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Introduction to A-O Deflectors/Scanners

An acoustic deflector/scanner changes the angle of direction of a laser beam and its angular position is linearly proportional to the acoustic frequency, so that the higher the frequency, the larger the diffracted angle.

$$\Delta\Theta \approx \lambda \cdot \frac{\Delta f}{V_a}$$

Where λ is the optical wavelength in air, V_a is the acoustic velocity, and Δf is the frequency bandwidth.

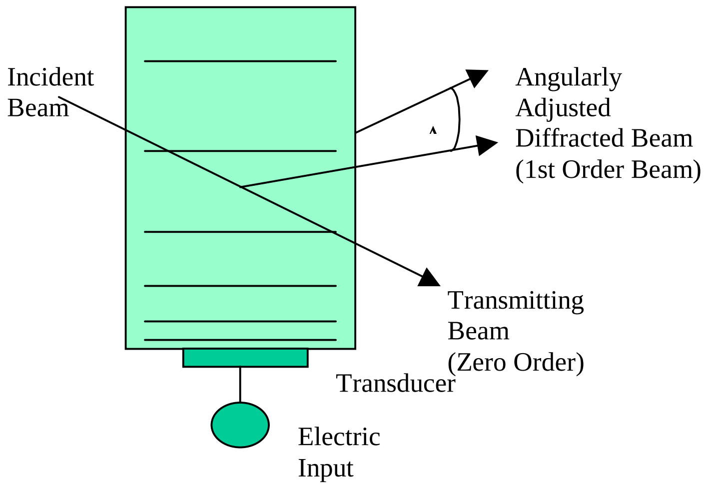
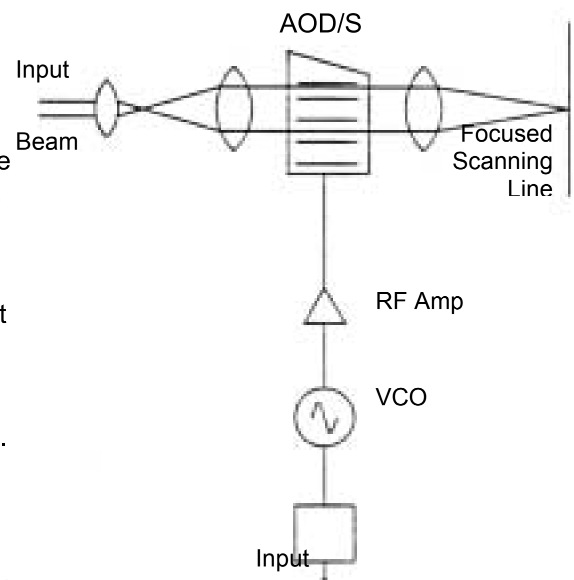


Figure 1.

AO Deflector/Scanner System



A schematic set-up of the AOD/S and driver electronics is show in Figure 2. The AOD/S physical characteristics are its optical aperture dimensions which are the optical height (H), and the width (D). Usually, the optical width is much larger than the height because of performance and design constraints. As a result, the input and output optical laser beam will require cylindrical optics to transform the incident laser beam from the a circular beam to a truncated profile rectangular beam, and then back to a circular beam after the deflector. The output optics usually focus the deflected circular beam to a line of focused spots in the output plane.

The electronics for the scanner are arranged in one of three ways depending on the application. For continuous laser beam scanners, since the deflection angle is directly proportional to the RF frequency, a linear voltage controlled oscillator (VCO) can be used to drive the RF amplifier and the AOD/S. A linear saw tooth waveform drives the VCO which in turn, outputs a linear RF signal. This signal will drive the AOD/S to output a line san. In the second application, where vector (random) scanning is needed, the electronic input is usually a digital word representing the location of the output beam. With this electrical input, the AOD/S deflects the laser beam to a specific point in the output plane. To address the next location, consideration must be given to the minimum fly back time, which is equal to the sum of the AOD/S aperture time (D/V_a) plus the electronics retrace time. In the third application, signal processing, an input RF signal drives the AOD/S amplifier, and no other electronics are required for the AOD/S.

