation	Linear, vertical to base
Active Aperture	1.0mm
Acoustic Mode	Compressional
Separation angle	14.9mrad
Rise time	113ns/mm
Loss Modulation	>=85%
Max RF Power	10W (max)
Storage Temperature	-20 to +70degC



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 6.5mm ²
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/cm ²
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:	65°C ± 5%
Water connectors:	Barbed
Housing material:	Aluminium
Temperature range:	-20°C to +70°C

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. Q-Switch used in DPSS lasers

3.1 41MHz 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	I-QS041-1.5C10G-4-SO12
Interaction Material	Crystal Quartz		
Wavelength	1047 to 1064nm		
Polarization	Linear, vertical to base		Random or linear
Anti-Reflection Coating	< 0.2% per surface		
Damage Threshold	> 1GW/cm ²		
Transmission (single pass)	> 99.6%		
Frequency	40.68MHz		
VSWR	<1.2:1 (50Ω input impedance)		
Active Aperture	1.6mm	1.8mm	1.5mm

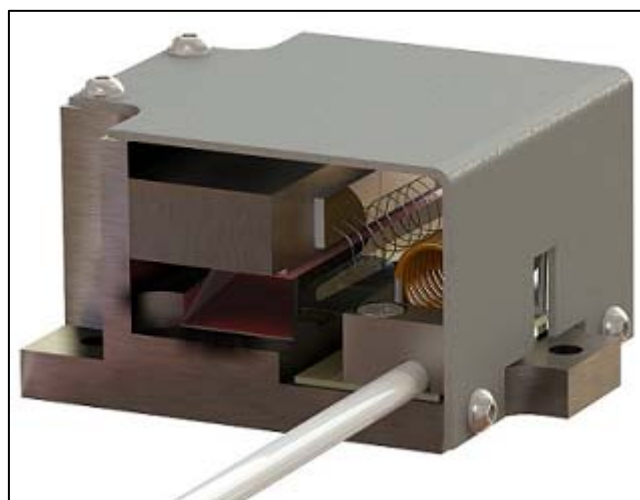
Acoustic Mode	Compressional		
Rise-Time / Fall-Time	109ns/mm	113ns/mm	113ns/mm
Loss Modulation	> 85%	> 85%	85% (polarised) 70% (unpolarised)
Separation Angle	7.6mrad		
RF Power Rating	20W CW		
Cooling	Conduction through base		
Dimension	35x33x24mm	35x35.7x26mm	33x31.9x24mm
Q-switch driver	R39041-20DMFPS-SC		

3.2 80MHz Q-switches

- 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.

Model	QS080-2G-3D1	I-QS080-1.5C10G-4-SO12
Interaction Material	Tellurium Dioxide	Crystal Quartz
Wavelength	1047 to 1064nm	1064nm
Polarization	Insensitive	Random or linearly polarised
Anti-Reflection Coating	<0.2% per surface	< 0.2% per surface
Damage Threshold	>10MWcm ²	> 1GW/cm ²
Transmission (single pass)	>99.5%	> 99.6%
Frequency	80MHz	80MHz
VSWR	<1.2:1 (50Ω input impedance)	<1.2:1 (50Ω input impedance)
Active Aperture	1.0mm	1.5mm
Acoustic Mode	Compressional	Compressional
Rise-Time / Fall-Time	153ns/mm	113ns/mm
Loss Modulation	>85% at 3W (typical)	>85% (polarised) >70% (unpolarised)
Beam Angle	20mrad	14.9mrad
RF Power Rating	3W, CW	20W
Cooling	Conduction through base	Conduction through base
RF Driver	R39080-3DMzzz-SC	

Model	97-03277-01	97-03278-02	97-03300-01	97-03306-01
Interaction Material	Crystal Quartz			
Acoustic Velocity	5.74mm/μs			
Active Aperture*	1 mm	1 mm	1.5 mm	2.0 mm
Center Frequency	80MHz			
VSWR	<1.2:1 (50Ω input impedance)			
Wavelength	1064nm			
Insertion Loss	Max 1%			
Reflectivity	Max 0.1% per surface			
AR Coating	MIL-C-48497			
Damage Threshold	500MW/cm ²			
Polarization	Linear, vertical to the base			
RF Power rating	12W	3.5W	20W	25W
Beam Separation	14.8 mrad			
Rise / Fall time	50nsec			
Loss Modulation	85%	50%	85%	85%

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.

