



*G.T. Microwave
Inc.*

MICROWAVE INTEGRATED COMPONENTS

I & Q VECTOR MODULATORS

CUSTOM SUB-ASSEMBLIES

BP & QPSK MODULATOR

PHASE SHIFTERS

ATTENUATORS

SWITCHES



GENERAL COMPANY PROFILE

G.T. Microwave, Inc. is a designer and manufacturer of "State-of-the-art" Microwave Integrated Components for use in ground base, shipboard, airborne and space-based applications. G.T. Microwave has amassed a customer base by providing the Leading Edge in Performance of the highest quality products with on-time delivery. Our experiences in industry are demonstrated by our involvement in highly visible programs.

Optimized narrowband or broadband technology, G.T. Microwave manufactures its catalog or custom components to operate in the VHF, UHF and Microwave bands, a frequency range from 30 MHz to 26.5 GHz. These devices are offered in passive, analog, current or voltage controlled, linearized and digitally controlled programmable models, including temperature compensation.

G.T. Microwave designs and manufactures PIN diode based components that include, but shall not be limited to:

Switches	Attenuators	Phase Invariant Attenuators
Phase Shifters	Pulse Modulators	I & Q Vector Modulators
Bias Tees	Directional Couplers	Bi-Phase & QPSK Modulators
D.C. Blocks	Coupler Detectors	90 & 180 Degree Hybrids
Diode Limiters	Negative Gain Equalizers	Power Dividers/Combiners

In a very natural progression, G.T. Microwave services also include custom Sub-Assembly Integration of Passive, Control and Active type devices.

COMPANY FOUNDATION:

George Apsley and Tony Baliotis founded the company, hence G.T. Microwave. Its a merger between the engineering and manufacturing capability of George Apsley and a RF design consulting firm owned by Tony Baliotis.

G.T. Microwave was incorporated in the State of New Jersey in 1995. Tony Baliotis serves as the Director of Corporate, Sales and Marketing and George Apsley serves as the Director of Manufacturing and Engineering.

Company Founders:

From 1978, George had worked for 10 years as the Chief Engineer for KDI/Triangle. Coincidentally, Tony also worked at KDI/Triangle as the RF Design Manager. Thereafter, George worked for Waveline Solid State as the Chief Engineer and Tony as an independent RF consultant for various high profile companies.

Business Goal:

G.T. Microwave's goal is to establish a microwave component company that is built on growth and is "debt free". This created a successful long-term investment of a company that shall be very competitive. G.T. Microwave is controlled by the knowledge of the microwave industry rather than a bottom line. As a result, as it has since its inception, G.T. Microwave continues to operate at a profit and is on a successful growing path.

COMPANY FACILITIES:

G.T. Microwave is located on 2 Emery Avenue, Randolph, New Jersey USA. This facility is used for the sales, engineering, administration, and manufacturing of microwave devices.

Testing Capability:

G.T. Microwave supports a complete testing program, including Environmental Screening, a substantial portion that is performed on-site. Electrical RF performance testing is performed with both Wiltron and Hewlett Packard Vector Network Analyzers. Off-site environmental testing is performed locally at Bell Technologies, Associated Test Laboratories.

TECHNICAL APPROACH:

Microwave devices are an integration of discrete components to create an integral assembly. Our goal is to provide a component, which shall meet the requirements in a reliable and cost effective way. G.T. Microwave uses industry proven computer aided tools such as EEsos's Touchstone, Hewlett Packard's AppCad, Autodesk's AutoCad and Grant's Computer Aided Manufacturing in order to achieve the objective. To this end, G.T. Microwave has a cumulative engineering expertise.

Published Articles:

G.T. Microwave has a demonstrated and mature capability in the manufacturing of microwave devices. As a result, various publications have printed articles authored by G.T. Microwave's staff and are available upon request.

The product feature "A Broadband I & Q Vector Modulator" published by the Microwave Journal in the December 1996 issue has been included on page 7-1 in this catalog.

DESIGN SPECIFICS:

G.T Microwave manufactures its devices with an integrity that shall be capable of withstanding the requirements of MIL-E-16400, Range 1 (Shipboard) and MIL-E-5400, Class 2 (Airborne) environments that operate within the -55 to +85° C temperature range. Custom devices shall be designed with an integrity capable of withstanding the requirements set forth.

Quality Control:

Presently, our Quality Assurance Program is a certified ISO 9002 Manufacturing Quality System and work is well on its way to ISO9001/2000.

Chassis Construction:

Housings are machined from solid plates of aluminum alloy #6061-T6 and are silver plated per QQ-S-365. This minimizes the weight, contact resistance, provide corrosion resistance and solder ability for manufacturing.

Printed Circuit Boards (PCB):

The microwave PCB is fabricated from a Teflon based substrate material that provides optimal RF performance and temperature stability. This PCB is soldered down flat to the floor of the housing. The controller PCB is fabricated from a rigid epoxy glass material that provides excellent temperature stability. This PCB shall be fastened to steps that are machined in the housing. All PCB's are solder-coated .0003 thick minimum for corrosion resistance.

Sealing, Marking and Finishing:

To minimize any RF/EMI radiation, all plate seams, connector flanges and screw heads are sealed using a silver epoxy. The devices are legibly marked. And, to provide an environmental-resilient seal, external surfaces are finished using a suitable primer, Gray enamel paint, and followed by a continuous conformal coating.

CONCLUSION:

This General Company Profile has provided the reader with a company that stands mature in the design and manufacturing of microwave devices. We at G.T. Microwave, Inc. are ready to provide our full services and join the ranks of your proud suppliers.

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Custom or Sub-Assembly Integration – Consult Factory

<i>Power Dividers/Combiners</i>	<i>Video & Harmonic Filtering</i>
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<i>Directional Couplers & Detectors</i>	<i>Digital Signal Suppression</i>
<i>Negative/Positive Gain Equalizers</i>	<i>Modulated Sideband Suppression</i>
<i>Slope Generating Attenuators</i>	<i>Severe Environment</i>
<i>Varactor Diode Phase Shifters</i>	<i>Integrate MMIC & GaAs Amplifiers</i>
<i>Digital Delay Line Phase Shifters</i>	<i>New Product Development</i>
<i>Bias Tees & D.C. Blocks</i>	<i>Engineering Consulting Services</i>

PIN DIODE ABSORPTIVE ATTENUATORS

Monotonic Attenuation Performance Guaranteed

Part Numbering for pin diode ABSORPTIVE ATTENUATORS

CODE	MODEL
C	CURRENT CONTROL - ANALOG
V	VOLTAGE CONTROL - ANALOG
L	LINEARIZED VOLTAGE - ANALOG
P	DIGITALLY CONTROLLED ANALOG
D	DIGITAL SWITCHED PAD

CODE	TEMPERATURE COMPENSATION
N	0° C to +50° C
A	-10° C to +65° C
T	-55° C to +85° C
X	OPTIMIZED RANGE

SUFFIX DESIGNATOR	
CODE	DESCRIPTION
[] []	IF REQUIRED; THE FACTORY MAY ASSIGN A UNIQUE MODEL IDENTIFIER



CODE	TYPE
0	CUSTOM
3	32 dB
6	64 dB
8	80 dB

CODE	CENTER FREQUENCY
0	CLASSIFIED FREQUENCY
1	≤ 300 MHz - VHF
2	≤ 1 GHz - UHF
3	≤ 2 GHz - L
4	≤ 4 GHz - S
5	≤ 8 GHz - C
6	≤ 12.4 GHz - X
7	≤ 18 GHz - Ku
8	> 18 GHz - K

CODE	BANDWIDTH
0	≤ 5 %
1	≤ 10 %
2	≤ 20 %
3	≤ 30 %
4	≤ 40 %
5	≤ 50 %
6	> 50 %
7	C.W. FREQ.
8	≥ OCTAVE
9	MULTIOCTAVE

CODE	SWITCH SPEED & No of BITS
0	CUSTOM LOGIC
1	1 μSEC - 10
2	7 μSEC - 10
3	1 μSEC - 8
4	7 μSEC - 8
5	150 nSEC - 4
6	150 nSEC - 6
7	7 μSEC - ANAL
8	1 μSEC - ANAL

$$f_c = \frac{f_h + f_l}{2}$$

$$BW = \frac{(f_h - f_l) 100}{f_c}$$

G.T. Microwave inc. part numbers are composed by selecting the codes for TYPE and MODEL, then calculating CENTER FREQUENCY and BANDWIDTH to obtain the codes, selecting the code for temperature range and finally selecting the code for SWITCHING SPEED. If required, the factory may assign a unique model identifier. Use the examples to the right or consult a factory representative.

Current controlled attenuator, 32 dB attenuation, Frequency 5 GHz, Temp. 0° to 50° C, switching speed 7 μSEC

A3C-57N-7

Programmable 10 BIT attenuator, 80 dB attenuation, Frequency 2-18 GHz, Temp. -55° to 85° C, switching speed 1 μSEC

A8P-69T-1

Environmental Ratings for pin diode ABSORPTIVE ATTENUATORS

EXPOSURE	MIL-STD-202	TEST CONDITION
ALTITUDE	METHOD 105C	C
HUMIDITY	METHOD 106E	
THERMAL SHOCK	METHOD 107D	A
LIFE TEST	METHOD 108A	D

EXPOSURE	MIL-STD-202	TEST CONDITION
SINE VIBRATION	METHOD 204D	D
RANDOM VIBRATION	METHOD 214	11D 15 min/axis
MECHANICAL SHOCK	METHOD 213B	G
TERMINAL STRENGTH	METHOD 211A	A, 2 lbs

Life Time Integrity: G.T. Microwave Devices are designed to meet MIL-E-16400, Range 1 and MIL-E-5400, Class 2 environments. Operating temperature range: -55° to +85° C. MIL-STD-883 screening and hermetic sealing are available.

For higher environmental levels; consult factory

DIGITAL SWITCHED PAD PIN DIODE ABSORPTIVE ATTENUATORS

G.T. Microwave Features:

Frequency Ranges: From 250 MHz to 20 GHz any optimized bandwidth is available.

TTL Compatible Logic: Logic '1'/BIT = Value of Attenuation and all Logic '0' = Insertion Loss. Attenuators without TTL driver; +1VDC @ +60mA = Value set and all -1VDC @ -60mA = Insertion Loss. For options, consult factory.

High Speed Switching: Attenuators listed are measured from 50% TTL to 10%/90% RF. Faster switching speeds are available upon request.

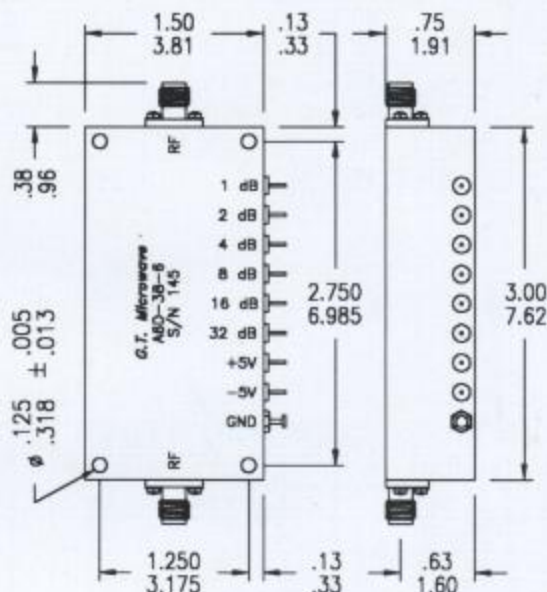
Low DC Power Consumption: Attenuators with TTL drivers require $\pm 5\text{VDC}$ @ $\pm 50\text{mA}$ /BIT.

High RF Power Handling: For power levels greater than listed, please consult factory.

Stable Attenuation: Variation vs Temperature listed is from -55° to 85°C .

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. DC/LOGIC connections are solder terminals. Call factory for optional connectors.

Matched Phase & Amplitude: Models listed are available matched unit to unit.



DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02 \pm .010$
 $\pm .05 \pm .025$

Electrical Specifications for DIGITAL SWITCHED PAD ABSORPTIVE ATTENUATORS

FREQUENCY RANGE GHz	ATTENUATION RANGE dB	FLATNESS Vs FREQUENCY \pm dB	INSERTION LOSS dB	SWITCHING SPEED nSEC	CONTROL INPUTS			V.S.W.R. MAX	INPUT POWER MAX
					dB & No.	LSB	MSB		
0.5-2.0	63	1.25 to 40 dB	4.0	150	1.0	32	6	1.6:1	+20 dBm
		1.50 to 63 dB							
2.0-8.0	63	1.50 to 40 dB	5.5	150	1.0	32	6	1.75:1	+20 dBm
		2.00 to 63 dB							
8.0-18.0	63	1.75 to 40 dB	8.0	150	1.0	32	6	2.0:1	+20 dBm
		2.50 to 63 dB							
2.0-18.0	63	2.25 to 40 dB	10.0	500	1.0	32	6	2.2:1	+20 dBm
		3.00 to 63 dB							

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

CURRENT CONTROLLED ATTENUATORS

G.T. Microwave Features:

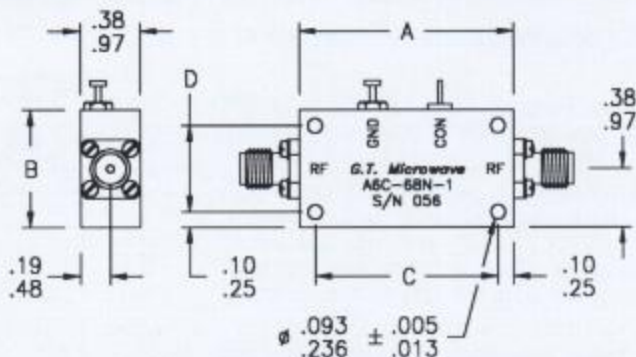
Frequency Ranges: From 250 MHz to 24 GHz any optimized bandwidth is available.

Current Controlled: 0 mA = Insertion Loss (zero attenuation) to +20 mA = Max Attenuation. For options, please consult factory.

High Speed Switching: Attenuators listed are measured from any set value to any value. Switching speeds upto 10 nSEC are available upon request.

Stable Attenuation: Variation vs Temperature from -55° to 85°C is typically ±10% of the set value.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. Control connections are solder terminals.



DIMENSIONS ARE EXPRESSED IN CM TOLERANCES ± .02 ± .010
± .05 ± .025

OUTLINE SIZE	'A' DIM. IN/CM	'B' DIM. IN/CM	'C' DIM. IN/CM	'D' DIM. IN/CM
1	3.00/7.62	2.50/6.35	2.750/6.985	2.250/5.715
2	1.80/4.57	1.70/4.32	1.600/4.064	1.500/3.810
3	1.35/3.43	.75/1.90	1.150/2.921	.550/1.397

See page 5 for Electrical Specifications

VOLTAGE CONTROLLED ATTENUATORS

G.T. Microwave Features:

Frequency Ranges: From 250 MHz to 24 GHz any optimized bandwidth is available.

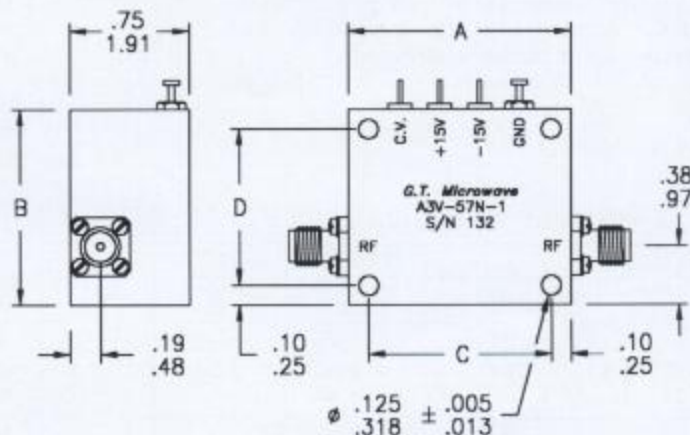
Voltage Controlled: 0 Volts = Insertion Loss (zero attenuation) to +10 Volts = Maximum attenuation. Linearized models upon request.

High Speed Switching: Attenuators listed are measured from any set value to any value. Switching speeds to 300 nSEC are available upon request.

Low DC Power Consumption: Attenuators require ±15VDC, ±1% Ⓢ ±50mA.

Stable Attenuation: Variation vs Temperature from -55° to 85°C is typically ±10% of the set value. Linearized models upon request.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. Control connections are solder terminals. Call factory for optional connectors.



DIMENSIONS ARE EXPRESSED IN CM TOLERANCES ± .02 ± .010
± .05 ± .025

OUTLINE SIZE	'A' DIM. IN/CM	'B' DIM. IN/CM	'C' DIM. IN/CM	'D' DIM. IN/CM
1	3.00/7.62	2.50/6.35	2.750/6.985	2.250/5.715
2	1.80/4.57	1.70/4.32	1.600/4.064	1.500/3.810
3	1.40/3.56	1.40/3.56	1.200/3.048	1.200/3.048

See page 5 for Electrical Specifications

DIGITALLY CONTROLLED ATTENUATORS

G.T. Microwave Features:

Frequency Ranges: From 250 MHz to 24 GHz any optimized bandwidth is available.

TTL Compatible Logic: G.T.M.I.'s binary logic Digital to Analog Converter with 8 inputs; Logic '1'/BIT = 256 discrete values of attenuation or all Logic '0' = Insertion Loss. Any resolution upto 12 Bits is available.

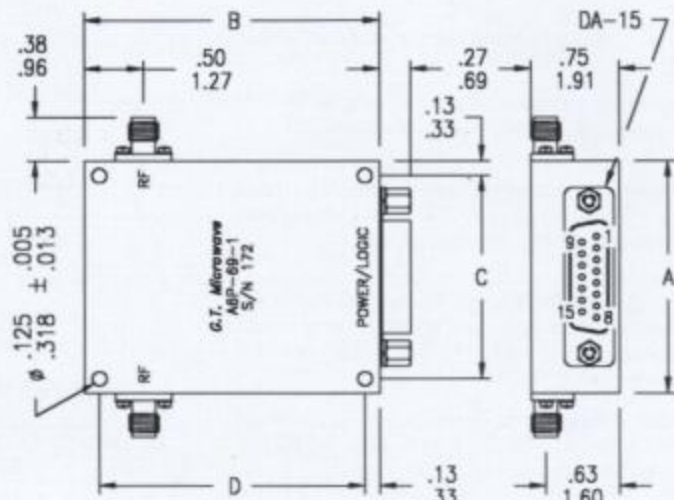
High Speed Switching: Attenuators listed are measured from any set value to any value. Switching speeds to 300 nSEC on request.

Low DC Power Consumption: Attenuators require $\pm 15\text{VDC}$, $\pm 1\%$ @ $+100/-50$ mA.

Stable Attenuation: Variation vs Temperature from -55° to 85°C is typically $\pm 10\%$ of the set value. Temperature Compensated models are $\pm 2\%$.

High RF Power Handling: For power levels greater than listed, please consult factory.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. Call factory for optional connectors.



DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02$ $\pm .010$
 $\pm .05$ $\pm .025$

SIZE	'A' DIM. IN/CM	'B' DIM. IN/CM	'C' DIM. IN/CM	'D' DIM. IN/CM
1	3.00/7.62	2.50/6.35	2.750/6.985	2.250/5.715
2 & 3	2.00/5.08	2.50/6.35	1.750/4.445	2.250/5.715

POWER/LOGIC Connections

No. of BITS	LOGIC PIN ASSIGNMENTS	+15V PIN	-15V PIN	GND PIN
8	L.S.B. @ 1 to M.S.B. @ 8	13	14	15
10	L.S.B. @ 1 to M.S.B. @ 10			

ALL UN-USED PINS HAVE NO INTERNAL CONNECTIONS

Electrical Specifications for - ALL - ANALOG ABSORPTIVE ATTENUATORS

FREQUENCY RANGE GHz	ATTENUATION dB	FLATNESS Vs FREQ. MAX	INSERTION LOSS dB	V.S.W.R. MAX	SWITCHING SPEED HARMONIC DISTORT. INPUT POWER	SWITCHING SPEED HARMONIC DISTORT. INPUT POWER	OUTLINE SIZE
0.5-2.0	32	± 1.75	2.50	1.8:1	7.0 μSEC MAX 50 dBc MAX +20 dBm MAX	1.0 μSEC MAX 30 dBc MAX +10 dBm MAX	1
	64	± 2.00					
	80	± 2.25					
2.0-8.0	32	± 2.00	2.50	1.9:1	7.0 μSEC MAX 50 dBc MAX +20 dBm MAX	1.0 μSEC MAX 35 dBc MAX +13 dBm MAX	2
	64	± 2.25					
	80	± 2.50					
6.0-18.0	32	± 2.00	3.25	1.9:1	7.0 μSEC MAX 50 dBc MAX +20 dBm MAX	1.0 μSEC MAX 35 dBc MAX +15 dBm MAX	3
	64	± 2.25					
	80	± 2.50	3.50	2.0:1			
2.0-18.0	32	± 2.50	4.50	2.1:1	7.0 μSEC MAX 50 dBc MAX +20 dBm MAX	1.0 μSEC MAX 35 dBc MAX +13 dBm MAX	2
	64	± 3.50					
	80	± 4.00	5.00				

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

DIGITALLY CONTROLLED PHASE SHIFTERS

G.T. Microwave Features:

Frequency Ranges: From 500 MHz to 24 GHz any optimized bandwidth is available.

TTL Compatible Logic: G.T.M.I.'s binary logic Digital to Analog Converter with 8 inputs; Logic '1'/BIT = 256 discrete phase shifts with a 1.4° Resolution (L.S.B.) or all Logic '0' = 0° Reference state. Any resolution upto 12 BITS is available.

Optional Models: Analog Voltage controlled or Switched Line Digital phase shifters are available, please consult factory.

High Speed Switching: Phase Shifters listed are measured from any set value to any value.

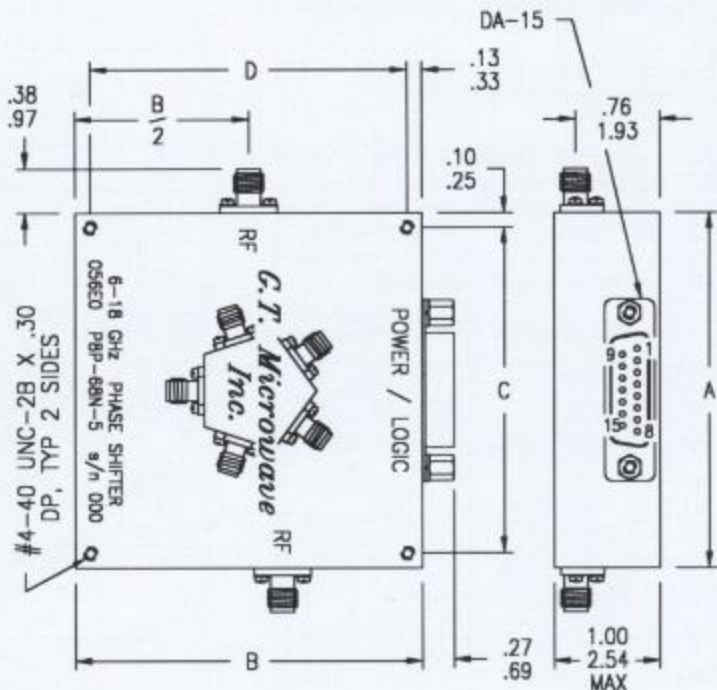
Low DC Power Consumption: Phase Shifters require $\pm 15\text{VDC}$, $\pm 100/-250\text{mA}$.

Stable Phase Shifts: Variation vs Temperature from -55° to 85°C is typically $\pm 0.2^\circ/\text{C}$ from set value. Temperature Compensated models are available upon request.

High RF Power Handling: For power levels greater than listed, please consult factory.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012.

Life Time Integrity: G.T.M.I.'s phase shifters are designed to meet MIL-E-16400, Range 1 and MIL-E-5400, Class 2 environments operating within the -55° to $+85^\circ\text{C}$ temperature range.



