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MODULATORS

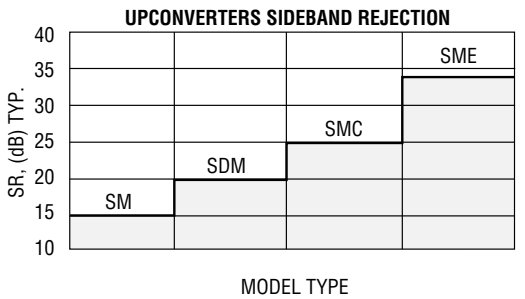
MODULATOR PRODUCTS

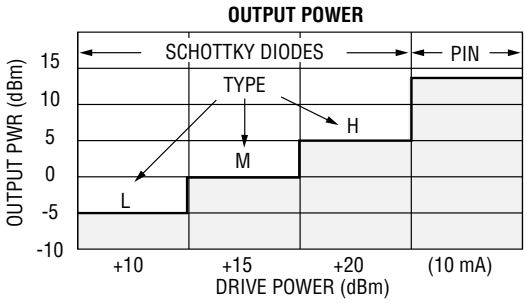
This detailed modulator upconverter section summarizes the important input, output and transfer characteristics of these devices. We look forward to helping you choose the best modulator from our increasing core of state-of-the-art products, so that your system will be more competitive in today's demanding marketplace. Most importantly, we are committed to satisfying not only the written technical specifications of any new product, but to ensure that the product satisfies its intended application requirements.

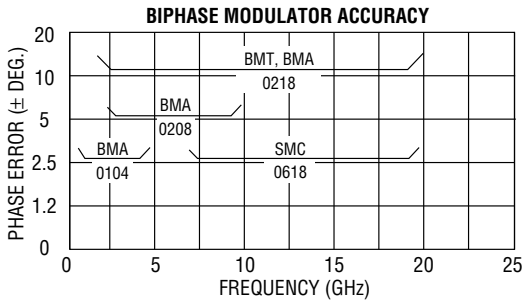
MODULATOR AND UPCONVERTER APPLICATION GUIDELINES

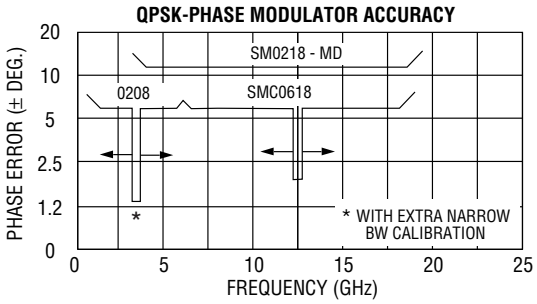
CRITICAL SPECIFICATIONS	BEST MODELS	CIRCUIT DESCRIPTION
GENERAL PURPOSE		
Low cost, size	BMA, SM, SDM, SME	Double balanced, octave bandwidth
Linear modulation, nonlinear, RF	(All series) - CD	DB, carrier driven
Linear RF, nonlinear, modulation	(All series) - MD	DB, modulation (IF) driven
COMMUNICATION		
BPSK, TTL, DC – 30 Mbps	BMT	Double balanced, PIN diodes
QPSK, ECL, DC – 200 Mbps	SDM, SMC	Schottky diodes, balanced ECL
DQPSK, raised cosine	SDM6474	Linear I/Q with RF amplifiers
FSK, digital control	SYS0302...	Direct digital synthesis I/Q drive
RADAR - EW		
Sinlge-sideband upconverter	SDM, SSM, SMC	Schottky diodes
SPECIAL - WIDEBAND		
2 – 26 GHz modulator/upconverter	SM0226, SML	Double balanced or even harmonics
4 – 40 GHz block converter	LNB	Triple balanced with LO, amplifiers
I/Q, high speed, accuracy	SMC0618, 2-6, CD	Quadrature, double balanced

TYPICAL PERFORMANCE RANGES

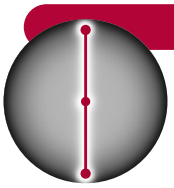




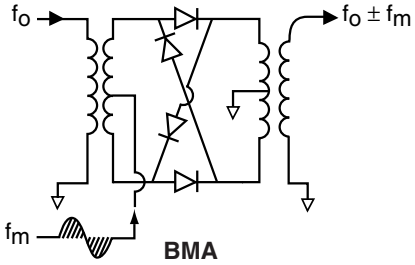




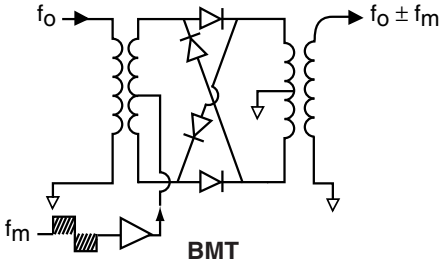
BIPHASE MODULATORS AND DSB UPCONVERTERS



BPSK



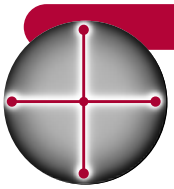
BMA
Linear Biphase



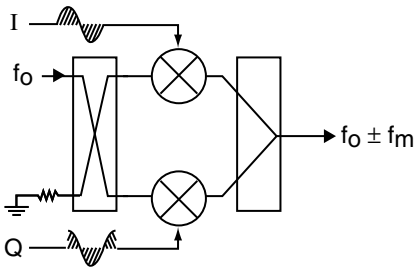
BMT
Digital Biphase

MODEL NUMBER	FREQUENCY RANGE RF (GHz)	FREQUENCY RANGE IF (GHz)	CARRIER DRIVEN (LINEAR IF MODULATION) (NOTE 1) CARRIER REJECTION (dBc)	CARRIER DRIVEN (LINEAR IF MODULATION) (NOTE 1) SIDEBAND HARMONICS (dBc)	MODULATION DRIVEN (LINEAR RF BPSK) PHASE/AMP ERROR (Max.) (±deg./±dB)	MODULATION DRIVEN (LINEAR RF BPSK) STATIC LOSS/P 1 dB (dB, Max.) / (dBm)	MODULATION DRIVEN (LINEAR RF BPSK) CARRIER REJECTION (dBc, Typ.)	NOTES	PAGE
BIPHASE MODULATORS AND DOUBLE-SIDEBAND UPCONVERTERS									
BMT65175HC10MD	0.65 – 1.75	TTL	N/A	N/A	3 / 0.3	6 / +15	30	PIN diodes	279
BMA0502LA2MD	0.5 – 2	DC – 0.5	35	30	3 / 0.3	9 / +5	30	Hermetic	281
BMA0104LA1MD	1 – 4	DC – 1	30	35	3 / 0.3	5 / +5	35	Hermetic	283
BMA0208LW2MD	2 – 8	DC – 2	25	30	5 / 0.5	5 / +5	35	Low 1/f Schottky	285
BMA0218LA1MD	2 – 18	DC – 0.5	15	25	10 / 0.75	5 / +5	20	Low 1/f Schottky	287
BMT0218HC10MD	2 – 18	TTL	N/A	N/A	10 / 0.75	6 / +20	25	PIN diodes	289
BMA0618LA1MD	6 – 18	DC – 0.5	20	25	10 / 0.75	6 / +5	20	Low 1/f Schottky	291

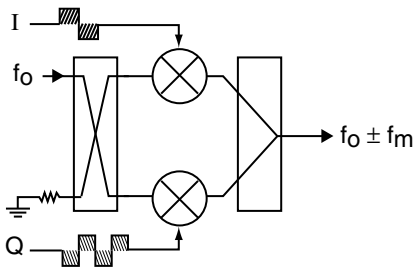
QPSK AND QAM MODULATORS



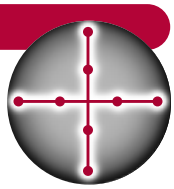
QPSK



SDM, SSM, SME, SM
Linear, I/Q



SMT
Digital, Linear RF

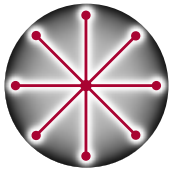


QAM

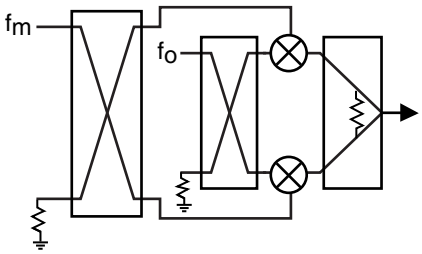
MODEL NUMBER	FREQUENCY RANGE RF (GHz)	FREQUENCY RANGE IF (GHz)	CARRIER REJECTION (dBc, Typ.)	SIDEBAND REJECTION (dBc, Typ.)	CONVERSION LOSS (dB, Typ./Max.)	NOTES	PAGE
QPSK AND MODULATION DRIVEN MODULATORS							
SDM0502LC1MD	0.5 – 2	DC – 0.5	33	25	7 / 10	1	295
SMT0502LC1MD	0.5 – 2	TTL	25	25	7 / 10	QPSK	297
SDM0102LC1MDQ	1 – 2	DC – 0.5	35	25	6 / 7	QPSK	299
SDM0104LC1MD	1 – 4	DC – 0.5	40	27	7 / 10	1	301
SME0104LI1MD	1 – 4	DC – 0.5	35	35	10 / 12	1	303
SSM0204(*)C2MD	2 – 4	DC – 0.5	20	20	7 / 9	1	305
SSM0208(*)C2MD	2 – 8	DC – 0.5	20	18	7 / 9	1	307
SME0208LI1MD	2 – 8	DC – 0.5	25	35	8 / 11	1	309
SSM0408(*)C2MD	4 – 8	DC – 0.5	30	24	6 / 9	1	311
SSM0812(*)C2MD	8 – 12	DC – 0.5	30	23	6 / 9	1	313
SMT0218LC1MD	2 – 18	TTL	25	20	9 / 12	QPSK	315
SM0218LC1MD	2 – 18	DC – 0.5	25	18	8 / 12	1	317
SSM0618(*)C2MD	6 – 18	DC – 0.5	25	20	8 / 12	1	319
SME0618LI1MD	6 – 18	DC – 0.5	25	28	9 / 13	1	321
SSM1218(*)C2MD	12 – 18	DC – 0.5	20	23	7 / 10	1	323
SM0226LC1MD	2 – 26	DC – 0.5	20	18	12 / 15	1	325

Note1: For QPSK specification, please see detailed data sheet.

SSB UPCONVERTERS AND VECTOR MODULATORS/PHASE SHIFTERS



MPSK



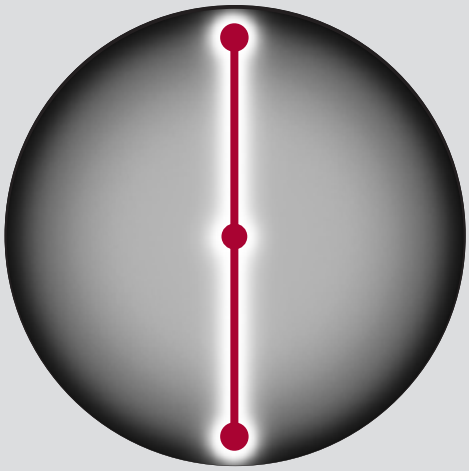
SDM, SML-A...D
Single-Sideband Upconverter
LO and 1/2 LO

MODEL NUMBER	FREQUENCY RANGE RF (GHz)	IF (GHz)	CARRIER REJECTION (dBc, Typ.)	SIDEBAND REJECTION (dBc, Typ.)	CONVERSION LOSS (dB, Typ./Max.)	NOTES	PAGE
SINGLE-SIDEBAND UPCONVERTERS – CARRIER DRIVEN							
SDM0102LC1CD	1 – 2	DC – 0.5	30	20	8 / 10		329
SM2737LI6CD	2.7 – 3.7	DC – 0.5	25	30	6 / 8		331
SDM0104LC1CD	1 – 4	DC – 0.5	35	25	8 / 10		333
SMC0206LI1CD	2 – 6	DC – 0.5	35	30	12 / 15		335
SDM0307LI1CDQ	3.5 – 6.5	DC – 0.5	30	25	8 / 11		337
SDM0208LC1CD	2 – 8	DC – 0.5	20	15	7 / 10		339
SDM0708LI3CDQ	7.2 – 8.4	DC – 0.3	30	25	7.5 / 8.5		341
SML0711LM8CDQ	7.1 – 11.7	DC – 0.2	45	30	9 / 11	Even Harmonic	343
SDM1015LI3CDQ	10 – 15	DC – 1	30	25	8 / 9		345
SM0218LC1CD	2 – 18	DC – 0.5	12	18	8 / 12		347
SME0618LI1CD	6 – 18	DC – 0.5	25	30	9 / 13		349
SMC0618LI1CD	6 – 18	DC – 0.5	35	32	16 / 19		351
SM1826NI7CD	18 – 26	DC – 0.5	30	30	9 / 12		353
SM3435LI7CD	34 – 35	0.02 – 0.2	N/A	25	9 / 10.5	LO Amplifier L-R Isolation: 25 dB	355

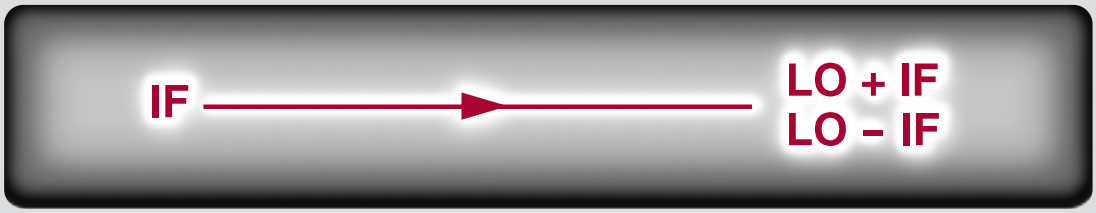
GENERAL

All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or modulation) has sufficient power to turn on the semiconductors used in the various designs (i.e., Schottky diodes or PIN diodes). All modulators yield a frequency spectrum that utilizes both sidebands on either side of the output suppressed carrier. SSB upconverters employ an internal IF 90 degree hybrid to yield only 1 RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) modulators have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. PIN or Schottky modulators that vary only the RF carrier phase, in many discrete steps or continuously, are referred to as phase shifters or frequency translators respectively. When output RF amplitude and phase control is required, the device is usually called a vector modulator. For the latter device, phase accuracy is usually specified over a given amplitude range (in dB).

MODULATOR PRODUCTS



BIPHASE MODULATORS



DOUBLE-SIDEBAND UPCONVERTERS

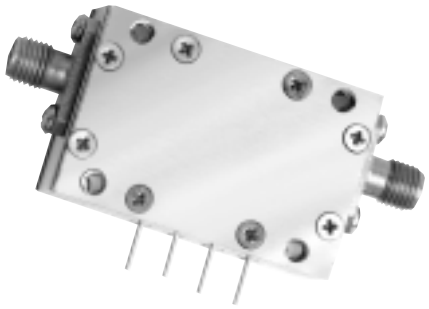
- **Detailed Data Sheets**

.65 TO 1.75 GHz TTL BIPHASE MODULATOR

MODEL: BMT65175HC10MD (Modulation Driven)

FEATURES

- **RF frequency range..... .65 to 1.75 GHz (usable from .5 to 2 GHz)**
- **Biphase accuracy..... ±1°**
- **Amplitude accuracy ..... ±0.1 dB**
- **Rise time ..... 10 ns**
- **Switching speed ..... 30 ns**
- **RF input..... +13 dBm (P1 dB)**

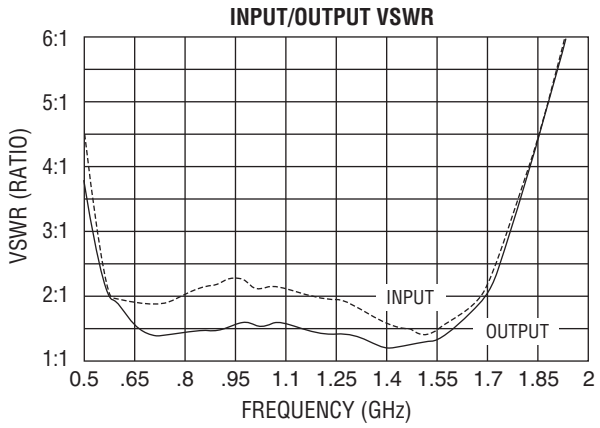


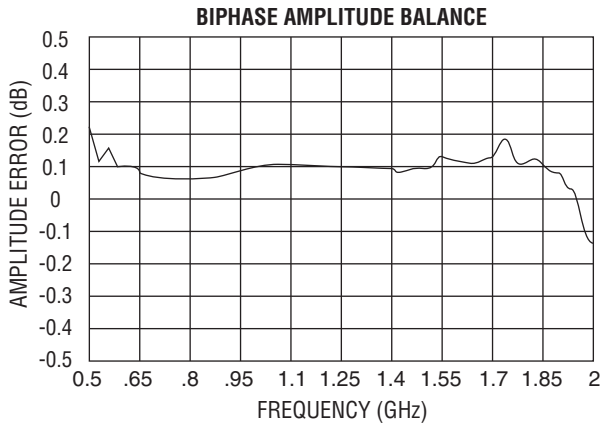
MITEQ's Model BMT65175HC10MD TTL-controlled biphase modulator is ideal for BPSK modulation over broad frequency ranges with extremely high input carrier levels (up to +16 dBm). The power handling capability is suited to simulator systems using high-level VCOs avoiding the requirement of an additional external amplifier. Since this is a TTL or modulation driven unit, the RF input-to-output power relation is linear up to the compression level.

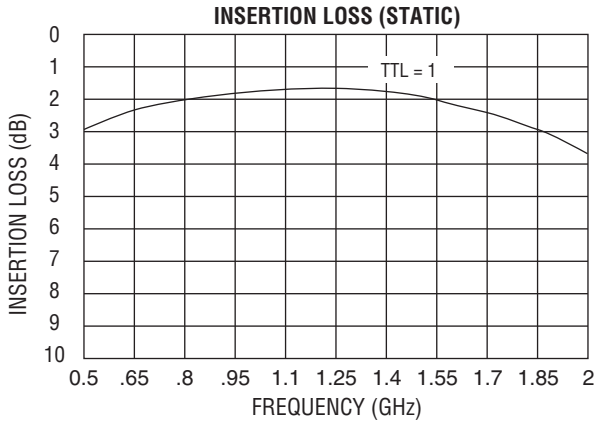
ELECTRICAL SPECIFICATIONS

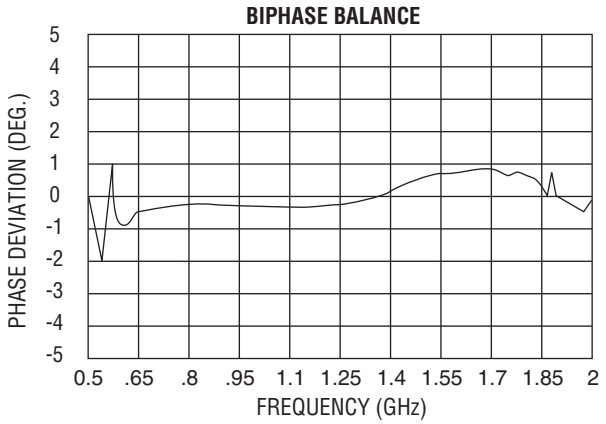
INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
RF carrier frequency range		GHz	.65		1.75
RF carrier VSWR		Ratio		2:1	
RF carrier power (linear)	Operating Nonoperating	dBm dBm	Noise	+13	 +23
TTL modulation rate		MBs	DC		30
DC power supply	±5 VDC	mA			30
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Insertion loss		dB		4	6
Carrier suppression		dBc	20	25	
Switching speed	50% TTL to 90% RF	ns		30	
Switching rise/fall time	10 to 90% RF	ns		10	
Phase balance (0 or 180°)		Degrees		±1	±3
Amplitude balance (0 or 180°)		dB		0.1	0.3
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Modulated RF frequency range		GHz	.65		1.75
Modulated RF VSWR		Ratio		2:1	
Video leakage	From .65 to 1.75 GHz	dBm		-65	

BMT65175HC10MD MODULATION DRIVEN TYPICAL TEST DATA







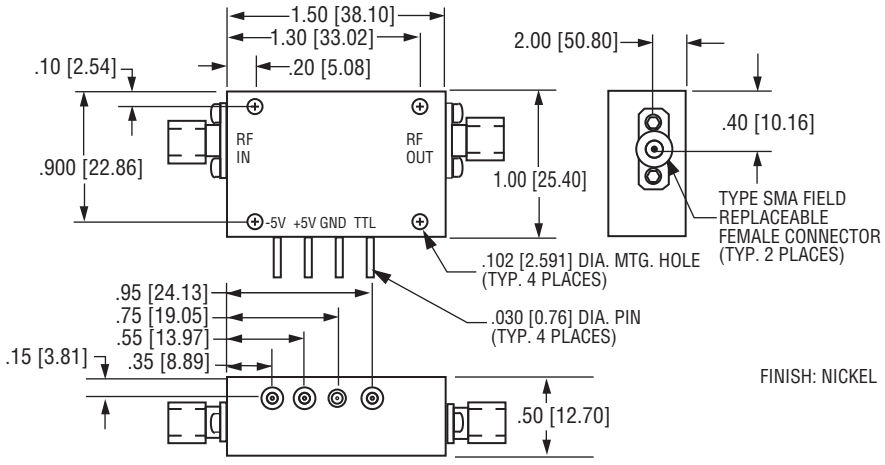


MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +95°C

NOTE: Test data supplied at 25°C; insertion loss and biphase accuracy.

OUTLINE DRAWING



NOTE: All dimensions shown in brackets [ ] are in millimeters.

0.5 TO 2 GHz LINEAR RF BIPHASE MODULATOR

MODEL: BMA0502LA2MD (Modulation Driven)

FEATURES

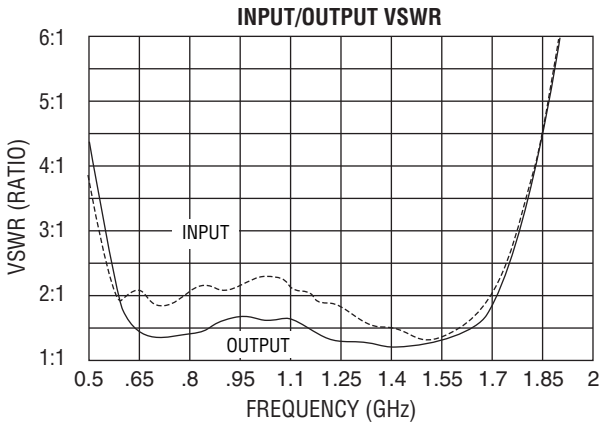
- **RF frequency ..... 0.5 to 2 GHz**
- **Modulation bandwidth ..... DC to 0.5 GHz**
- **Biphase accuracy..... ±1°**
- **Amplitude accuracy ..... ±0.1 dB**
- **Modulator to RF isolation..... 40 dB**

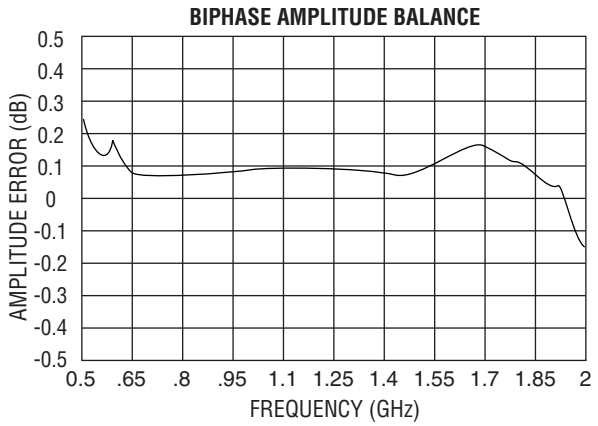
The unusually high port-to-port isolation of MITEQ's BMA Series of biphase modulators makes them well-suited for directly modulating microwave carriers in the linear RF or linear IF modulation modes. The latter or carrier driven mode is useful for low BER digital transmission using Gaussian shaped pulses for minimum bandwidth. Optional diodes are available for more output power using proportionally greater input LO or carrier power. TTL drivers are also available (BMT Series). The specifications shown below are for the modulation driven mode (linear RF). An optional model (-CD) can be ordered and tested in the carrier driven or linear modulation mode.

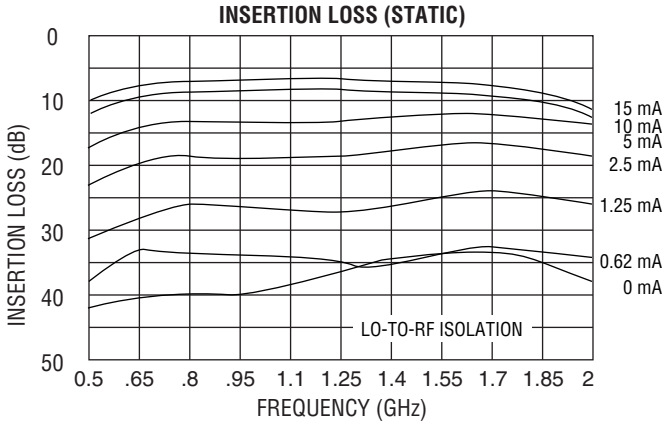
ELECTRICAL SPECIFICATIONS

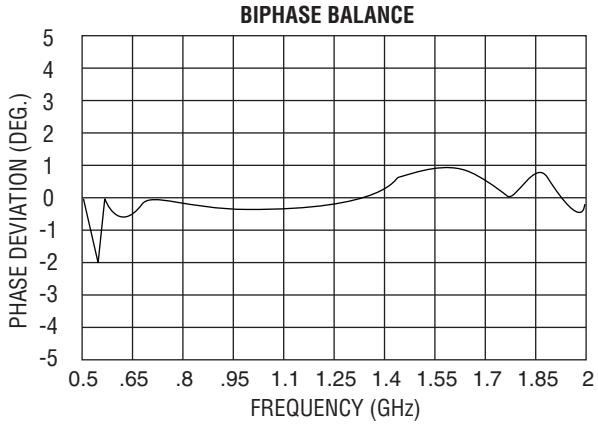
INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
RF frequency range		GHz	0.5		2
RF power		dBm	Noise		+5
RF VSWR	0.75 to 1.5 GHz	Ratio		2:1	
IF frequency range		GHz	DC		0.5
IF current (antiparallel diode input)		mA	-10		+10
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Biphase accuracy	.5 to 2 GHz 0.75 to 1.5 GHz	Degrees		1 0.5	3 1.5
Biphase amplitude balance	IF = ±10 mA	dB		0.1	0.3
Switch loss	IF = ±10 mA	dB		7	9
Isolation RF in to RF out IF in to RF in IF in to RF out	RF = +10, IF = Off RF = +10, IF = Off RF = +10, IF = Off	dB dB dB	30	35 40 40	
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range (modulated carrier)		GHz	0.5		2
RF power at 1 dB compression		dBm		0	
RF VSWR	0.75 to 1.5 GHz	Ratio		1.5:1	

BMA0502LA2MD MODULATION DRIVEN TYPICAL TEST DATA









MAXIMUM RATINGS

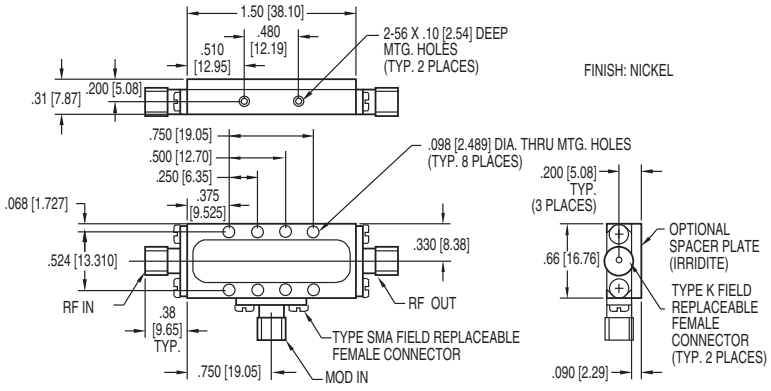
Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +95°C

GENERAL NOTE

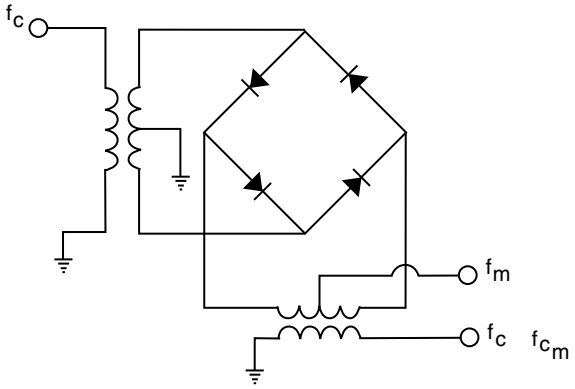
1. Linear RF or modulation driven mode (RF = 0 dBm, IF = ±10 mA).

NOTE: Test data supplied at 25°C; insertion loss and biphase accuracy.

OUTLINE DRAWING



BLOCK DIAGRAM



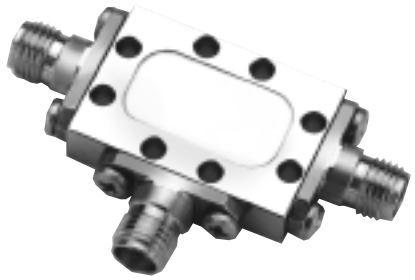
NOTE: All dimensions shown in brackets [ ] are in millimeters.