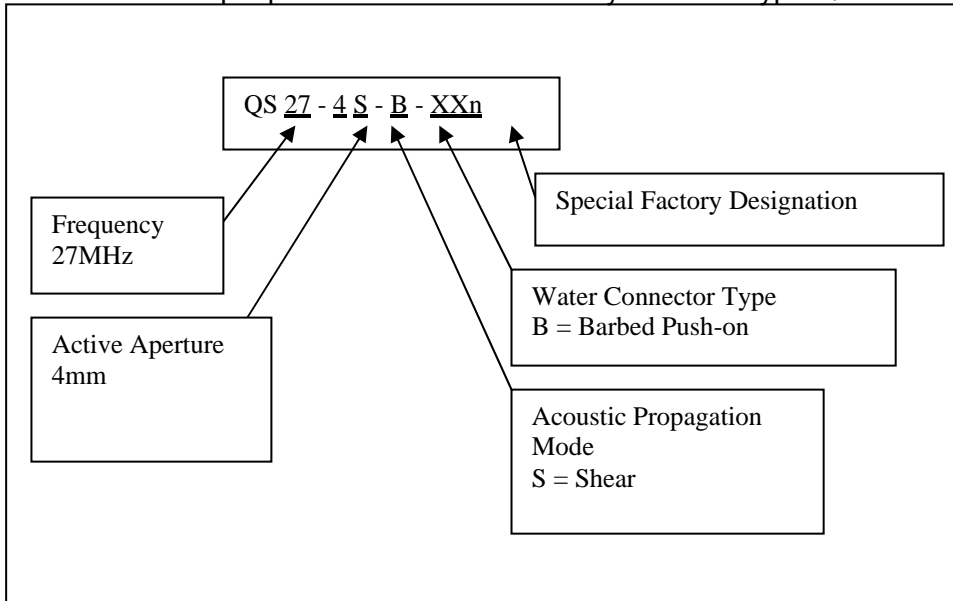
Can I trust the damage threshold quoted in the data sheet?

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.

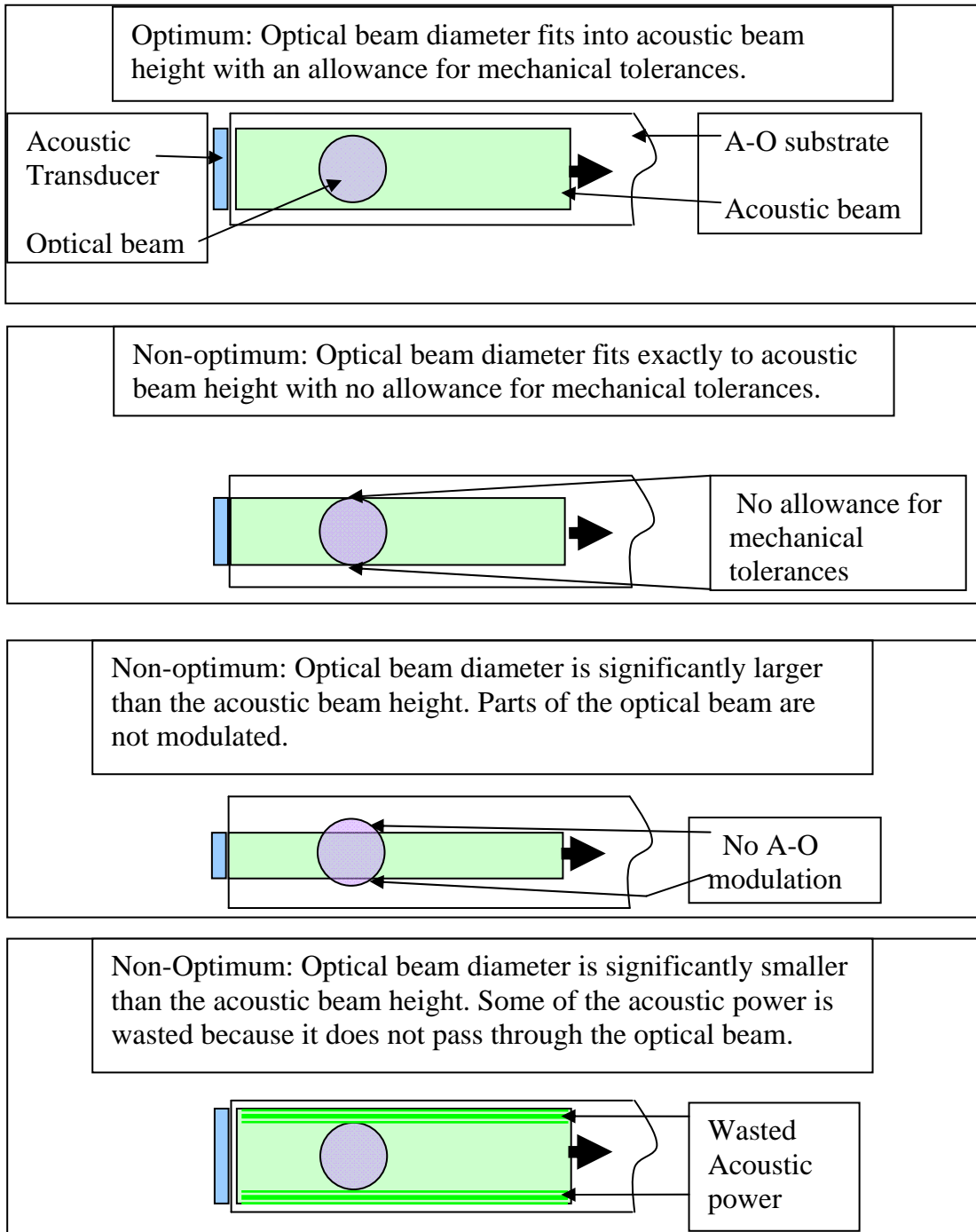
For example if you have a 1.7mm diameter laser then a -2 Q-switch would be appropriate (2mm active aperture, just a little larger than the optical beam diameter).

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** QS27-4**S**-**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))