FOR SIZES SEE PAGE 7

DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02 \pm .010$
 $\pm .05 \pm .025$

POWER/LOGIC Connections

No. of BITS	LOGIC PIN ASSIGNMENTS	+15V PIN	-15V PIN	GND PIN
8	L.S.B. ① 1 to M.S.B. ① 8	13	14	15

ALL UN-USED PINS HAVE NO INTERNAL CONNECTIONS

Electrical Specifications for DIGITALLY CONTROLLED 360° PHASE SHIFTERS

G.T.M.I.'s MODEL NUMBER	FREQUENCY RANGE GHz	PHASE ERROR Vs FREQ. MAX	AMPLITUDE BALANCE MAX	INSERTION LOSS MAX	V.S.W.R. MAX	SWITCHING SPEED nSEC MAX	RF INPUT POWER dBm CW MAX	OUTLINE SIZE
P8P-39N-5	0.5-2.0	±10.0°	±1.50 dB	13.0 dB	1.70:1	500	+15 +20	1
P8P-38N-5	1.0-3.0			11.0 dB	1.80:1			2
P8P-48N-5	2.0-6.0			12.0 dB	1.90:1			3
P8P-68N-5	6.0-18.0	±22.0°	±2.00 dB	15.0 dB	2.20:1			4
P8P-84N-5	16.0-24.0	±22.0°	±3.00 dB	16.0 dB	2.20:1			

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

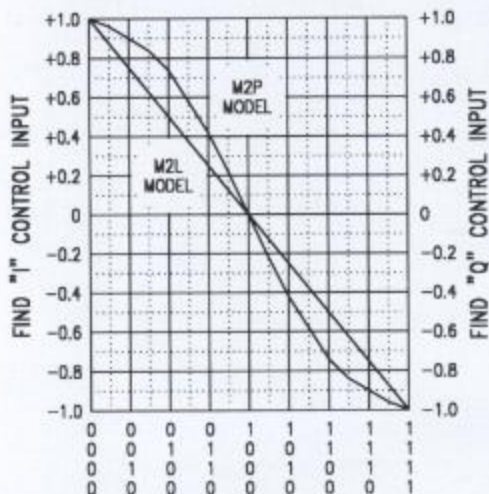
20 dB/360° I & Q VECTOR MODULATORS

G.T. Microwave Features:

Frequency Ranges: From 500 MHz to 24 GHz any optimized bandwidth is available.

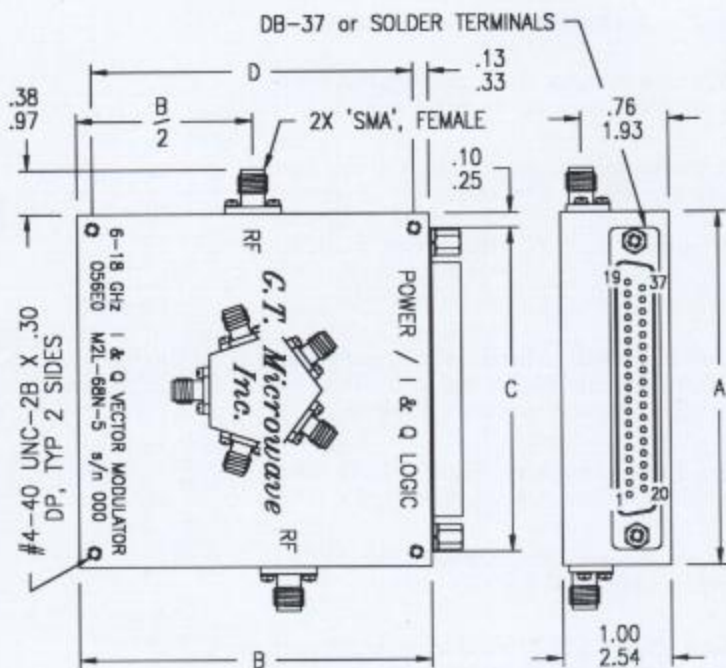
Digital or Voltage Control: I & Q vector modulators simultaneously control attenuation (dB) and phase shift (θ) by finding their $I = 10^{-(dB/20)} \cos \theta$ & $Q = 10^{-(dB/20)} \sin \theta$ on the chart below and submitting the results to the POWER/I & Q LOGIC connector.

OPTIONAL CONTROL INPUT SLOPES



Low DC Power Consumption: I & Q Vector Modulators require $\pm 15VDC$, $\pm 1\%$ @ $+150/-50mA$.

Stable Performance: Operating Temperature range is from -55° to $85^\circ C$.



DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02 \pm .010$
 $\pm .05 \pm .025$

FOR POWER/I & Q LOGIC CONNECTIONS SEE PAGE 7-3

SIZE	'A' DIM. IN/CM	'B' DIM. IN/CM	'C' DIM. IN/CM	'D' DIM. IN/CM
1	4.95/12.57	3.38/8.58	4.750/12.065	3.125/7.938
2	3.25/8.26	3.25/8.26	3.050/7.747	3.000/7.620
3	3.00/7.62	3.00/7.62	2.800/7.112	2.750/6.985
4	4.25/10.80	3.50/8.89	3.250/8.255	3.250/8.255

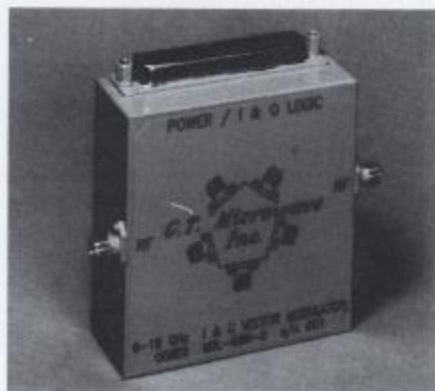
FOR HIGH DYNAMIC RANGE MODELS SEE PAGE 7-3

Electrical Specifications for 20 dB/360° I & Q VECTOR MODULATORS

G.T.M.I.'s MODEL NUMBER	FREQUENCY RANGE GHz	PHASE ERROR Vs FREQ. MAX	ATTENUATION ERROR MAX	INSERTION LOSS MAX	V.S.W.R. MAX	SWITCHING SPEED nSEC MAX	RF INPUT POWER dBm CW MAX	OUTLINE SIZE
M2L-39N-5	0.5-2.0	$\pm 10.0^\circ$	± 1.50 dB	13.0 dB	1.70:1	500	+15 +20	1
M2L-38N-5	1.0-3.0			12.0 dB	1.80:1			2
M2L-48N-5	2.0-6.0			12.0 dB	1.90:1			3
M2L-68N-5	6.0-18.0	$\pm 22.0^\circ$	± 2.00 dB	15.0 dB	2.20:1			4
M2L-84N-5	16.0-24.0	$\pm 22.0^\circ$	± 3.00 dB	16.0 dB	2.20:1			

2.0-18 GHz models have 15 dB/360° of dynamic range

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models



A BROADBAND I & Q VECTOR MODULATOR

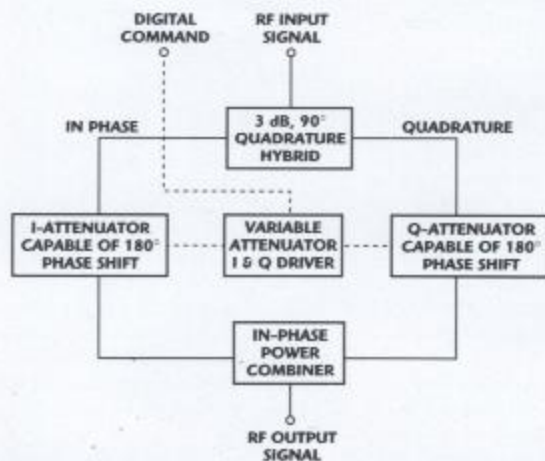
The function of an I & Q vector modulator is to simultaneously control the phase and amplitude characteristics in the processing of a microwave signal. This device will convert a signal to a desired vector location via a digital command.

The theory of operation is to divide the input signal into two equal signals 90° apart, I (in-phase) and Q (quadrature), which allows the magnitude of each signal to be relocated along its vector's axis. The two signals are then combined. In accordance with the Pythagorean theorem, the sum of the vectors produces the resultant output signal.

THE MODULATOR DESCRIPTION

The circuit for an I & Q vector modulator consists of a 3 dB, 90° quadrature hybrid; two variable attenuators capable of a 180° phase shift; an in-phase power combiner; and drive circuits to control the variable attenuators, as shown in **Figure 1**. The device's key component is the 3 dB, 90° quadrature hybrid that is used nine times in a vector modulator. The input

Fig. 1 The I & Q vector modulator's block diagram.



signal is processed by the first hybrid, which divides the amplitude equally, applies a 90° phase shift to the quadrature path and isolates the two signals. This process places the I & Q vectors on their respective

axes. The remaining hybrids are used in the variable attenuators in the I & Q channels. Each attenuator controls the magnitude with a 180° phase shift capability, allowing four-quadrant operation, as shown in **Figure 2**. The vector modulator's in-phase power combiner combines the signals in vector addition to the output.

CIRCUIT TOPOLOGY

In the RF design of a vector modulator the preferred medium is microstrip. However, traditional hybrids are designed in stripline. Whether incorporating the hybrid as part of the circuitry or as a discrete hybrid used in a microstrip configuration, the result is that microwave fields of propagation are excited. This result creates a discontinuity within the transmission line of the device. Techniques can be employed to minimize the discontinuity, but with nine four-port hybrids, this unwanted condition occurs directly or indirectly 36 times. To this end, changing media alters

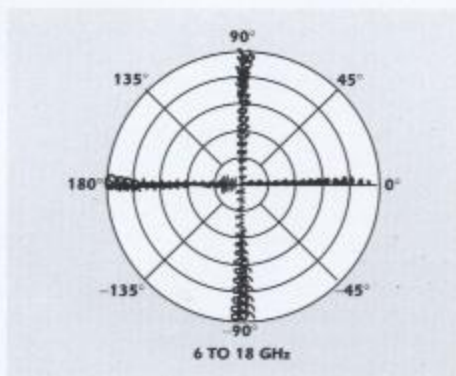
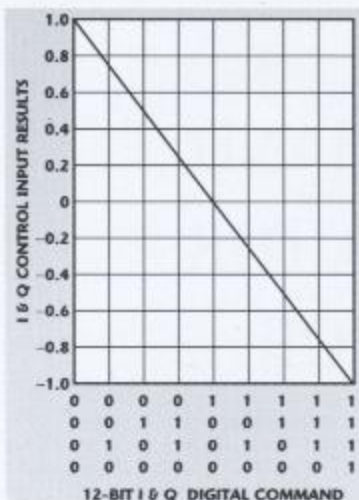


Fig. 2 Independent quad operation using five-bit resolution.

PRODUCT FEATURE



▲ Fig. 3 The control input slope characteristic.

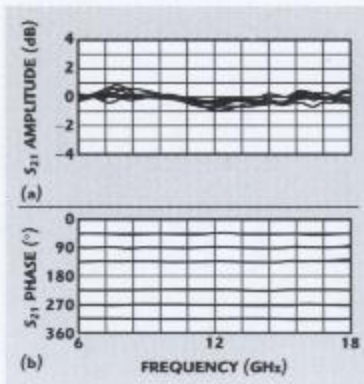
fringing fields, thus creating adverse effects and degrading performance.

To eliminate the 36 discontinuities, hybrids have been developed in microstrip. In a stripline hybrid, tuning is performed between measurements because the hybrid's circuitry is not accessible. Microstrip hybrids allow access to the circuitry while being measured, providing a more precise tuning capability. This technique yields an improvement in optimization and performance. The new microstrip hybrid exhibits a four-to-one bandwidth with an amplitude balance of ± 0.5 dB, a phase balance of $\pm 2^\circ$, an isolation of 25 dB (min) and an SWR of 1.3 (max).

OTHER DESIGN CONSIDERATIONS

With the transmission problems eliminated by the entire microwave circuit topology configured in microstrip, other design considerations were incorporated. The type of diode used in the circuit is an important design consideration. The use of chip diodes with a ribbon lead in a shunt configuration has drawbacks. In a high frequency broadband application, the inductance of a ribbon lead affects the attenuation and phase adversely. A beam lead diode installed using a proprietary technique reduces the series inductance and provides an improvement in performance.

To minimize adverse effects from biasing, the bias networks are placed as far as possible from the direct signal paths. The transmission line



▲ Fig. 4 Forty-five degree phase steps with zero amplitude; (a) amplitude and (b) phase.

length between adjacent hybrids is zero in the I & Q channels for optimal broadband performance.

THE DIGITAL CONTROL

Even with the described improvements in the vector modulator's microwave performance, it is the control circuitry that provides the final accuracy for the overall device. The digitally controlled section of the vector modulator is designed as two independent I & Q drivers. Each driver has a resolution capability of 64 KB to control and compensate the device. The two drivers will provide any control input slope characteristic desired. The optimal performance values are stored in the driver's electrically erasable programmable read-only memory (EEPROM), ready to be commanded from the external I and Q digital control input.