1 TO 4 GHz LINEAR RF BIPHASE MODULATOR

MODEL: BMA0104LA1MD (Modulation Driven)

FEATURES

- **RF frequency range ..... 1 to 4 GHz**
- **Modulation bandwidth ..... DC to 1 GHz**
- **Biphase accuracy..... ±1°**
- **Amplitude accuracy ..... ±0.1 dB**
- **Modulator to RF isolation..... 40 dB**

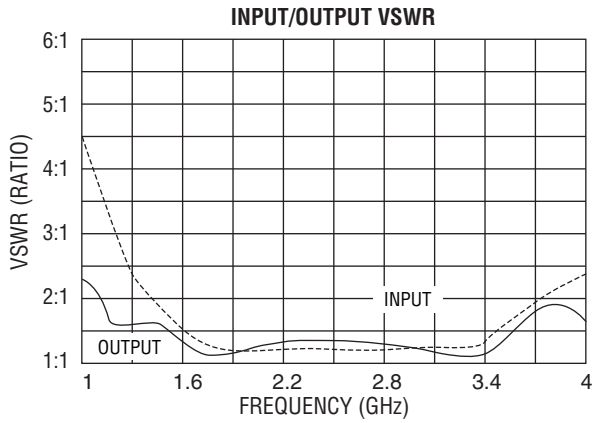


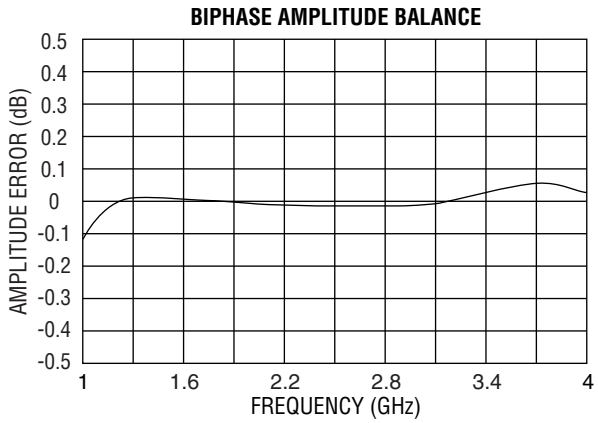
The unusually high port-to-port isolation of MITEQ's BMA Series of biphase modulators makes them well-suited for directly modulating microwave carriers in the linear RF or linear IF modulation modes. The latter or carrier driven mode is useful for low BER digital transmission using Gaussian shaped pulses for minimum bandwidth. Optional diodes are available for more output power using proportionally greater input LO or carrier power. TTL drivers are also available (BMT Series). The specifications shown below are for the modulation driven mode (linear RF). An optional model (-CD) can be ordered and tested in the carrier driven or linear modulation mode.

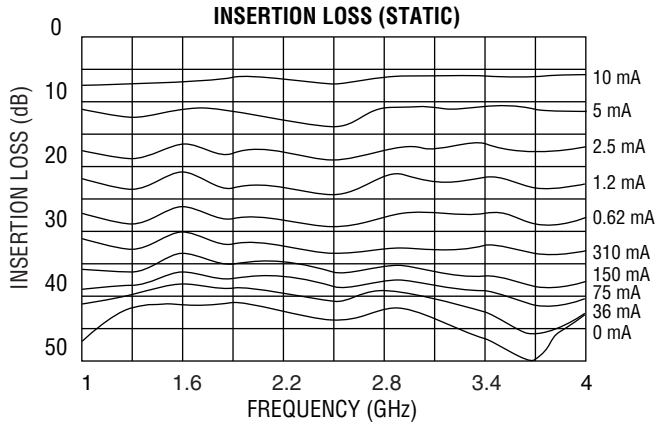
ELECTRICAL SPECIFICATIONS

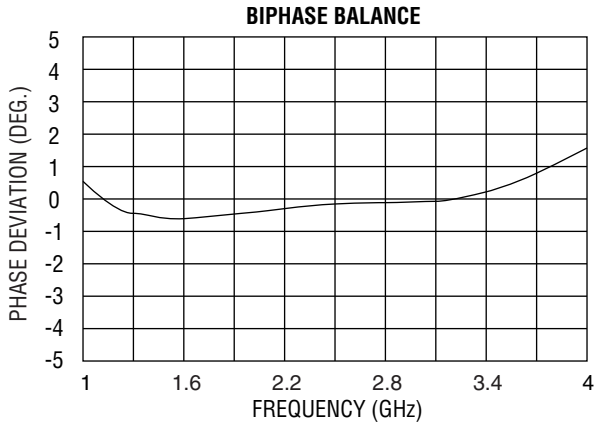
INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
RF frequency range		GHz	1		4
RF power		dBm	Noise		+5
RF VSWR	1.25 to 3.75 GHz	Ratio		2:1	
IF frequency range		GHz	DC		1
IF current (antiparallel diode input)		mA	-10		+10
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Biphase accuracy	1 to 4 GHz 1.5 to 3 GHz	Degrees		1 0.5	3 2
Biphase amplitude balance	IF = ±10 mA	dB		0.1	0.3
Switch loss	IF = ±10 mA	dB		4	5
Isolation RF in to RF out IF in to RF in IF in to RF out	RF = +10, IF = Off RF = +10, IF = Off RF = +10, IF = Off	dB dB dB	30	35 40 40	
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range (modulated carrier)	1.25 to 3.75	GHz	1		4
RF power at 1 dB compression		dBm		0	
RF VSWR	Mode 2	Ratio		1.5:1	

BMA0104LA1MD MODULATION DRIVEN TYPICAL TEST DATA









MAXIMUM RATINGS

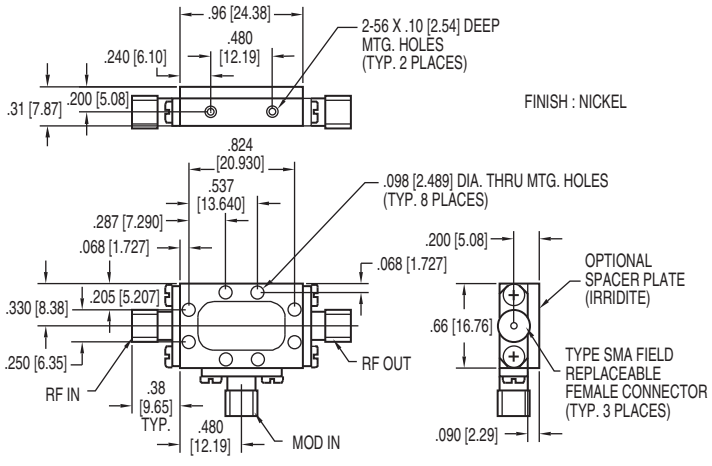
Specification temperature ..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +95°C

GENERAL NOTE

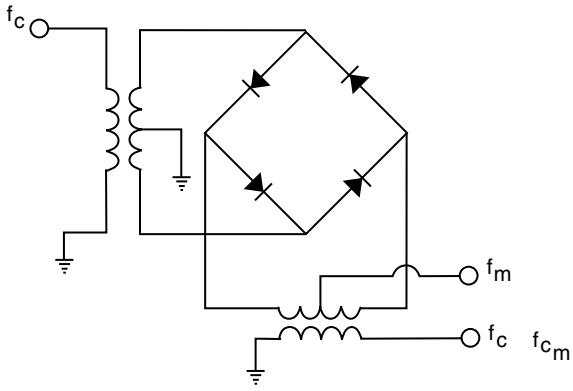
1. Linear RF or modulation driven mode (RF = 0 dBm, IF = ±10 mA).

NOTE: Test data supplied at 25°C; insertion loss and biphase accuracy.

OUTLINE DRAWING



BLOCK DIAGRAM



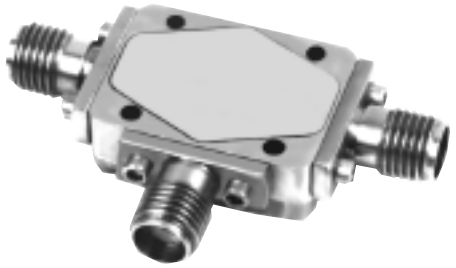
NOTE: All dimensions shown in brackets [ ] are in millimeters.

2 TO 8 GHz LINEAR RF BIPHASE MODULATOR

MODEL: BMA0208LW2MD (Modulation Driven)

FEATURES

- **RF frequency range ..... 2 to 8 GHz**
- **Modulation bandwidth ..... DC to 2 GHz**
- **Biphase accuracy..... ±2°**
- **Amplitude accuracy ..... ±0.2 dB**
- **Modulator to RF isolation..... 40 dB**

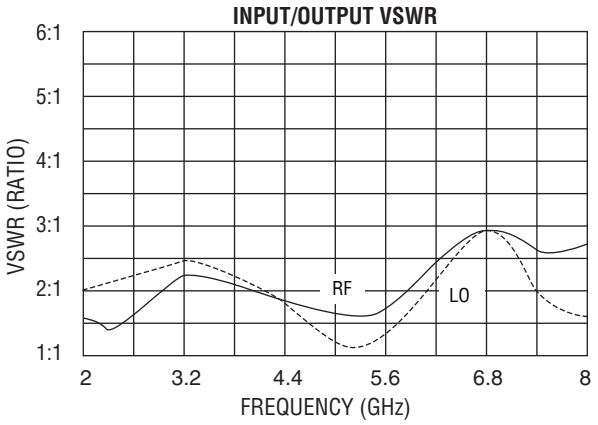


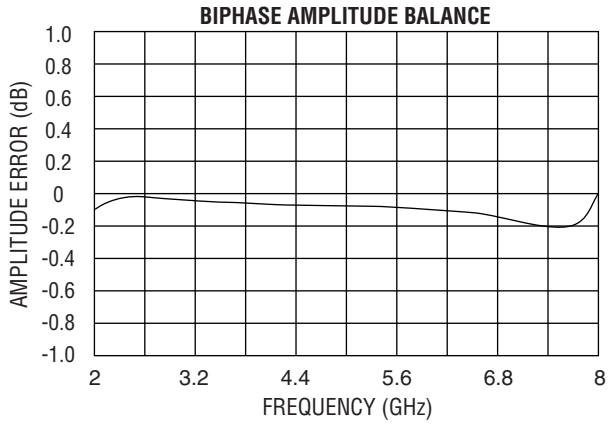
The unusually high port-to-port isolation of MITEQ's BMA Series of biphase modulators makes them well-suited for directly modulating microwave carriers in the linear RF or linear IF modulation modes. The latter or carrier driven mode is useful for low BER digital transmission using Gaussian shaped pulses for minimum bandwidth. Optional diodes are available for more output power using proportionally greater input LO or carrier power. TTL drivers are also available (BMT Series). The specifications shown below are for the modulation driven mode (linear RF). An optional model (-CD) can be ordered and tested in the carrier driven or linear modulation mode.

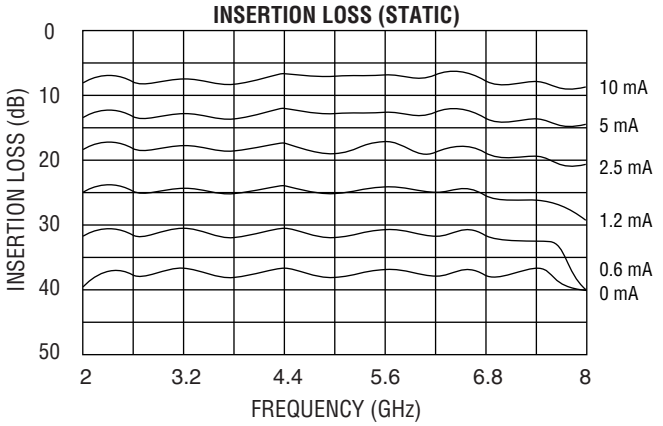
ELECTRICAL SPECIFICATIONS

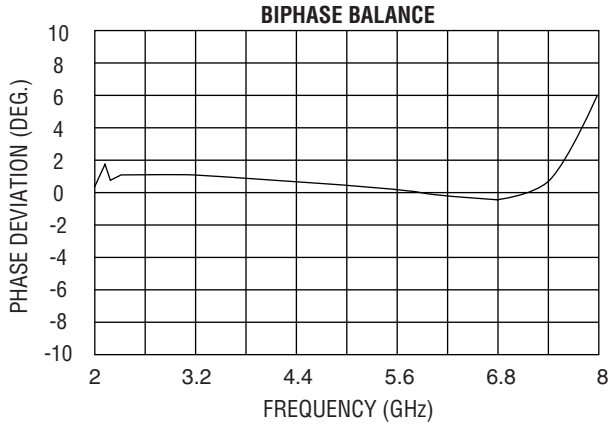
INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
RF frequency range		GHz	2		8
RF power	Mode 2	dBm	Noise		+5
RF VSWR		Ratio		2:1	
IF frequency range		GHz	DC		2
IF current (antiparallel diode input)		mA	-10		+10
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Biphase accuracy	2 to 8 GHz 3 to 6 GHz	Degrees		2 1	7.5 2
Biphase amplitude balance	IF = ±10 mA	dB		0.2	0.5
Switch loss	IF = ±10 mA	dB		3	5
Isolation RF in to RF out IF in to RF in IF in to RF out	RF = +10, IF = Off RF = +10, IF = Off RF = +10, IF = Off	dB dB dB	30	35 40 40	
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range (modulated carrier)		GHz	2		8
RF power at 1 dB compression		dBm		0	
RF VSWR	Mode 2	Ratio		2.5:1	

BMA0208LW2MD MODULATION DRIVEN TYPICAL TEST DATA









MAXIMUM RATINGS

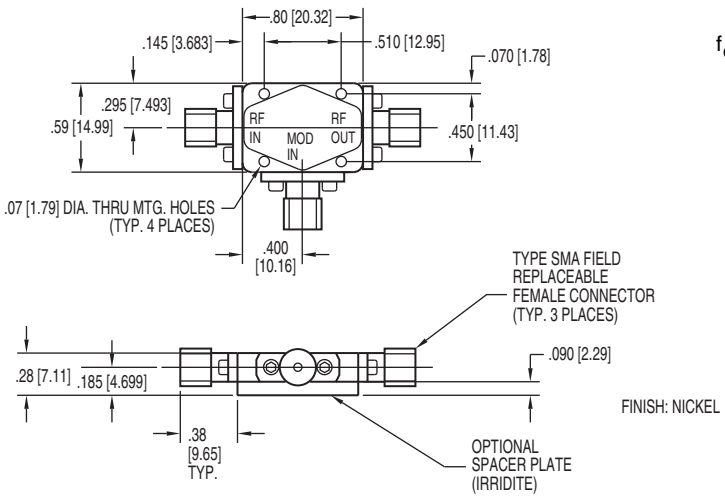
Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +95°C

GENERAL NOTE

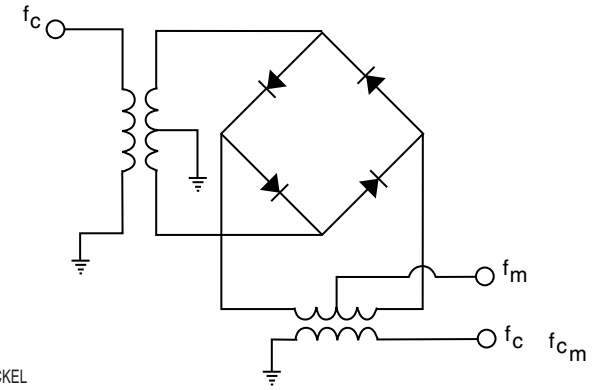
1. Linear RF or modulation driven mode (RF = 0 dBm, IF = ±10 mA).

NOTE: Test data supplied at 25°C; insertion loss and biphase accuracy.

OUTLINE DRAWING



BLOCK DIAGRAM



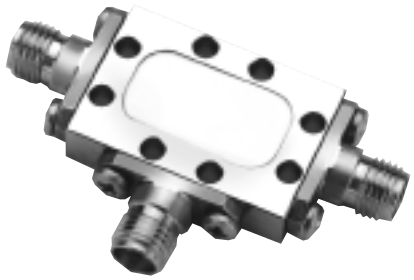
NOTE: All dimensions shown in brackets [ ] are in millimeters.

2 TO 18 GHz LINEAR RF BIPHASE MODULATOR

MODEL: BMA0218LA1MD (Modulation Driven)

FEATURES

- **RF frequency range..... 2 to 18 GHz**
- **Modulation bandwidth ..... DC to 0.5 GHz**
- **Biphase accuracy..... ±5°**
- **Amplitude accuracy ..... ±0.5 dB**
- **Modulator to RF isolation..... 20 dB**

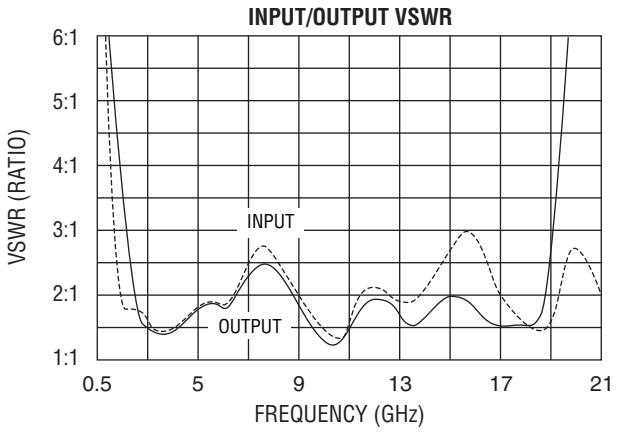


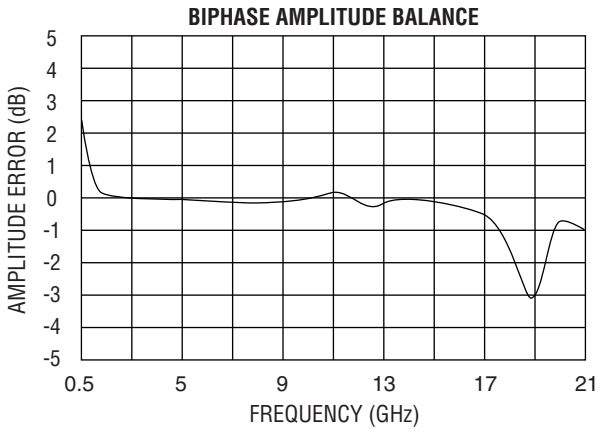
This double-balanced multioctave mixer is suitable for general purpose biphase modulator applications. When the diodes are driven by the carrier power (mode 1), a 10 to 15 dB IF amplitude control is possible. In the modulation driven mode, close, biphase control of the carrier is possible over a wide RF dynamic range. The specifications shown below are for the modulation driven mode (linear RF). An optional model (-CD) can be ordered and tested in the carrier driven or linear modulation mode.

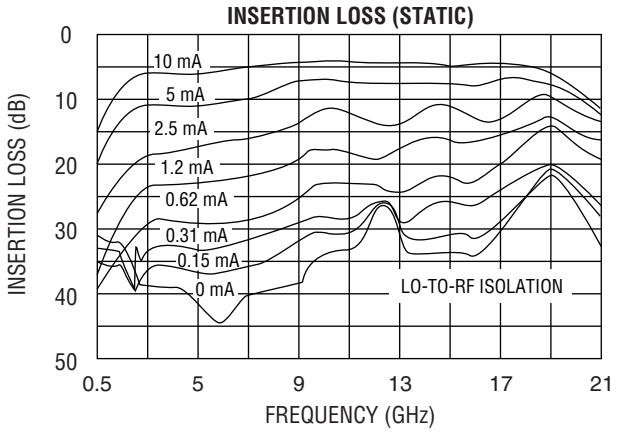
ELECTRICAL SPECIFICATIONS

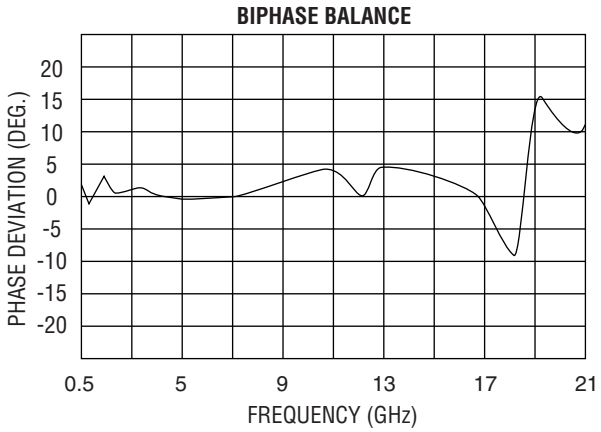
INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
RF frequency range		GHz	2		18
RF power		dBm	Noise		+5
RF VSWR		Ratio		2:1	
IF frequency range		GHz	DC		0.5
IF current (antiparallel diode input)		mA	-10		+10
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Biphase accuracy	2 to 18 GHz 3 to 17 GHz	Degrees		5 2	10 5
Biphase amplitude balance	IF = ±10 mA	dB		0.5	
Switch loss	IF = ±10 mA	dB		3	5
Isolation RF in to RF out IF in to RF in IF in to RF out	RF = +10, IF = Off RF = +10, IF = Off RF = +10, IF = Off	dB dB dB	18	20 15 30	
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range (modulated carrier)		GHz	2		18
RF power at 1 dB compression		dBm		0	
RF VSWR		Ratio		2.5:1	

BMA0218LA1MD MODULATION DRIVEN TYPICAL TEST DATA









MAXIMUM RATINGS

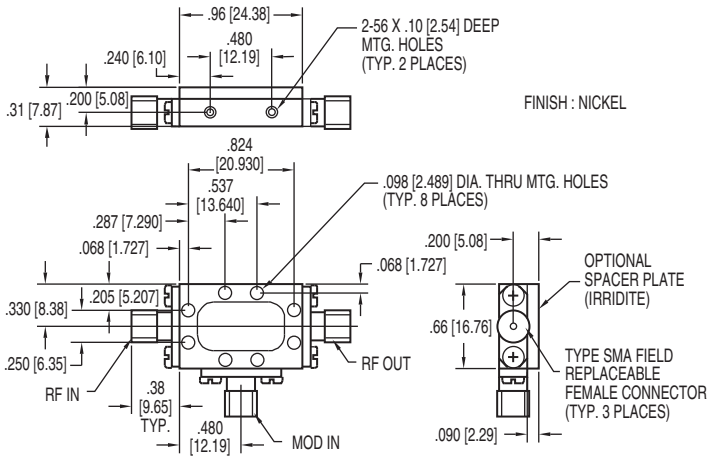
Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +95°C

GENERAL NOTE

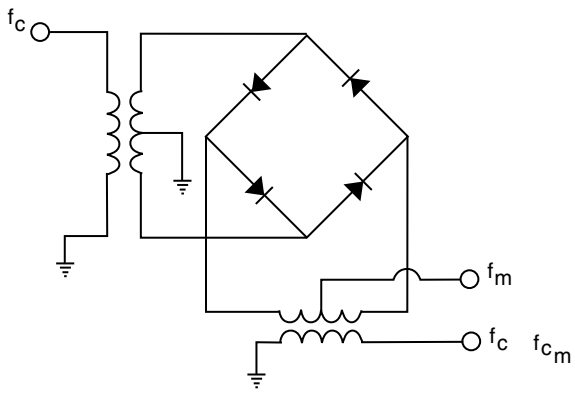
1. Linear RF or modulation driven mode (RF = 0 dBm, IF = ±10 mA).

NOTE: Test data supplied at 25°C; insertion loss and biphase accuracy.

OUTLINE DRAWING



BLOCK DIAGRAM



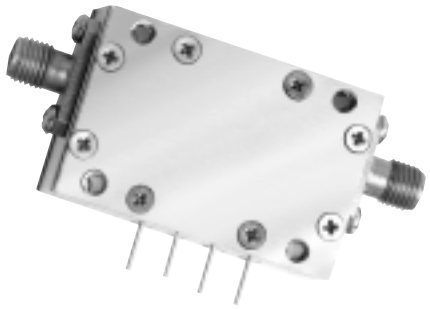
NOTE: All dimensions shown in brackets [ ] are in millimeters.

2 TO 18 GHz TTL BIPHASE MODULATOR

MODEL: BMT0218HC10MD (Modulation Driven)

FEATURES

- **RF frequency range..... 2 to 18 GHz**
- **Biphase accuracy..... ±5°**
- **Amplitude accuracy ..... ±0.5 dB**
- **Rise time ..... 10 ns**
- **Switching speed ..... 30 ns**
- **RF input..... +15 dBm (P1 dB)**

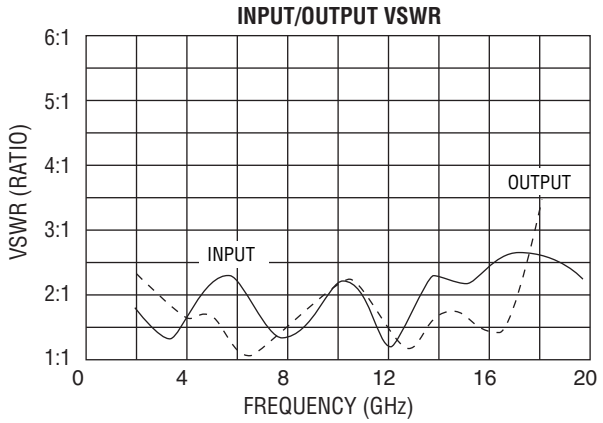


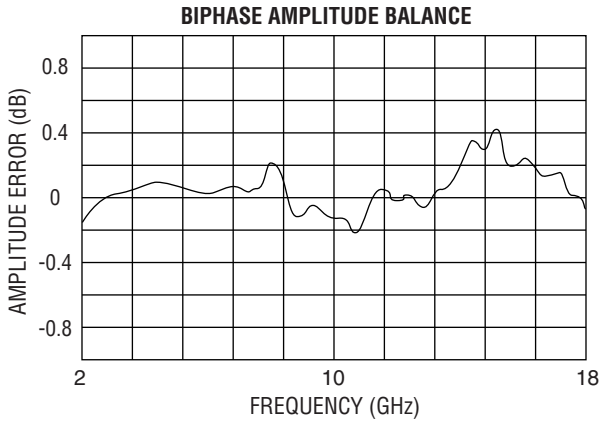
MITEQ's Model BMT0218HC10MD TTL-controlled biphase modulator is ideal for BPSK modulation over broad frequency ranges with extremely high input carrier levels (up to +20 dBm). The power handling capability is suited to simulator systems using high-level VCOs avoiding the requirement of an additional external amplifier. Since this is a TTL or modulation driven unit, the RF input-to-output power relation is linear up to the compression level.

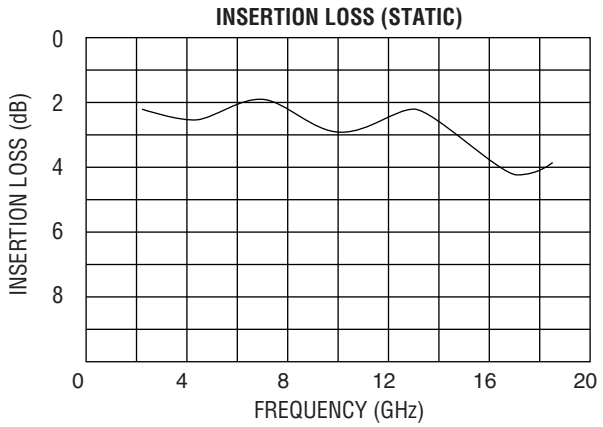
ELECTRICAL SPECIFICATIONS

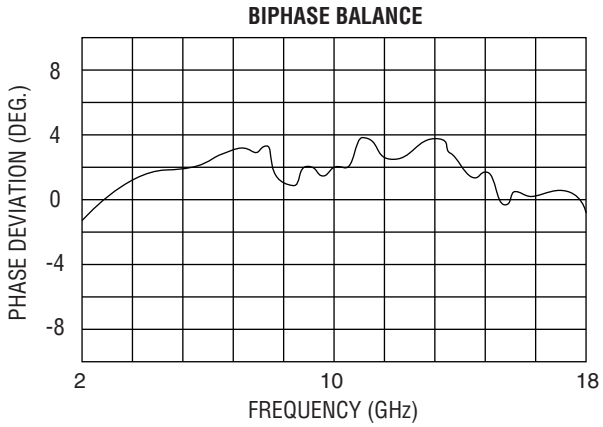
INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
RF carrier frequency range		GHz	2		18
RF carrier VSWR		Ratio		2.8:1	3.5:1
RF carrier power (linear)	Operating Nonoperating	dBm dBm	+15	+20 +23	
TTL modulation rate		MHz	DC		30
DC power supply	±5 VDC	mA			30
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Insertion loss		dB		4.	6
Carrier suppression		dBc	20	25	
Switching speed	50% TTL to 90% RF	ns		30	
Switching rise/fall time	10 to 90% RF	ns		10	
Phase balance (0 or 180°)		Degrees		±5	±10
Amplitude balance (0 or 180°)		dB		±0.5	±0.75
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Modulated RF frequency range		GHz	2		18
Modulated RF VSWR		Ratio		2.8:1	3.5:1
Video leakage	From 2 to 18 GHz	dBm		-65	

BMT0218HC10MD MODULATION DRIVEN TYPICAL TEST DATA







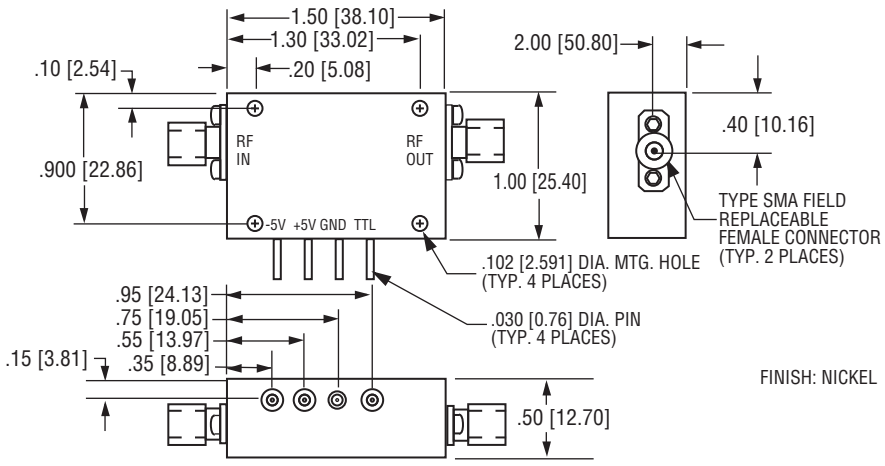


MAXIMUM RATINGS

Specification temperature ..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C
Weight ..... 26 grams

NOTE: Test data supplied at 25°C; insertion loss and biphase accuracy.

OUTLINE DRAWING



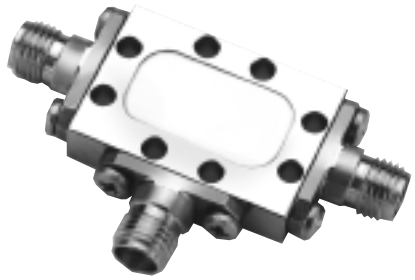
NOTE: All dimensions shown in brackets [ ] are in millimeters.