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Optical Resolution/Time-Bandwidth Product

Optical deflectors, whether they are mechanical or solid state in nature, obey the same fundamental equations for resolution. Assume the deflector aperture is 'D'. The natural divergence of a collimated laser beam of width 'd' is equal to:

$$\Delta\phi = \frac{\lambda}{D}$$

If the total scan angle of the deflector is defined as Θ, the total number of resolvable spots is:

$$N = \frac{\theta}{\Delta\phi} = \frac{\theta \cdot D}{\lambda}$$

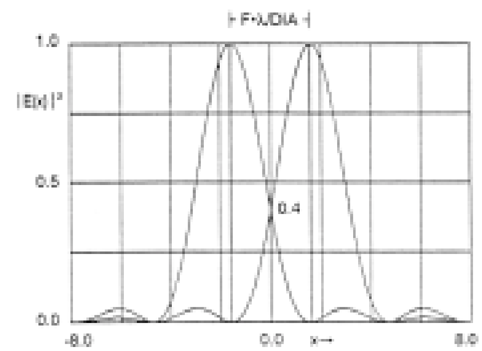
The above equation holds for all deflectors. Now, this equation is applied to the AOD/S. The total angular sweep, 'Θ' (theta), of the AOBD is:

$$\theta = \lambda \cdot \frac{\Delta F_a}{V_a}$$

where λ = the optical wavelength, ΔF_a = the acousto-optic bandwidth, and V_a = the acoustic velocity. Now substitute 'θ' into the resolution equation. Then,

$$N = \Delta F_a \cdot \frac{D}{V_a} = \Delta F_a \cdot \Delta T$$

Or in other words, the number of resolution elements is equal to the aperture time of the AOD/S multiplied by the acousto-optic bandwidth (commonly known as time bandwidth product). The value 'N' is obtained with uniform illumination of the aperture, 'D'. When the output of the deflector is focused to a spot, the neighboring spots are such that the peak of one intensity spot is on the first zero intensity of the neighbor. The two spots cross over at the 40% intensity points, and the spots profiles are shown in Figure 3. There are several factors that will degrade the total number of resolution elements, and these will be discussed below.



Scan Fly Back Time

Since it takes a finite time for the acoustic wave to fill the AOD/S optical aperture, the total number of resolvable spots is reduced to:

$$N = \{1 - \frac{\Delta T}{T}\} \cdot \{\Delta T \cdot \frac{\Delta F_a}{a}\}$$

Where 'T' is the total linear FM scan time, and a=1 (for a rectangular beam) or 'a'=1.34 (for a Gaussian beam).

Cylinder Lensing Effect

The linear FM modulation in the AOD/S produces a lensing effect in addition to deflection. The focal length (FL) is given by:0

$$FL = \frac{V_a^2}{\lambda \cdot \frac{df_a}{dt}}$$

Wher'dfa/dt' is the FM slope.

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High Resolution UV-VIS-IR Deflectors (1-Dimentional)

Optical Range 380 nm – 1600 nm

Short Access Time

Model Numbers	TED-130-60	TED-200-100	TED-320-200	TED-400-200
Laser Wavelength	543.5 nm	633 nm	633 nm	633 nm
Substrate	Tellurium Dioxide (TeO_2)			
Active Aperture	1.0 x 4.2 mm	1.0 x 4.2 mm	0.5 x 9.0 mm	0.5 x 5.0 mm
Frequency Range	100 – 160 MHz	150 – 250 MHz	220 – 420 MHz	300 – 500 MHz
Bandwidth (3dB)	60 MHz	100 MHz	200 MHz	200 MHz
Optical Transmission	95%	95%	95%	95%
Maximum Diffraction Efficiency	70%	70%	60%	50%
Access Time	1 μsec	1.0 μsec	2.0 μsec	1.0 μsec
Resolution	60 spots	100 spots	400 spots	200 spots
Deflection Angle	0.44 deg	0.8 deg	1.69 deg	1.69 deg
Acoustic Velocity	4.2E+3 m/sec	4.2E+3 m/sec	4.2E+3 m/sec	4.2E+3 m/sec
Maximum Electric Input Power	2 Watts	2 Watts	2 Watts	2 Watts
Input Impedance	50 Ohms	50 Ohms	50 Ohms	50 Ohms
V.S.W.R.	2.1:1	2.1:1	2.1:1	2.1:1
Optical Polarization	Circular	Linear	Linear	Linear
Case	C	A	B	A
Compatible RF Drivers	VFB-130-60-V-A-F2	VFB-200-100-V-A-F2	VFB-320-200-V-A-F2	VFB-400-100-V-A-F2