The control input slope characteristic is accomplished using a computer with I/O and IEEE controller cards, a proprietary computer program and a vector network analyzer. The computer's I/O port sets the external control input for I or Q, then ramps each driver along the I & Q vectors using another I/O port to an internal control input. While ramping the drivers the vector network analyzer measures each step and sends the data to the computer via the IEEE bus. The optimal performance is calculated by the computer, which programs the driver's EEPROMs for the required control input slope.

For the control input slope characteristic of the I & Q channels to be linear with output voltage, as shown in Figure 3, the computer uses

attenuation (dB) =

$$20 \log \left(\frac{\text{input count}}{2048} \right)$$

for an input count from 0 to 2048 and attenuation (dB) =

$$20 \log \left(\frac{4095 - \text{input count}}{2048} \right)$$

for an input count from 2049 to 4095.

I & Q VECTOR MODULATOR OPERATION

Operating an I & Q vector modulator for simultaneous control of attenuation and phase shift is accomplished by finding the vector's respective I and Q components using

$$I = 10^{-(X/20)} \cos \theta$$

$$Q = 10^{-(X/20)} \sin \theta$$

where

X = desired attenuation in dB

θ = desired phase shift in degrees

The I and Q results are submitted to the control input connector as commands, expressed as

$$I \text{ digital count} = 2048(1 - I)$$

$$Q \text{ digital count} = 2048(1 - Q)$$

For example, for a desired output of -3.0 dB of attenuation and 45 degrees of phase shift,

$$I = (0.707)(0.707) = 0.5$$

$$Q = (0.707)(0.707) = 0.5$$

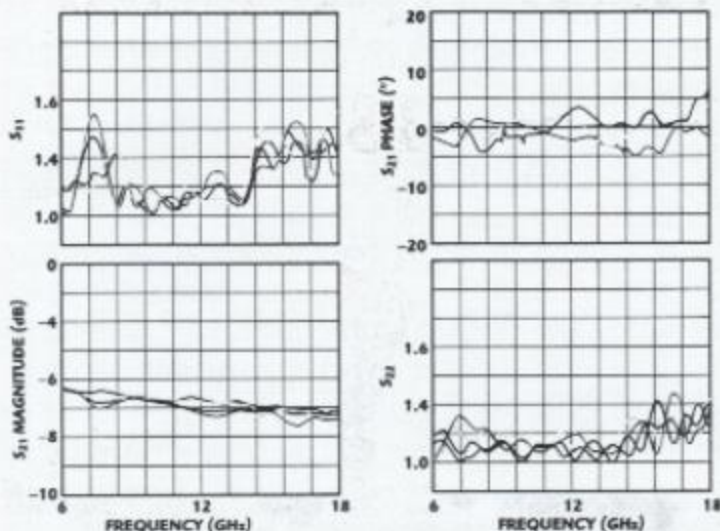
The resultant commands to the digital control input would be

$$I \text{ digital count} = 2048(1 - 0.5) = 1024$$

$$Q \text{ digital count} = 2048(1 - 0.5) = 1024$$

The vector modulator example is optimized over a 3:1 bandwidth from 6 to 18 GHz with 20 dB of attenuation and 360° of phase shift. The envelope conforms in form, fit and function to industry-standard packaging. Using two independent test laboratories to verify results, the test data in Figure 4 show the amplitude and

PRODUCT FEATURE

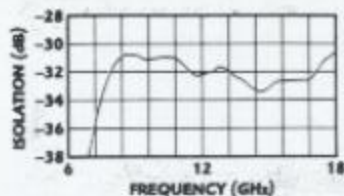


▲ Fig. 5 Phase states for 0, 90°, 180° and 270° at 0 dB amplitude.

phase S_{21} data resulting from successive 45° phase steps. Figure 5 shows S-parameter data for 0, 90°, 180° and 270° phase states at 0 dB amplitude. Figure 6 shows the I & Q isolation.

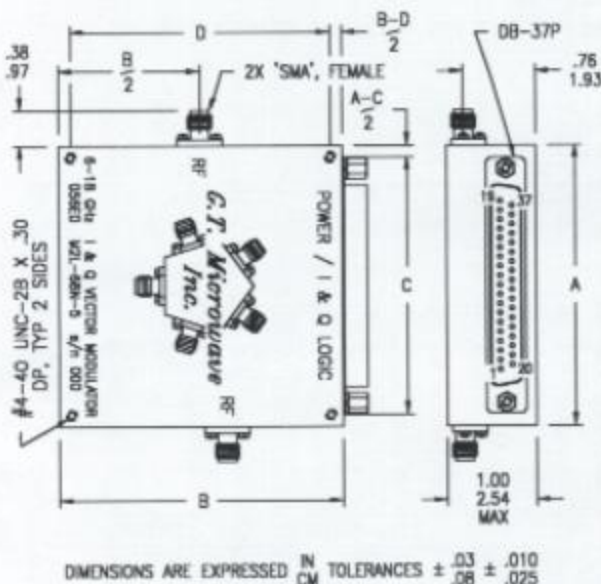
CONCLUSION

This technology applies to a variety of products including biphasic and quadrature phase-shift keying modulators, vector modulators, phase



▲ Fig. 6 The I & Q isolation.

shifters and phase-free attenuators. The models are offered with options that include digital control with up to 64 KB of resolution, linearized or with any desired control input slope characteristic; narrowband optimized performance; temperature compensation; video filtering; and subassembly integration capabilities. These new components provide improved performance at a lower cost to solve tomorrow's sophisticated modulation requirements.



DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .03$ $\pm .010$ $\pm .08$ $\pm .025$

POWER/LOGIC CONNECTIONS

PIN	FUNCTION	PIN	FUNCTION
1	I-5	20	I-4
2	I-6	21	I-7
3	I-8	22	I-3
4	I-9	23	I-2
5	I-10	24	I-1 (LSB)
6	I-11	25	I-12 (MSB)
7	N/C	26	N/C
8	+15V @ 150mA	27	N/C
9	GND	28	GND
10	GND	29	N/C
11	-15V @ 50mA	30	N/C
12	Q-3	31	N/C
13	Q-2	32	Q-4
14	Q-1 (LSB)	33	N/C
15	Q-5	34	N/C
16	Q-6	35	Q-12 (MSB)
17	Q-7	36	Q-11
18	Q-8	37	Q-10
19	Q-9		

ALL UN-USED PINS HAVE NO INTERNAL CONNECTIONS

Specifications for I & Q Vector Modulators with 60 dB/360° dynamic range

MODEL NUMBER	FREQUENCY RANGE GHz	PHASE ERROR MAX	AMPLITUDE ERROR dB MAX	INSERTION LOSS MAX	V.S.W.R. MAX	SWITCHING SPEED nSEC MAX	RF POWER + dBm CW/MAX	'A' DIMENSION IN/CM	'B' DIMENSION IN/CM	'C' DIMENSION IN/CM	'D' DIMENSION IN/CM
MZL-48N-SHD	2.0-6.0	±15.0°	±2.00	14.0 dB	1.80:1	500	15/30	5.50/13.97	3.25/8.26	5.250/13.34	3.050/7.75
MZL-58N-SHD	4.0-12.0			15.0 dB	1.80:1			4.75/12.07	3.25/8.26	4.500/11.43	3.000/7.62
MZL-68N-SHD	6.0-18.0	17.0 dB	2.00:1	3.25/8.26	3.00/7.62			3.000/7.62	2.750/6.99		
MZL-84N-SHD	16.0-24.0	±22.0°	±2.50	20.0 dB	2.20:1			3.25/8.26	3.00/7.62	3.000/7.62	2.750/6.99

15-24 GHz models have 40 dB/360° of dynamic range

For a substantial improvement in performance, ask for OPTIMIZED NARROWBAND models

PIN DIODE SWITCHES

Part Numbering for REFLECTIVE and ABSORPTIVE pin diode SWITCHES

REFLECTIVE MODELS			ABSORPTIVE MODELS		
CODE	CONTROL	ISOLATION	CODE	CONTROL	ISOLATION
A	TTL DRIVER	> 30 dB	L	TTL DRIVER	> 30 dB
B		> 45 dB	M		> 45 dB
C		> 60 dB	N		> 60 dB
D		> 80 dB	P		> 80 dB
E	NO DRIVER	> 30 dB	R	NO DRIVER	> 30 dB
F		> 45 dB	T		> 45 dB
G		> 60 dB	W		> 60 dB
H		> 80 dB	X		> 80 dB

SUFFIX DESIGNATOR	
CODE	DESCRIPTION
[] []	IF REQUIRED; THE FACTORY MAY ASSIGN A UNIQUE MODEL IDENTIFIER



CODE	TYPE
0	DPDT
1	SP1T
2	SP2T
3	SP3T
4	SP4T
5	SP5T
6	SP6T
7	SP7T
8	SP8T
9	SPMT

CODE	CENTER FREQUENCY
0	CLASSIFIED FREQUENCY
1	≤ 300 MHz - VHF
2	≤ 1 GHz - UHF
3	≤ 2 GHz - L
4	≤ 4 GHz - S
5	≤ 8 GHz - C
6	≤ 12.4 GHz - X
7	≤ 18 GHz - Ku
8	> 18 GHz - K

CODE	BANDWIDTH
0	≤ 5 %
1	≤ 10 %
2	≤ 20 %
3	≤ 30 %
4	≤ 40 %
5	≤ 50 %
6	> 50 %
7	C.W. FREQ.
8	≥ OCTAVE
9	MULTIOCTAVE

CODE	SWITCH SPEED
0	CUSTOM LOGIC
1	< 1 μSEC
2	< 100 nSEC
3	< 30 nSEC

$$f_c = \frac{f_h + f_l}{2}$$

$$BW = \frac{(f_h - f_l) 100}{f_c}$$

G.T. Microwave, Inc. part numbers are composed by selecting the codes for TYPE and MODEL, then calculating CENTER FREQUENCY and BANDWIDTH to obtain the codes and finally selecting the code for SWITCHING SPEED. If required, the factory may assign a unique model identifier. Use the examples to the right or consult a factory representative.

Switch, SP2T, Absorptive with 60 dB Isolation, Frequency range 2-4 GHz and 100 nSEC switching speed with TTL driver

S2N-48-2

Switch, SP8T, Absorptive with 80 dB Isolation, Frequency range 2-18 GHz and 30 nSEC switching speed with TTL driver

S8P-69-3

Environmental Ratings for PIN diode SWITCHES

EXPOSURE	MIL-STD-202	TEST CONDITION
ALTITUDE	METHOD 105C	C
HUMIDITY	METHOD 106E	
THERMAL SHOCK	METHOD 107D	A
LIFE TEST	METHOD 108A	D

EXPOSURE	MIL-STD-202	TEST CONDITION
SINE VIBRATION	METHOD 204D	D
RANDOM VIBRATION	METHOD 214	11D 15 min/axis
MECHANICAL SHOCK	METHOD 213B	G
TERMINAL STRENGTH	METHOD 211A	A, 2 lbs

Life Time Integrity: G.T. Microwave Devices are designed to meet MIL-E-16400, Range 1 and MIL-E-5400, Class 2 environments. Operating temperature range: -55° to +85° C. MIL-STD-883 screening and hermetic sealing are available.

For higher environmental levels; consult factory

PIN DIODE SWITCHES - SP1T

G.T. Microwave Features:

Frequency Ranges: From 100 MHz to 24 GHz any optimized bandwidth is available.

TTL Compatible Logic: Logic '0' = Isolation and Logic '1' = Insertion Loss. For switches without TTL driver; +1VDC @ +50mA = Isolation and -1VDC @ -50mA = Insertion Loss. For logic options, please consult factory.

High Speed Switching: Switches listed are measured from 50% TTL to 10%/90% RF.

Low DC Power Consumption: Switches with TTL drivers require $\pm 5VDC$ @ $\pm 50mA$.

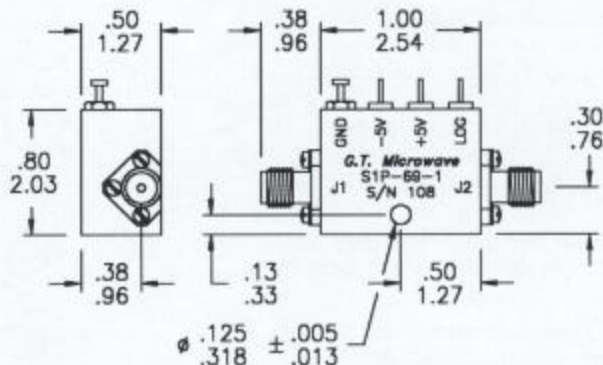
High RF Power Handling: For power levels greater than listed, please consult factory.