6 TO 18 GHz LINEAR RF BIPHASE MODULATOR

MODEL: BMA0618LA1MD (Modulation Driven)

FEATURES

- **RF frequency range..... 6 to 18 GHz**
- **Modulation bandwidth ..... DC to 0.5 GHz**
- **Biphase accuracy..... ±5°**
- **Amplitude accuracy ..... ±0.75 dB**
- **Modulator to RF isolation..... 35 dB**



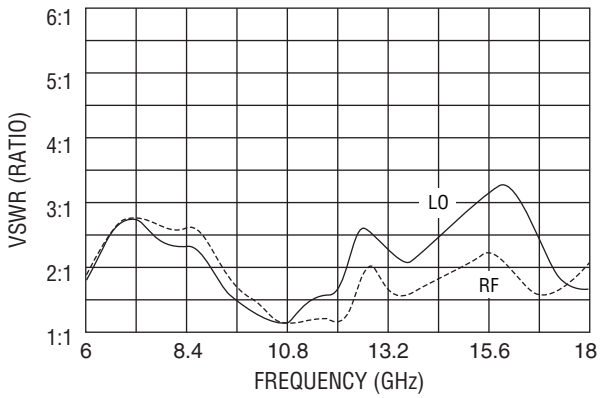
The unusually high port-to-port isolation of MITEQ's BMA Series of biphase modulators makes them well-suited for directly modulating microwave carriers in the linear RF or linear IF modulation modes. The latter or carrier driven mode is useful for low BER digital transmission using Gaussian shaped pulses for minimum bandwidth. Optional diodes are available for more output power using proportionally greater input LO or carrier power. TTL drivers are also available (BMT Series). The specifications shown below are for the modulation driven mode (linear RF). An optional model (-CD) can be ordered and tested in the carrier driven or linear modulation mode.

ELECTRICAL SPECIFICATIONS

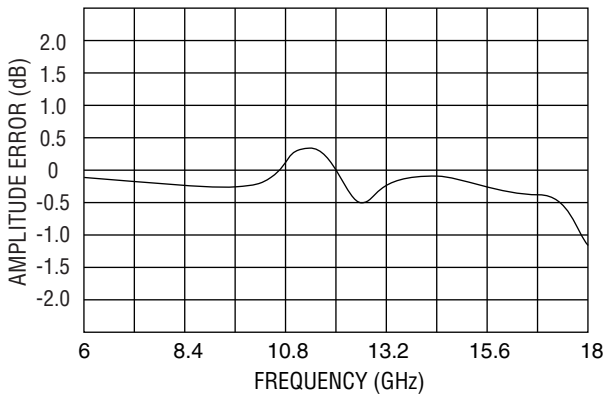
INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
RF frequency range		GHz	6		18
RF power		dBm	Noise		+5
RF VSWR		Ratio		2:1	
IF frequency range		GHz	DC		0.5
IF current (antiparallel diode input)		mA	-10		+10
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Biphase accuracy	6 to 18 GHz 8 to 16 GHz	Degrees		±5 ±2	±10 ±5
Biphase amplitude balance	IF = ±10 mA	dB		±0.75	
Switch loss	IF = ±10 mA	dB		4	6
Isolation RF in to RF out IF in to RF in IF in to RF out	RF = +10, IF = Off RF = +10, IF = Off RF = +10, IF = Off	dB dB dB	20	35 20 30	
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range (modulated carrier)		GHz	6		18
RF power at 1 dB compression		dBm		0	
RF VSWR		Ratio		2.5:1	

BMA0618LA1MD MODULATION DRIVEN TYPICAL TEST DATA

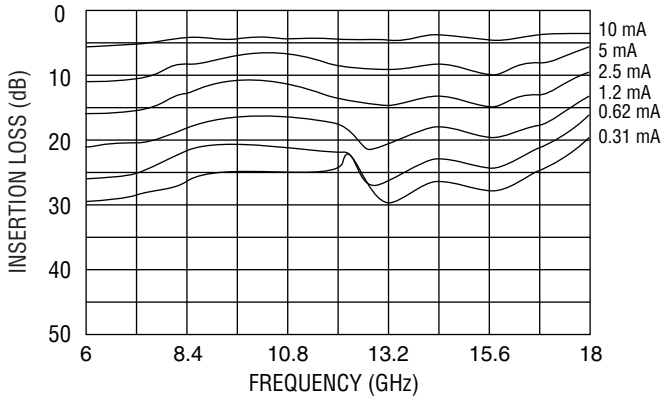
INPUT/OUTPUT VSWR



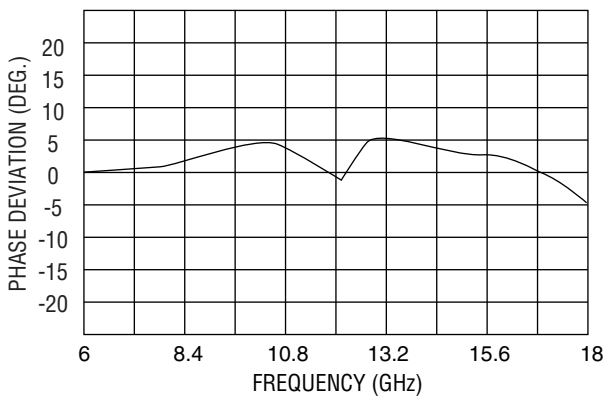
BIPHASE AMPLITUDE BALANCE



INSERTION LOSS (STATIC)



BIPHASE BALANCE



MAXIMUM RATINGS

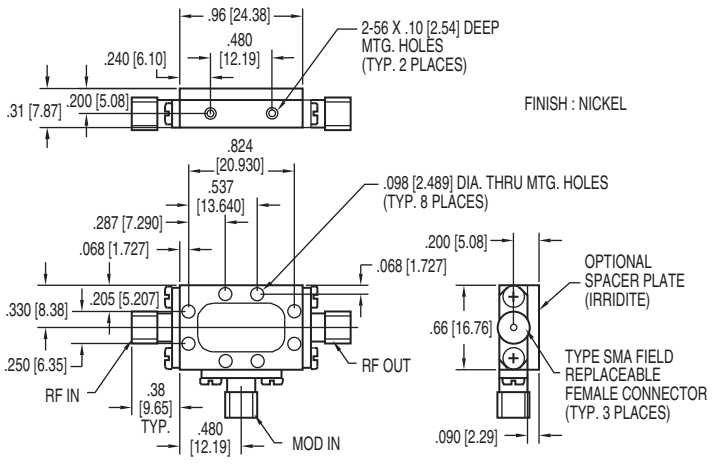
Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +95°C

GENERAL NOTE

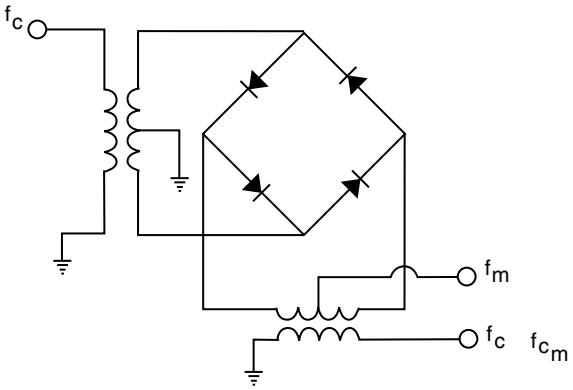
1. Linear RF or modulation driven mode (RF = 0 dBm, IF = ±10 mA).

NOTE: Test data supplied at 25°C; insertion loss and biphase accuracy.

OUTLINE DRAWING



BLOCK DIAGRAM



NOTE: All dimensions shown in brackets [ ] are in millimeters.

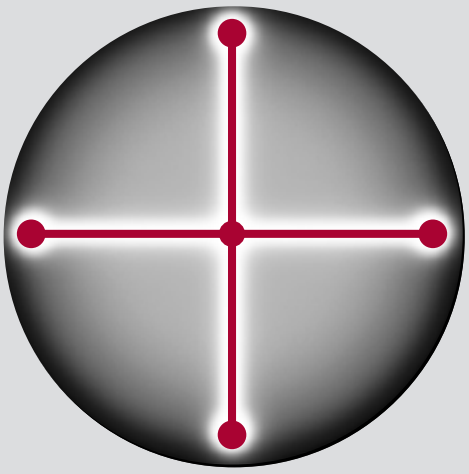
APPLICATION NOTES FOR BIPHASE MODULATORS AND DSB UPCONVERTERS

The double-balanced mixer is useful for modulator and upconverter applications, but the methods and circuit balance required are somewhat different for each application.

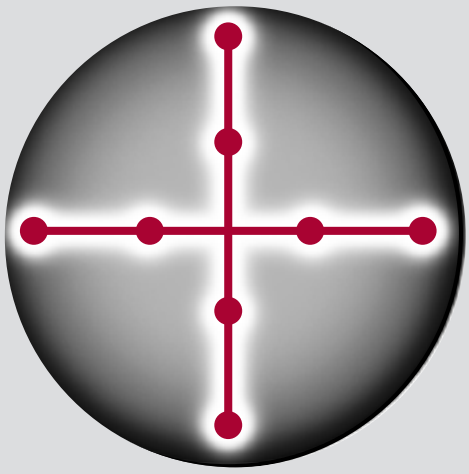
The upconverter is typically used to raise the frequency of an existing modulated signal from the VHF/UHF range into the microwave spectrum. In the process, two signals are generated above and below the applied LO or carrier signal. Carrier leakage is usually not important for the upconverter because a bandpass filter can be used to eliminate this widely separated signal. Either the IF or RF can be used to turn on the diodes depending upon whether the output harmonics of the IF or RF are important. In general, the linear signal input power is kept at least 5 dB below the diode drive signal for compression levels of less than -1 dB.

Biphase modulator applications usually require double-balanced mixers with superior carrier rejection (LO-to-RF isolation). For this application, the modulation sidebands are close to the carrier and unwanted carrier leakage will introduce biphase output spectrum errors (the relationship between these variables are discussed in the Q and A section of this catalog). High-frequency biphase modulated signals have traditionally been generated by using a low-frequency torrid type mixer with 40 to 50 dB LO-to-RF isolation as a narrow band modulator and a second-stage upconverter mixer/LO with any necessary filters to clean up the spectrum. Recently, better baluns and small corrective DC offset voltages have been used in the 1 or 20 GHz range to improve the isolation of double-balanced mixers so that direct (on-carrier) modulation without a separate upconverter is possible. MITEQ has improved the balance (-45 dB) of traditional microwave mixers so that special direct on-carrier biphase modulators up to 30 GHz are possible. The Model BMA0104LA1MD is an example of a unit with multioctave baluns (1 to 4 GHz) yielding ±2° and ±0.1 dB biphase accuracy. Furthermore, data rates of DC to 1 GHz are possible with reduced accuracy.

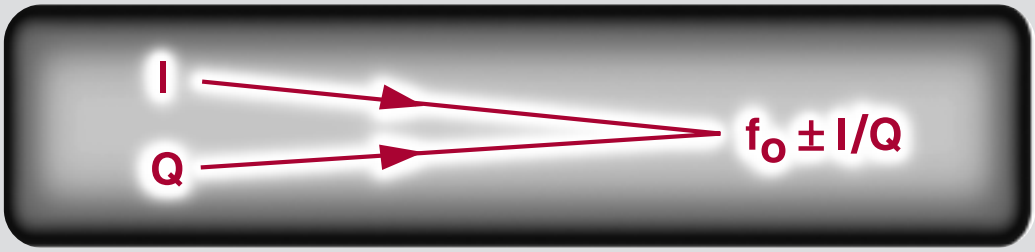
MODULATOR PRODUCTS



QPSK



QAM



MODULATORS

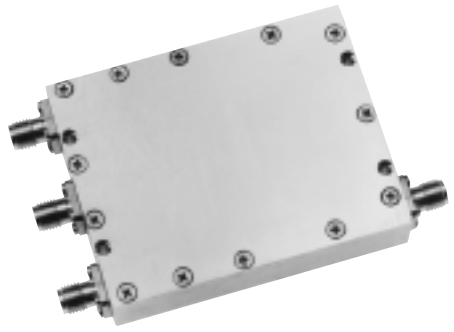
- **Detailed Data Sheets**

0.5 TO 2 GHz SINGLE-SIDEBAND UPCONVERTER OR I/Q MODULATOR

MODEL: SDM0502LC1MD* (Modulation Driven)

FEATURES

- **RF output/carrier input ..... 0.5 to 2 GHz**
- **Modulation bandwidth ..... DC to 500 MHz (Q)**
- **Carrier input linear power ..... Up to +5 dBm**
- **Modulation input power..... +7 to +13 dBm**
- **Sideband suppression..... 25 dB**
- **Carrier rejection..... 33 dB**
- **Modulation options:**
  Single sideband..... A, B and C (internal hybrid)
  I/Q modulator..... Q (separate inputs)
  QPSK digital..... SMT (TTL input)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or modulation) has sufficient power to turn on the semiconductors. This model employs modulation drive. All modulators yield a frequency spectrum that utilizes both sidebands on either side of the output suppressed carrier. SSB upconverters, however, employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) modulators have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This modulation driven unit is used when the RF input has a wide dynamic range, such as for military and commercial Doppler frequency or phase-shift generation.

ELECTRICAL SPECIFICATIONS

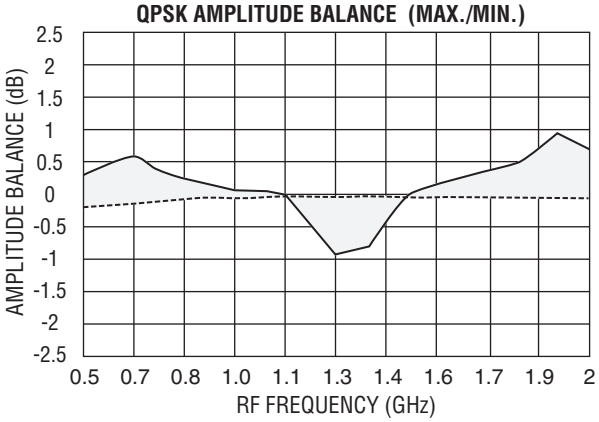
INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	0.5		2
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		1.5:1	
RF power at 1 dB compression (IF = +10 dBm)	dBm		+5	
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (50 ohm)	dBm	+7	+10	+13
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		7	10
Carrier suppression	dBc	30	33	
Sideband suppression upconverter mode (Note 2)				
Carrier – fundamental IF	dBc	15	25	
Carrier ±2 IF, 4 IF, etc.	dBc		50	
Carrier ±3 IF	dBc		10	
Quadrature phase accuracy, I/Q mode (see Graph Key)	Degrees		±7.5	±10
Quadrature amplitude accuracy	dB		±1	±1.5
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	0.5		2
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		2.5:1	

SDM0502LC1MDQ MODULATION DRIVEN TYPICAL TEST DATA

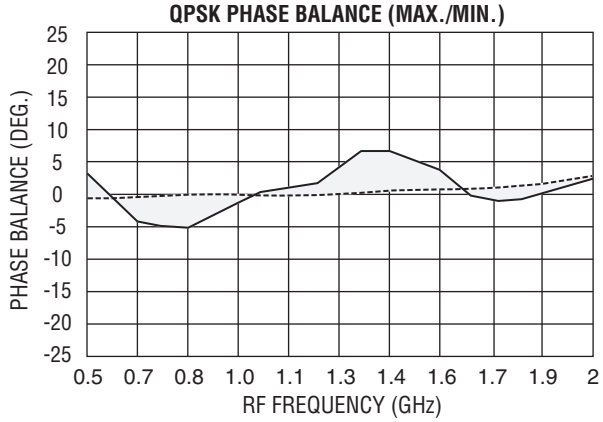
RF Phase (Deg.) / I/Q	Graph Key 0 +/+	+90 -/+	-90 +/-	+180 -/-

I/Q MODE (RF = 0 dBm, I/Q = +10 dBm or ±10 mA)

QPSK AMPLITUDE BALANCE (MAX./MIN.)



QPSK PHASE BALANCE (MAX./MIN.)



SDM0502LC1MDC MODULATION DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 100 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
.5	6.7	29	39	44	51	12	27
.75	7	23	42	53	53	10	33
1	7.1	28	42	54	52	11	30
1.25	7.6	28	38	56	54	12	31
1.5	7.6	25	36	54	54	11	33
1.75	8.1	30	34	56	52	10	26
2	8	19	31	51	46	10	30

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

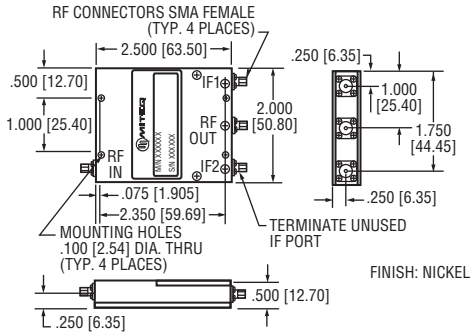
1. Insertion loss relative to 0 dBm RF input. All other outputs, including f_O, are relative to the desired upper ($f_O + f_M$) output.
2. Standard units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

*3. Available part numbers: SDM0502LC1MD_*
A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

NOTE: Test data supplied at 25°C; insertion loss, phase and amplitude balance per spectrum table.

OUTLINE DRAWING

SDM0502LC1MDC

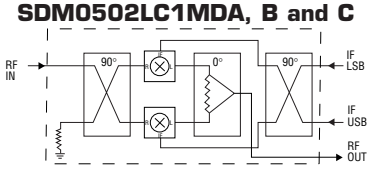


NOTE: All dimensions shown in brackets [ ] are in millimeters.

BLOCK DIAGRAMS

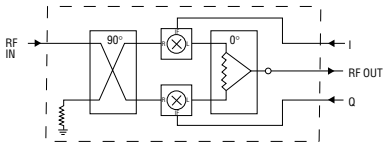
SDM0502LC1MDA, B and C

SSB UPCONVERTER



SDM0502LC1MDQ

I/Q MODULATOR

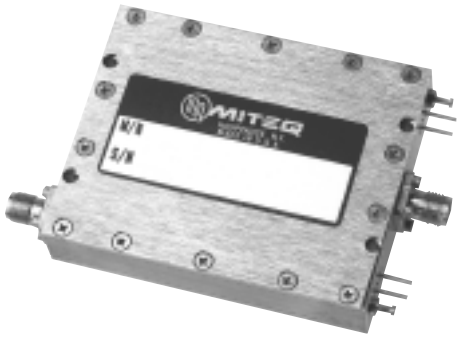


0.5 TO 2.0 GHz TTL QPSK MODULATOR

MODEL: SMT0502LC1MD (Modulation Driven)

FEATURES

- **RF/LO Coverage..... 0.5 to 2.0 GHz**
- **TTL-controlled I and Q inputs**
- **Amplitude accuracy..... ±0.5 dB**
- **QPSK phase accuracy..... ±5°**
- **Switching speed..... 30 ns**
- **Rise time..... 10 ns**



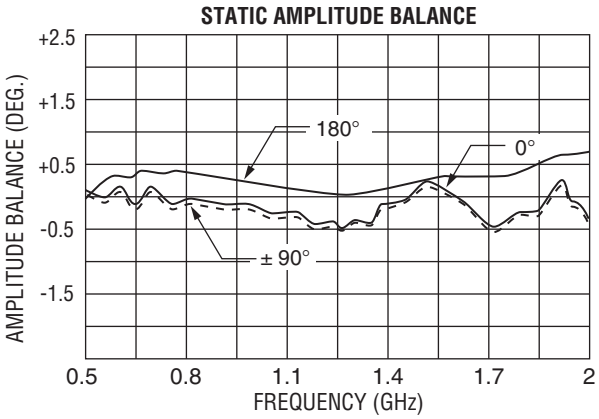
MITEQ's Model SMT0502LC1MD quadrature phase-shift keying (QPSK) modulator is designed for rapid digital TTL-control applications. For example, two channels (I/Q) of isolated digital modulation can be transmitted in the same bandwidth as required for one biphase modulator.

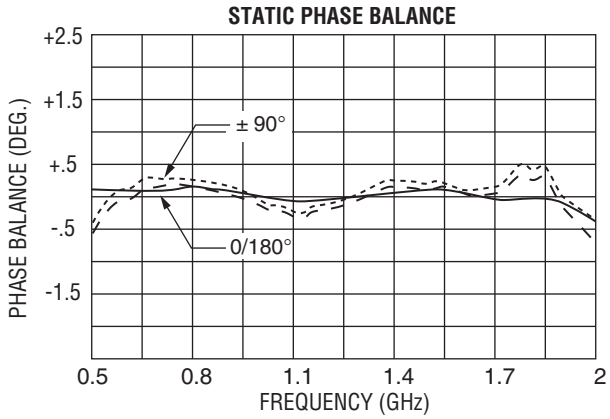
ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
RF carrier		GHz	0.5		2
RF carrier level (maximum)		dBm		0	+3
RF VSWR	50 ohm reference	Ratio		2:1	2.5:1
IF modulation input	2 BITS			TTL	
DC power	+12 volts -12 volts	mA mA			150 150
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Insertion loss		dB		7	10
Quadra-state phase balance		Degrees		±5	±10
Quadra-state amplitude balance		dB		±0.5	±1.5
Switching speed (50% TTL to 90% RF)		ns		10	30
Modulation to RF output isolation		dB	25		
Carrier suppression		dBc	18	25	
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range		GHz	0.5		2
RF VSWR	50 ohm reference	Ratio		2.5:1	
Output phase matrix		**TTL LEVELS**		**PHASE**	**UNITS**
		0	0	Ref.	Degrees
		1	0	90	Degrees
		1	1	180	Degrees
		0	1	270	Degrees

SMT0502LC1MD MODULATION DRIVEN TYPICAL TEST DATA

RF = 0 dBm, I/Q = TTL





SMT0502LC1MD MODULATION DRIVEN OUTPUT SPECTRUM TABLE

OUTPUT SPECTRUM RELATIVE TO CARRIER +20 MHz OUTPUT

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
0.5	-5.6	-25.9	-45.9	-37.9	-46.4	-12.4	-30.8
0.6	-5.9	-26.8	-34.3	-43.4	-47	-10.1	-37.9
0.7	-6.2	-28	-33.3	-45.9	-44.8	-9.9	-30.6
0.8	-6.1	-27.7	-35	-46	-45.9	-10.6	-33.5
0.9	-5.8	-28.4	-36.5	-46.4	-47.7	-11.1	-37.8
1	-5.7	-26.8	-38.3	-48.4	-49.7	-11	-31.8
1.1	-6	-26.4	-42.4	-47.1	-49.1	-10.8	-36.7
1.2	-5.9	-26.8	-45.2	-47.1	-47.6	-11.2	-40
1.3	-6.3	-26	-49.6	-46.1	-47.4	-10.5	-38.9
1.4	-6.6	-30.5	-48.4	-46.8	-47.2	-10.4	-35.4
1.5	-7	-31.5	-44.7	-46	-46.9	-10.3	-33
1.6	-7.4	-28.6	-41.5	-45.8	-47.1	-10.2	-35.3
1.7	-7.7	-25.6	-39.9	-46.7	-45.5	-10.3	-45.7
1.8	-7.7	-24.9	-36.2	-47.8	-43.7	-10.4	-30.4
1.9	-7.2	-26.8	-31.5	-46.9	-40.5	-11	-30.3
2	-6.5	-24	-28.1	-47.2	-37	-11.4	-41.5
Worst case	-7.7	-24	-28.1	-37.9	-37	-9.9	-30.3

MAXIMUM RATINGS

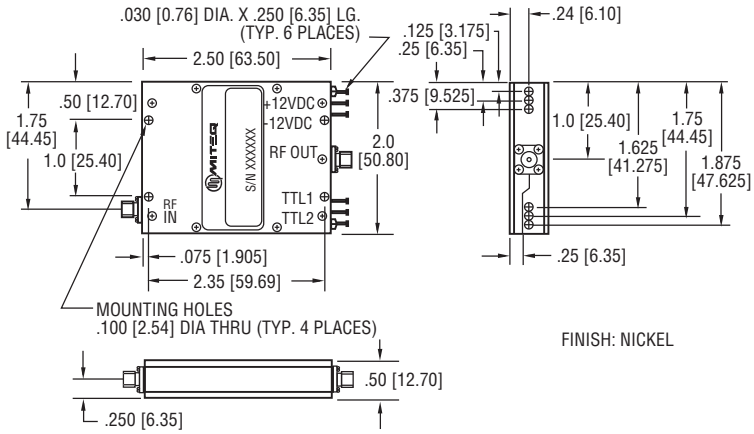
Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Conversion loss is relative to RF carrier input (0 dBm).
2. RF = 0 dBm, I/Q = TTL.
3. PIN diode for high level operation (RF = +20 dBm).

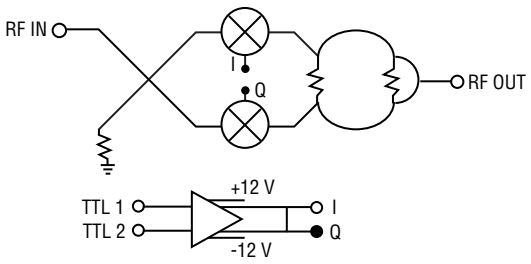
NOTE: Test data supplied at 25°C; insertion loss, phase and amplitude balance.

OUTLINE DRAWING



FINISH: NICKEL

BLOCK DIAGRAM



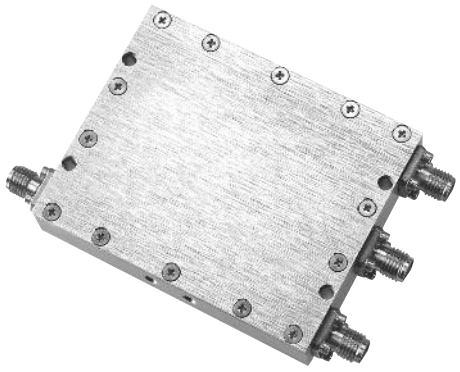
NOTE: All dimensions shown in brackets [ ] are in millimeters.

1 TO 2 GHz QPSK MODULATOR

MODEL: SDM0102LC1MDQ (Modulation Driven)

FEATURES

- **RF output/carrier input ..... 1 to 2 GHz**
- **Modulation bandwidth ..... DC to 500 MHz (Q)**
- **Carrier linear input ..... Up to +5 dBm**
- **Modulation input power..... +7 to +13 dBm**
- **Sideband suppression..... 25 dB**
- **Carrier isolation..... 35 dB**
- **Modulation options:**
  QPSK digital..... SMT (TTL input)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or modulation) has sufficient power to turn on the semiconductors. This model employs modulation drive. All modulators yield a frequency spectrum that utilizes both sidebands on either side of the output suppressed carrier. SSB upconverters, however, employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) modulators have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This modulation driven unit is used when the RF input has a wide dynamic range, such as for military and commercial Doppler frequency or phase-shift generation.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	1		2
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		1.5:1	
RF power at 1 dB compression (IF = +10 dBm)	dBm		+5	
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation current	mA	+7	+10	+13
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		6	7
Carrier isolation	dBc		35	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc		25	
Carrier ±2 IF, 4 IF, etc.	dBc		45	
Carrier ±3 IF	dBc		10	
Quadrature phase accuracy, I/Q mode (see Graph Key)	Degrees		±5	±7
Quadrature amplitude accuracy	dB		±0.5	±0.75
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	1		2
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		2.5:1	

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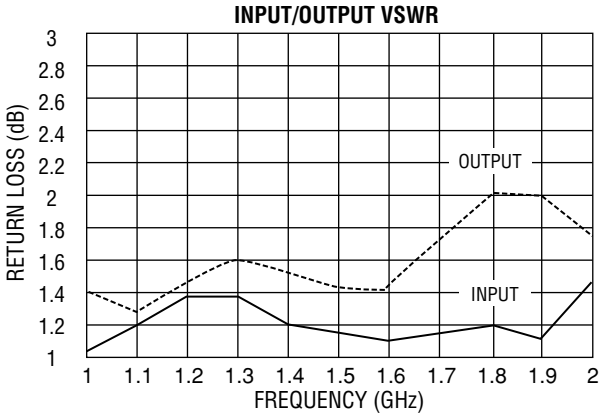
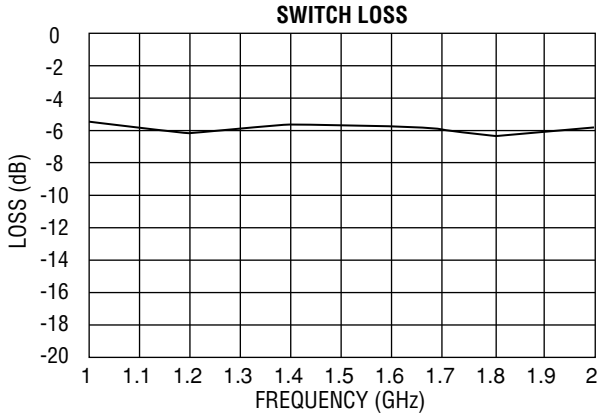
Revised: 03/17/14

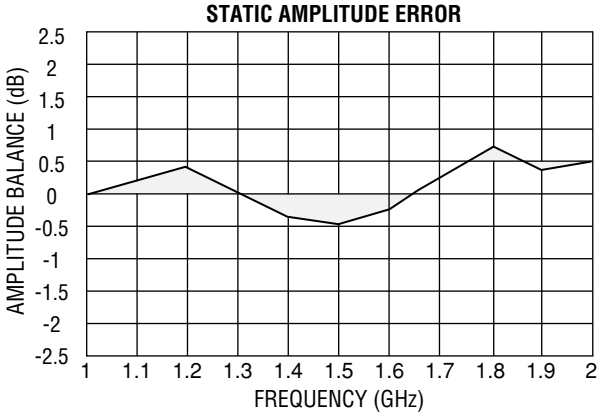
SDM0102LC1MDQ MODULATION DRIVEN TYPICAL TEST DATA

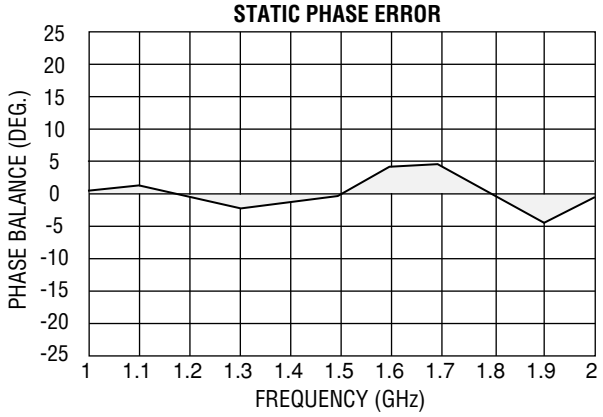
RF Phase (Deg.) I/Q	Graph Key 0 +/+	+90 -/+	-90 +/-	+180 -/-

I/Q MODE (RF = 0 dBm, I/Q = ±10 mA)









MAXIMUM RATINGS

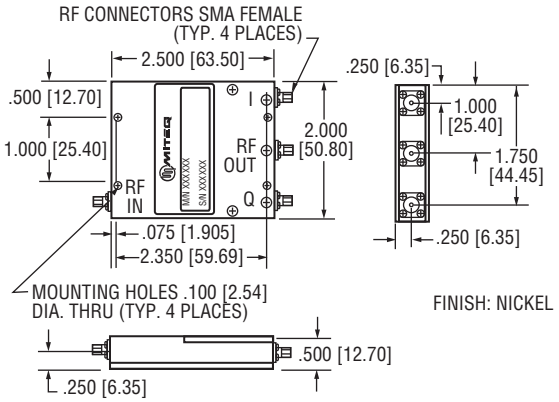
Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

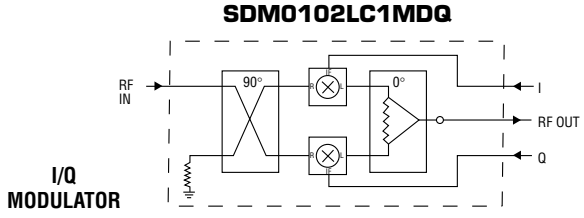
1. Conversion loss is relative to RF carrier input (0 dBm).
2. Relative to desired output sideband.
3. PIN diode for high level operation (RF = +20 dBm).