Long Access Time
λ = 488 nm

Model #	TED10-100-60-.488	TED20-100-60.488	TED30-75-60-.488
Time-Bandwidth Product	600	1200	1800
Center Frequency	100 MHz	100 MHz	100 MHz
3dB Bandwidth	60MHz	60 MHz	60 MHz
Access Time/Aperture	10μs/3x7 mm	20μs/3x14 mm	30μs/3x21 mm
Deflection Angle	2.5 deg.	2.5 deg.	2.5 deg.
Diffraction Efficiency	> 75 MHz %	>70 MHz %	> 65 MHz %
Acoustic Velocity	650 m/s	650 m/s	650 m/s
Compatible RF Driver	VFB-160-V-A-F1		

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λ = 532 nm

Model #	**TED10-100-50-.532**	**TED20-100-50-.532**	**TED30-100-50-.532**
Time-Bandwidth Product	500	1000	1500
Center Frequency	100 MHz	100 MHz	100 MHz
3dB Bandwidth	50MHz	50 MHz	50 MHz
Access Time/Aperture	10µs/3x7 mm	20µs/3x14 mm	30µs/3x21 mm
Deflection Angle	3 deg.	3 deg.	3 deg.
Diffraction Efficiency	> 70 MHz %	>70 MHz %	> 65 MHz %
Acoustic Velocity	660 m/s	660 m/s	660 m/s
Compatible RF Driver	VFB-100-50-V-A-F1		

λ = 633 nm

Model #	**TED10-75-50-.633**	**TED20-75-50-.633**	**TED30-75-50-.633**
Time-Bandwidth Product	500	1000	1500
Center Frequency	75 MHz	75 MHz	75 MHz
3dB Bandwidth	50MHz	50 MHz	50 MHz
Access Time/Aperture	10µs/3x7 mm	20µs/3x14 mm	30µs/3x21 mm
Deflection Angle	3 deg.	3 deg.	3 deg.
Diffraction Efficiency	> 75 MHz %	>70 MHz %	> 65 MHz %
Acoustic Velocity	660 m/s	660 m/s	660 m/s
Compatible RF Driver	VFB-75-50-V-A-F1		

λ = 800 nm

Model #	**TED10-60-40**	**TED20-60-40**	**TED30-60-40**
Time-Bandwidth Product	400	800	1200
Center Frequency	60 MHz	60 MHz	60 MHz
3dB Bandwidth	40MHz	40 MHz	40 MHz
Access Time/Aperture	10µs/3x7 mm	20µs/3x14 mm	30µs/3x21 mm
Deflection Angle	2 deg.	2 deg.	2 deg.
Diffraction Efficiency	> 70 MHz %	> 65 MHz %	> 60 MHz %
Acoustic Velocity	660 m/s	660 m/s	660 m/s
Compatible RF Driver	VFB-60-40-V-A-F1		

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λ = 1060 nm

Model #	**TED10-50-30-1.06**	**TED20-50-30-1.06**	**TED30-50-30-1.06**
Time-Bandwidth Product	300	600	900
Center Frequency	50 MHz	50 MHz	50 MHz
3dB Bandwidth	30MHz	30 MHz	30 MHz
Access Time/Aperture	10µs/3x7 mm	20µs/3x14 mm	30µs/3x21 mm
Deflection Angle	2.7 deg.	2.7 deg.	2.7 deg.
Diffraction Efficiency	> 75 MHz %	>70 MHz %	> 65 MHz %
Acoustic Velocity	660 m/s	660 m/s	660 m/s
Compatible RF Driver	VFB-50-30-V-A-F2		

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High Speed VIS-NIR Deflectors (1-Dimentional)