Absorptive Switches: On these models the J1 port is NON-REFLECTIVE.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. DC/LOGIC connections are solder terminals. Call factory for optional connectors.

Matched Phase & Amplitude: Models listed can be matched unit to unit. Please consult factory.

Actual Size Shown



SP1T Switch Outline Drawing

DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02 \pm .010$
 $\pm .05 \pm .025$

Electrical Specifications for REFLECTIVE and ABSORPTIVE switches - SP1T

FREQ. RANGE GHz	ISOLATION dB	INSERTION LOSS dB & SWITCHING SPEED REFL		ABSP μ SEC	INSERTION LOSS dB & SWITCHING SPEED REFL		ABSP nSEC	INSERTION LOSS dB & SWITCHING SPEED REFL		ABSP nSEC	V.S.W.R. MAX	INPUT POWER WATTS	
		REFL	ABSP		REFL	ABSP		REFL	ABSP			TYP	MAX
0.5-2.0	30	0.4	0.8	1.0	0.6	1.0	100	0.7	1.1	30	1.4:1	0.1	1.0
	60	0.6	1.0		0.8	1.2		0.9	1.3				
	80	0.7	1.1		0.9	1.3		1.0	1.4				
2.0-8.0	30	0.8	1.2	1.0	1.0	1.4	100	1.1	1.5	30	1.6:1	0.2	1.0
	60	0.9	1.3		1.1	1.5		1.2	1.6				
	80	1.0	1.4		1.2	1.6		1.3	1.7				
6.0-18.0	30	1.6	2.0	1.0	1.8	2.2	100	1.9	2.3	30	2.0:1	0.2	1.0
	60	1.8	2.2		2.0	2.4		2.1	2.5				
	80	2.0	2.4		2.2	2.6		2.3	2.7				
2.0-18.0	30	1.7	2.1	1.0	1.9	2.3	100	2.0	2.4	30	2.0:1	0.2	1.0
	60	1.9	2.3		2.1	2.5		2.2	2.6				
	80	2.1	2.5		2.3	2.7		2.4	2.8				

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

PIN DIODE SWITCHES - SP2T

G.T. Microwave Features:

Frequency Ranges: From 100 MHz to 24 GHz any optimized bandwidth is available.

TTL Compatible Logic: Logic '1' = Low Loss J1-J3 and Logic '0' = Low Loss J1-J2. Switches without TTL driver; +1VDC @ +50mA = Isolation and -1VDC @ -50mA = Insertion Loss. For logic options, please consult factory.

High Speed Switching: Switches listed are measured from 50% TTL to 10%/90% RF.

Low DC Power Consumption: Switches with TTL drivers require $\pm 5VDC$ @ $\pm 50mA$.

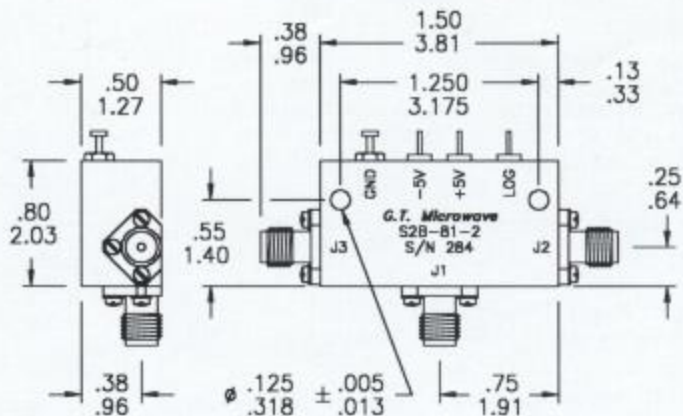
High RF Power Handling: For power levels greater than listed, please consult factory.

Absorptive Switches: On these models the J2 & J3 ports are NON-REFLECTIVE.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. DC/LOGIC connections are solder terminals. Call factory for optional connectors.

Matched Phase & Amplitude: Models listed are available with matched ports. Please consult factory.

Actual Size Shown



SP2T Switch Outline Drawing

DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02 \pm .010$
 $\pm .05 \pm .025$

Electrical Specifications for REFLECTIVE and ABSORPTIVE switches - SP2T

FREQ. RANGE GHz	ISOLATION dB	INSERTION LOSS dB & SWITCHING SPEED REFL ABSP μ SEC		1.0	INSERTION LOSS dB & SWITCHING SPEED REFL ABSP nSEC		100	INSERTION LOSS dB & SWITCHING SPEED REFL ABSP nSEC		30	V.S.W.R. MAX	INPUT POWER WATTS TYP MAX	
		0.45	0.85		0.65	1.05		0.75	1.15			0.1	1.0
0.5-2.0	30	0.45	0.85	1.0	0.65	1.05	100	0.75	1.15	30	1.4:1	0.1	1.0
	60	0.65	1.05		0.85	1.25		0.95	1.35				
	80	0.75	1.15		0.95	1.35		1.05	1.45				
2.0-8.0	30	0.85	1.25	1.0	1.05	1.45	100	1.15	1.55	30	1.6:1	0.2	1.0
	60	1.0	1.4		1.2	1.6		1.3	1.7				
	80	1.1	1.5		1.3	1.7		1.4	1.8				
6.0-18.0	30	1.8	2.2	1.0	2.0	2.4	100	2.1	2.5	30	1.8:1	0.2	1.0
	60	2.0	2.4		2.2	2.6		2.3	2.7				
	80	2.2	2.6		2.4	2.8		2.5	2.9		2.0:1		
2.0-18.0	30	1.9	2.3	1.0	2.1	2.5	100	2.2	2.6	30	2.0:1	0.2	1.0
	60	2.1	2.5		2.3	2.7		2.4	2.8				
	80	2.3	2.7		2.5	2.9		2.6	3.0				

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

PIN DIODE SWITCHES - SP3T

G.T. Microwave Features:

Frequency Ranges: From 100 MHz to 24 GHz any optimized bandwidth is available.

TTL Compatible Logic: Logic '1' = Isolation and Logic '0' = Insertion Loss. For switches without TTL driver; +1VDC @ +50mA = Isolation and -1VDC @ -50mA = Insertion Loss. For logic options, please consult factory.

High Speed Switching: Switches listed are measured from 50% TTL to 10%/90% RF.

Low DC Power Consumption: Switches with TTL drivers require ± 5 VDC @ +100/-60mA.

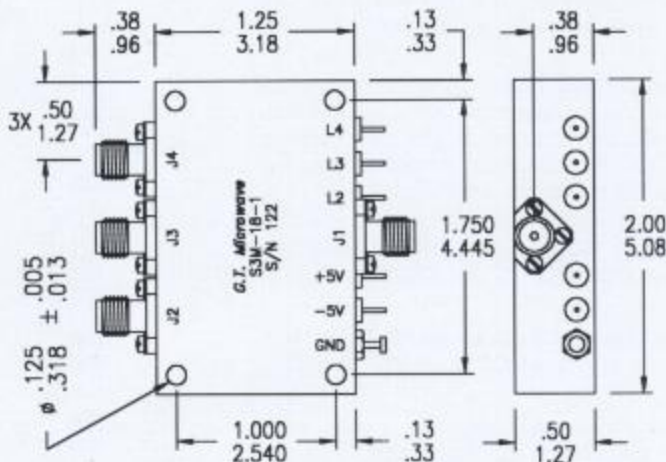
High RF Power Handling: For power levels greater than listed, please consult factory.

Absorptive Switches: On these models the J2 - J4 ports are NON-REFLECTIVE.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. DC/LOGIC connections are solder terminals. Call factory for optional connectors.

Matched Phase & Amplitude: Models listed are available with matched ports. Please consult factory.

Actual Size Shown



SP3T Switch Outline Drawing

DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02 \pm .010$
 $\pm .05 \pm .025$

Electrical Specifications for REFLECTIVE and ABSORPTIVE switches - SP3T

FREQ. RANGE GHz	ISOLATION dB	INSERTION LOSS dB & SWITCHING SPEED REFL ABSP μ SEC			INSERTION LOSS dB & SWITCHING SPEED REFL ABSP nSEC			INSERTION LOSS dB & SWITCHING SPEED REFL ABSP nSEC		V.S.W.R. MAX	INPUT POWER WATTS TYP MAX		
0.5-2.0	30	0.5	0.9	1.0	0.7	1.1	100	0.8	1.2	30	1.5:1	0.1	1.0
	60	0.7	1.1		0.9	1.3		1.0	1.4				
	80	0.8	1.2		1.0	1.4		1.1	1.5				
2.0-8.0	30	0.9	1.3	1.0	1.1	1.5	100	1.2	1.6	30	1.7:1	0.2	1.0
	60	1.1	1.5		1.3	1.7		1.4	1.8				
	80	1.2	1.6		1.4	1.8		1.5	1.9				
6.0-18.0	30	1.95	2.35	1.0	2.15	2.55	100	2.25	2.65	30	2.0:1	0.2	1.0
	60	2.15	2.55		2.35	2.75		2.45	2.85				
	80	2.35	2.75		2.55	2.95		2.65	3.05				
2.0-18.0	30	2.05	2.45	1.0	2.25	2.65	100	2.35	2.75	30	2.0:1	0.2	1.0
	60	2.25	2.65		2.45	2.85		2.55	2.95				
	80	2.45	2.85		2.65	3.05		2.75	3.15				

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

PIN DIODE SWITCHES - SP4T

G.T. Microwave Features:

Frequency Ranges: From 100 MHz to 24 GHz any optimized bandwidth is available.

TTL Compatible Logic: Logic '1' = Isolation and Logic '0' = Insertion Loss. For switches without TTL driver; +1VDC @ +50mA = Isolation and -1VDC @ -50mA = Insertion Loss. For logic options, please consult factory.

High Speed Switching: Switches listed are measured from 50% TTL to 10%/90% RF.

Low DC Power Consumption: Switches with TTL drivers require ±5VDC @ +150/-65mA.

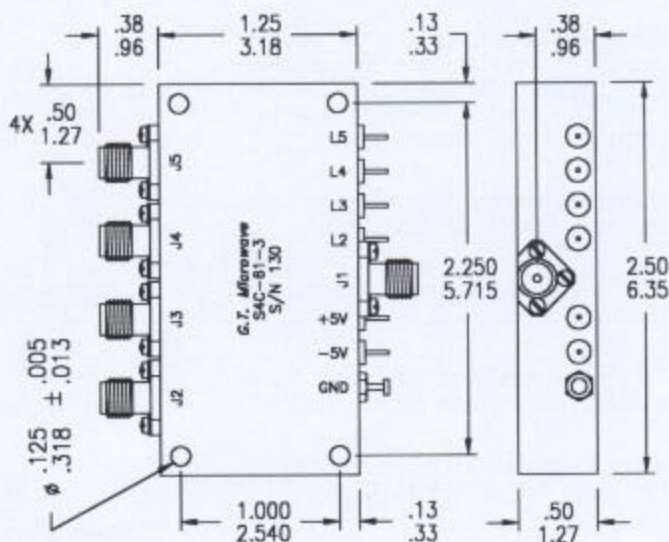
High RF Power Handling: For power levels greater than listed, please consult factory.

Absorptive Switches: On these models the J2 - J5 ports are NON-REFLECTIVE.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. DC/LOGIC connections are solder terminals. Call factory for optional connectors.

Matched Phase & Amplitude: Models listed are available with matched ports. Please consult factory.