NOTE: Test data supplied at 25°C; insertion loss, phase and amplitude balance.

OUTLINE DRAWING



BLOCK DIAGRAM



NOTE: All dimensions shown in brackets [ ] are in millimeters.

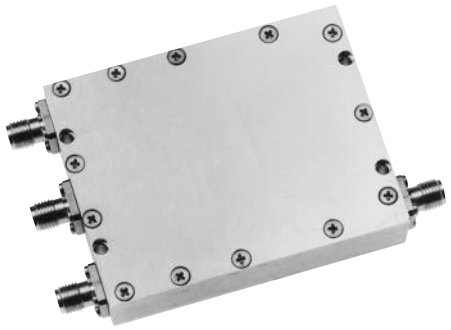
Revised: 03/13/14

1 TO 4 GHz SINGLE-SIDEBAND UPCONVERTER (OR I/Q) MODULATOR

MODEL: SM0104LC1MD_* (Modulation Driven)

FEATURES

- **RF output/carrier input ..... 1 to 4 GHz**
- **Modulation bandwidth ..... DC to 500 MHz (Q)**
- **Sideband suppression..... 25 dB**
- **Carrier isolation..... 35 dB**
- **Modulation options:**
  Single sideband..... A, B and C (internal hybrid)
  I/Q modulator ..... Q (separate inputs)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or modulation) has sufficient power to turn on the semiconductors. This model employs modulation drive. All modulators yield a frequency spectrum that utilizes both sidebands on either side of the output suppressed carrier. SSB upconverters, however, employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) modulators have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This modulation driven unit is used when the RF input has a wide dynamic range, such as for military and commercial Doppler frequency or phase-shift generation.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	1		4
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		1.5:1	
RF power at 1 dB compression (IF = +10 dBm)	dBm		+5	
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (50 ohm input)	dBm	+7	+10	+13
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		8	11
Carrier isolation	dBc	27	37	
Sideband suppression upconverter mode(Note 2)				
Carrier – fundamental IF	dBc	12	20	
Carrier ±2 IF, 4 IF, etc.	dBc		45	
Carrier ±3 IF	dBc		10	
Quadrature phase accuracy, I/Q mode (see Graph Key)	Degrees		±15	±17.5
Quadrature amplitude accuracy	dB		±20	±2.5
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	1		4
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		2.5:1	

Revised: 03/17/14

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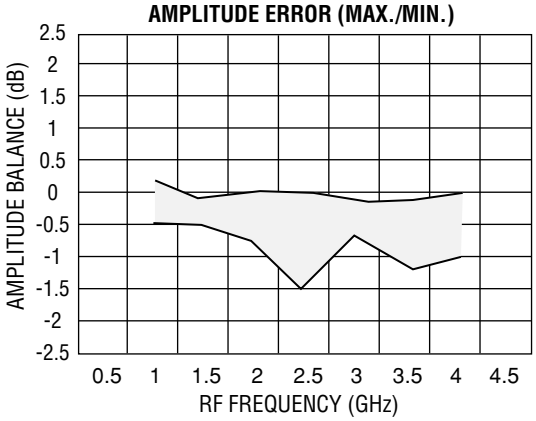
SM0104LC1MDQ MODULATION DRIVEN TYPICAL TEST DATA

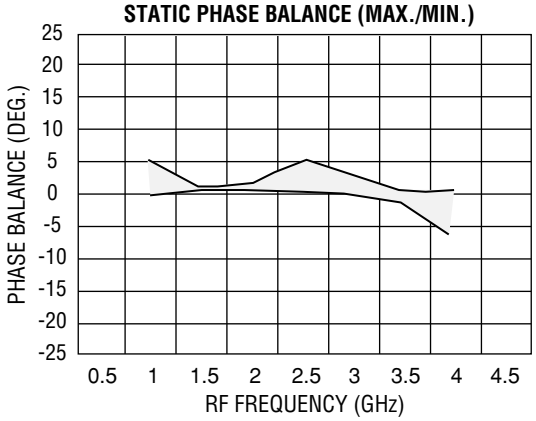
RF Phase (Deg.) I/Q	Graph Key 0 +/+	+90 -/+	-90 +/-	+180 -/-

I/Q MODE (RF = 0 dBm, I/Q =+10 dBm or ±10 mA)

AMPLITUDE ERROR (MAX./MIN.)



STATIC PHASE BALANCE (MAX./MIN.)



SM0104LC1MDC MODULATION DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 100 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
1	8.8	26	39	50	51	13	29
1.5	6	36	43	52	53	11	30
2	5.7	37	45	48	53	12	26
2.5	7.2	22	48	49	50	9.5	26
3	6.5	25	44	47	52	11	28
3.5	7.3	30	40	51	54	11.5	26
4	9.8	27	46	46	45	10	24

MAXIMUM RATINGS

Specification temperature ..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Insertion loss relative to +3 dBm input. All other outputs are relative to the desired upper ($f_0 + f_m$) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

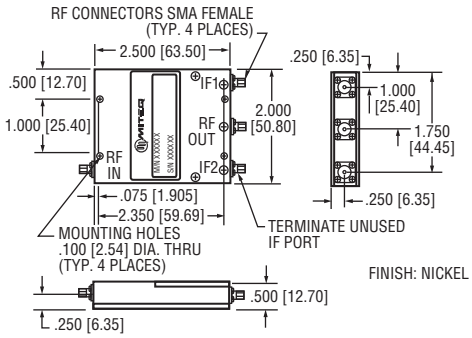
*3. Available part numbers: SM0104LC1MD_*

A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

NOTE: Test data supplied at 25°C; insertion loss, phase and amplitude balance per spectrum table.

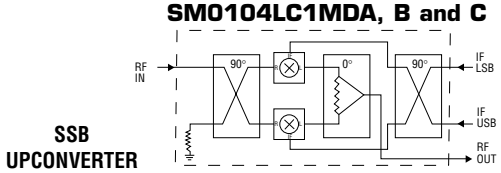
OUTLINE DRAWING

SM0104LC1MDC

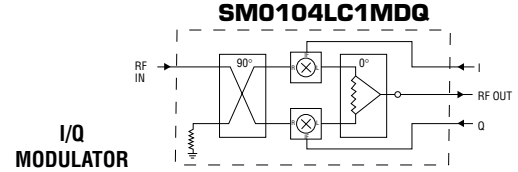


BLOCK DIAGRAMS

SM0104LC1MDA, B and C



SM0104LC1MDQ



NOTE: All dimensions shown in brackets [ ] are in millimeters.

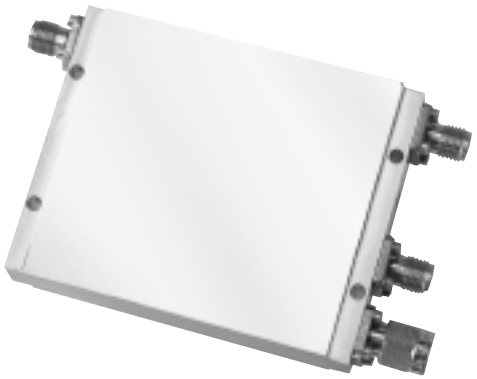
Revised: 03/13/14

1 TO 4 GHz SINGLE-SIDEBAND UPCONVERTER

MODEL: SME0104LI1MD_* (IF Driven)

FEATURES

- **RF output/carrier input ..... 1 to 4 GHz**
- **Modulation bandwidth ..... DC to 500 MHz (Q)**
- **Modulation input power..... +10 to +13 dBm**
- **Sideband suppression..... 30 dB**
- **Carrier rejection..... 25 dB**
- **Modulation options:**
  Single sideband..... A, B and C (internal hybrid)
  I/Q modulator ..... Q (separate inputs)
  QPSK digital..... SMT (TTL input)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or IF) has sufficient power to turn on the semiconductors. This model employs IF drive. SSB upconverters employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) upconverters have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This IF driven unit is used when the RF input has a wide dynamic range, such as for military and commercial Doppler frequency or phase-shift generation. Enhanced sideband rejection (30 dB typ.) is obtained by using a multiple 90° cancellation circuit which is unique to MITEQ's design.

ELECTRICAL SPECIFICATIONS

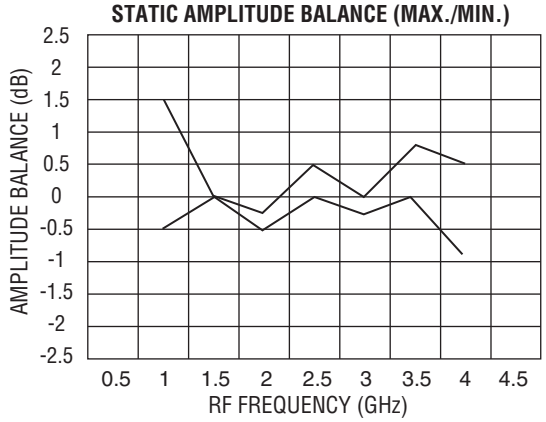
INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	1		4
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		2:1	
RF power at 1 dB compression (IF = +10 dBm)	dBm		+5	
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range	dBm	+10		+13
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		10	12
Carrier suppression	dBc	18	28	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	25	30	
Carrier ±2 IF, 4 IF, etc.	dBc		40	
Carrier ±3 IF	dBc		13	
Quadrature phase accuracy, I/Q mode (see Graph Key)	Degrees		±5	
Quadrature amplitude accuracy	dB		±0.75	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	1		4
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		2.5:1	

SME0104LI1MDQ IF DRIVEN TYPICAL TEST DATA

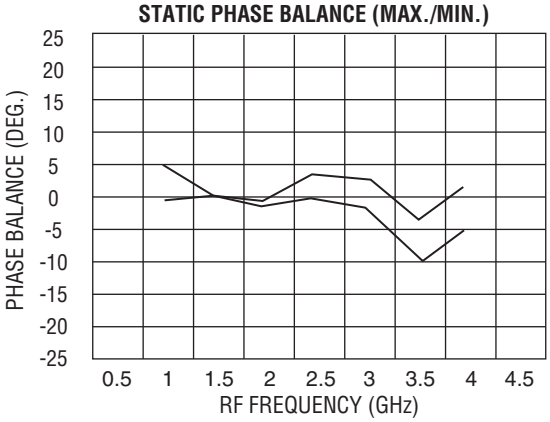
RF Phase (Deg.) I/Q	Graph Key 0 +/+	+90 -/+	-90 +/-	+180 -/-

I/Q MODE (RF = 0 dBm, I/Q =+10 dBm or ±10 mA)

STATIC AMPLITUDE BALANCE (MAX./MIN.)



STATIC PHASE BALANCE (MAX./MIN.)



SME0104LI1MDC IF DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 100 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
1	10.4	27	25	42	46	19	34
1.5	9.7	36	28	38	39	14	51
2	7.4	32	34	35	40	12	36
2.5	7.8	34	26	36	52	16	38
3	10.1	36	33	43	33	15	33
3.5	7.2	34	22	34	39	18	29
4	10	29	19	37	40	17	35

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

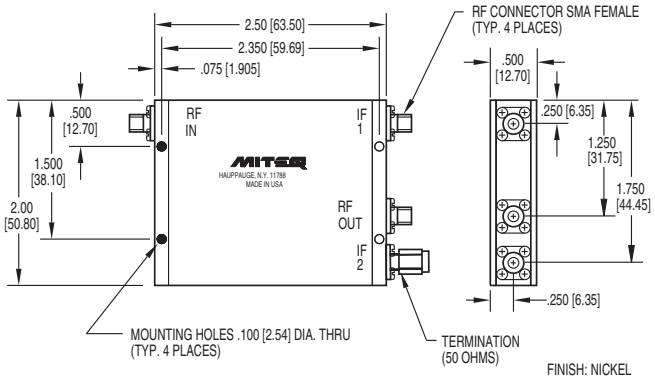
1. Insertion loss relative to +3 dBm input. All other outputs, including f_O, are relative to the desired upper (f_O + f_M) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

*3. Available part numbers: SME0104LI1MD_*
A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

NOTE: Test data supplied at 25°C;
insertion loss, phase and amplitude balance per spectrum table.

OUTLINE DRAWING

SME0104LI1MDC

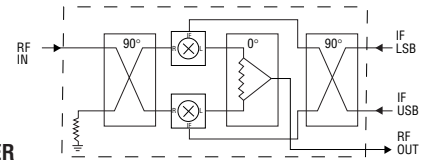


NOTE: All dimensions shown in brackets [ ] are in millimeters.

BLOCK DIAGRAMS

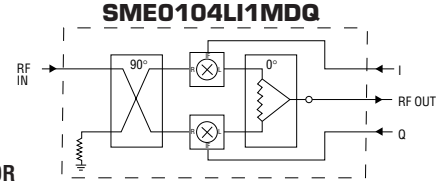
SME0104LI1MDA, B and C

SSB UPCONVERTER



SME0104LI1MDQ

I/Q MODULATOR

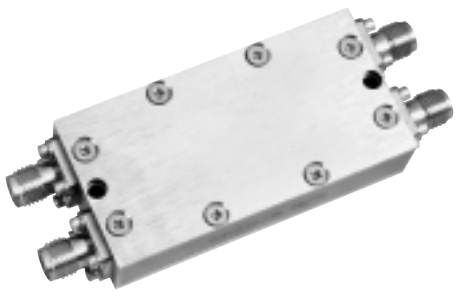


2 TO 4 GHz SINGLE-SIDEBAND UPCONVERTER

MODEL: SSM0204(*)C2MD(**)

FEATURES

- **RF output/carrier input ..... 2 to 4 GHz**
- **IF bandwidth ..... DC to 500 MHz (Q)**
- **Linear RF input ..... Up to +5 dBm**
- **IF input power ..... +10 to +13 dBm**
- **Sideband suppression ..... 24 dB**
- **Carrier rejection ..... 30 dB**
- **IF options:**
  Single sideband ..... A, B and C (internal hybrid)
  Multioctave IFs ..... Q (separate inputs)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or IF) has sufficient power to turn on the semiconductors. This model employs IF drive. SSB upconverters employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) upconverters have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This IF driven unit is used when the RF input has a wide dynamic range, such as for military and commercial Doppler frequency or phase-shift generation. If desired, higher rejection of the undesired sideband is possible with the SME model series.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF carrier	GHz	2		4
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		1.5:1	
RF power at 1 dB compression (IF = +10 dBm)	dBm		+6	
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (50 ohm input)	dBm	+10		+13
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		6	9
Carrier suppression	dBc	20	30	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	20	24	
Carrier ±2 IF, 4 IF, etc.	dBc		45	
Carrier ±3 IF	dBc		10	
Truth table	SSM0204(*)C2MDQ	**PORT**	**RF < LO**	**RF > LO**
		I	0	-90
		Q	-90	0
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	2		4
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		2.5:1	

SSM0204LC2MDC IF DRIVEN OUTPUT SPECTRUM TABLES

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 100 MHz) (Upper sideband)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
2	-6.6	-24.3	-26.3	-40	-38.9	-14.9	-36.6
2.2	-6.3	-28.5	-24.7	-52	-39.3	-13.3	-34
2.4	-6.1	-26.5	-25.3	-54.7	-40.1	-12.5	-32.4
2.6	-6.7	-23.4	-25.3	-50.3	-40.3	-11.3	-29.9
2.9	-7.5	-22.5	-26.3	-51.2	-39.9	-11.4	-28.4
3.1	-7.5	-21.9	-28	-48.4	-41.5	-12.5	-31.5
3.3	-7.7	-21.6	-30.3	-46.9	-42	-12.7	-35.1
3.6	-7.2	-21	-34	-45.4	-43.4	-13	-45.6
3.8	-6.3	-22.2	-33.8	-44.3	-43.7	-13.5	-45.7
4.0	-7.6	-21.4	-28.4	-43.2	-43.2	-12.9	-38.8

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 100 MHz) (Lower sideband)

Frequency (GHz)	f_0 + IF (dBc)	f_0 - IF (I.L., dB) Note 1	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
2	-23.4	-6.6	-24.9	-38	-49.7	-33.4	-14.2
2.2	-30.1	-6.2	-24.8	-40.2	-50.1	-34.7	-13.2
2.4	-48.6	-6	-25.3	-40.7	-47.8	-35.8	-13.4
2.6	-34	-6.2	-26	-40	-49.5	-36.4	-13.2
2.9	-31.3	-7.4	-26.6	-39	-47	-36.1	-12.2
3.1	-30.3	-7.5	-28.8	-39.8	-44.3	-38.6	-12.2
3.3	-28.1	-7.8	-30.7	-41.3	-43	-51.9	-12.3
3.6	-25.9	-6.9	-34	-41.9	-43.5	-45.2	-12.9
3.8	-22.5	-6.8	-33	-41.8	-41.8	-40.3	-12.5
4.0	-22.2	-7.1	-28.9	-42.4	-41.3	-43.7	-12.5

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Insertion loss relative to 0 dBm RF input. All other outputs, including f_0, are relative to the desired upper ($f_0 + f_m$) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

*3.

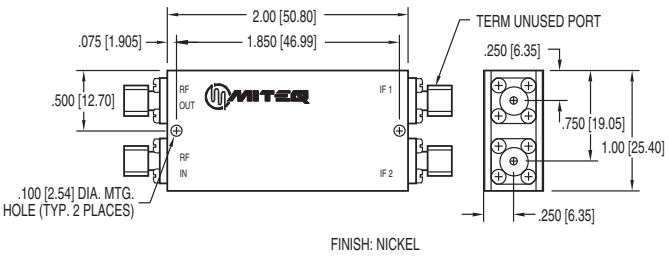
Model Number Option Table

(*) Add Letter	LO Power Range (dBm)	P1 dB (dBm)	(**) Add Letter	IF Frequency (MHz)
L	10–13	+6	A	20–40
M	13–16	+10	B	40–80
H	17–20	+15	C	100–200
			Q	DC-500(I/Q)

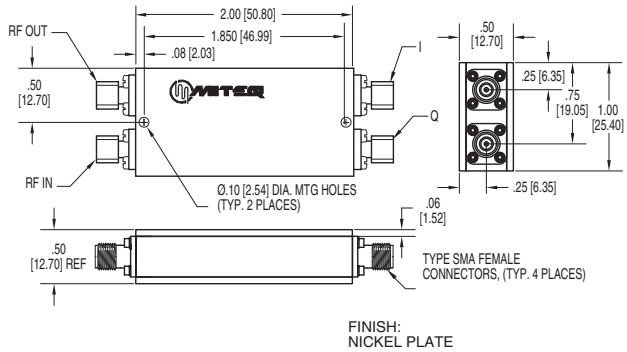
NOTE: Test data supplied at 25°C; per spectrum table.

OUTLINE DRAWINGS

SSM0204(*)C2MDA, B and C



SSM0204(*)C2MDQ



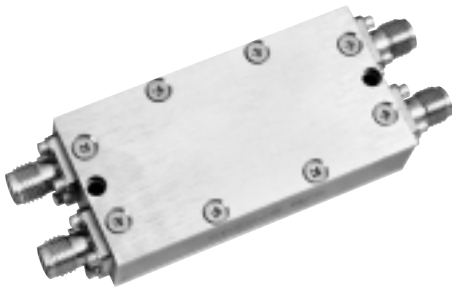
NOTE: All dimensions shown in brackets [ ] are in millimeters.

2 TO 8 GHz SINGLE-SIDEBAND UPCONVERTER

MODEL: SSM0208(*)C2MD(**)

FEATURES

- **RF output/carrier input ..... 2 to 8 GHz**
- **IF bandwidth ..... DC to 500 MHz (Q)**
- **Linear RF input..... Up to +5 dBm**
- **IF input power..... +10 to +13 dBm**
- **Sideband suppression..... 24 dB**
- **Carrier rejection..... 30 dB**
- **IF options:**
  Single sideband..... A, B and C (internal hybrid)
  Multioctave IFs ..... Q (separate inputs)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or IF) has sufficient power to turn on the semiconductors. This model employs IF drive. SSB upconverters employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) upconverters have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This IF driven unit is used when the RF input has a wide dynamic range, such as for military and commercial Doppler frequency or phase-shift generation. If desired, higher rejection of the undesired sideband is possible with the SME model series.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	2		8
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		1.5:1	
RF power at 1 dB compression (IF = +10 dBm)	dBm		+5	
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (50 ohm input)	dBm	+10		+13
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		6	9
Carrier suppression	dBc	20	30	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	18	24	
Carrier ±2 IF, 4 IF, etc.	dBc		45	
Carrier ±3 IF	dBc		10	
Truth table	SSM0208(*)C2MDQ	**PORT**	**RF < LO**	**RF > LO**
		I	0	-90
		Q	-90	0
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	2		8
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		2.5:1	

SSM0208LC2MDC IF DRIVEN OUTPUT SPECTRUM TABLES

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 100 MHz) (Upper sideband)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
2	-6.6	-24.3	-26.3	-40	-38.9	-14.9	-36.6
2.4	-6.1	-26.5	-25.3	-54.7	-40.1	-12.5	-32.4
2.9	-7.5	-22.5	-26.3	-51.2	-39.9	-11.4	-28.4
3.3	-7.7	-21.6	-30.3	-46.9	-42	-12.7	-35.1
3.8	-6.3	-22.2	-33.8	-44.3	-43.7	-13.5	-45.7
4.3	-6.8	-23	-26.4	-42	-43.2	-13	-33.8
4.7	-7.4	-23.8	-23.4	-39.7	-42.1	-12	-30.8
5.2	-7.5	-20.5	-22.4	-36.7	-43.4	-12.5	-40.5
5.6	-6.8	-19.1	-27.8	-35.6	-48.7	-12.8	-47
6.1	-7.2	-21.9	-32.9	-38	-39.1	-11.2	-41.7
6.6	-6.8	-29.5	-43.4	-42.2	-37.7	-12.7	-34.7
7.0	-6.7	-21.6	-37.3	-42	-38.6	-13.5	-32.7
7.5	-7.3	-19.3	-39	-40.4	-40.4	-12.4	-32.2
8	-8.4	-19.6	-35.8	-38.2	-40.2	-12	-27.2

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 100 MHz) (Lower sideband)

Frequency (GHz)	f_0 + IF (dBc)	f_0 - IF (I.L., dB) Note 1	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
2	-23.4	-6.6	-24.9	-38	-49.7	-33.4	-14.2
2.4	-48.6	-6	-25.3	-40.7	-47.8	-35.8	-13.4
2.9	-31.3	-7.4	-26.6	-39	-47	-36.1	-12.2
3.3	-28.1	-7.8	-30.7	-41.3	-43	-51.9	-12.3
3.8	-22.5	-6.8	-33	-41.8	-41.8	-40.3	-12.5
4.3	-21.1	-7.5	-25.5	-40.8	-40.5	-39.8	-12.5
4.7	-26.5	-7.6	-22.5	-39.2	-37.5	-32.2	-11.8
5.2	-29.6	-7.5	-22.5	-42.1	-34.6	-28.6	-11.7
5.6	-20.3	-7	-28.9	-48.9	-36	-28.9	-11.8
6.1	-24.5	-6.6	-34.8	-42.6	-40.7	-34	-12.36
6.6	-45.5	-7.1	-48	-38.9	-41.9	-36.9	-11.9
7.0	-26.3	-6.6	-38.5	-38.9	-41.4	-34.2	-13.4
7.5	-25.2	-6.3	-40	-40.6	-40.9	-32	-15.5
8	-19.9	-7.8	-38	-40.3	-40.3	-28	-14.3

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Insertion loss relative to 0 dBm RF input. All other outputs, including f_0, are relative to the desired upper (f_0 + f_m) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

NOTE: Test data supplied at 25°C; per spectrum table.

GENERAL NOTES (CONT.)

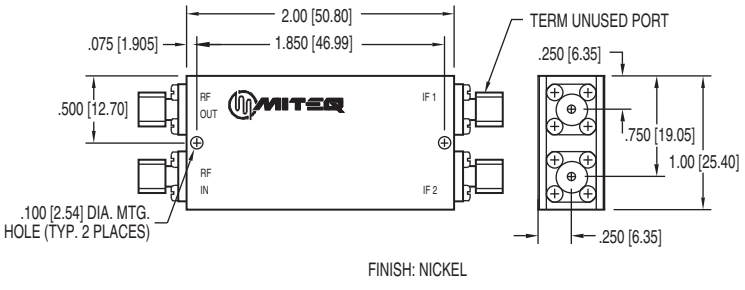
*3.

Model Number Option Table

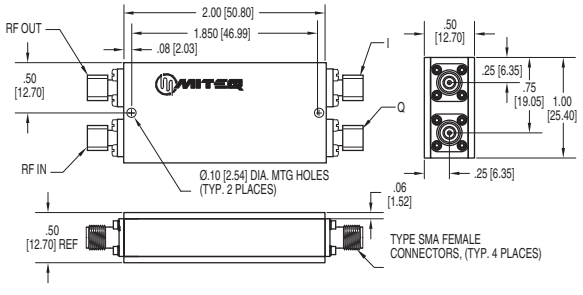
(*) Add Letter	LO Power Range (dBm)	P1 dB (dBm)	(**) Add Letter	IF Frequency (MHz)
L	10–13	+6	A	20–40
M	13–16	+10	B	40–80
H	17–20	+15	C	100–200
			Q	DC-500(I/Q)

OUTLINE DRAWINGS

SSM0208(*)C2MDA, B and C



SSM0208(*)C2MDQ



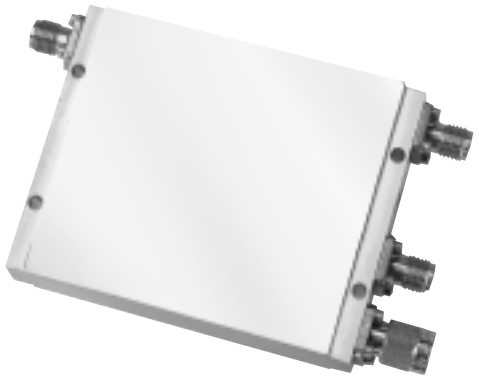
NOTE: All dimensions shown in brackets [ ] are in millimeters.

2 TO 8 GHz SINGLE-SIDEBAND ENHANCED UPCONVERTER

MODEL: SME0208LI1MD* (IF Driven)

FEATURES

- **RF output/carrier input ..... 2 to 8 GHz**
- **IF bandwidth ..... DC to 500 MHz (Q)**
- **Linear RF input ..... Up to +5 dBm**
- **IF input power ..... +10 to +16 dBm**
- **Sideband suppression ..... 35 dB**
- **Carrier rejection ..... 25 dB**
- **IF options:**
  Single sideband ..... A, B and C (internal hybrid)
  Multioctave IFs ..... Q (separate inputs)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or IF) has sufficient power to turn on the semiconductors. This model employs IF drive. SSB upconverters employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) upconverters have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This IF driven unit is used when the RF input has a wide dynamic range, such as for military and commercial Doppler frequency or phase-shift generation. Enhanced sideband rejection (30 dB typ.) is obtained by using a multiple 90° cancellation circuit which is unique to MITEQ's design.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	2		8
RF VSWR (RF = 0 dBm, IF modulation = +13 dBm)	Ratio		1.5:1	
RF power (low-level diodes)	dBm	Noise	0	+5
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (total I/Q)	dBm	+10	+13	+16
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		8	12
Carrier suppression	dBc	20	25	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	25	35	
Carrier ±2 IF, 4 IF, etc.	dBc		40	
Carrier ±3 IF	dBc		13	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	2		8
RF VSWR (RF = 0 dBm, IF modulation = +13 dBm)	Ratio		2.5:1	

SME0208LI1MDA TYPICAL IF DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = 0 dBm, IF = +13 dBm total, IF = 30 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
2	-8.4	-31.8	-37.4	-40.6	-49.8	-12.8	-35.4
2.25	-8	-44.6	-34.6	-46.1	-51.2	-13.2	-37.4
2.5	-7.1	-44.6	-37.5	-55.2	-44.7	-14	-35.6
2.75	-7.4	-42.3	-39.7	-52.4	-42.8	-14.4	-35.1
3	-7.4	-43.3	-36.1	-47	-44.6	-13.9	-41.1
3.25	-7.1	-49.4	-32.5	-41.7	-48.6	-14	-41.4
3.5	-7	-40.1	-28.3	-41.3	-41.9	-14.2	-51.9
3.75	-8	-42	-28.3	-43.2	-40.9	-12.4	-33.9
4	-7.8	-30.3	-29.1	-46.3	-41.3	-13.2	-42.4
4.25	-7.8	-39.1	-30.3	-57	-38.8	-14.7	-33.8
4.5	-8.1	-29	-28.8	-51.6	-40.5	-15.2	-45.2
4.75	-8.4	-28.9	-28.9	-46	-41.4	-13.9	-37.4
5	-7.8	-41	-30.7	-43.9	-46.5	-14	-45.3
5.25	-8.3	-33.2	-42.3	-50.8	-44.4	-12.9	-41.6
5.5	-8.6	-36.4	-30.5	-53.9	-47.8	-13.1	-47.1
5.75	-8.3	-33.4	-30	-49.3	-45.4	-12.9	-35.7
6	-9.6	-33.5	-29.2	-41.9	-38.6	-14	-34.2
6.25	-9.1	-31.7	-36.5	-41.3	-46.5	-14.8	-38.2
6.5	-8.6	-34.3	-24.3	-37.9	-37.5	-13.9	-41.5
6.75	-8.8	-33.5	-20.5	-41.2	-39.4	-12.9	-40.4
7	-9.2	-31.3	-22.9	-37.5	-45	-13.3	-53.7
7.25	-9.3	-30.3	-26.3	-35.2	-31.6	-12.9	-49.3
7.5	-9.3	-32	-25.9	-48.7	-30.2	-13	-32
7.75	-10	-37.6	-25.8	-37.8	-36.4	-16.3	-33.5
8	-10.1	-27.7	-26.4	-35.1	-40.4	-15.8	-28.4

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Insertion loss relative to 0 dBm RF input. All other outputs, including f_0, are relative to the desired upper ($f_0 + f_m$) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

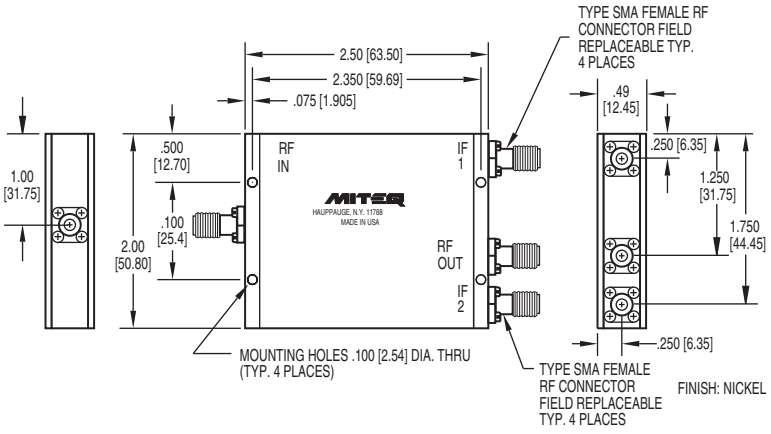
*3. Available part numbers: SME0208LI1MD_*

A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

NOTE: Test data supplied at 25°C; per spectrum table.