Optical Range

Model Numbers	GPD-250-100	GPD2-250-100	GPD-350-200
Laser Wavelength	633 nm	633 nm	633 nm
Substrate	Gallium Phosphide (GaP)		
Active Aperture	0.75 x 5.0 mm	0.75 x 13.0 mm	0.75 x 5.0 mm
Frequency Range	200 – 300 MHz	200 – 300 MHz	250 – 450 MHz
Bandwidth (3dB)	100 MHz	100 MHz	200 MHz
Optical Transmission	80%	80%	80%
Maximum Diffraction Efficiency	70%	40%	40%
Access Time	0.7 μsec	2.0 μsec	0.7 μsec
Resolution	70 spots	200 spots	140 spots
Deflection Angle	0.57 deg	0.57 deg	1.15 deg
Acoustic Velocity	6.31E+3 m/sec	6.31E+3 m/sec	6.31E+3 m/sec
Maximum Electric Input Power	1 Watt	1 Watt	1 Watt
Input Impedance	50 Ohms	50 Ohms	50 Ohms
V.S.W.R.	2.1:1	2.1:1	2.1:1
Optical Polarization	Linear	Linear	Linear
Case	A	B	A
Compatible RF Driver	VFB-250-100-V- A-F1	VFB-250-100-V-A-F1	VFB-350-250-V-A-F1

Model Numbers	GPD2-350-200	GPD-650-300	GPD2-650-300
Laser Wavelength	633 nm	633 nm	633 nm
Substrate	Gallium Phosphide (GaP)		
Active Aperture	0.75 x 13.0 mm	0.18 x 5.0 mm	0.18 x 13.0 mm
Frequency Range	250 – 450 MHz	500 – 800 MHz	500 – 800 MHz
Bandwidth (3dB)	200 MHz	300 MHz	300 MHz
Optical Transmission	80%	80%	80%
Maximum Diffraction Efficiency	35%	40%	30%
Access Time	2.0 μsec	0.7 μsec	2.0 μsec
Resolution	400 spots	210 spots	600 spots
Deflection Angle	1.15 deg	2.25 deg	2.25 deg
Acoustic Velocity	6.31E+3 m/sec	6.31E+3 m/sec	6.31E+3 m/sec
Maximum Electric Input Power	1 Watt	1 Watt	1 Watt
Input Impedance	50 Ohms	50 Ohms	50 Ohms
V.S.W.R.	2.1:1	2.1:1	2.1:1
Optical Polarization	Linear	Linear	Linear
Case	B	A	B
Compatible RF Driver	VFB-350-200-V-A-F1	VFB-650-300-V-A-F1	VFB-850-300-V-A-F1

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High Bandwidth VIS-IR Deflectors (.6-1.6 μm)

Model Numbers (Self Collimated Mode)	GPD-800-500-SC	GPD2-800-500-SC	GPD-800-500
Laser Wavelength	633 nm	633 nm	633 nm
Substrate	Gallium Phosphide (GaP)		
Active Aperture	0.18 x 4.2 mm	0.18 x 8.4 mm	0.076 x 5.0 mm
Frequency Range	550 – 1050 MHz	550 – 1050 MHz	550 – 1050 MHz
Bandwidth (3dB)	500 MHz	500 MHz	500 MHz
Optical Transmission	80%	80%	80%
Maximum Diffraction Efficiency	30%	25%	50%
Access Time	1.0 μsec	2.0 μsec	0.7 μsec
Resolution	500 spots	1000 spots	350 spots
Deflection Angle	4.3 deg	4.3 deg	2.9 deg
Acoustic Velocity	4.2E+3 m/sec	4.2E+3 m/sec	6.31E+3 m/sec
Maximum Electric Input Power	1 Watt	1 Watt	1 Watt
Input Impedance	50 Ohms	50 Ohms	50 Ohms
V.S.W.R.	2.1:1	2.1:1	2.1:1
Optical Polarization	Linear	Linear*	Linear
Case	A	B	A
Compatible RF Driver	VFB-800-500-V-A-F1		

- Polarization of the deflected beam is 90° shifted compared with the undeflected beam.