Actual Size Shown



SP4T Switch Outline Drawing

DIMENSIONS ARE EXPRESSED IN CM TOLERANCES ± .02 ± .010
± .05 ± .025

Electrical Specifications for REFLECTIVE and ABSORPTIVE switches - SP4T

FREQ. RANGE GHz	ISOLATION dB	INSERTION LOSS dB & SWITCHING SPEED REFL ABSP μSEC			INSERTION LOSS dB & SWITCHING SPEED REFL ABSP nSEC			INSERTION LOSS dB & SWITCHING SPEED REFL ABSP nSEC		V.S.W.R. MAX	INPUT POWER WATTS TYP MAX		
		REFL	ABSP	μSEC	REFL	ABSP	nSEC	REFL	ABSP		nSEC		
0.5-2.0	30	0.55	0.95	1.0	0.75	1.15	100	0.85	1.25	30	1.5:1	0.1	1.0
	60	0.75	1.15		0.95	1.35		1.05	1.45				
	80	0.85	1.25		1.05	1.45		1.15	1.55				
2.0-8.0	30	0.95	1.35	1.0	1.15	1.55	100	1.25	1.65	30	1.7:1	0.2	1.0
	60	1.2	1.6		1.4	1.8		1.5	1.9				
	80	1.3	1.7		1.5	1.9		1.6	2.0				
6.0-18.0	30	2.1	2.5	1.0	2.3	2.7	100	2.4	2.8	30	2.0:1	0.2	1.0
	60	2.3	2.7		2.5	2.9		2.6	3.0				
	80	2.5	2.9		2.7	3.1		2.8	3.2				
2.0-18.0	30	2.2	2.6	1.0	2.4	2.8	100	2.5	2.9	30	2.0:1	0.2	1.0
	60	2.4	2.8		2.6	3.0		2.7	3.1				
	80	2.6	3.0		2.8	3.2		2.9	3.3				

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

PIN DIODE SWITCHES - SP5T

G.T. Microwave Features:

Frequency Ranges: From 100 MHz to 20 GHz any optimized bandwidth is available.

TTL Compatible Logic: Logic '1' = Isolation and Logic '0' = Insertion Loss. For switches without TTL driver; +1VDC @ +50mA = Isolation and -1VDC @ -50mA = Insertion Loss. For logic options, please consult factory.

High Speed Switching: Switches listed are measured from 50% TTL to 10%/90% RF.

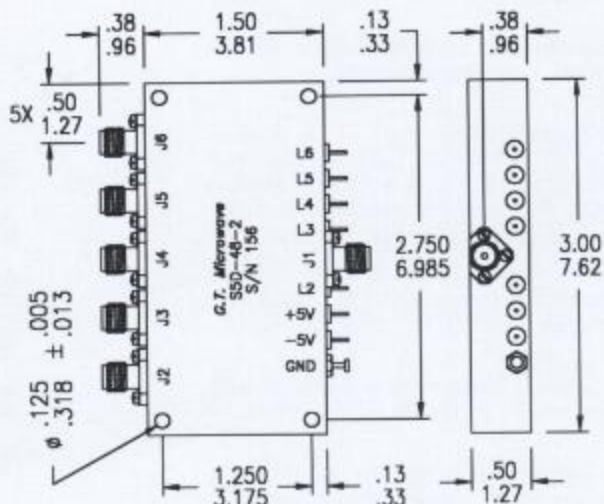
Low DC Power Consumption: Switches with TTL drivers require $\pm 5\text{VDC}$ @ +200/-70mA.

High RF Power Handling: For power levels greater than listed, please consult factory.

Absorptive Switches: On these models the J2 - J6 ports are NON-REFLECTIVE.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. DC/LOGIC connections are solder terminals. Call factory for optional connectors.

Matched Phase & Amplitude: Models listed are available with matched ports. Otherwise add .25 dB loss to ports J2 & J6.



SP5T Switch Outline Drawing

DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02$ $\pm .010$
 $\pm .05$ $\pm .025$

Electrical Specifications for REFLECTIVE and ABSORPTIVE switches - SP5T

FREQ. RANGE GHz	ISOLATION dB	INSERTION LOSS dB & SWITCHING SPEED REFL		ABSP	uSEC	INSERTION LOSS dB & SWITCHING SPEED REFL		ABSP	nSEC	INSERTION LOSS dB & SWITCHING SPEED REFL		ABSP	nSEC	V.S.W.R. MAX	INPUT POWER WATTS	
		TYP	MAX			TYP	MAX			TYP	MAX				TYP	MAX
0.5-2.0	30	0.6	1.0	1.0		0.8	1.2	100		0.9	1.3	30	1.5:1	0.1	1.0	
	60	0.8	1.2			1.0	1.4			1.1	1.5					
	80	0.9	1.3			1.1	1.5			1.2	1.6					
2.0-8.0	30	1.0	1.4	1.0		1.2	1.6	100		1.3	1.7	30	1.7:1	0.2	1.0	
	60	1.3	1.7			1.5	1.9			1.6	2.0					
	80	1.4	1.8			1.6	2.0			1.7	2.1					
6.0-18.0	30	2.25	2.65	1.0		2.45	2.85	100		2.55	2.95	30	2.0:1	0.2	1.0	
	60	2.45	2.85			2.65	3.05			2.75	3.15					
	80	2.65	3.05			2.85	3.25			2.95	3.35					
2.0-18.0	30	2.35	2.75	1.0		2.55	2.95	100		2.65	3.05	30	2.0:1	0.2	1.0	
	60	2.55	2.95			2.75	3.15			2.85	3.25					
	80	2.75	3.15			2.95	3.35			3.05	3.45					

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

PIN DIODE SWITCHES - SP6T

G.T. Microwave Features:

Frequency Ranges: From 100 MHz to 20 GHz any optimized bandwidth is available.

TTL Compatible Logic: Logic '1' = Isolation and Logic '0' = Insertion Loss. For switches without TTL driver; +1VDC @ +50mA = Isolation and -1VDC @ -50mA = Insertion Loss. For logic options, please consult factory.

High Speed Switching: Switches listed are measured from 50% TTL to 10%/90% RF.

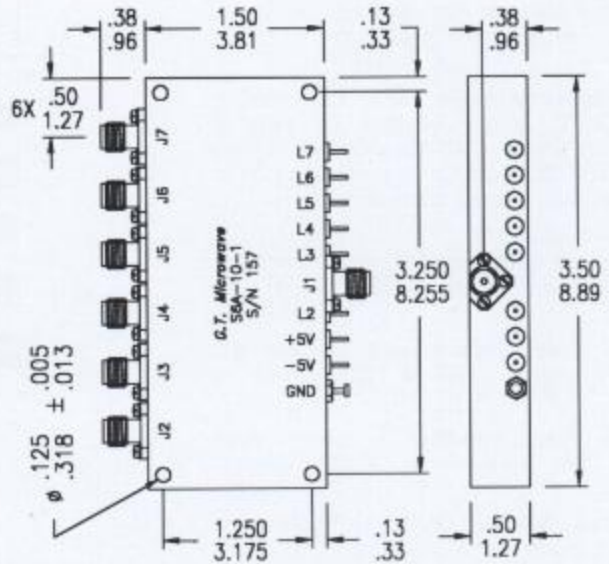
Low DC Power Consumption: Switches with TTL drivers require $\pm 5\text{VDC}$ @ +250/-75mA.

High RF Power Handling: For power levels greater than listed, please consult factory.

Absorptive Switches: On these models the J2 - J7 ports are NON-REFLECTIVE.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. DC/LOGIC connections are solder terminals. Call factory for optional connectors.

Matched Phase & Amplitude: Models listed are available with matched ports. Otherwise add .25 dB loss to ports J2 & J7.



SP6T Switch Outline Drawing

DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02$ $\pm .010$ $\pm .05$ $\pm .025$

Electrical Specifications for REFLECTIVE and ABSORPTIVE switches - SP6T

FREQ. RANGE GHz	ISOLATION dB	INSERTION LOSS dB & SWITCHING SPEED REFL		ABSP	uSEC	INSERTION LOSS dB & SWITCHING SPEED REFL		ABSP	nSEC	INSERTION LOSS dB & SWITCHING SPEED REFL		ABSP	nSEC	V.S.W.R. MAX	INPUT POWER WATTS	
		TYP	MAX			TYP	MAX			TYP	MAX				TYP	MAX
0.5-2.0	30	0.65	1.05	1.0		0.85	1.25	100		0.95	1.35	30		1.5:1	0.1	1.0
	60	0.85	1.25			1.05	1.45			1.15	1.55					
	80	0.95	1.35			1.15	1.55			1.25	1.65					
2.0-8.0	30	1.05	1.45	1.0		1.25	1.65	100		1.35	1.75	30		1.7:1	0.2	1.0
	60	1.4	1.8			1.6	2.0			1.7	2.1					
	80	1.5	1.9			1.7	2.1			1.8	2.2					
6.0-18.0	30	2.4	2.8	1.0		2.6	3.0	100		2.7	3.1	30		2.0:1	0.2	1.0
	60	2.6	3.0			2.8	3.2			2.9	3.3					
	80	2.8	3.2			3.0	3.4			3.1	3.5					
2.0-18.0	30	2.5	2.9	1.0		2.7	3.1	100		2.8	3.2	30		2.0:1	0.2	1.0
	60	2.7	3.1			2.9	3.3			3.0	3.4					
	80	2.9	3.3			3.1	3.5			3.2	3.6					

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

PIN DIODE SWITCHES - SP7T

G.T. Microwave Features:

Frequency Ranges: From 100 MHz to 20 GHz any optimized bandwidth is available.

TTL Compatible Logic: Logic '1' = Isolation and Logic '0' = Insertion Loss. For switches without TTL driver; +1VDC @ +50mA = Isolation and -1VDC @ -50mA = Insertion Loss. For logic options, please consult factory.

High Speed Switching: Switches listed are measured from 50% TTL to 10%/90% RF.

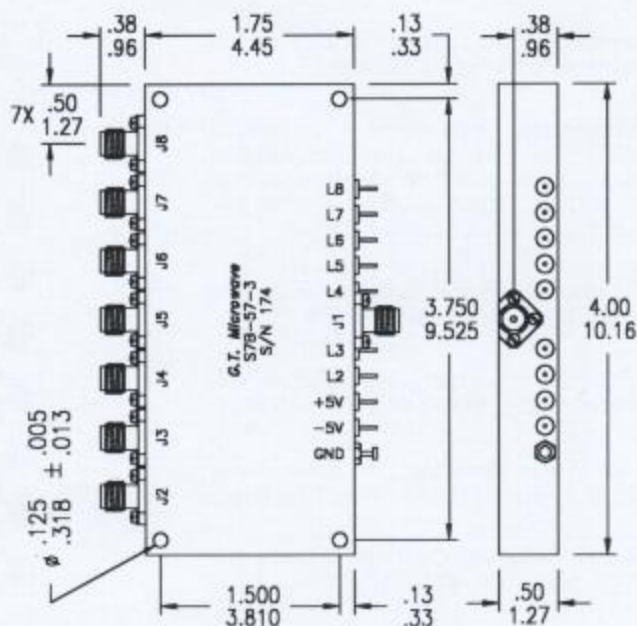
Low DC Power Consumption: Switches with TTL drivers require $\pm 5\text{VDC}$ @ +300/-80mA.

High RF Power Handling: For power levels greater than listed, please consult factory.

Absorptive Switches: On these models the J2 - J8 ports are NON-REFLECTIVE.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. DC/LOGIC connections are solder terminals. Call factory for optional connectors.

Matched Phase & Amplitude: Models listed are available with matched ports. Otherwise add .25 dB loss to ports J2 & J8.



SP7T Switch Outline Drawing

DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02$ $\pm .010$
 $\pm .05$ $\pm .025$

Electrical Specifications for REFLECTIVE and ABSORPTIVE switches - SP7T

FREQ. RANGE GHz	ISOLATION dB	INSERTION LOSS dB & SWITCHING SPEED REFL ABSP μSEC			INSERTION LOSS dB & SWITCHING SPEED REFL ABSP nSEC			INSERTION LOSS dB & SWITCHING SPEED REFL ABSP nSEC		V.S.W.R. MAX	INPUT POWER WATTS TYP MAX		
		REFL	ABSP	μSEC	REFL	ABSP	nSEC	REFL	ABSP		nSEC	TYP	MAX
0.5-2.0	30	0.7	1.1	1.0	0.9	1.3	100	1.0	1.4	30	1.5:1	0.1	1.0
	60	0.9	1.3		1.1	1.5		1.2	1.6				
	80	1.0	1.4		1.2	1.6		1.3	1.7				
2.0-8.0	30	1.1	1.5	1.0	1.3	1.7	100	1.4	1.8	30	1.7:1	0.2	1.0
	60	1.5	1.9		1.7	2.1		1.8	2.2				
	80	1.6	2.0		1.8	2.2		1.9	2.3				
6.0-18.0	30	2.55	2.95	1.0	2.75	3.15	100	2.85	3.25	30	2.0:1	0.2	1.0
	60	2.75	3.15		2.95	3.35		3.05	3.45				
	80	2.95	3.35		3.15	3.55		3.25	3.65				
2.0-18.0	30	2.65	3.05	1.0	2.85	3.25	100	2.95	3.35	30	2.0:1	0.2	1.0
	60	2.85	3.25		3.05	3.45		3.15	3.55				
	80	3.05	3.45		3.25	3.65		3.35	3.75				

For substantial improvement in performance, ask for OPTIMIZED NARROWBAND models

PIN DIODE SWITCHES - SP8T

G.T. Microwave Features:

Frequency Ranges: From 100 MHz to 20 GHz any optimized bandwidth is available.