OUTLINE DRAWING

SME0208LI1MDA

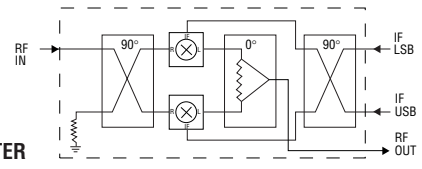


NOTE: All dimensions shown in brackets [ ] are in millimeters.

BLOCK DIAGRAM

SME0208LI1MDA, B and C

SSB UPCONVERTER

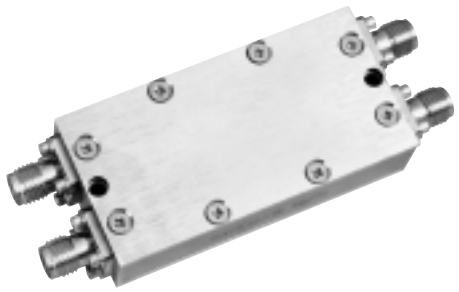


4 TO 8 GHz SINGLE-SIDEBAND UPCONVERTER

MODEL: SSM0408(*)C2MD(**)

FEATURES

- **RF output/carrier input ..... 4 to 8 GHz**
- **IF bandwidth ..... DC to 500 MHz (Q)**
- **Linear RF input ..... Up to +5 dBm**
- **IF input power ..... +10 to +13 dBm**
- **Sideband suppression ..... 25 dB**
- **Carrier rejection ..... 30 dB**
- **IF options:**
  Single sideband ..... A, B and C (internal hybrid)
  Multioctave IFs ..... Q (separate inputs)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or IF) has sufficient power to turn on the semiconductors. This model employs IF drive. SSB upconverters employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) upconverters have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This IF driven unit is used when the RF input has a wide dynamic range, such as for military and commercial Doppler frequency or phase-shift generation. If desired, higher rejection of the undesired sideband is possible with the SME model series.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	4		8
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		1.5:1	
RF power at 1 dB compression (IF = +10 dBm)	dBm		+5	
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (50 ohm input)	dBm	+10		+13
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		6	9
Carrier suppression	dBc	20	30	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	18	25	
Carrier ±2 IF, 4 IF, etc.	dBc		45	
Carrier ±3 IF	dBc		10	
Truth table	SSM0408(*)C2MDQ	**PORT**	**RF < LO**	**RF > LO**
		I	0	-90
		Q	-90	0
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	4		8
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		2.5:1	

SSM0408LC2MDA IF DRIVEN OUTPUT SPECTRUM TABLES

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 30 MHz) (Upper sideband)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
4	-6.2	-34.2	-29.2	-38.9	-44.8	-11.3	-31
4.5	-6.6	-27.2	-25.1	-36.6	-53.3	-10.5	-29.8
5	-6.6	-22.9	-24.3	-37.3	-42	-11.3	-35.8
5.5	-6.5	-21.4	-23	-42.2	-37.3	-11.8	-59.4
6	-6.8	-21.5	-22.2	-40.7	-39.7	-11.2	-34.6
6.5	-7.2	-26.7	-27.5	-39.3	-36.8	-11.3	-33.1
7	-7.4	-28.9	-26.3	-46.3	-37	-11.5	-38.6
7.5	-7.6	-21.3	-25.3	-39.8	-37.4	-10.7	-29.1
8	-7.8	-18.8	-22.5	-37.9	-40.1	-11.1	-22.3

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 30 MHz) (Lower sideband)

Frequency (GHz)	f_0 + IF (dBc)	f_0 - IF (I.L., dB) Note 1	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
4	-31	-6.2	-29.1	-42.5	-38.2	-35.4	-11
4.5	-24.5	-6.3	-25.7	-50.7	-37.9	-30.1	-11.8
5	-20.9	-6.8	-24.1	-46.6	-37	-28.9	-11.3
5.5	-21.3	-6.6	-23	-36.7	-41	-33.9	-11.6
6	-24.5	-6.6	-22.6	-38.1	-41	-29.9	-11.9
6.5	-25.5	-7.4	-27.6	-36.6	-39.3	-31.1	-10.9
7	-34.7	-7.4	-26.2	-35.9	-46.9	-30.9	-11.7
7.5	-26.4	-7.3	-25.4	-36.9	-40.3	-26.1	-11.8
8	-18.9	-8	-22.5	-40.6	-37.6	-21.1	-11.3

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Insertion loss relative to 0 dBm RF input. All other outputs, including f_0, are relative to the desired upper (f_0 + f_m) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

*3.

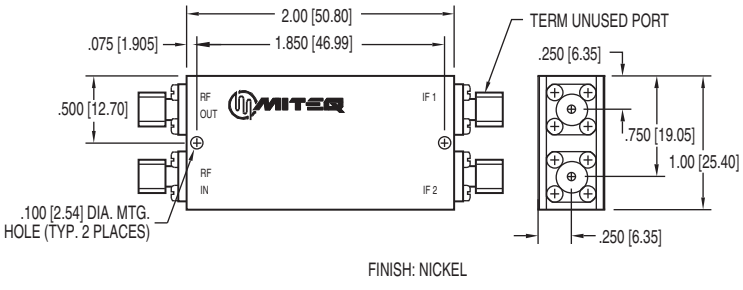
Model Number Option Table

(*) Add Letter	LO Power Range (dBm)	P1 dB (dBm)	(**) Add Letter	IF Frequency (MHz)
L	10–13	+6	A	20–40
M	13–16	+10	B	40–80
H	17–20	+15	C	100–200
			Q	DC-500(I/Q)

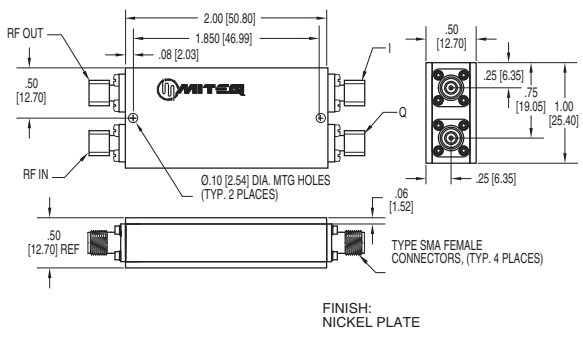
NOTE: Test data supplied at 25°C; per spectrum table.

OUTLINE DRAWINGS

SSM0408(*)C2MDA, B and C



SSM0408(*)C2MDQ



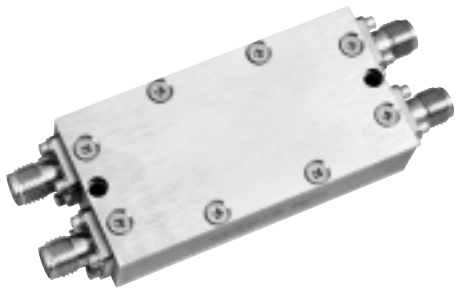
NOTE: All dimensions shown in brackets [ ] are in millimeters.

8 TO 12 GHz SINGLE-SIDEBAND UPCONVERTER

MODEL: SSM0812(*)C2MD(**)

FEATURES

- **RF output/carrier input ..... 8 to 12 GHz**
- **Modulation bandwidth ..... DC to 500 MHz (Q)**
- **Linear RF input ..... Up to +5 dBm**
- **IF input power ..... +10 to +13 dBm**
- **Sideband suppression ..... 25 dB**
- **Carrier rejection ..... 35 dB**
- **IF options:**
  Single sideband ..... A, B and C (internal hybrid)
  Multioctave IFs ..... Q (separate inputs)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or IF) has sufficient power to turn on the semiconductors. This model employs IF drive. SSB upconverters employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) upconverters have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This IF driven unit is used when the RF input has a wide dynamic range, such as for military and commercial Doppler frequency or phase-shift generation. If desired, higher rejection of the undesired sideband is possible with the SME model series.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	8		12
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		1.5:1	
RF power at 1 dB compression (IF = +10 dBm)	dBm		+5	
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (50 ohm)	dBm	+10		+13
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		6	9
Carrier suppression	dBc	20	30	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	20	25	
Carrier ±2 IF, 4 IF, etc.	dBc		45	
Carrier ±3 IF	dBc		10	
Truth table	SSM0812(*)C2MDQ	**PORT**	**RF < LO**	**RF > LO**
		I	0	-90
		Q	-90	0
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	8		12
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		2.5:1	

SSM0812LC2MDC IF DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 100 MHz) (Upper sideband)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
8	-7.8	-31.3	-32.3	-46.9	-47.2	-11.4	-27.9
8.2	-7.8	-32.7	-32.9	-46.6	-46.3	-11.2	-26.1
8.4	-7.8	-30.9	-34.2	-47	-46.3	-11.4	-25.9
8.6	-7.5	-30.8	-35.4	-47.3	-46.3	-10.9	-25.5
8.8	-7.5	-32.6	-36	-47.9	-46	-11.4	-26.5
9	-7.5	-30.7	-36.8	-46.6	-45.4	-11.1	-26.9
9.2	-7.9	-29.8	-35.1	-44.4	-42.8	-11.1	-27.6
9.4	-8	-34.6	-32.7	-45	-42.6	-11.4	-29.1
9.6	-8.2	-35.1	-32.7	-44.3	-43.7	-11	-30.4
9.8	-8	-34.3	-32.8	-44.8	-45.3	-11.4	-33.4
10	-8	-32.3	-32.8	-44.5	-46.4	-11.5	-32
10.2	-7.9	-29	-32.9	-44.3	-49.9	-10.9	-27.7
10.4	-7.7	-27.3	-33.4	-44.1	-50.8	-11.7	-26.7
10.6	-7.7	-25.3	-34.6	-43.7	-50	-12.5	-25.5
10.8	-7.4	-24.3	-36.2	-42.1	-47.5	-12.5	-25.4
11	-7.4	-23.4	-38	-42.1	-45.4	-12.7	-26.4
11.2	-7.2	-24.3	-39.9	-42.9	-42.5	-13.3	-26.4
11.4	-7.8	-26.7	-41.8	-43.6	-41.5	-11.6	-25.6
11.6	-8.2	-29.9	-44.9	-44.4	-40.2	-11.2	-24.2
11.8	-8.4	-37.6	-46.8	-45.9	-40.4	-11	-24
12	-8.4	-38.1	-46.1	-45.9	-40.2	-10.4	-24.1

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Insertion loss relative to 0 dBm RF input. All other outputs, including f_0, are relative to the desired upper (f_0 + f_m) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

*3.

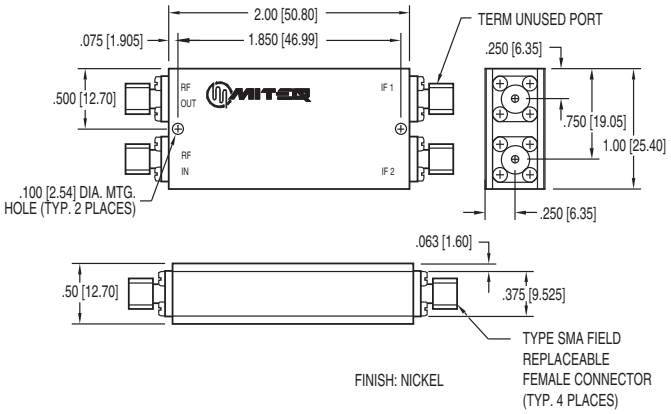
Model Number Option Table

(*) Add Letter	LO Power Range (dBm)	P1 dB (dBm)	(**) Add Letter	IF Frequency (MHz)
L	10–13	+6	A	20–40
M	13–16	+10	B	40–80
H	17–20	+15	C	100–200
			Q	DC-500(I/Q)

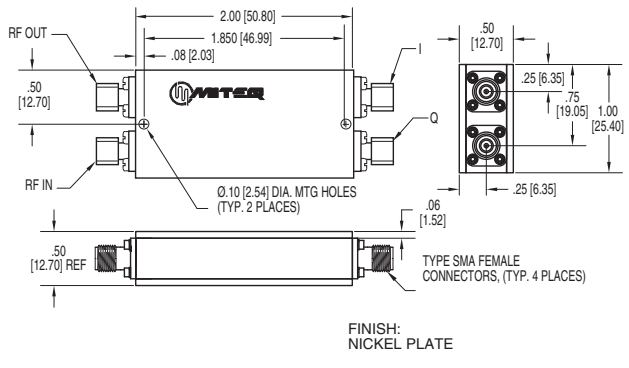
NOTE: Test data supplied at 25°C; per spectrum table.

OUTLINE DRAWINGS

SSM0812(*)C2MDA, B and C



SSM0812(*)C2MDQ



NOTE: All dimensions shown in brackets [ ] are in millimeters.

2 TO 18 GHz TTL QPSK DIGITAL MODULATOR

MODEL: SMT0218LC1MD (Modulation Driven)

FEATURES

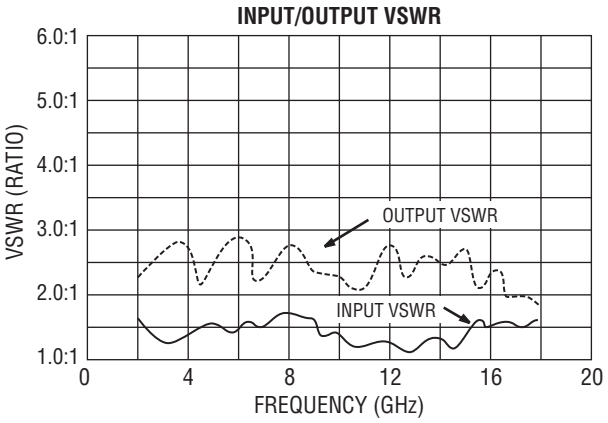
- **RF/LO coverage..... 2 to 18 GHz**
- **TTL-controlled I and Q inputs**
- **Phase accuracy ..... ±8° typical**
- **Amplitude accuracy ..... ±0.75 dB typical**
- **Delay time ..... 30 ns maximum**

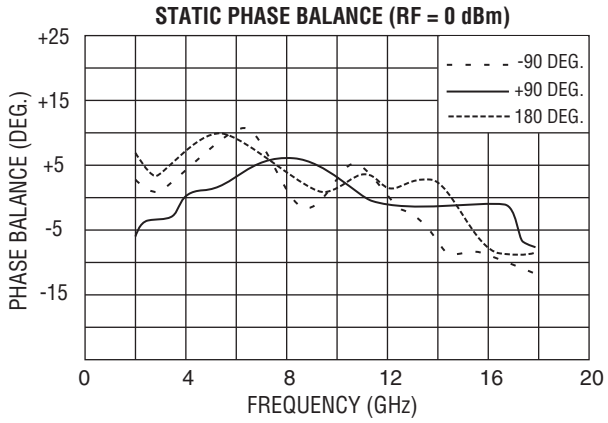
MITEQ's Model SMT0218LC1Q quadrature phase-shift keying (QPSK) modulators are designed for rapid digital TTL control applications. This device can be used in EW or radar simulator applications or in communication test systems. For example, two channels (I/Q) of isolated digital modulation can be transmitted in the same bandwidth as required for one biphase modulator.

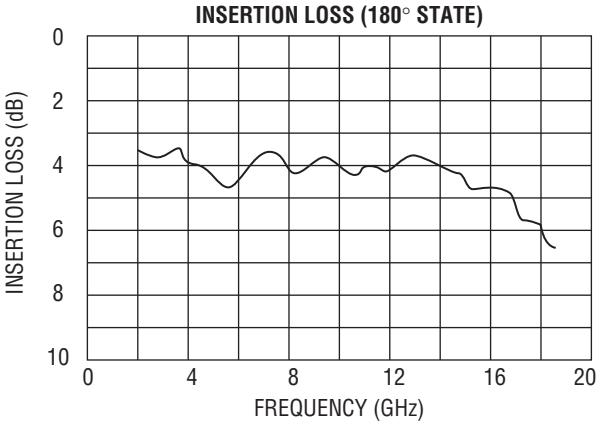
ELECTRICAL SPECIFICATIONS

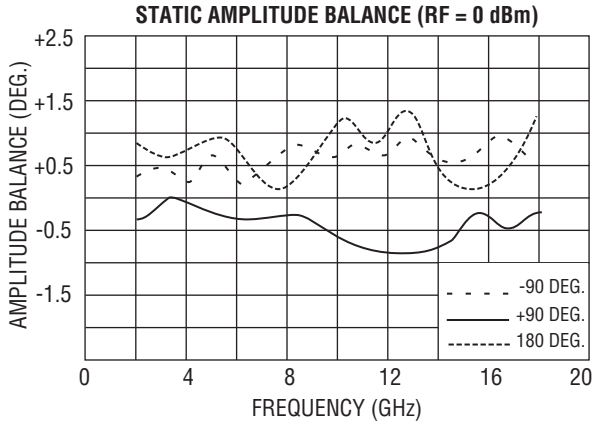
INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	2		18	
RF carrier level (Note 1)		dBm		0	+3
RF VSWR	50 ohm reference	Ratio		2.5:1	
IF modulation	2 bits			TTL	
DC power	+12 V -12 V	mA mA		20 20	
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Insertion loss		dB		9	12
Quadra-state phase balance		Degrees		±8	±15
Quadra-state amplitude balance		dB		±0.75	±1.5
Switching speed (50% TTL to 90% RF)		ns		10	30
Modulation to RF output isolation		dB	25		
Carrier suppression	50 ohm reference	dBc	18	25	
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range		GHz	2		18
RF VSWR	50 ohm reference	Ratio		2.5:1	
Output phase matrix		**TTL LEVELS**		**PHASE**	**UNITS**
Note: 8 and 12 BIT TTL versions also available for smaller phase increments, such as in vector modulators.		0 1 1 0	0 0 1 1	Ref. 90 180 270	Degrees Degrees Degrees Degrees

SMT0218LC1MD MODULATION DRIVEN TYPICAL TEST DATA









MAXIMUM RATINGS

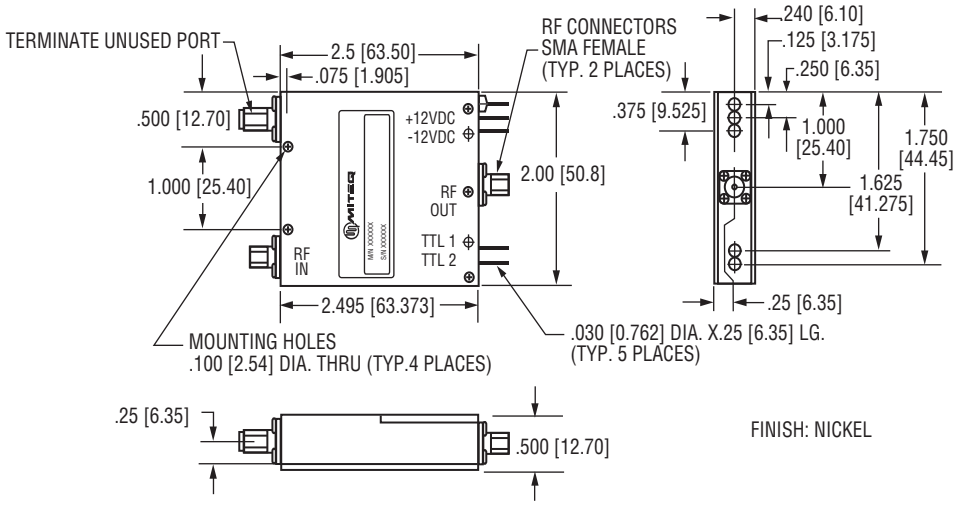
Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. PIN diodes for +20 dBm RF inputs.
2. Analog I/Q inputs for QAM.

NOTE: Test data supplied at 25°C; insertion loss, phase and amplitude balance.

OUTLINE DRAWING



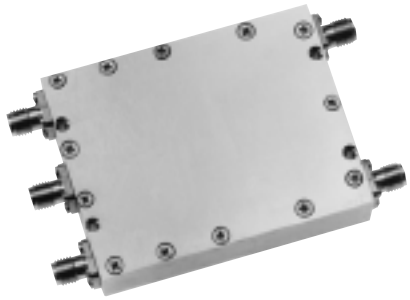
NOTE: All dimensions shown in brackets [ ] are in millimeters.

2 TO 18 GHz SINGLE-SIDEBAND UPCONVERTER OR I/Q MODULATOR

MODEL: SM0218LC1MD_* (Modulation Driven)

FEATURES

- **RF output/carrier input ..... 2 to 18 GHz**
- **Carrier input linear power ..... Noise to +5 dBm**
- **Modulation input power..... +10 to +13 dBm**
- **Sideband suppression..... 20 dB**
- **Carrier rejection..... 25 dB**
- **IF options:**
  Single sideband..... A, B and C (internal hybrid)
  I/Q modulator ..... Q (separate inputs)
  QPSK digital..... SMT (TTL input)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or modulation) has sufficient power to turn on the semiconductors. This model employs modulation drive. All modulators yield a frequency spectrum that utilizes both sidebands on either side of the output suppressed carrier. SSB upconverters, however, employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) modulators have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This IF driven unit is used when the RF input has a wide dynamic range, such as for military and commercial Doppler frequency or phase-shift generation.

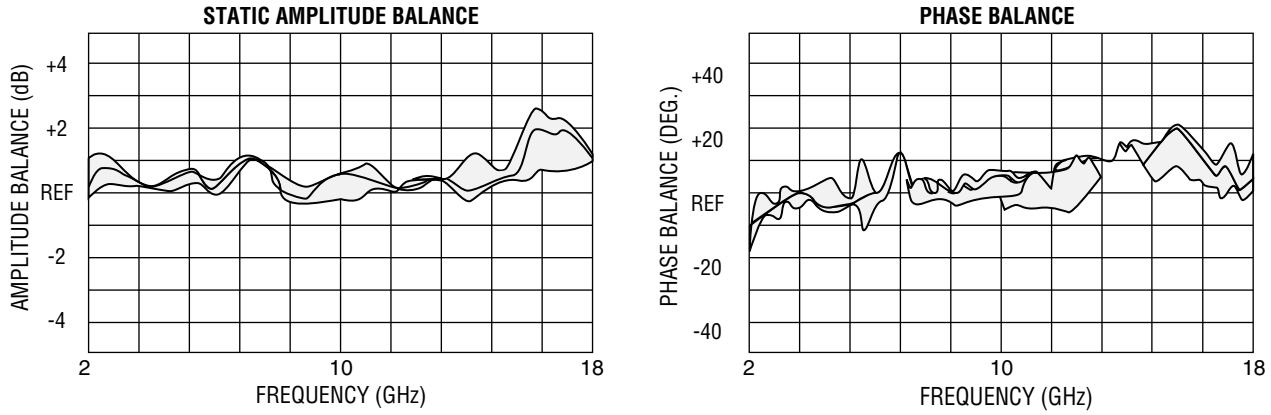
ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	2		18
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		2:1	
RF power at 1 dB compression (IF = +10 dBm)	dBm		+5	
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range	dBm	+10		+13
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		9	13
Carrier suppression	dBc		25	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	15	20	
Carrier ±2 IF, 4 IF, etc.	dBc		25	
Carrier ±3 IF	dBc		10	
Quadrature phase accuracy, I/Q mode (see Graph Key)	Degrees		±7.5	
Quadrature amplitude accuracy	dB		±0.75	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	2		18
RF VSWR (RF = -10 dBm, IF = +10 dBm)	Ratio		2.5:1	

SM0218LC1MDQ MODULATION DRIVEN TYPICAL TEST DATA

RF Phase (Deg.) I/Q	Graph Key 0 +/+	+90 -/+	-90 +/-	+180 -/-

I/Q MODE (RF = 0 dBm, I/Q = +10 dBm or ±10 mA)



SM0218LC1MDC MODULATION DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 100 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
2	9	19	18	32	38	11	27
4	9	27	33	49	44	12	28
6	8	30	31	34	40	16	25
8	8	40	37	46	41	13	30
10	8	25	31	40	42	11	26
12	8	25	30	40	40	11	25
14	9	23	29	40	38	11	21
16	10	32	19	37	37	10	30
18	11	25	29	35	37	12	27

MAXIMUM RATINGS

Specification temperature ..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

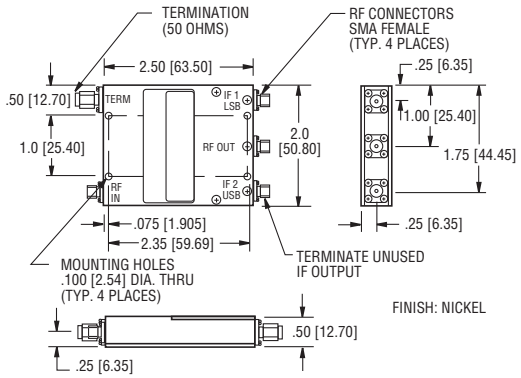
1. Insertion loss relative to 0 dBm RF input. All other outputs, including f_O, are relative to the desired upper ($f_O + f_m$) output.
2. Standard units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

*3. Available part numbers: SM0218LC1MD_*
A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

NOTE: Test data supplied at 25°C; insertion loss, phase and amplitude balance per spectrum table.

OUTLINE DRAWING

SM0218LC1MDA, B and C

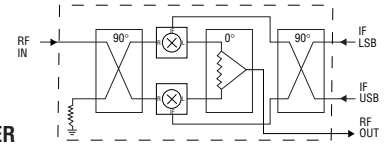


NOTE: All dimensions shown in brackets [ ] are in millimeters.

BLOCK DIAGRAMS

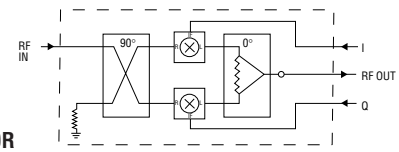
SM0218LC1MDA, B and C

SSB UPCONVERTER



SM0218LC1MDQ

I/Q MODULATOR

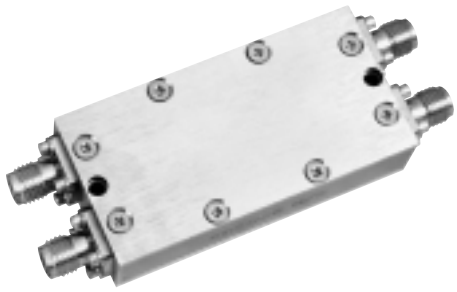


6 TO 18 GHz SINGLE-SIDEBAND UPCONVERTER

MODEL: SSM0618(*)C2MD(**)

FEATURES

- **RF output/carrier input ..... 6 to 18 GHz**
- **IF bandwidth ..... DC to 500 MHz (Q)**
- **Linear RF input..... Up to +5 dBm**
- **IF input power..... +10 to +13 dBm**
- **Sideband suppression..... 20 dB**
- **Carrier rejection..... 25 dB**
- **Modulation options:**
  Single sideband..... A, B and C (internal hybrid)
  Multioctave IFs ..... Q (separate inputs)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or IF) has sufficient power to turn on the semiconductors. This model employs IF drive. SSB upconverters employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) upconverters have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This IF driven unit is used when the RF input has a wide dynamic range, such as for military and commercial Doppler frequency or phase-shift generation.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	6		18
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		1.5:1	
RF power at 1 dB compression (IF = +10 dBm)	dBm		+5	
IF frequency range (Note 3)	MHz	DC		500
IF power range (50 ohm input)	dBm	+10		+13
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		8	12
Carrier suppression	dBc	20	25	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	18	20	
Carrier ±2 IF, 4 IF, etc.	dBc		35	
Carrier ±3 IF	dBc		13	
Truth table	SSM0618(*)C2MDQ	**PORT**	**RF < LO**	**RF > LO**
		I	0	-90
		Q	-90	0
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	6		18
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		2.5:1	

SSM0618LC2MDA IF DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 30 MHz)

Frequency (GHz)	f_O + IF (I.L., dB) Note 1	f_O - IF (dBc)	f_O (dBc)	f_O - 2 IF (dBc)	f_O + 2 IF (dBc)	f_O - 3 IF (dBc)	f_O + 3 IF (dBc)
6	-9.6	-25.7	-26.1	-40.4	-33.1	-13.8	-35.6
6.5	-8.8	-27.5	-27.2	-36.6	-33	-13.9	-29.9
7	-7.8	-24.8	-27.1	-34.9	-36	-14.6	-32.2
7.5	-8.5	-22.9	-23	-34.4	-34.8	-13.3	-27.7
8	-7.7	-20.5	-26.4	-37.2	-32.4	-12.5	-27
8.5	-5.3	-20.4	-26	-37.9	-32.3	-11.8	-29.7
9	-7	-21.7	-28.4	-38.6	-32.3	-12.2	-34.8
9.5	-8	-24.7	-31.6	-34.7	-32.8	-13.3	-27.9
10	-5.1	-32.4	-31.8	-33	-35.4	-14.2	-27.4
10.5	-9.2	-28.1	-29.2	-32.5	-34.9	-13.9	-29.1
11	-7.3	-23.7	-27.5	-32	-37.3	-14.2	-32.7
11.5	-6.7	-21	-26.6	-31.9	-32.6	-11.7	-38
12	-7.6	-21.9	-25.9	-37.1	-30	-11.8	-34.8
12.5	-7.6	-23.2	-24.8	-40.1	-28.7	-12	-28.7
13	-8.2	-34	-23.4	-34.3	-30.5	-12.2	-30.4
13.5	-8.8	-25.9	-22.7	-35	-31.8	-12.2	-31.7
14	-8.6	-21.8	-23.1	-33.7	-30.4	-13	-33.7
14.5	-8.7	-20.8	-24.8	-30.8	-30.9	-13.8	-31.1
15	-9.9	-19.6	-27.8	-28.7	-33.5	-15.2	-35.9
15.5	-9.6	-20.1	-33.2	-28.2	-34.7	-14.5	-31.9
16	-8.4	-20.7	-37.2	-28.7	-31.7	-13.9	-30.3
16.5	-9.1	-21.7	-29.1	-29.9	-28.5	-12	-33.3
17	-8.9	-24.9	-28.3	-34.4	-26.5	-11.7	-31.9
17.5	-8.8	-32.5	-26.3	-42.1	-27.5	-13.1	-31.3
18	-8.6	-19.2	-26.9	-35.7	-30.3	-13.7	-37.4

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Insertion loss relative to 0 dBm RF input. All other outputs, including f_O, are relative to the desired upper ($f_O + f_m$) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

*3.