Model Numbers	GPD-1000-500	GPD-1500-1000
Laser Wavelength	633 nm	633 nm
Substrate	Gallium Phosphide (GaP)	
Active Aperture	0.076 x 7.0 mm	0.075 x 6.3 mm
Frequency Range	750 – 1250 MHz	1000 – 2000 MHz
Bandwidth (3dB)	500 MHz	1000 MHz
Optical Transmission	80%	80%
Maximum Diffraction Efficiency	20%	15-20%
Access Time	0.25 μsec	0.25 μsec
Resolution	500 spots	1000 spots
Deflection Angle	2.9 deg	5.7 deg
Acoustic Velocity	6.31E+3 m/sec	6.31E+3 m/sec
Maximum Electric Input Power	1 Watt	1 Watt
Input Impedance	50 Ohms	50 Ohms
V.S.W.R.	2.1:1	2.1:1
Optical Polarization	Linear	Linear
Case	A	A
Compatible RF Driver	VFB-100-500-V-A-F1	VFB-1500-1000-V-A-F1

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Model Numbers	**LND-2500-1000**	**LND-2500-1500**
Laser Wavelength	630 & 830 nm	630 & 830 nm
Substrate	Lithium Niobate ($LiNbO_3$)	
Active Aperture	0.075 x 3.4 mm	0.05 x 3.5 mm
Frequency Range	2000 – 3000 MHz	1750 – 3250 MHz
Bandwidth (3dB)	1000 MHz	1500 MHz
Optical Transmission	95%	95%
Maximum Diffraction Efficiency	10 - 15%	5%
Access Time	1.0 μsec	1.0 μsec
Resolution	1000 spots	1500 spots
Deflection Angle @630	10 deg	15 deg
Acoustic Velocity	3.415E+3 m/sec	3.415E+3 m/sec
Maximum Electric Input Power	0.25 Watts	0.25 Watts
Input Impedance	50 Ohms	50 Ohms
V.S.W.R.	2.5:1	2.5:1
Optical Polarization	Linear	Linear
Case	A	A

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High Speed NIR Deflectors

Optical Range (1000 nm – 2100 nm)

Model Numbers	**IPD-200-50**	**IPD-400-150**
Laser Wavelength	1150 nm	1150 nm
Substrate	Indium Phosphide (InP)	
Active Aperture	0.75 x 6.0 mm	0.75 x 6.0 mm
Frequency Range	175 – 225 MHz	325 – 475 MHz
Bandwidth (3dB)	50 MHz	150 MHz
Optical Transmission	90%	90%
Maximum Diffraction Efficiency	40%	35%
Access Time	1.0 μsec	1.0 μsec
Resolution	50 spots	150 spots
Deflection Angle	0.65 deg	1.95 deg
Acoustic Velocity	5.1E+3 m/sec	5.1E+3 m/sec
Maximum Electric Input Power	1 Watt	1 Watt
Input Impedance	50 Ohms	50 Ohms
V.S.W.R.	2.1:1	2.1:1
Optical Polarization	Linear	Linear
Case	A	A
Compatible RF Driver	VFB-200-50-V-A-F1	VFB-400-150-V-A-F1

Model Numbers	**IPD-600-200**	**IPD-1000-300**
Laser Wavelength	1150 nm	1150 nm
Substrate	Indium Phosphide (InP)	
Active Aperture	0.18 x 6.0 mm	0.076 x 6.0 mm
Frequency Range	500 – 700 MHz	850 – 1150 MHz
Bandwidth (3dB)	200 MHz	300 MHz
Optical Transmission	90%	90%
Maximum Diffraction Efficiency	30%	15%
Access Time	1.0 μsec	1.0 μsec
Resolution	200 spots	350 spots
Deflection Angle	2.6 deg	4.5 deg
Acoustic Velocity	5.1E+3 m/sec	5.1E+3 m/sec
Maximum Electric Input Power	1 Watt	1 Watt
Input Impedance	50 Ohms	50 Ohms
V.S.W.R.	2.1:1	2.1:1
Optical Polarization	Linear	Linear
Case	A	A
Compatible RF Driver	VFB-600-200-V-A-F1	VFB-1000-300-V-A-F1