TTL Compatible Logic: Logic '1' = Isolation and Logic '0' = Insertion Loss. For switches without TTL driver; +1VDC @ +50mA = Isolation and -1VDC @ -50mA = Insertion Loss. For logic options, please consult factory.

High Speed Switching: Switches listed are measured from 50% TTL to 10%/90% RF.

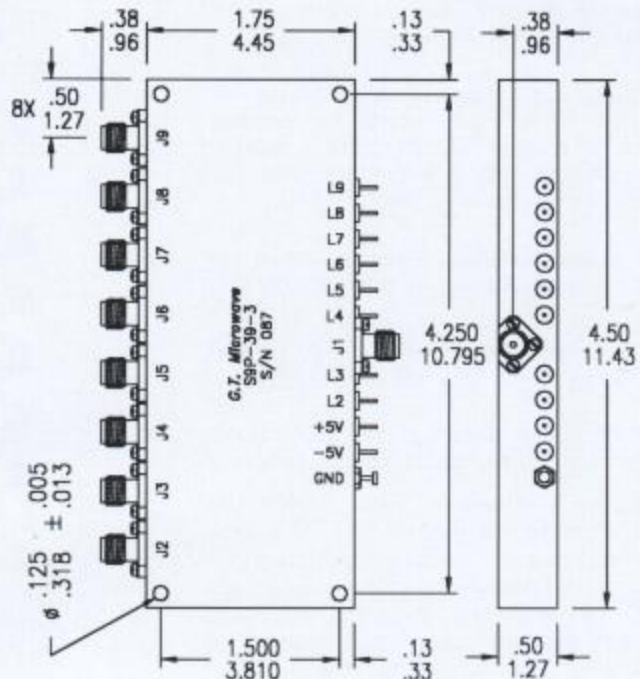
Low DC Power Consumption: Switches with TTL drivers require ±5VDC @ +350/-85mA.

High RF Power Handling: For power levels greater than listed, please consult factory.

Absorptive Switches: On these models the J2 - J9 ports are NON-REFLECTIVE.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. DC/LOGIC connections are solder terminals. Call factory for optional connectors.

Matched Phase & Amplitude: Models listed are available with matched ports. Otherwise add .25 dB loss to ports J2 & J9.



SP8T Switch Outline Drawing

DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02$ $\pm .010$ $\pm .05$ $\pm .025$

Electrical Specifications for REFLECTIVE and ABSORPTIVE switches - SP8T

FREQ. RANGE GHz	ISOLATION dB	INSERTION LOSS dB & SWITCHING SPEED REFL ABSP μ SEC			INSERTION LOSS dB & SWITCHING SPEED REFL ABSP nSEC			INSERTION LOSS dB & SWITCHING SPEED REFL ABSP nSEC		V.S.W.R. MAX	INPUT POWER WATTS TYP MAX		
0.5-2.0	30	0.75	1.15	1.0	0.95	1.35	100	1.05	1.45	30	1.5:1	0.1	1.0
	60	0.95	1.35		1.15	1.55		1.25	1.65				
	80	1.1	1.5		1.3	1.7		1.4	1.8				
2.0-8.0	30	1.2	1.6	1.0	1.4	1.8	100	1.5	1.9	30	1.7:1	0.2	1.0
	60	1.6	2.0		1.8	2.2		1.9	2.3				
	80	1.7	2.1		1.9	2.3		2.0	2.4				
6.0-18.0	30	2.7	3.1	1.0	2.9	3.3	100	3.0	3.4	30	2.0:1	0.2	1.0
	60	2.9	3.3		3.1	3.5		3.2	3.6				
	80	3.1	3.5		3.3	3.7		3.4	3.8				
2.0-18.0	30	2.8	3.2	1.0	3.0	3.4	100	3.1	3.5	30	2.0:1	0.2	1.0
	60	3.0	3.4		3.2	3.6		3.3	3.7				
	80	3.2	3.6		3.4	3.8		3.5	3.9				

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

PIN DIODE TRANSFER SWITCHES – DPDT

G.T. Microwave Features:

Frequency Ranges: From 100 MHz to 20 GHz
any optimized bandwidth is available.

TTL Compatible Logic: Logic '1' = Low Loss
J1-J2/J3-J4 & Logic '0' = Low Loss J1-J4/
J2-J3. Switches without TTL driver; +1VDC @
+60mA = Low Loss J1-J2 & -1VDC @ -60mA =
Low Loss J3-J4 on 2 independent logic inputs
or vice versa for J1-J4/J2-J3. For logic options,
please consult factory.

High Speed Switching: Switches listed are
measured from 50% TTL to 10%/90% RF.

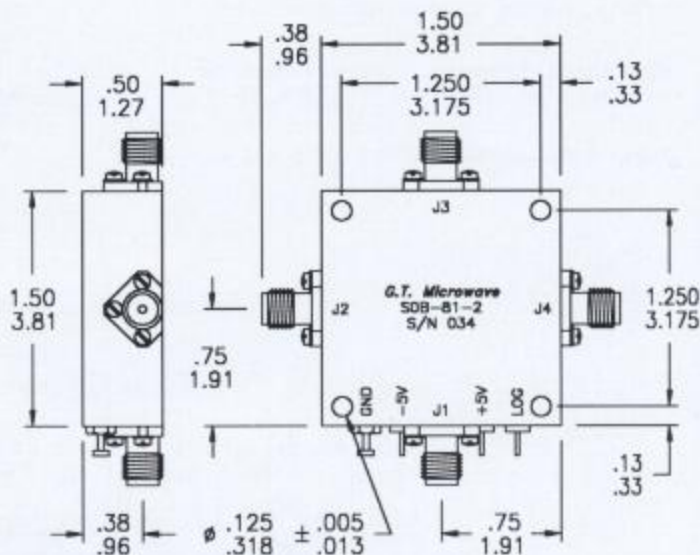
Low DC Power Consumption: Switches with
TTL drivers require ±5VDC @ ±60mA.

High RF Power Handling: For power levels
greater than listed, please consult factory.

Standard Interfaces: RF part connectors are
'SMA', female per MIL-C-39012. DC/LOGIC
connections are solder terminals. Call
factory for optional connectors.

Matched Phase & Amplitude: Models listed
are available with matched parts. Please
consult factory.

Actual Size Shown



DPDT Switch Outline Drawing

DIMENSIONS ARE EXPRESSED IN CM TOLERANCES ? .02 ? .010
CM .05 ? .025

Electrical Specifications for TRANSFER switches – DPDT

FREQ. RANGE GHz	ISOLATION dB	INSERTION LOSS dB & SWITCHING SPEED REFL uSEC		INSERTION LOSS dB & SWITCHING SPEED REFL nSEC		INSERTION LOSS dB & SWITCHING SPEED REFL nSEC	V.S.W.R. MAX	INPUT POWER WATTS TYP MAX		
		REFL	uSEC	REFL	nSEC			TYP	MAX	
0.5-2.0	30	0.7	1.0	0.9	100	1.0	30	1.4:1	0.1	1.0
	60	0.9		1.1		1.2				
2.0-8.0	30	1.8	1.0	2.0	100	2.1	30	1.6:1	0.2	1.0
	60	2.0		2.2		2.3		1.8:1		
6.0-18.0	30	2.8	1.0	3.0	100	3.1	30	2.0:1	0.2	1.0
	60	3.1		3.3		3.4				
2.0-18.0	30	2.9	1.0	3.1	100	3.2	30	2.0:1	0.2	1.0
	60	3.2		3.4		3.5				

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

PIN DIODE PULSE MODULATOR-SP1T

G.T. Microwave Features:

Frequency Ranges: From 40 MHz to 20 GHz any optimized bandwidth is available.

TTL Compatible Logic: Logic '0' = Isolation and Logic '1' = Insertion Loss. For logic options, please consult factory.

High Speed Switching: Pulse modulators are measured from 50% TTL to 10%/90% RF.

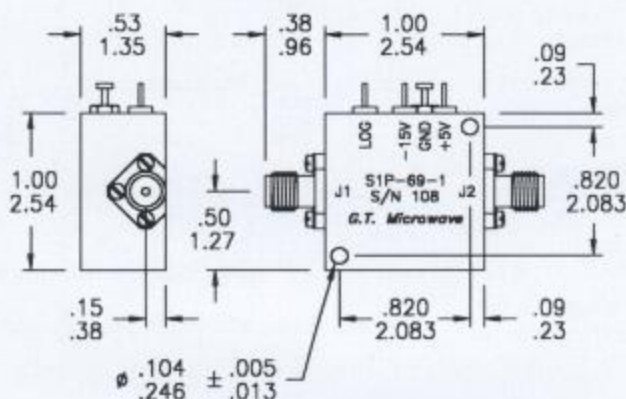
Power Consumption: +5/-15 VDC @ ±50 mA

High RF Power Handling: For power levels greater than listed, please consult factory.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. DC/LOGIC connections are solder terminals. Call factory for optional connectors.

Matched Phase & Amplitude: Models listed can be matched unit to unit. Please consult factory.

Actual Size Shown



DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02 \pm .010$
 $\pm .05 \pm .025$

Electrical Specifications for ABSORPTIVE input PULSE MODULATOR

FREQUENCY RANGE:	2.0 - 18.0 GHz
ISOLATION:	80 dB MINIMUM
INSERTION LOSS:	3.0 dB MAXIMUM
V.S.W.R.:	2.0:1 MAXIMUM
RF INPUT POWER:	+27 dBm CW, 1.0 WATT MAXIMUM

VIDEO FILTERING:	5 mV @ 100 MHz BW
HARMONIC GENERATION:	-60 dBc MINIMUM
SWITCHING SPEED:	15 nSEC RF + 15 nSEC DELAY
	----- 30 nSEC MAXIMUM

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

PIN DIODE BPSK MODULATOR

G.T. Microwave Features:

Frequency Ranges: From 500 MHz to 24 GHz any optimized bandwidth is available.

TTL Compatible Logic: Logic '0' = 0° REF and Logic '1' = 180° Phase Shift.

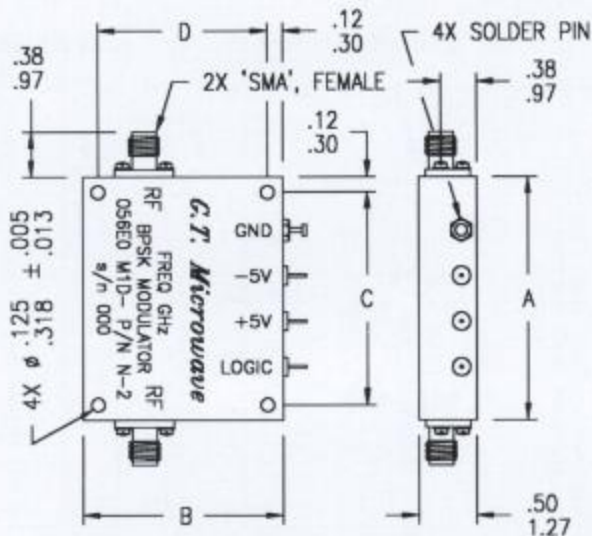
High Speed Switching: Pulse modulators are measured from 50% TTL to 10%/90% RF.

DC Power Consumption: ± 5 V @ ± 50 mA.

High RF Power Handling: For power levels greater than listed, please consult factory.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. DC/LOGIC connections are solder terminals. Call factory for optional connectors.

Matched Phase & Amplitude: Models listed can be matched unit to unit. Please consult factory.



DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02$ $\pm .010$
 $\pm .05$ $\pm .025$

Electrical Specifications for BI-PHASE MODULATORS - BPSK

MODEL NUMBER	FREQUENCY RANGE GHz	PHASE ERROR MAX	AMPLITUDE ERROR dB MAX	INSERTION LOSS MAX	V.S.W.R. MAX	SWITCHING SPEED nSEC MAX	RF POWER + dBm CW/MAX	'A' DIMENSION IN/CM	'B' DIMENSION IN/CM	'C' DIMENSION IN/CM	'D' DIMENSION IN/CM
M1D-39N-2	0.5-2.0	$\pm 10.0^\circ$	± 1.00	3.0 dB	1.75:1	100	15/30	3.75/9.53	1.75/4.45	3.500/7.62	1.500/3.81
M1D-38N-2	1.0-3.0							2.25/5.72	1.63/4.14	2.000/5.08	1.375/3.49
M1D-48N-2	2.0-6.0							1.38/3.51	1.38/3.51	1.175/2.99	1.175/2.99
M1D-68N-2	6.0-18.0							1.38/3.51	1.38/3.51	1.175/2.99	1.175/2.99
M1D-84N-2	16.0-24.0	$\pm 20.0^\circ$	± 2.00	4.0 dB	2.0:1			1.38/3.51	1.38/3.51	1.175/2.99	1.175/2.99
M1D-69N-2	2.0-18.0	$\pm 20.0^\circ$	± 2.00	5.0 dB	2.0:1			2.50/6.35	2.25/5.72	2.250/5.72	2.000/5.08

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

PIN DIODE QPSK MODULATOR

G.T. Microwave Features:

Frequency Ranges: From 500 MHz to 24 GHz
any optimized bandwidth is available.

DC Power Consumption: ± 5 V @ ± 100 mA.

TTL Compatible 2 BIT Binary Logic:

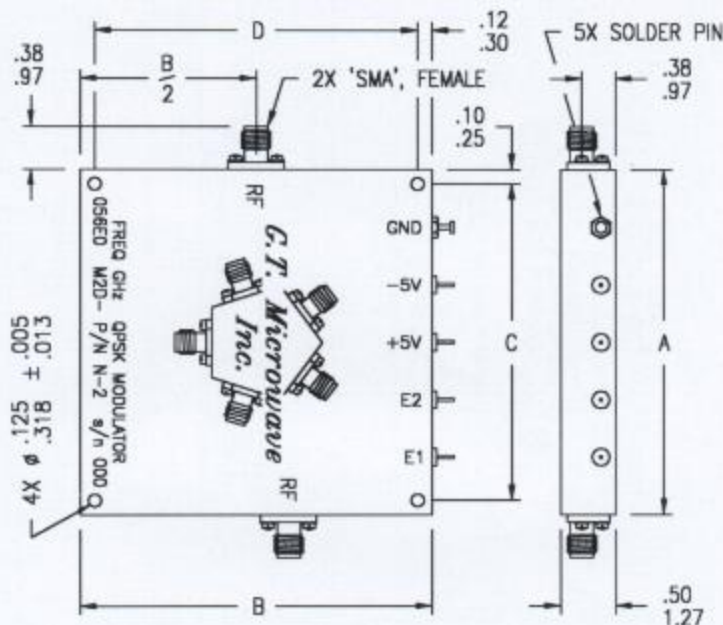
E1	E2	OUTPUT
0	0	0° REF
1	0	+270°
1	1	+180°
0	1	+90°

High RF Power Handling: For power levels greater than listed, please consult factory.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. DC/LOGIC connections are solder terminals. Call factory for optional connectors.

High Speed Switching: QPSK modulators are measured from 50% TTL to 10%/90% RF.

Matched Phase & Amplitude: Models listed can be matched unit to unit. Please consult factory.



DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02 \pm .010$
 $.05 .025$

Electrical Specifications for QUAD-PHASE MODULATORS - QPSK

MODEL NUMBER	FREQUENCY RANGE GHz	PHASE ERROR MAX	AMPLITUDE ERROR dB MAX	INSERTION LOSS MAX	V.S.W.R. MAX	SWITCHING SPEED nSEC MAX	RF POWER + dBm CW/MAX	'A' DIMENSION IN/CM	'B' DIMENSION IN/CM	'C' DIMENSION IN/CM	'D' DIMENSION IN/CM
M2D-39N-2	0.5-2.0	$\pm 10.0^\circ$	± 1.00	9.0 dB	1.75:1	100	15/30	4.95/12.57	3.38/8.58	4.750/12.07	3.125/7.94
M2D-38N-2	1.0-3.0							3.25/8.26	3.25/8.26	3.050/7.75	3.000/7.62
M2D-48N-2	2.0-6.0							3.00/7.62	3.00/7.62	2.800/7.11	2.750/6.99
M2D-68N-2	6.0-18.0							4.25/10.80	3.50/8.89	3.250/8.26	3.250/8.26
M2D-84N-2	16.0-24.0	$\pm 20.0^\circ$	± 2.00	11.0 dB	2.0:1						
M2D-69N-2	2.0-18.0										

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

DIGITALLY CONTROLLED PHASE INVARIANT ATTENUATORS

G.T. Microwave Features:

Frequency Ranges: From 500 MHz to 24 GHz any optimized bandwidth is available.

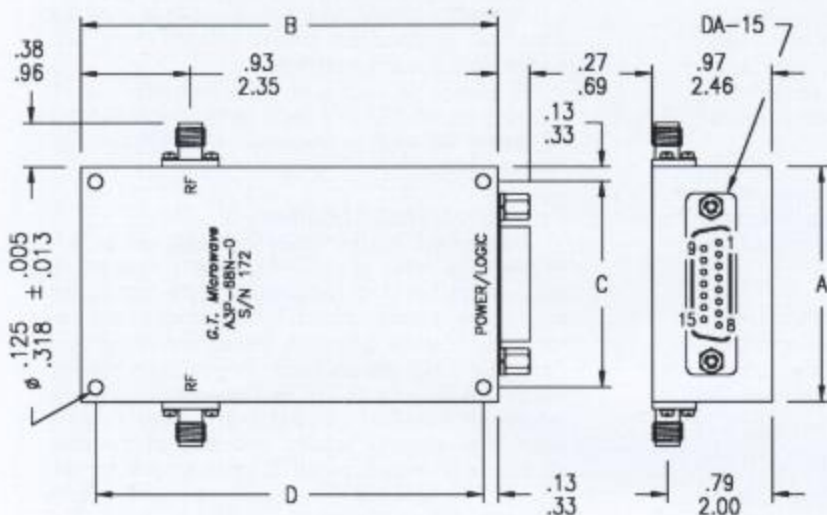
TTL Compatible Logic: G.T.'s binary logic from Digital to Analog Converter with 8 inputs; Logic '1'/BIT = 256 discrete values of attenuation or all Logic '0' = Insertion Loss.

High Speed Switching: Attenuator listed is measured from 50% TTL to 10%/90% RF from any set value to any set value.

High RF Power Handling: For power levels greater than listed, please consult factory.

Standard Interfaces: RF port connectors are 'SMA', female per MIL-C-39012. DC/LOGIC connections are solder terminals. Call factory for optional connectors.

Matched Phase & Amplitude: Models listed can be matched unit to unit. Please consult factory.



DIMENSIONS ARE EXPRESSED IN CM TOLERANCES $\pm .02 \pm .010$
 $\pm .05 \pm .025$

'A' DIM. IN/CM	'B' DIM. IN/CM	'C' DIM. IN/CM	'D' DIM. IN/CM
2.00/5.08	3.50/8.89	1.750/4.445	3.250/8.255

POWER/LOGIC CONNECTION

PIN	FUNCTION
1	-15 VDC @ 125 mA
2	+15 VDC @ 30 mA
3	NOT USED
4	0.125 dB (LSB)
5	0.5 dB
6	4 dB
7	16 dB (MSB)
8	8 dB
9	GROUND
10	NOT USED
11	2 dB
12	0.25 dB
13	1 dB
14	NOT USED
15	+5 VDC @ 100 mA

Electrical Specifications for absorptive Phase Invariant attenuator

FREQUENCY RANGE: 6.0 - 18.0 GHz	INSERTION LOSS: 7.0 dB MAXIMUM
DYNAMIC RANGE: 32 dB	V.S.W.R.: 2.0:1 MAXIMUM
RESOLUTION: 0.125 dB	INPUT POWER: 100 mW CW, 0.5 W MAXIMUM
MONOTICITY: GUARANTEED	SWITCHING SPEED: 350 nSEC MAXIMUM
ACCURACY: ± 0.5 dB	DELTA PHASE: $\pm 5.0^\circ$ to 20 dB $\pm 10^\circ$ to 32 dB
FLATNESS Vs FREQ: ± 0.8 to 20 dB ± 1.3 to 32 dB	

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models

ORDERING, TERMS & CONDITIONS

How to Order:

In the United States and Canada orders for G.T. Microwave's products may be placed with our sales representatives or directly with G.T. Microwave, Inc. sales department located in New Jersey, telephone 1-973-361-5700 or facsimile 1-973-361-5722 or U.S. Mail to: G.T. Microwave, Inc.
2 Emery Avenue
Randolph, New Jersey 07869

International:

Customers outside the United States are served by local representatives and inquiries and purchase orders may be directed through these representatives. Your local representative will provide a quotation in local currency which can include all freight charges, customs duty, custom clearance costs and taxes (where applicable). Please consult with your local representative for your requirements or contact G.T. Microwave, Inc. directly if no representation exists.

Specify when Ordering:

Please specify when ordering catalog model number and name of component desired. If special non-standard features are desired, they should be fully described on your order in detail.

Minimum Order Value:

Due to the costs of efficiently processing orders, G.T. Microwave's policy includes that for any item(s) ordered the minimum value of the total order is to be \$500.00.

Prices:

Substantial discounts are allowed on large quantity orders. Contact G.T. Microwave's sales department for quotations.

Due to G.T. Microwave's constant product improvement program, prices and specifications are subject to change, without notice.

Terms of Payment:

All invoices are due and payable within 30 days from the date of invoice.

Unless credit has been previously established with G.T. Microwave, shipments will be made C.O.D., or upon receipt of payment in advance.

F.O.B. Point:

Sales are made F.O.B. Randolph, New Jersey unless otherwise specified and title passes to the buyer upon delivery to the carrier.

If your order does not indicate a specified carrier, G.T. Microwave will select one usually from Parcel Post, UPS, FED-EX, Air Freight...etc.

Local Sales Representatives:

Technical assistance in selecting equipment, and engineering consultation for your special application, is available through local G.T. Microwave's Engineering Sales Representatives whose offices are maintained in principal cities. Please call upon them at any time for delivery or pricing information, technical data and assistance, or for any other information concerning G.T. Microwave's products and services.

Restocking Charge:

There is a 15% restocking charge for returned catalog items.

Change Orders and Cancellations:

No order placed with G.T. Microwave may be cancelled, or changed, unless authorized by G.T. Microwave's sales department.

A change in scope of work, cancellation, or decrease in quantity is subject to additional charges as determined by G.T. Microwave, or negotiated with the customer.

Return of Merchandise:

An excellent service facility is maintained by G.T. Microwave to repair any G.T. Microwave component. If you wish to return a component to the factory for any reason, please contact G.T. Microwave, Inc. for instructions before shipment. Please give Model No., Name, Serial No. and as much information as possible concerning the reason for return. All such requests receive our immediate attention and complete cooperation. Non-warranty repairs are made at the cost of labor and materials plus a small service charge.

Source Inspections:

Customer and government inspections usually incur a delay in making timely shipments due to duplicate standard final inspections.

An additional charge for these inspections is applicable, and is usually based on an hourly rate, depending on the scope of inspection. If source inspection is required, a surcharge of \$250.00 minimum charge, per item is applicable.

G.T. Microwave recommends that a certificate of compliance which is available at no charge be substituted for source inspection to minimize delay.

Environmental Testing:

G.T. Microwave offers an extensive environmental testing service on and off site. These environmental tests are known as either Qualification Test, First Article Inspections Test or Group B Test. G.T. Microwave will design its units to accommodate the impact of those environmental parameters.

* Warranty *

All products purchased from G.T. Microwave are guaranteed to be free from any defects in workmanship and material for a period of one year from date of shipment under normal usage. G.T. Microwave's responsibility under this warranty is limited to the repair or replacement of defective part returned to the factory prepaid. G.T. Microwave reserves the right to replace with merchandise of equal performance, although not identical in every way, to that originally sold. In no event does G.T. Microwave assume liability for installation and handling damages.

Notice of breach of this warranty must be received by G.T. Microwave within one year of date of shipment. G.T. Microwave makes no other warranty expressed or implied.

Represented in your area by:

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