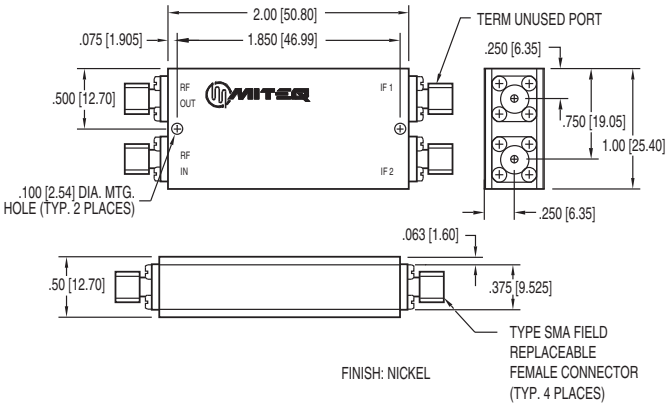
Model Number Option Table

(*) Add Letter	LO Power Range (dBm)	P1 dB (dBm)	(**) Add Letter	IF Frequency (MHz)
L	10–13	+6	A	20–40
M	13–16	+10	B	40–80
H	17–20	+15	C	100–200
			Q	DC-500(I/Q)

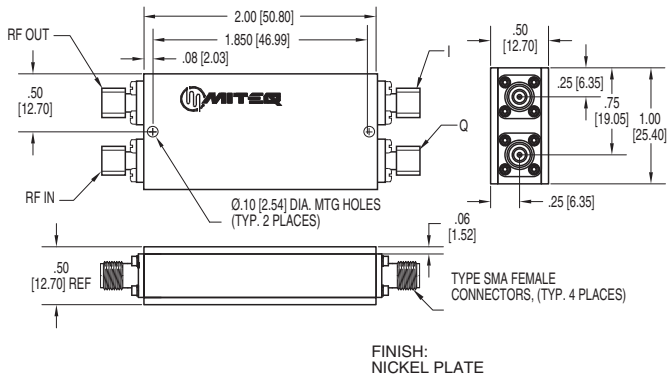
NOTE: Test data supplied at 25°C; per spectrum table.

OUTLINE DRAWINGS

SSM0618(*)C2MDA, B and C



SSM0618(*)C2MDQ



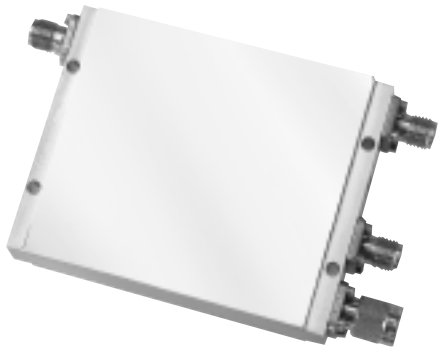
NOTE: All dimensions shown in brackets [ ] are in millimeters.

6 TO 18 GHz SINGLE-SIDEBAND ENHANCED UPCONVERTER

MODEL: SME0618LI1MD_* (IF Driven)

FEATURES

- **RF output/carrier input ..... 6 to 18 GHz**
- **IF bandwidth ..... DC to 500 MHz (Q)**
- **Linear RF input ..... Up to +5 dBm**
- **IF input power ..... +10 to +16 dBm**
- **Sideband suppression ..... 35 dB**
- **Carrier rejection ..... 30 dB**
- **IF options:**
  Single sideband ..... A, B and C (internal hybrid)
  Multioctave IFs ..... Q (separate inputs)



All SSB upconverters require that at least one of the input frequency bands (carrier or IF) has sufficient power to turn on the semiconductors. This model employs IF drive. SSB upconverters employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) upconverters have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. Greater output power can be achieved by using higher level diodes with proportional increases in carrier power. This IF driven unit is used when the RF input to RF output must be linear (low harmonics). Enhanced sideband rejection (30 dB typ.) is obtained by using a multiple 90° cancellation circuit which is unique to MITEQ's design.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	6		18
RF VSWR (RF = 0 dBm, IF modulation = +10 dBm)	Ratio		1.5:1	
RF power (low-level diodes)	dBm	Noise	0	+5
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (total I/Q)	dBm	+10	+13	+16
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		9	13
Carrier suppression	dBc	23	30	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	25	35	
Carrier ±2 IF, 4 IF, etc.	dBc		40	
Carrier ±3 IF	dBc		10	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	6		18
RF VSWR (RF = 0 dBm, IF modulation = +10 dBm)	Ratio		2.5:1	

SME0618LI1MDB IF DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = 0 dBm, IF = +13 dBm total, IF = 60 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
6	-10.9	-29.7	-31.9	-47.9	-49.9	-11.8	-36.3
6.5	-10.4	-32.3	-31.3	-51	-47.1	-13.3	-41.6
7	-9.8	-46.5	-31	-51.8	-49.9	-13.1	-33
7.5	-9.9	-32	-34.3	-51.7	-49.1	-11.8	-32.2
8	-9.1	-41.4	-36.4	-50.6	-49.3	-11.3	-41.1
8.5	-9.4	-31.1	-38.5	-51.2	-50.6	-10.7	-39.8
9	-10	-36.2	-40.5	-48.1	-48	-10.7	-37.6
9.5	-9.3	-34	-38.9	-46.6	-52.3	-12.7	-47.1
10	-9.7	-40.2	-35.5	-45.6	-50	-11.6	-39.7
10.5	-10.1	-32.4	-34.3	-44.9	-47.8	-11.3	-43.6
11	-9.4	-34.7	-36.3	-46.8	-48.9	-11.8	-46.4
11.5	-9.4	-38.3	-37.8	-48.4	-45.2	-11.2	-34
12	-10.6	-45.2	-47.2	-47.7	-44.9	-10.4	-38.4
12.5	-10.2	-32.6	-41.2	-48.6	-46.7	-10.2	-34.3
13	-10.2	-26.4	-39.3	-51	-44.4	-10.1	-36.5
13.5	-10.5	-28.7	-34.2	-47.9	-42.4	-9	-37
14	-10.4	-25.5	-33.9	-44	-46	-10.4	-38.4
14.5	-10.7	-26.8	-33.3	-45.8	-46.9	-11.1	-40.6
15	-10.8	-30.7	-29.4	-45.2	-47.1	-12.1	-35.9
15.5	-11.7	-29.3	-29.4	-40.1	-44.1	-11.6	-39.5
16	-11.6	-36	-28.5	-40.4	-40.1	-10.5	-38.7
16.5	-11.2	-36.7	-27.8	-44.5	-39.5	-10.1	-34.4
17	-11.2	-41.2	-26.6	-43.5	-44.5	-9	-42.3
17.5	-12.4	-29.5	-27.6	-42	-39.3	-9.7	-32
18	-12.8	-30.9	-25.1	-42.3	-37.1	-10.5	-35.1

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Insertion loss relative to 0 dBm RF input. All other outputs, including f_0, are relative to the desired upper ($f_0 + f_m$) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

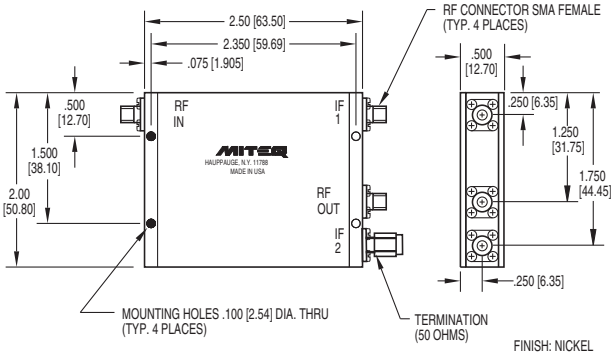
3. Available part numbers: SME0618LI1MD

A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

NOTE: Test data supplied at 25°C; per spectrum table.

OUTLINE DRAWING

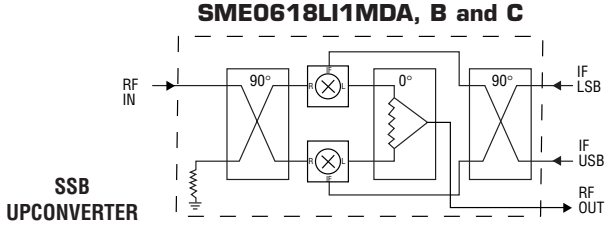
SME0618LI1MDB



NOTE: All dimensions shown in brackets [ ] are in millimeters.

BLOCK DIAGRAM

SME0618LI1MDA, B and C

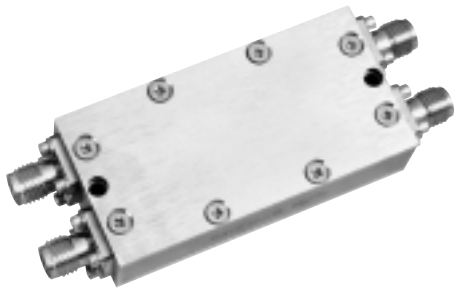


12 TO 18 GHz SINGLE-SIDEBAND UPCONVERTER

MODEL: SSM1218(*)C2MD(**)

FEATURES

- **RF output/carrier input ..... 12 to 18 GHz**
- **IF bandwidth ..... DC to 500 MHz (Q)**
- **Linear RF input..... Up to +5 dBm**
- **IF input power..... +10 to +13 dBm**
- **Sideband suppression..... 25 dB**
- **Carrier rejection..... 30 dB**
- **Modulation options:**
  Single sideband..... A, B and C (internal hybrid)
  Multioctave IFs ..... Q (separate inputs)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or IF) has sufficient power to turn on the semiconductors. This model employs IF drive. SSB upconverters employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) upconverters have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This IF driven unit is used when the RF input has a wide dynamic range, such as for military and commercial Doppler frequency or phase-shift generation.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	12		18
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		1.5:1	
RF power at 1 dB compression (IF = +10 dBm)	dBm		+5	
IF modulation frequency range (Note 3)	GHz	DC		500
IF modulation power range (50 ohm input)	dBm	+10		+13
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		10	12
Carrier suppression	dBc	20	25	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	18	23	
Carrier ±2 IF, 4 IF, etc.	dBc		35	
Carrier ±3 IF	dBc		10	
Truth table	SSM1218(*)C2MDQ	**PORT**	**RF < LO**	**RF > LO**
		I	0	-90
		Q	-90	0
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	12		18
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		2.5:1	

SSM1218LC2MDC TYPICAL IF DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 100 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
12	-8.8	-20.8	-28.3	-37.2	-33.3	-10.9	-20.3
12.5	-9.2	-20.1	-28.7	-38.5	-33.4	-10.4	-20.1
13	-9.4	-23.3	-28.6	-37.1	-35.5	-9.9	-22.1
13.5	-8.6	-27.1	-27.7	-36.4	-38	-12	-25.1
14	-9.3	-27.5	-28.1	-36.9	-36.5	-9.6	-25.4
14.5	-8.5	-30.2	-24.2	-38.9	-36.6	-11.2	-25.6
15	-8.3	-28.3	-29.1	-45.1	-35.7	-12.1	-26.8
15.5	-8.7	-36.4	-29.9	-43.5	-39.3	-13	-27.8
16	-8.8	-44	-29.7	-41.1	-44.8	-11.5	-29.2
16.5	-8.9	-31.5	-37.6	-37.4	-42.3	-10.3	-28.7
17	-9.2	-29.3	-36	-36.9	-38.2	-10.1	-26.2
17.5	-9	-29.8	-35.7	-36.9	-33.5	-10.4	-29.5
18	-9.7	-33.5	-29.9	-40.2	-32.8	-10.8	-27.4

MAXIMUM RATINGS

Specification temperature ..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Insertion loss relative to 0 dBm RF input. All other outputs, including f_0, are relative to the desired upper ($f_0 + f_m$) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

*3.

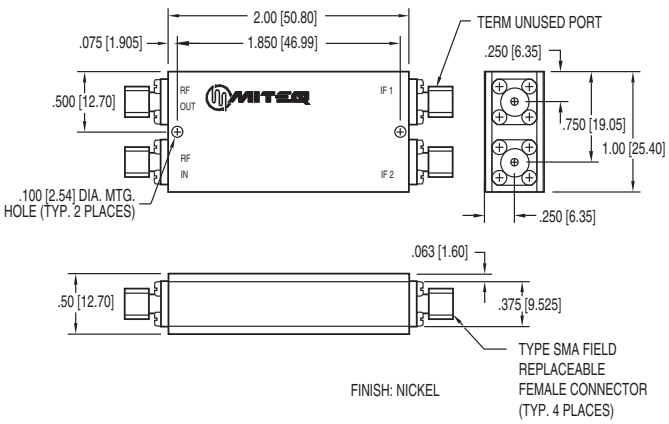
Model Number Option Table

(*) Add Letter	LO Power Range (dBm)	P1 dB (dBm)	(**) Add Letter	IF Frequency (MHz)
L	10–13	+6	A	20–40
M	13–16	+10	B	40–80
H	17–20	+15	C	100–200
			Q	DC-500(I/Q)

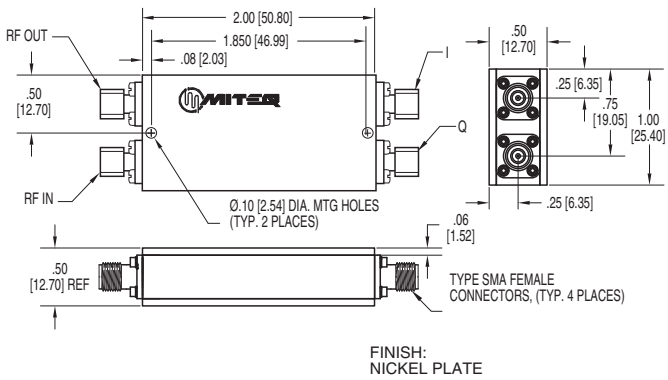
NOTE: Test data supplied at 25°C; per spectrum table.

OUTLINE DRAWINGS

SSM1218(*)C2MDA, B OR C



SSM1218(*)C2MDQ



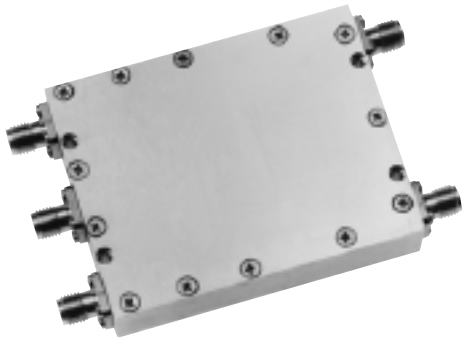
NOTE: All dimensions shown in brackets [ ] are in millimeters.

2 TO 26 GHz SINGLE-SIDEBAND UPCONVERTER

MODEL: SM0226LC1MD* (IF Driven)

FEATURES

- **RF output/carrier input ..... 2 to 26 GHz**
- **IF bandwidth ..... DC to 500 MHz (Q)**
- **Linear RF input ..... Up to +5 dBm**
- **IF input power ..... +10 to +13 dBm**
- **Sideband suppression ..... 25 dB**
- **Carrier rejection ..... 25 dB**
- **Modulation options:**
  Single sideband ..... A, B and C (internal hybrid)
  Multioctave IFs ..... Q (separate inputs)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or IF) has sufficient power to turn on the semiconductors. This model employs IF drive. SSB upconverters employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) upconverters have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This IF driven unit is used when the RF input has a wide dynamic range, such as for military and commercial Doppler frequency or phase-shift generation.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	2		26
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		1.5:1	
RF power at 1 dB compression (IF = +10 dBm)	dBm		+5	
IF frequency range (Note 3)	MHz	DC		500
IF power range (50 ohm input)	dBm	+10		+13
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		12	15
Carrier suppression	dBc		25	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	15	20	
Carrier ±2 IF, 4 IF, etc.	dBc		45	
Carrier ±3 IF	dBc		10	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	2		26
RF VSWR (RF = -10 dBm, IF modulation = +10 dBm)	Ratio		2.5:1	

SM0226LC1MDA TYPICAL IF DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = 0 dBm, IF = +10 dBm total, IF = 30 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
2	-8.6	-17.1	-22.3	-46.8	-43.8	-9.2	-26.4
3	-8.1	-24.6	-27.2	-55	-60.9	-11	-29.2
4	-8.4	-24.4	-27.1	-48.5	-48.1	-10.8	-29.5
5	-7.7	-21.1	-39.6	-57	-47.8	-11.9	-27.5
6	-8.7	-20.5	-38.9	-53.3	-44.9	-12.3	-30
7	-9.4	-24.4	-39.4	-47.1	-44.6	-10.9	-28.3
8	-7.6	-25.6	-30.1	-42.6	-47.5	-11.5	-31.1
9	-9.5	-26.5	-27	-47.7	-41.6	-11.6	-26.8
10	-9	-25.4	-26.5	-48.1	-43.3	-10.9	-28
11	-9	-29	-26.9	-41.5	-46	-10.6	-26.8
12	-8.9	-25.4	-27.3	-42.1	-46.4	-10.8	-27.3
13	-8.4	-22.6	-28.2	-41.4	-43.7	-11.4	-25.8
14	-9.5	-21.5	-26	-43.2	-38.5	-10.3	-25.8
15	-9.9	-26.6	-26.4	-40.1	-40.3	-11.3	-26.8
16	-8.9	-30.5	-26.7	-38.1	-46.4	-10.2	-25.8
17	-9.1	-21.7	-29.7	-46.8	-39.7	-11	-24.5
18	-9.8	-30.3	-29.5	-40	-44.4	-11	-23.2
19	-10.9	-22.5	-25.2	-38.4	-37.2	-9.2	-27
20	-11.8	-23.8	-27.9	-38.5	-42.6	-10.9	-27.3
21	-12.3	-26.5	-26.9	-40.1	-37.2	-11.2	-22.9
22	-12.6	-30.5	-24	-37.8	-38.6	-12	-24.2
23	-13.7	-19.8	-27.5	-30	-36.6	-10.6	-21.8
24	-12.7	-17.2	-23.9	-33.3	-28.7	-10.9	-23.7
25	-13.8	-22.1	-27.7	-32.4	-32.8	-13.2	-26.9
26	-14.3	-28.3	-18.5	-28.2	-32.3	-11.5	-24.4

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

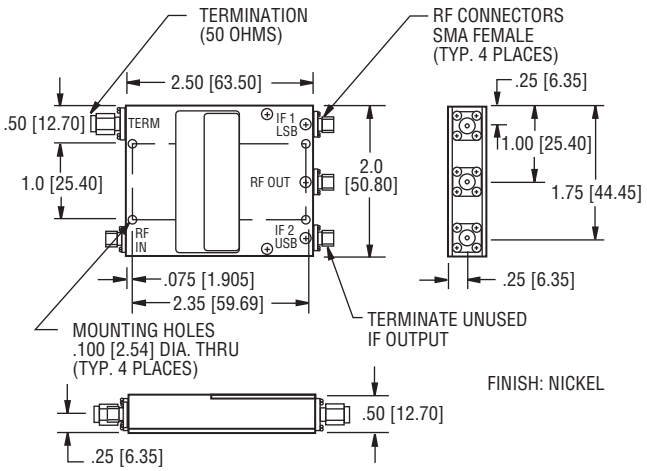
1. Insertion loss relative to 0 dBm RF input. All other outputs, including f_0, are relative to the desired upper ($f_0 + f_m$) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

*3. Available part numbers: SM0226LC1MD_*
A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

NOTE: Test data supplied at 25°C; per spectrum table.

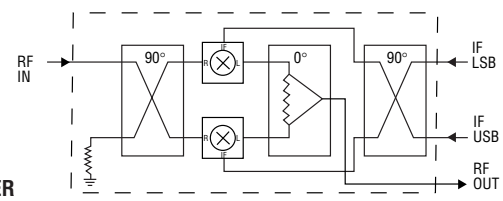
OUTLINE DRAWING

SM0226LC1MDA



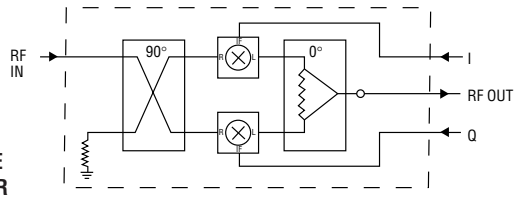
BLOCK DIAGRAMS

SM0226LC1MDA, B and C



SSB UPCONVERTER

SM0226LC1MDQ



QUADRATURE UPCONVERTER

NOTE: All dimensions shown in brackets [ ] are in millimeters.

APPLICATION NOTES FOR QPSK AND QAM MODULATORS

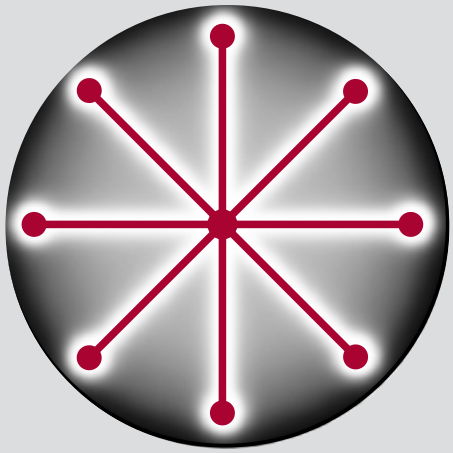
MITEQ's high-isolation biphase modulators are useful in quadrature coupled matched pairs for "Direct On-Carrier" QPSK and QAM applications. The QPSK modulator is, traditionally, used to apply more information on the RF carrier because each component (I or Q) biphase modulator acts in quadrature to keep its information separated while using the same common RF bandwidth. Greater amounts of information or (bits/symbol) are possible if each quadrature channel has more than two amplitude states (±1). For example, 16 QAM employs four amplitude states (±1, ±0.5) in each quadrature channel. However, QAM modulators and some QPSK modulators (with bandwidth restriction filters) require a linear amplitude response to insure that each modulation level or "constellation" remain undistorted.

Linear I and Q modulators require that the modulation envelope be transferred to the RF without distortion or spectral spreading. In order to accomplish this, an RF or carrier driven QPSK modulator is required with I and Q inputs of 0 dBm typical and RF +10 dBm. The higher carrier power level of this operating mode makes carrier to output (LO-to-RF) isolation especially important so that QPSK phase and amplitude accuracy is maintained. The Model SMC0206LI1CD QPSK modulator is an example of high-isolation (50 dB LO to RF) mixers driven by the carrier at +16 dBm which achieves ±4°, ±0.4 dB phase and amplitude accuracy with +10 dBm I/Q inputs. The second- and third-harmonic suppression of I/Q signals is typically -60 dBc relative to the desired output, thus making spectrum spreading a negligible problem.

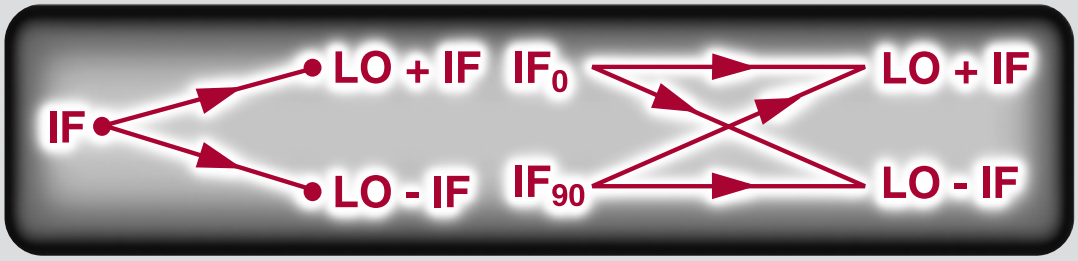
In general, each QPSK data sheet describes performance in either the modulation driven (linear RF) or carrier driven (linear I/Q) modes. In many cases, the hardware is identical; but the catalog test data describes and guarantees either QPSK amplitude/phase accuracy for the modulation driven units or sideband suppression for the carrier driven units. Optional data is available in both modes.

Many of the QPSK/QAM modulators in this section of the catalog are wide RF bandwidth units intended for test and military applications. However, various specialized narrow bandwidth communication modulators have been supplied in lower cost "drop-in" configurations including high-isolation even-harmonic (1/2 LO) units such as the Model SML0711M8CDQ with externally combined RF outputs to allow highly balanced quadrature phase/amplitude accuracy.

MODULATOR PRODUCTS



ANALOG PHASE SHIFTERS



SSB UPCONVERTER

QIFM

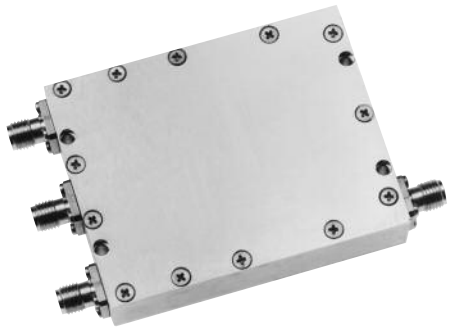
- **Detailed Data Sheets**

1 TO 2 GHz SINGLE-SIDEBAND UPCONVERTER

MODEL: SDM0102LC1CD_*_ (Carrier Driven)

FEATURES

- **RF output/carrier input ..... 1 to 2 GHz**
- **IF bandwidth ..... DC to 500 MHz (Q)**
- **Linear IF input..... Up to +5 dBm**
- **Carrier input power ..... +7 to +13 dBm**
- **Sideband suppression..... 25 dB**
- **Carrier isolation..... 23 dB**
- **Modulation options:**
  Single sideband..... A, B and C (internal hybrid)
  Multioctave IFs ..... Q (separate inputs)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or IF) has sufficient power to turn on the semiconductors. This model employs carrier drive. SSB upconverters employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) upconverters have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. PIN diode (optional) designs can only be driven at modulation rates of less than 30 MHz, but will yield output RF powers exceeding +5 dBm. This carrier driven unit is used when the IF input has a wide dynamic range and high linearity is required.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	1		2
RF VSWR (RF = +10 dBm, IF modulation = 0 dBm)	Ratio		1.5:1	
RF carrier power range (50 ohm input)	dBm	+7	+10	+13
IF power at 1 dB compression (RF = +10 dBm)	dBm		+5	
IF frequency range (Note 3)	MHz	DC		500
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		8	10
Carrier isolation (IF = +5 dBm)	dBc	25	30	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	15	20	
Carrier ±2 IF, 4 IF, etc.	dBc		45	
Carrier ±3 IF	dBc		10	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	1		2
RF VSWR (RF = +10 dBm, IF modulation = 0 dBm)	Ratio		2.5:1	

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Revised: 03/17/14

SDM0102LC1CDC CARRIER DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = +10 dBm, IF = 0 dBm total, IF = 150 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
1	-9.3	-24.9	-13.3	-40.9	-45.6	-50.6	-45.3
1.1	-9.5	-25.2	-20.3	-27.8	-41.7	-46.8	-39.2
1.2	-9.6	-25	-19.5	-23.2	-38.9	-50.2	-41.6
1.3	-7.4	-26.9	-23	-39.6	-45.7	-56	-43.4
1.4	-7	-22.1	-22.8	-40.6	-45.6	-62.7	-61
1.5	-6.9	-26.6	-22.2	-44.5	-63.1	-64.2	-62.2
1.6	-6.5	-25.3	-21.8	-43.5	-57.9	-63.9	-63.4
1.7	-6.2	-24.2	-22.4	-42	-54.9	-64.6	-62.9
1.8	-5.9	-22.5	-23.1	-38	-55.5	-63.5	-63.9
1.9	-5.4	-24.6	-36.1	-38.5	-60.5	-63	-62.7
2	-7.2	-33.5	-22.6	-39.2	-50.2	-63.3	-61.7

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

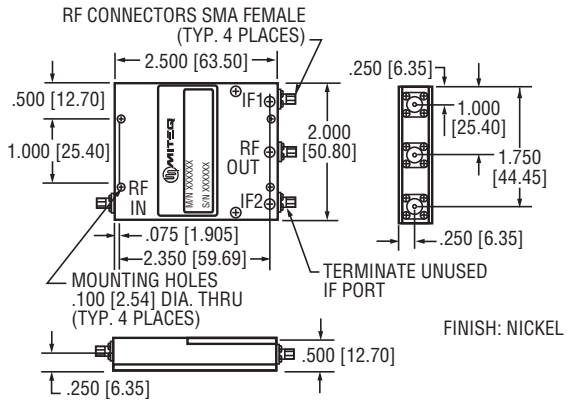
GENERAL NOTES

1. Insertion loss relative to 0 dBm IF input. All other outputs are relative to the desired upper ($f_0 + f_m$) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

*3. Available part numbers: SDM0102LC1CD ★
A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

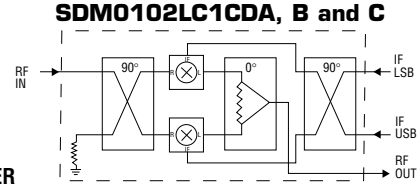
NOTE: Test data supplied at 25°C; per spectrum table.