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Multichannel VIS Deflectors

Model Numbers	**MGPD-300-200**	**MGPD-800-400**	**MGPD-800-500**
Laser Wavelength	633 nm	633 nm	633 nm
Substrate	Gallium Phosphide (GaP)		
Acoustic Mode	Longitudinal	Shear	Longitudinal
Active Aperture	1.0 x 13.0 mm	0.075 x 9.0 mm	0.075 x 7.0 mm
Center Frequency	300 MHz	800 MHz	800 MHz
Bandwidth (3dB)	200 MHz	400 MHz	500 MHz
Optical Transmission	80%	80%	80%
Maximum Diffraction Efficiency	30%	10%	30%
Time-Bandwidth Product	400	800	500
Time Aperture	2.0 μsec	2.0 μsec	1.0 μsec
Number of Channels (Please Specify when placing order)	8, 16, or 32	8, 16, or 32	8, 16, or 32
Center-Center Channel Spacing	2.0 mm	0.5 mm	0.5 mm
Channel Isolation	20 dB	20 dB	20 dB
Acoustic Velocity	6.31E+3 m/sec	4.2E+3 m/sec	6.31E+3 m/sec
Maximum Electric Input Power	1 Watt	1 Watt	1 Watt
Input Impedance	50 Ohms	50 Ohms	50 Ohms
V.S.W.R.	2.1:1	2.1:1	2.1:1
Optical Polarization	Linear	Linear	Linear
Case	Custom	Custom	Custom

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Multichannel VIS Deflectors

Model Numbers	MTED-70-40	MTED-80-30	MTED-300-200
Laser Wavelength	633 nm	633 nm	633 nm
Substrate	Tellurium Dioxide (TeO_2)		
Acoustic Mode	Shear	Longitudinal	Longitudinal
Active Aperture	1.0 x 12.0 mm	1.0 x 20.0 mm	1.0 x 10.0 mm
Center Frequency	70 MHz	80 MHz	300 MHz
Bandwidth (3dB)	40 MHz	30 MHz	200 MHz
Optical Transmission	>95%	>95%	>95%
Maximum Diffraction Efficiency	40%	70%	30%
Time-Bandwidth Product	720	141	400
Time Aperture	18.0 μsec	4.7 μsec	2.0 μsec
Number of Channels (Please Specify when placing order)	8, 16, or 32	8, 16, or 32	8, 16, or 32
Center-Center Channel Spacing	2.0 mm	2.5 mm	2.0 mm
Channel Isolation	25 dB	25 dB	25 dB
Acoustic Velocity	617 m/sec	4.2E+3 m/sec	4.2E+3 m/sec
Maximum Electric Input Power	1 Watt	1 Watt	1 Watt
Input Impedance	50 Ohms	50 Ohms	50 Ohms
V.S.W.R.	2.1:1	2.1:1	2.1:1
Optical Polarization	Circular	Linear	Linear
Case	Custom	Custom	Custom

Model Numbers	MTED-600-250	MTED-800-300
Laser Wavelength	633 nm	633 nm
Substrate	Tellurium Dioxide (TeO_2)	
Acoustic Mode	Longitudinal	Longitudinal
Active Aperture	0.18 x 5.0 mm	0.076 x 5.0 mm
Center Frequency	600 MHz	800 MHz
Bandwidth (3dB)	250 MHz	300 MHz
Optical Transmission	>95%	>95%
Maximum Diffraction Efficiency	25%	20%
Time-Bandwidth Product	250	300
Time Aperture	1.0 μsec	1.0 μsec
Number of Channels(Please Specify when placing order)	8, 16, or 32	8, 16, or 32
Center-Center Channel Spacing	0.5 mm	0.5 mm
Channel Isolation	25 dB	25 dB
Acoustic Velocity	4.2E+3 m/sec	4.2E+3 m/sec
Maximum Electric Input Power	1 Watt	1 Watt
Input Impedance	50 Ohms	50 Ohms
V.S.W.R.	2.1:1	2.1:1
Optical Polarization	Linear	Linear
Case	Custom	Custom

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Variable Frequency Drivers

General Specifications

Frequency Range	Corresponding to the AO Device Requirements
Tuning Voltage	0 – 10 V analog (-2 to +20 VDC no damage)
Frequency Accuracy	1% nom after 15 minute warm-up, constant temperature
Scanning Speed	50 micro sec from min to max frequency with step change in tuning voltage
Output Power	1-2 Watts (Power is optimized for peak efficiency with supplied A-O device)
Operating Power	110 - 220 VAC, 50-60 Hz
Enclosure	The unit will be packaged in a nominal 6.75 inch wide by 2.6 inch high by 8.3 inch deep instrument case. The rear panel heat sink increases depth to 10.5 inches max. Size is exclusive of connectors. A detachable AC line cord is provided.
Environmental	Nominal laboratory conditions: Max temperature +35 deg C. The unit is not sealed against moisture or condensing humidity.

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