OUTLINE DRAWING

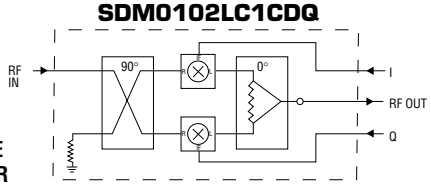


BLOCK DIAGRAMS

SDM0102LC1CDA, B and C



SDM0102LC1CDQ



NOTE: All dimensions shown in brackets [ ] are in millimeters.

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2.7 TO 3.7 GHz SINGLE-SIDEBAND UPCONVERTER (OR I/Q) MODULATOR

MODEL: SM2737LI6CD* (Carrier Driven)

FEATURES

- **RF output/carrier input ..... 2.7 to 3.7 GHz**
- **Packaging ..... Hermetically sealed**
- **Linear modulation input ..... Up to 0 dBm**
- **Carrier input power ..... +10 to +13 dBm**
- **Sideband suppression ..... 30 dB**
- **Carrier rejection ..... 25 dB**
- **Modulation options:**
  Single sideband ..... A, B and C (internal hybrid)
  I/Q modulator ..... Q (separate inputs)

All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or modulation) has sufficient power to turn on the semiconductors. This model employs carrier drive. All modulators yield a frequency spectrum that utilizes both sidebands on either side of the output suppressed carrier. SSB upconverters, however, employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) modulators have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. Greater output power can be achieved by using higher level diodes with proportional increases in carrier power. This carrier driven unit is used when the modulation input to RF output must be linear (low harmonics). A typical application is for digital QPSK with cosine shaped pulses (for minimum bandwidth). Many SSB upconverters also require input-to-output signal linearity, thus requiring LO drive.

ELECTRICAL SPECIFICATIONS

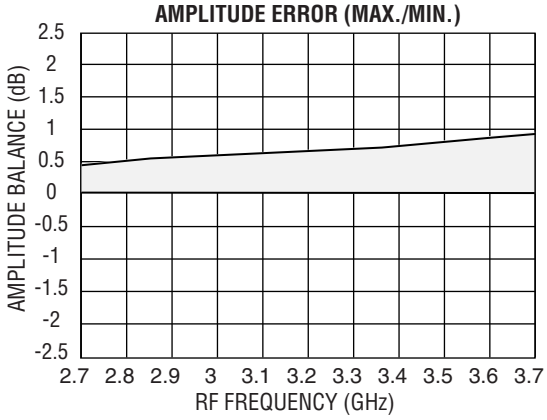
INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	2.7		3.7
RF VSWR (RF = +13 dBm, IF modulation = 0 dBm)	Ratio		1.5:1	
RF power (low-level diodes)	dBm	+7	+10	+13
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (total I/Q)	dBm	Noise		+5
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		6	8
Carrier suppression (IF = +5 dBm)	dBc	20	25	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	25	30	
Carrier ±2 IF, 4 IF, etc.	dBc		40	
Carrier ±3 IF	dBc		40	
Quadrature phase accuracy, I/Q mode (see Graph Key)	Degrees		±6	
Quadrature amplitude accuracy	dB		±0.6	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	2.7		3.7
RF VSWR (RF = +13 dBm, IF modulation = 0 dBm)	Ratio		2.5:1	

SM2737LI6CDQ CARRIER DRIVEN TYPICAL TEST DATA

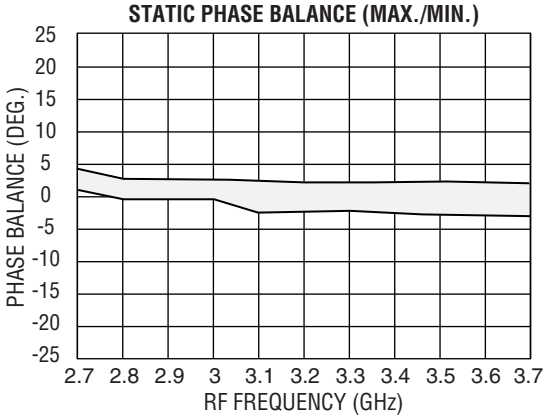
RF Phase (Deg.) I/Q	Graph Key 0 +/+	+90 -/+	-90 +/-	+180 -/-

I/Q MODE (RF = +10 dBm, I/Q = -3 dBm each input (0.225 volts peak across 50 ohm load)

AMPLITUDE ERROR (MAX./MIN.)



STATIC PHASE BALANCE (MAX./MIN.)



SM2737LI6CDC CARRIER DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = +10 dBm, IF = 0 dBm total, IF = 200 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
2.7	6.5	33	26	46	38	47	51
2.9	6	33	27	46	39	44	49
3.1	5.8	33	28	44	39	44	48
3.3	5.3	32	28	43	40	43	46
3.5	5	33	27	43	42	42	45
3.7	5.9	34	26	44	40	40	44

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

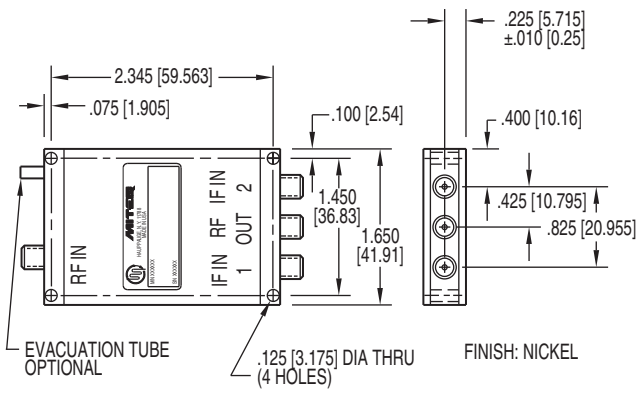
1. Insertion loss relative to +3 dBm input. All other outputs, including f_O, are relative to the desired upper ($f_O + f_m$) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

*3. Available part numbers: SM2737LI6CD__ *

A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

NOTE: Test data supplied at 25°C; insertion loss, phase and amplitude balance per spectrum table.

OUTLINE DRAWING

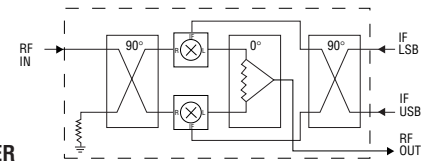


NOTE: All dimensions shown in brackets [ ] are in millimeters.

BLOCK DIAGRAMS

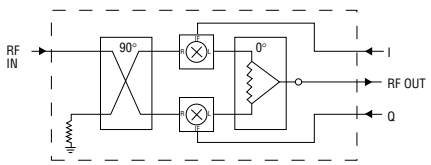
SM2737LI6CDA, B and C

SSB UPCONVERTER



SM2737LI6CDQ

I/Q MODULATOR

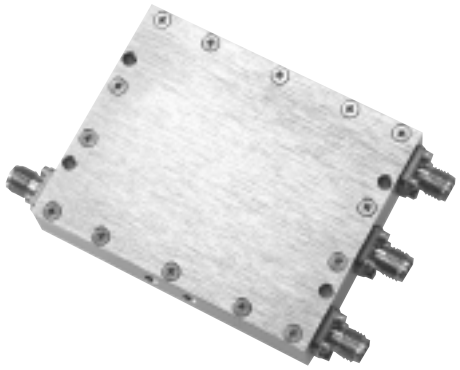


1 TO 4 GHz SINGLE-SIDEBAND UPCONVERTER (OR I/Q) MODULATOR

MODEL: SDM0104LC1CD_*_ (Carrier Driven)

FEATURES

- **RF output/carrier input ..... 1 to 4 GHz**
- **Modulation bandwidth ..... DC to 500 MHz (Q)**
- **Linear modulation input ..... Up to +5 dBm**
- **Carrier input power ..... +10 to +13 dBm**
- **Sideband suppression ..... 25 dB**
- **Carrier rejection ..... 35 dB**
- **Modulation options:**
  Single sideband ..... A, B and C (internal hybrid)
  I/Q modulator ..... Q (separate inputs)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or modulation) has sufficient power to turn on the semiconductors. This model employs carrier drive. All modulators yield a frequency spectrum that utilizes both sidebands on either side of the output suppressed carrier. SSB upconverters, however, employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) modulators have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. Greater output power can be achieved by using higher level diodes with proportional increases in carrier power. This carrier driven unit is used when the modulation input to RF output must be linear (low harmonics). A typical application is for digital QPSK with cosine shaped pulses (for minimum bandwidth). Many SSB upconverters also require input-to-output signal linearity, thus requiring LO drive.

ELECTRICAL SPECIFICATIONS

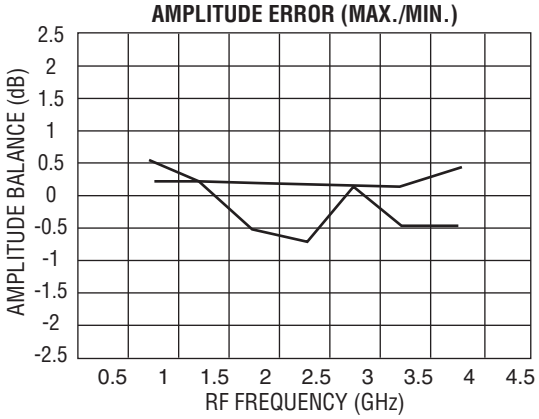
INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	1		4
RF VSWR (RF = +13 dBm, IF modulation = 0 dBm)	Ratio		1.5:1	
RF power (low-level diodes)	dBm	+10		+13
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (total I/Q)	dBm	Noise		+5
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		8	10
Carrier suppression (IF = +5 dBm)	dBc	30	35	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	15	25	
Carrier ±2 IF, 4 IF, etc.	dBc		50	
Carrier ±3 IF	dBc		40	
Quadrature phase accuracy, I/Q mode (see Graph Key)	Degrees		±6	
Quadrature amplitude accuracy	dB		±0.6	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	1		4
RF VSWR (RF = +13 dBm, IF modulation = 0 dBm)	Ratio		2.5:1	

SDM0104LC1CDQ CARRIER DRIVEN TYPICAL TEST DATA

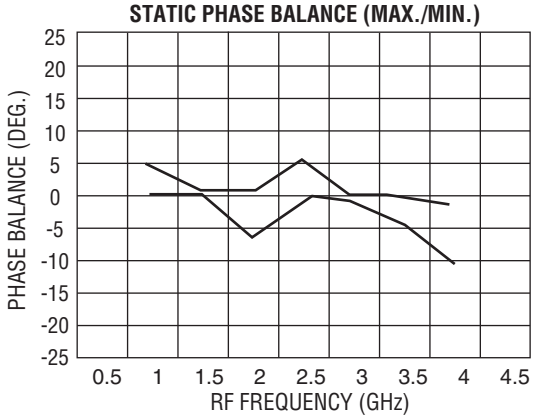
RF Phase (Deg.) I/Q	Graph Key 0 +/+	+90 -/+	-90 +/-	+180 -/-

I/Q MODE (RF = +13 dBm, I/Q = 0 dBm each input (0.316 volts peak across 50 ohm load)

AMPLITUDE ERROR (MAX./MIN.)



STATIC PHASE BALANCE (MAX./MIN.)



SDM0104LC1CDC CARRIER DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = +13 dBm, IF = +3 dBm total, IF = 100 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
1	7	19	37	47	55	32	41
1.5	6.6	29	33	47	49	25	38
2	5.1	27	36	48	53	48	63
2.5	6.1	32	37	47	55	48	58
3	5.5	24	37	48	56	44	53
3.5	5.5	24	38	48	53	43	49
4	6.1	17	34	94	57	31	34

MAXIMUM RATINGS

Specification temperature ..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Insertion loss relative to +3 dBm input. All other outputs, including f_0, are relative to the desired upper (f_0 + f_m) output.
2. Standard SSB units with IF hybrids are aligned for upper side band operation. For lower sideband or selectable sideband, contact MITEQ.

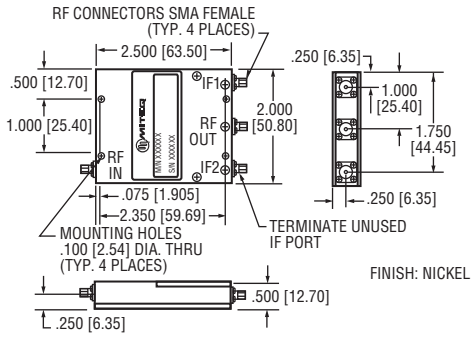
3. Available part numbers: SDM0104LC1CD

A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

NOTE: Test data supplied at 25°C; insertion loss, phase and amplitude balance per spectrum table.

OUTLINE DRAWING

SDM0104LC1CDC

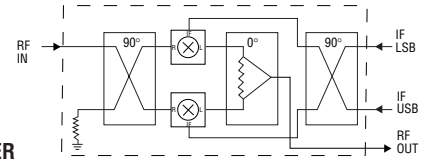


NOTE: All dimensions shown in brackets [ ] are in millimeters.

BLOCK DIAGRAMS

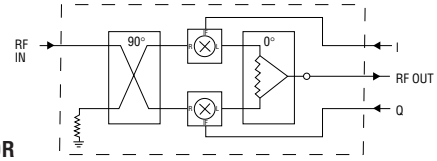
SDM0104LC1CDA, B and C

SSB UPCONVERTER



SDM0104LC1CDQ

I/Q MODULATOR



2 TO 6 GHz QPSK/QAM MODULATOR OR SSB UPCONVERTER

MODEL: SMC0206LI1CD_* (Carrier Driven)

FEATURES

- **RF output/carrier input ..... 2 to 6 GHz**
- **Linear modulation input ..... Up to +10 dBm**
- **Carrier input power ..... +15 to +18 dBm**
- **Sideband suppression ..... 30 dB**
- **Carrier rejection ..... 35 dB**
- **Options:**
  Single sideband ..... A, B and C (internal hybrid)
  I/Q modulator ..... Q (separate inputs)

All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or modulation) has sufficient power to turn on the semiconductors. This model employs carrier drive. All modulators yield a frequency spectrum that utilizes both sidebands on either side of the output suppressed carrier. SSB upconverters, however, employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) modulators have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. Greater output power can be achieved by using higher level diodes with proportional increases in carrier power. This carrier driven unit is used when the modulation input to RF output must be linear (low harmonics). A typical application is for digital QPSK with cosine shaped pulses (for minimum bandwidth). Many SSB upconverters also require input-to-output signal linearity, thus requiring LO drive.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	2		6
RF VSWR (RF = +13 dBm, IF modulation = 0 dBm)	Ratio		1.5:1	
RF power (low-level diodes)	dBm	+15	+16	+18
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (total I/Q)	dBm	Noise		+13
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		12	15
Carrier suppression (IF = +13 dBm)	dBc	25	35	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	23	30	
Carrier ±2 IF, 4 IF, etc.	dBc		40	
Carrier ±3 IF	dBc		30	
Quadrature phase accuracy, I/Q mode (see Graph Key)	Degrees		±8	
Quadrature amplitude accuracy	dB		±1	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	2		6
RF VSWR (RF = +13 dBm, IF modulation = 0 dBm)	Ratio		2.5:1	

Revised: 06/07/13

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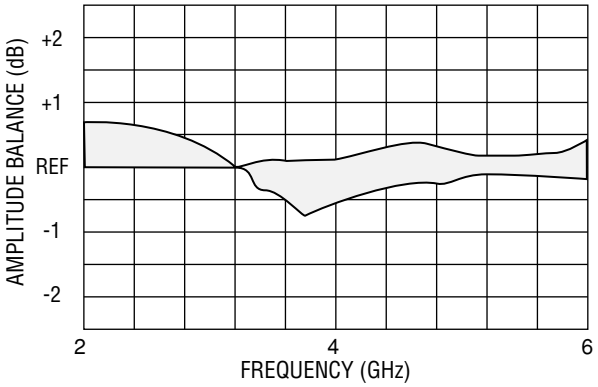
SMC0206LI1CDQ CARRIER DRIVEN TYPICAL TEST DATA

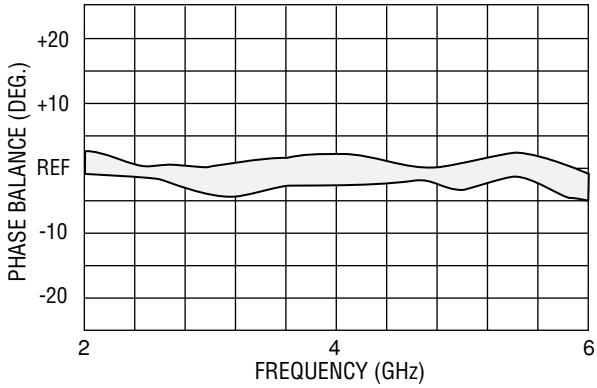
RF Phase (Deg.) I/Q (1 V)	Graph Key 0 +/+	+90 -/+	-90 +/-	+180 -/-

I/Q MODE (RF = +16 dBm, I/Q = +10 dBm each input (1 volt peak across 50 ohm load)

STATIC AMPLITUDE BALANCE



STATIC PHASE BALANCE



SMC0206LI1CDA CARRIER DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = +16 dBm, IF = +13 dBm total, IF = 20 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
2	13.8	31	39	64	65	64	65
2.5	13.1	34	56	64	65	49	67
3	13.9	30	38	66	65	61	66
3.5	13.6	30	39	64	64	63	64
4	13.9	31	41	63	63	62	63
4.5	14.4	34	37	62	62	60	63
5	15.1	34	42	61	63	57	62
5.5	14.4	35	44	63	63	58	62
6	13.8	30	35	64	64	55	64

MAXIMUM RATINGS

Specification temperature ..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

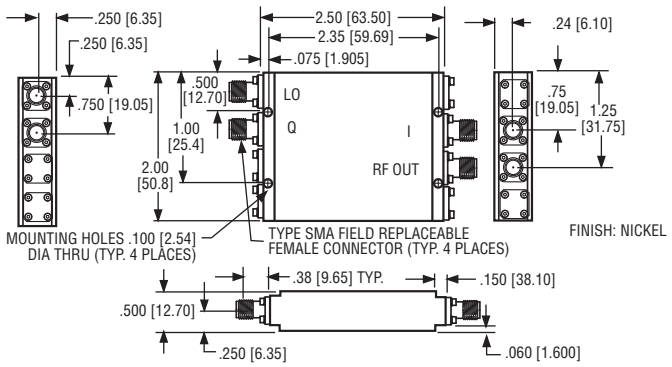
1. Insertion loss relative to +10 dBm input. All other outputs, including f_0, are relative to the desired upper ($f_0 + f_m$) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

*3. Available part numbers: SMC0206LI1CD_*
A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

NOTE: Test data supplied at 25°C; insertion loss, phase and amplitude balance per spectrum table.

OUTLINE DRAWING

SMC0206LI1CDQ

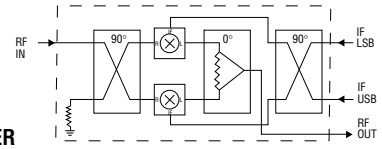


NOTE: All dimensions shown in brackets [ ] are in millimeters.

BLOCK DIAGRAMS

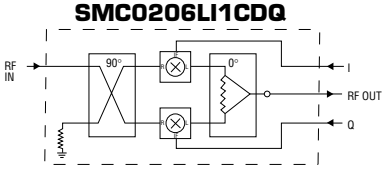
SMC0206LI1CDA, B and C

SSB UPCONVERTER



SMC0206LI1CDQ

I/Q MODULATOR



Revised: 06/07/13

3.7 TO 6.4 GHz DIRECT SATELLITE I/Q TEST MODULATOR

MODEL: SDM0307LI1CDQ (Carrier Driven)

FEATURES

- **Tri-band, C**
  Downlink ..... 3.7 to 4.2 GHz
  Uplink ..... 5.9 to 6.4 GHz
- **Direct linear I/Q modulation ..... DC to 500 MHz**
- **Carrier/sideband rejection..... 25 dB**
- **Harmonic rejection..... 30 dB**
- **Packaging ..... Hermetically sealed**

Microwave QAM signals are traditionally generated by linearly mixing or modulating a VHF or UHF carrier oscillator with band limited I and Q information. The resulting phase and/or amplitude states of the carrier are then multiplied or upconverted by another mixer, local oscillator and sideband filter to the actual transmitted frequency. I/Q modulation has traditionally been done in this manner because lower frequency high isolation mixers tend to yield the best carrier and sideband rejection. The latter qualities are most important for accurate I/Q phase states or transmitted signal constellations. More recently at MITEQ, the electrical and physical symmetry of microwave baluns have been improved to yield mixers with LO-to-RF isolations of 45 dB up to 18 GHz. This unit uses these mixers to achieve direct I/Q modulation of a microwave carrier without the costly lower frequency upconversion.

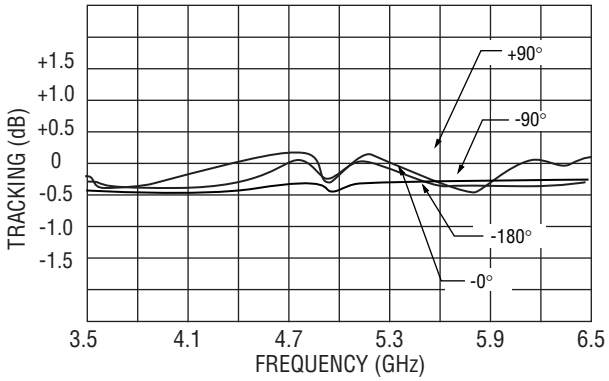
ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
Carrier frequency range		GHz	3.5		6.5
Carrier VSWR	RF = +16 dBm	Ratio		1.5:1	
Carrier power		dBm	+13	+16	+19
Modulation frequency range	I/Q	MHz	DC		500
Modulation power	I/Q (50 ohms)	dBm	Noise	0	+6
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (IF = 100 MHz) (desired output relative to I/Q input)	RF = +10 dBm I/Q = 0 dBm	dB		8	11
Carrier rejection (relative to desired output)	IF = +6 dBm	dB	22	30	
Upper or lower sideband	$f_O \pm$ IF	dB	22	25	
Second-harmonic sideband	$f_O \pm 2$ IF	dB	30	45	
Third-harmonic sideband	$f_O \pm 3$ IF	dB	35	40	
Insertion loss (I/Q switch mode)	I/Q = +10 mA	dB	10	7	
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range		GHz	3.5		6.5
RF VSWR (RF = -10 dBm, LO = +10 dBm)		Ratio		2.5:1	

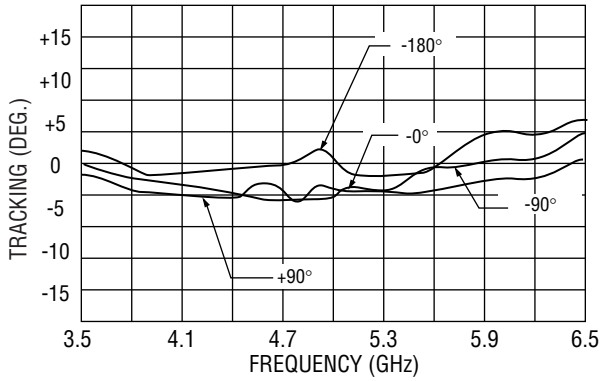
CARRIER DRIVEN TYPICAL TEST DATA

SDM0307LC1CDQ

AMPLITUDE TRACKING
(RF = +16 dBm)



PHASE TRACKING
(RF = +16 dBm)



f_O LEVEL: +16 dBm, I/Q LEVEL: +4 dBm (20 MHz)

OUTPUT SPECTRUM RELATIVE TO CARRIER +20 MHz OUTPUT

Frequency (GHz)	f_O + IF (I.L., dB)	f_O - IF (dBc)	f_O (dBc)	f_O - 2 IF (dBc)	f_O - 2 IF (dBc)	f_O - 3 IF (dBc)	f_O + 3 IF (dBc)
3.5	-8	-30.2	-42.2	-48.6	-47.5	-45.9	-50.4
4	-8.6	-24.5	-30.8	-48.2	-48.6	-48.6	-51.8
4.5	-8.8	-24.1	-27.8	-47.8	-48.1	-45.8	-52.2
5	-8.9	-27.6	-28.2	-47.6	-48.9	-42.4	-51.7
5.5	-8	-25	-28.7	-46.7	-48.5	-45.6	-51.7
6	-7.6	-30.2	-28.9	-47	-49	-41	-52.6
6.5	-7.7	-28.2	-34.3	-47.2	-49.4	-42.7	-51.6

Note: Upper sideband is desired output, IL is relative to total I/Q input power.

MAXIMUM RATINGS

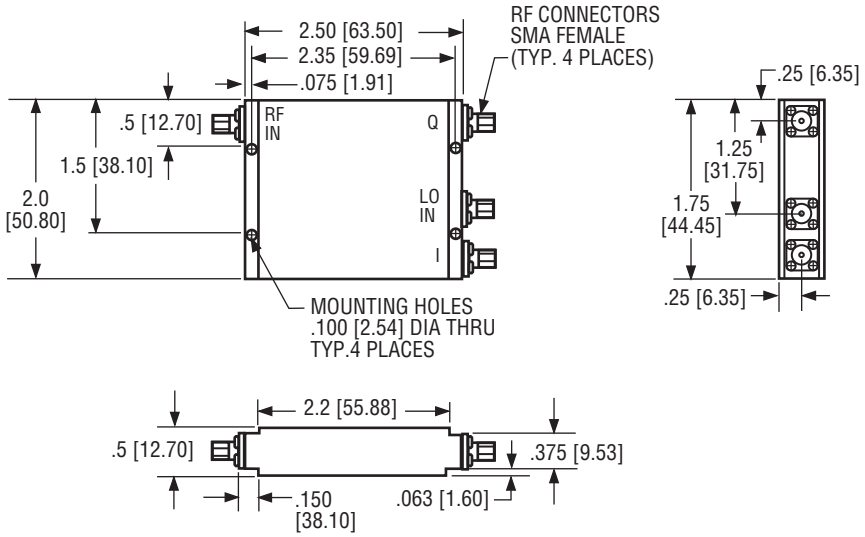
Specification temperature ..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTE

1. Higher output power and I/Q TTL drive circuit available.

NOTE: Test data supplied at 25°C; phase and amplitude tracking.

OUTLINE DRAWING



NOTE: All dimensions shown in brackets [ ] are in millimeters.

2 TO 8 GHz SINGLE-SIDEBAND UPCONVERTER OR I/Q MODULATOR

MODEL: SDM0208LC1CD_* (Carrier Driven)

FEATURES

- **RF output/carrier input ..... 2 to 8 GHz**
- **Modulation bandwidth ..... DC to 500 MHz (Q)**
- **Linear modulation input ..... Up to +5 dBm**
- **Carrier input power ..... +10 to +13 dBm**
- **Sideband suppression ..... 25 dB**
- **Carrier rejection ..... 20 dB**
- **Modulation options:**
  Single sideband ..... A, B and C (internal hybrid)
  I/Q modulator ..... Q (Separate inputs)

All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or modulation) has sufficient power to turn on the semiconductors. This model employs carrier drive. All modulators yield a frequency spectrum that utilizes both sidebands on either side of the output suppressed carrier. SSB upconverters, however, employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) modulators have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. Greater output power can be achieved by using higher level diodes with proportional increases in carrier power. This carrier driven unit is used when the modulation input to RF output must be linear (low harmonics). A typical application is for digital QPSK with cosine shaped pulses (for minimum bandwidth). Many SSB upconverters also require input-to-output signal linearity, thus requiring LO drive.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier input	GHz	2		8
RF VSWR (RF = +13 dBm, IF modulation = 0 dBm)	Ratio		1.5:1	
RF input power (low-level diodes)	dBm	+10		+13
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (total I/Q)	dBm	Noise		+7
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		7	10
Carrier isolation (RF = +13 dBm)	dBc	20	30	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	15	30	
Carrier ±2 IF, 4 IF, etc.	dBc		45	
Carrier ±3 IF	dBc		40	
Quadrature phase accuracy, I/Q mode (see Graph Key)	Degrees		±10	
Quadrature amplitude accuracy	dB		±1	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF output frequency range	GHz	2		8
RF output VSWR (RF = +10 dBm, IF modulation = 0 dBm)	Ratio		2.5:1	

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Revised: 05/13/14

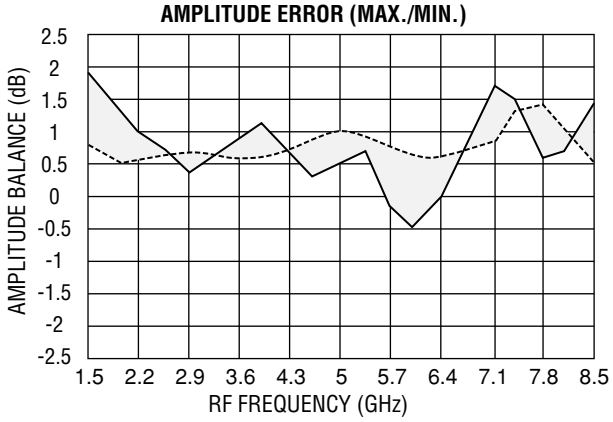
CARRIER DRIVEN TYPICAL TEST DATA

SDM0208LC1CDQ

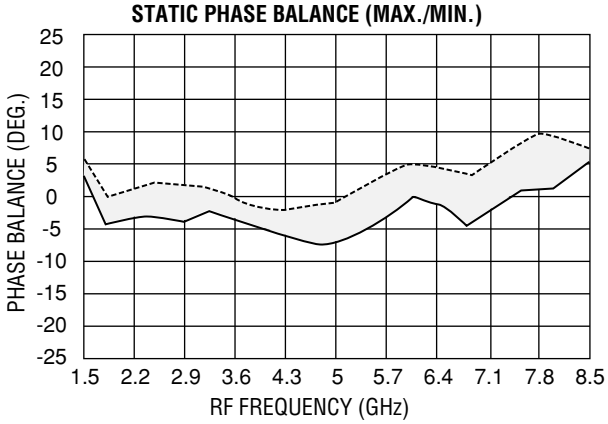
RF Phase (Deg.) I/Q	Graph Key 0 +/+	+90 -/+	-90 +/-	+180 -/-

I/Q MODE (RF = +13 dBm, I/Q = 0 dBm each input (0.316 volts peak across 50 ohm load)

AMPLITUDE ERROR (MAX./MIN.)



STATIC PHASE BALANCE (MAX./MIN.)



SDM0208LC1CDC

SSB UPCONVERTER (RF = +13 dBm, IF = +3 dBm total, IF = 100 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
2	-6.7	-30.7	-23.2	-58.3	-54.2	-38	-66.4
2.5	-6.2	-34.2	-22.1	-60.3	-50.5	-46.1	-62.2
3	-8	-30.8	-21.4	-62.1	-50.9	-39.2	-59.4
3.5	-7.7	-46.9	-22.5	-70.6	-63.7	-47.6	-72.7
4	-7	-30.2	-22.4	-61	-58.3	-51	-71
4.5	-7.9	-28.1	-20.9	-70.7	-54.3	-47	-62.3
5	-9	-30.4	-19.8	-72.2	-63.6	-48.1	-73.2
5.5	6.5	-32.9	-20	-59.4	-52	-43.3	-73.7
6	-7.2	-24.5	-20.6	-51.1	-46.3	-33.3	-50.9
6.5	-7.6	-32.1	-21.5	-68.4	-50.5	-37.7	-57.2
7	-7.9	-25.4	-20.8	-63.7	-47.6	-37.7	-73.9
7.5	-10.4	-26.7	-18.5	-62.7	-61.6	-46	-64
8	-8.1	-34.7	-17.9	-65.5	-67.1	-48.8	-68.2

MAXIMUM RATINGS

Specification temperature ..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

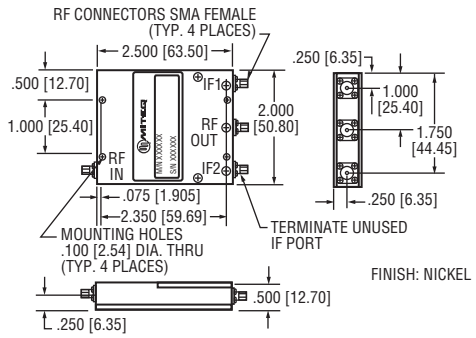
GENERAL NOTES

1. Insertion loss relative to +3 dBm IF input. All other outputs, including f_0, are relative to the desired upper (f_0 + f_m) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

*3. Available part numbers: SDM0208LC1CD ★
A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

NOTE: Test data supplied at 25°C; phase and amplitude balance per spectrum table.

OUTLINE DRAWING

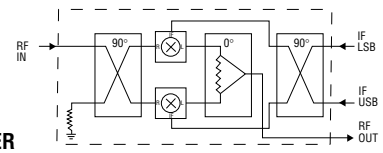


NOTE: All dimensions shown in brackets [ ] are in millimeters.

BLOCK DIAGRAMS

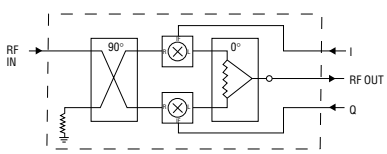
SDM0208LC1CDA, B and C

SSB UPCONVERTER



SDM0208LC1CDQ

I/Q MODULATOR



Revised: 05/13/14

7.2 TO 8.4 GHz SATELLITE I/Q TEST MODULATOR

MODEL: SDM0708LI3CDQ (TRI-BAND, X)

FEATURES

- **Tri-band, X**
  Downlink ..... 7.2 to 7.7 GHz
  Uplink ..... 7.9 to 8.4 GHz
- **Direct linear I/Q modulation ..... DC to 300 MHz**
- **Carrier/sideband rejection ..... 25 dB**
- **Harmonic rejection ..... 30 dB**
- **Packaging ..... Hermetically sealed**

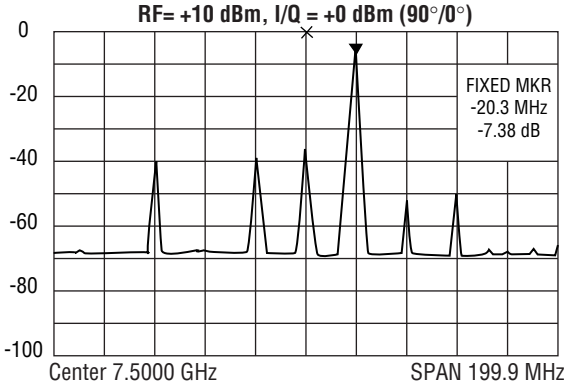
Microwave QAM signals are traditionally generated by linearly mixing or modulating a VHF or UHF carrier oscillator with band limited I and Q information. The resulting phase and/or amplitude states of the carrier are then multiplied or upconverted by another mixer, local oscillator and sideband filter to the actual transmitted frequency. I/Q modulation has traditionally been done in this manner because lower frequency high-isolation mixers tend to yield the best carrier and sideband rejection. The latter qualities are most important for accurate I/Q phase states or transmitted signal constellations. More recently at MITEQ, the electrical and physical symmetry of microwave baluns have been improved to yield mixers with LO-to-RF isolations of 45 dB up to 18 GHz. This unit uses these new mixers to achieve direct I/Q modulation of a microwave carrier without the costly lower frequency upconversion.

ELECTRICAL SPECIFICATIONS

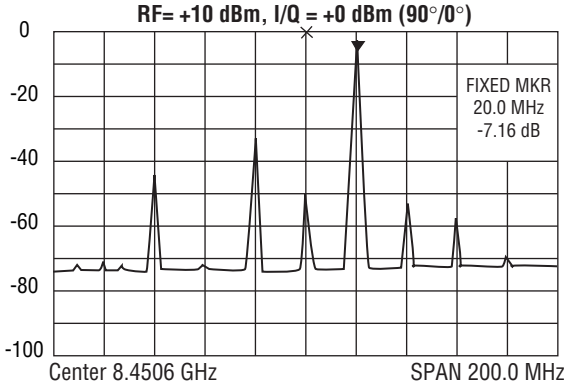
INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
Carrier frequency range		GHz	7.2		8.4
Carrier VSWR (RF = +16 dBm)		Ratio		1.5:1	
Carrier power		dBm	+8	+10	+12
Modulation frequency range	I/Q	MHz	DC		300
Modulation power	I/Q (50 ohms)	dBm	Noise	0	+6
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (IF = 100 MHz) (desired output relative to I/Q input)	RF = +10 dBm I/Q = 0 dBm	dB		7.5	8.5
Carrier rejection (relative to desired output)	IF = +6 dBm	dB		30	
Upper or lower sideband	f_O ±IF	dB	23	25	
Second-harmonic sideband	f_O ±2 IF	dB		20	
Third-harmonic sideband	f_O ±3 IF	dB		20	
Insertion loss (I/Q switch mode)	I/Q = +10 mA	dB		8	
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range		GHz	7.2		8.4
RF VSWR (RF = +16 dBm)		Ratio		2.5:1	

SDM0708LI3CDQ TRI-BAND TYPICAL SPECTRUM DATA

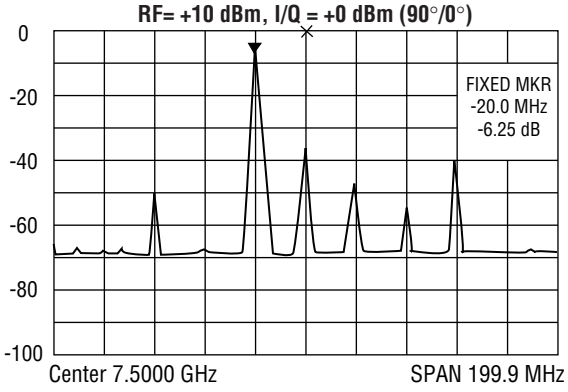
LOWER BAND EDGE SPECTRUM AND UPPER SIDEBAND OUTPUT
RF= +10 dBm, I/Q = +0 dBm (90°/0°)



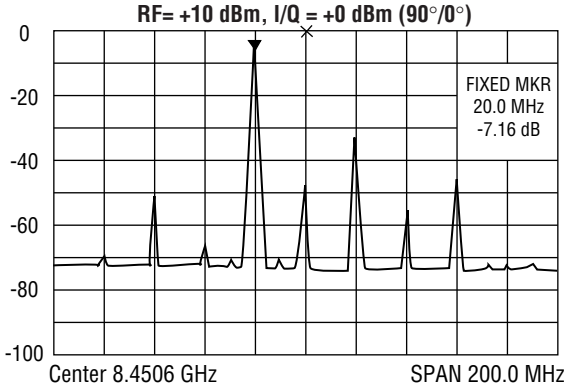
UPPER BAND EDGE SPECTRUM AND UPPER SIDEBAND OUTPUT
RF= +10 dBm, I/Q = +0 dBm (90°/0°)



LOWER BAND EDGE SPECTRUM AND LOWER SIDEBAND OUTPUT
RF= +10 dBm, I/Q = +0 dBm (90°/0°)



UPPER BAND EDGE SPECTRUM AND LOWER SIDEBAND OUTPUT
RF= +10 dBm, I/Q = +0 dBm (90°/0°)



MAXIMUM RATINGS

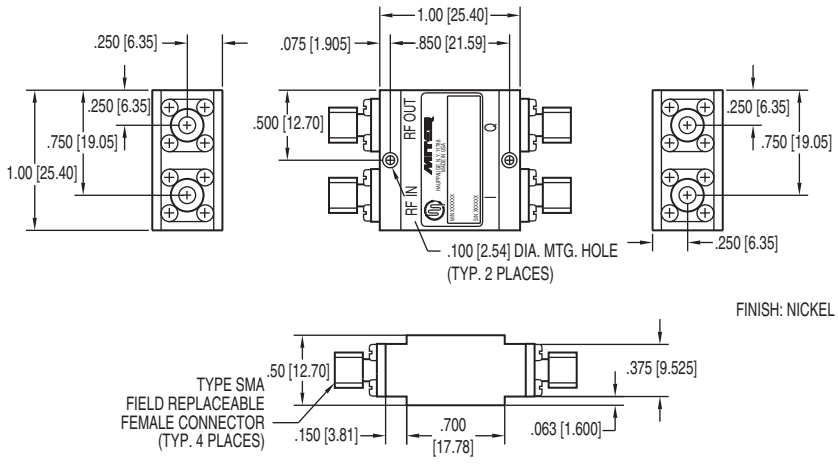
Specification temperature ..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Input/output RF amplifiers optional.
2. Filtered digital inputs available.

NOTE: Test data supplied at 25°C; per spectrum data.

OUTLINE DRAWING



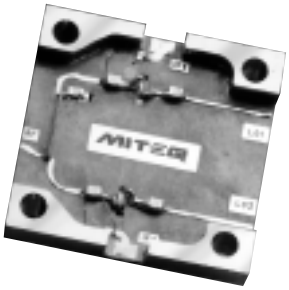
NOTE: All dimensions shown in brackets [ ] are in millimeters.

EVEN-HARMONIC, SUPPRESSED CARRIER MODULATOR

MODEL: SML0711LM8CDQ (Carrier Driven)

FEATURES

- **Modulated output frequency range..... 7 to 12 GHz**
- **Carrier input frequency..... 3.5 to 6 GHz**
- **Carrier rejection..... 45 dB typical**
- **Linear modulation rates (I/Q) ..... DC to 200 MHz**
- **Carrier power required (at 1/2 frequency)..... +6 dBm**



An increasingly popular design technique for digital communication exciters and receivers is to use even-harmonic mixers. The principal performance advantages are low LO reradiation for the receiver and ultra-high carrier rejection for the transmitter modulator. The latter feature is necessary to achieve low BER (bit error rates). MITEQ Model SML0711LM8Q combines two 1/2 LO mixers and a 90° RF hybrid on one miniature drop-in substrate, thus reducing system size and LO cost. This unit is available with an integrated LO power divider or with separate individually adjustable inputs.

ELECTRICAL SPECIFICATIONS

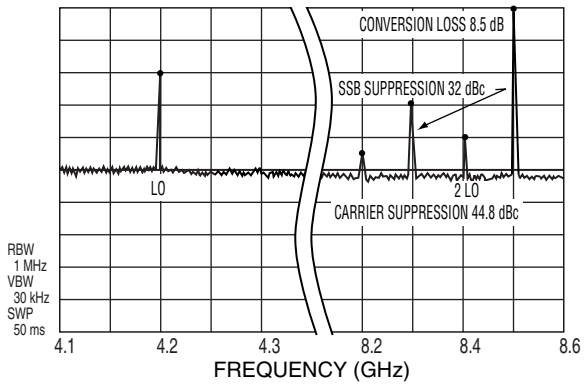
INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
Carrier frequency range	Dual LO inputs	GHz	3.55		5.85
Carrier VSWR		Ratio		2.5:1	
Carrier power into both ports	Approx. in phase	dBm	+5		+7
Modulation frequency range	Linear I/Q	MHz	DC		200
Modulation power into both ports	90° phase difference	dBm			-3
Modulation VSWR	-3 dBm	Ratio		2.5:1	
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss* (desired output relative to I/Q input)	100 MHz	dB		9	11
Carrier rejection (relative to desired output)	-3 dBm mod. power	dBc	35	45	
Upper or lower sideband*	Optimized at midband	dBc	18	30	
Second-harmonic sideband*	I/Q level dependent	dBc		45	
Third-harmonic sideband*	I/Q level dependent	dBc		25	
Other harmonic sideband*	I/Q level dependent	dBc		30	
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range		GHz	7.1		11.7
RF VSWR (output RF/input carrier)	RF = -10/LO = +7 dBm	Ratio		2.5:1	

* Data measured with external LO and IF hybrid.

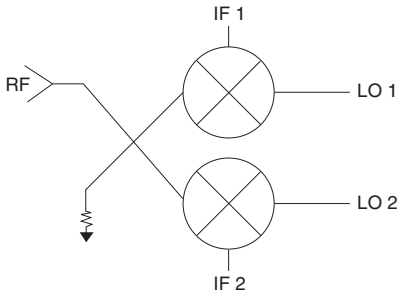
SML0711LM8CDQ CARRIER DRIVEN TYPICAL TEST DATA

CARRIER SUPPRESSION

TYPICAL OPERATING POINTS 10 dB/DIV.



BLOCK DIAGRAM



SML0711LM8CDQ MODULATION DRIVEN OUTPUT SPECTRUM TABLE

DYNAMIC MODULATION SPECTRUM (f_O = +7 dBm, I/Q = 100 MHz, 0 dBm)

Frequency (GHz)	f_O + IF (I.L., dB) 10 dB Max. Note 1	f_O - IF (dBc) 20 dBc Min.	f_O (dBc) 35 dBc Min.	f_O - 2 IF (dBc) 30 dBc Min.	f_O + 2 IF (dBc) 30 dBc Min.	f_O - 3 IF (dBc) 20 dBc Min.	f_O + 3 IF (dBc) 20 dBc Min.
7	9	20	45	60	50	27	40
7.5	9.4	20	45	60	48	25	49
8	8.6	24	40	55	48	24	38
8.5	8.5	32	38	55	50	24	33
9	8.2	31	37	50	48	23	35
9.5	8.2	29	38	50	48	23	42
10	8.6	25	37	50	47	24	44
10.5	9.5	23	38	52	45	23	40
11	10	22	39	55	45	22	35

Note: Upper sideband is desired output (conversion loss relative to total I/Q power of 0 dBm).

MAXIMUM RATINGS

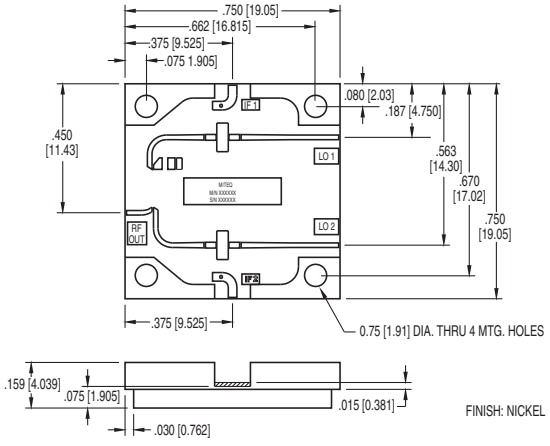
Specification temperature..... 25°C
Operating temperature ..... -50 to +85°C
Storage temperature ..... -65 to +125°C

NOTE: Test data supplied at 25°C; per spectrum table.

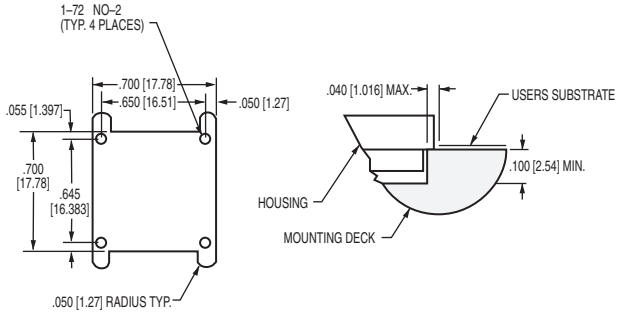
GENERAL NOTE

1. Insertion loss is relative to lowest power input (f_O or f_{IF}). All other outputs (including f_O) are relative to the desired upper (f_O + f_{IF}) output.

OUTLINE DRAWING



MOUNTING DIAGRAM



MACHINING DATA

NOTE: All dimensions shown in brackets [ ] are in millimeters.

10 TO 15 GHz SATELLITE I/Q TEST MODULATOR

MODEL: SDM1015LI3CDQ

FEATURES

- **Tri-band, Ku**
  Downlink ..... 10.75 to 12.75 GHz
  Uplink ..... 14 to 14.5 GHz
- **Direct linear I/Q modulation..... DC to 1000 MHz**
- **Carrier/sideband rejection ..... 25 dB**
- **Harmonic rejection ..... 30 dB**
- **Packaging ..... Hermetically sealed**

Microwave QAM signals are traditionally generated by linearly mixing or modulating a VHF or UHF carrier oscillator with band limited I and Q information. The resulting phase and/or amplitude states of the carrier are then multiplied or upconverted by another mixer, local oscillator and sideband filter to the actual transmitted frequency. I/Q modulation has traditionally been done in this manner because lower frequency high-isolation mixers tend to yield the best carrier and sideband rejection. The latter qualities are most important for accurate I/Q phase states or transmitted signal constellations. More recently at MITEQ, the electrical and physical symmetry of microwave baluns have been improved to yield mixers with LO-to-RF isolations of 45 dB up to 18 GHz. This unit uses these new mixers to achieve direct I/Q modulation of a microwave carrier without the costly lower frequency upconversion.

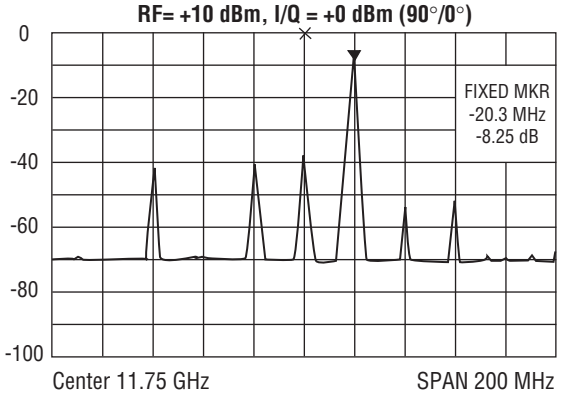
ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
Carrier frequency range		GHz	10		15
Carrier VSWR (RF = +16 dBm)		Ratio		1.5:1	
Carrier power		dBm	+8	+10	+12
Modulation frequency range	I/Q @ -3 dB	MHz	DC		1000
Modulation power	I/Q (50 ohms)	dBm	Noise	0	+6
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (IF = 100 MHz) (desired output relative to I/Q input)	RF = +10 dBm I/Q = 0 dBm	dB		8	9
Carrier rejection (relative to desired output)	IF = +6 dBm	dB	20	30	
Upper or lower sideband	$f_o \pm$ IF	dB	20	25	
Second-harmonic sideband	$f_o \pm 2$ IF	dB		30	
Third-harmonic sideband	$f_o \pm 3$ IF	dB		30	
Insertion loss (I/Q switch mode)	I/Q = +10 mA	dB		9	
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range		GHz	10		15
RF VSWR (RF = +16 dBm)		Ratio		2.5:1	

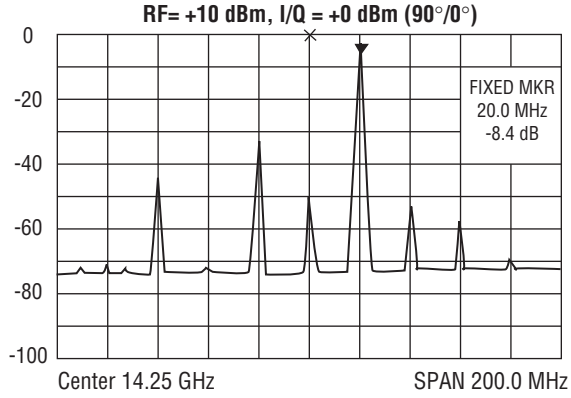
Revised: 03/19/12

SDM1015LI3CDQ TYPICAL SPECTRUM DATA

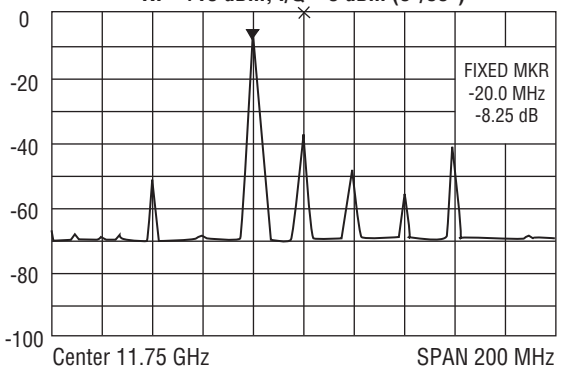
LOWER BAND EDGE SPECTRUM
AND UPPER SIDEBAND OUTPUT
RF= +10 dBm, I/Q = +0 dBm (90°/0°)



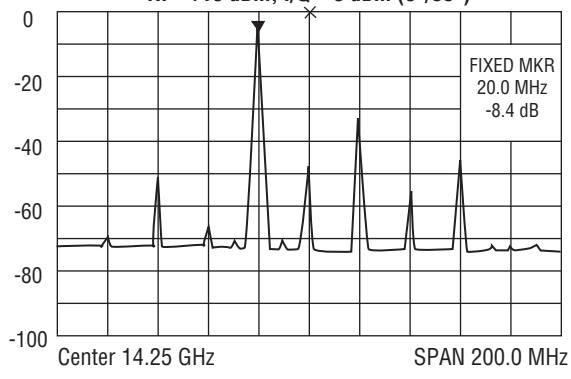
UPPER BAND EDGE SPECTRUM
AND UPPER SIDEBAND OUTPUT
RF= +10 dBm, I/Q = +0 dBm (90°/0°)



LOWER BAND EDGE SPECTRUM
AND LOWER SIDEBAND OUTPUT
RF= +10 dBm, I/Q = 0 dBm (0°/90°)



UPPER BAND EDGE SPECTRUM
AND LOWER SIDEBAND OUTPUT
RF= +10 dBm, I/Q = 0 dBm (0°/90°)



MAXIMUM RATINGS

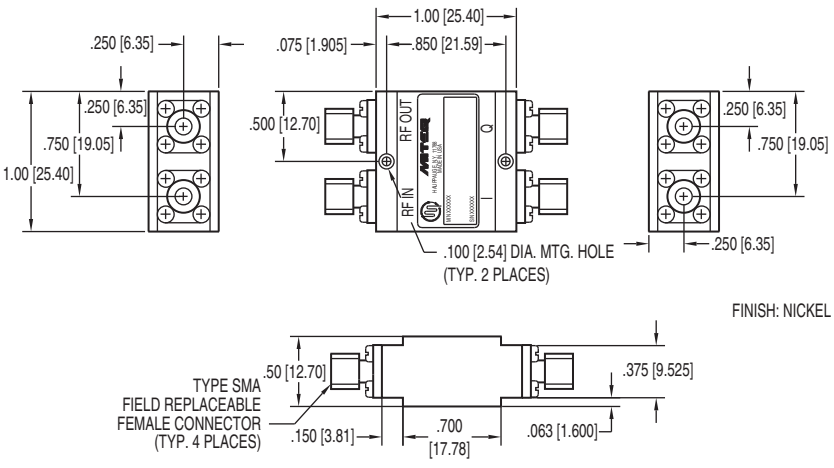
Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Input/output RF amplifiers optional.
2. Filtered digital inputs available.

NOTE: Test data supplied at 25°C; per spectrum data.

OUTLINE DRAWING



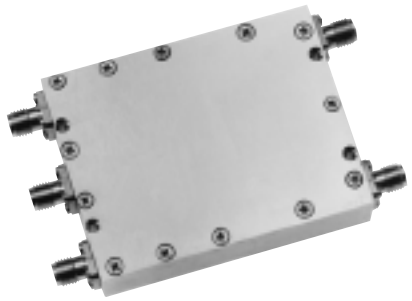
NOTE: All dimensions shown in brackets [ ] are in millimeters.

2 TO 18 GHz SINGLE-SIDEBAND UPCONVERTER OR I/Q MODULATOR

MODEL: SM0218LC1CD_* (Carrier Driven)

FEATURES

- **RF output/carrier input ..... 2 to 18 GHz**
- **Linear modulation input ..... Up to +5 dBm**
- **Carrier input power ..... +10 to +16 dBm**
- **Sideband suppression ..... 20 dB**
- **Carrier rejection ..... 25 dB**
- **IF options:**
  Single sideband ..... A, B and C (internal hybrid)
  I/Q modulator ..... Q (separate inputs)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or modulation) has sufficient power to turn on the semiconductors. This model employs carrier drive. All modulators yield a frequency spectrum that utilizes both sidebands on either side of the output suppressed carrier. SSB upconverters, however, employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) modulators have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. Greater output power can be achieved by using higher level diodes with proportional increases in carrier power. This carrier driven unit is used when the modulation input to RF output must be linear (low harmonics). A typical application is for digital QPSK with cosine shaped pulses (for minimum bandwidth). Many SSB upconverters also require input-to-output signal linearity, thus requiring LO drive.

ELECTRICAL SPECIFICATIONS

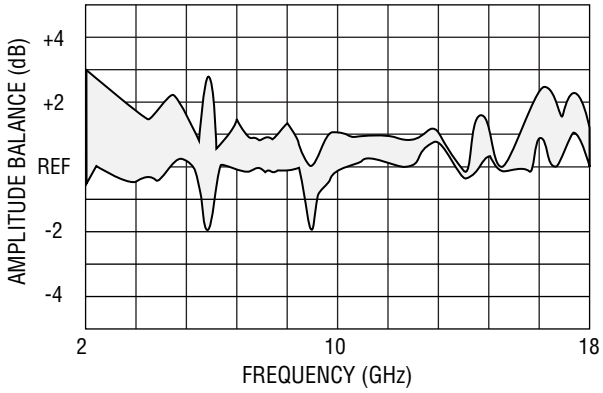
INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	2		18
RF VSWR (RF = +13 dBm, IF modulation = 0 dBm)	Ratio		2:1	
RF power (low-level diodes)	dBm	+10	+13	+16
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (total I/Q)	dBm	Noise		+7
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		8	12
Carrier suppression (RF = +13 dBm, IF modulation = +5 dBm)	dBc		12	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	15	18	
Carrier ±2 IF, 4 IF, etc.	dBc		45	
Carrier ±3 IF	dBc		40	
Quadrature phase accuracy, I/Q mode (see Graph Key)	Degrees		±10	
Quadrature amplitude accuracy	dB		±1	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	2		18
RF VSWR (RF = +13 dBm, IF modulation = 0 dBm)	Ratio		2.5:1	

SM0218LC1CDQ CARRIER DRIVEN TYPICAL TEST DATA

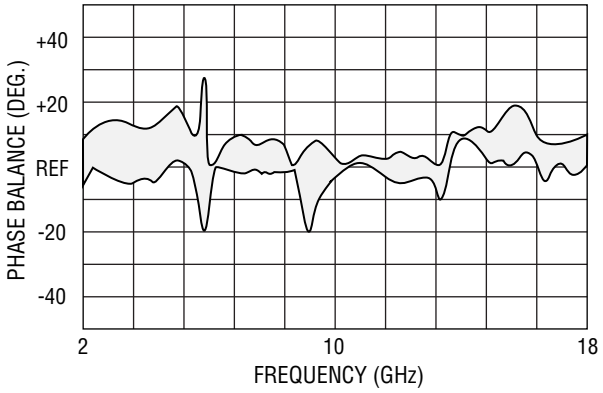
RF Phase (Deg.) I/Q	Graph Key 0 +/+	+90 -/+	-90 +/-	+180 -/-

I/Q MODE (RF = +13 dBm, I/Q = 0 dBm each input (0.316 volts peak across 50 ohm load)

STATIC AMPLITUDE BALANCE



STATIC PHASE BALANCE



SM0218LC1CDC CARRIER DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = +13 dBm, IF = +3 dBm total, IF = 100 MHz)

Frequency (GHz)	f_O + IF (I.L., dB) Note 1	f_O - IF (dBc)	f_O (dBc)	f_O - 2 IF (dBc)	f_O + 2 IF (dBc)	f_O - 3 IF (dBc)	f_O + 3 IF (dBc)
2	9	28	9	35	36	32	50
4	11	31	17	52	53	41	41
6	9	32	18	46	51	53	43
8	8	35	37	48	48	48	44
10	8	21	30	49	47	48	41
12	7	25	22	46	45	43	42
14	8	24	16	47	42	38	38
16	10	22	12	40	40	34	37
18	10	21	20	38	39	33	37

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Insertion loss relative to +3 dBm IF input. All other outputs, including f_O, are relative to the desired upper (f_O + f_M) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

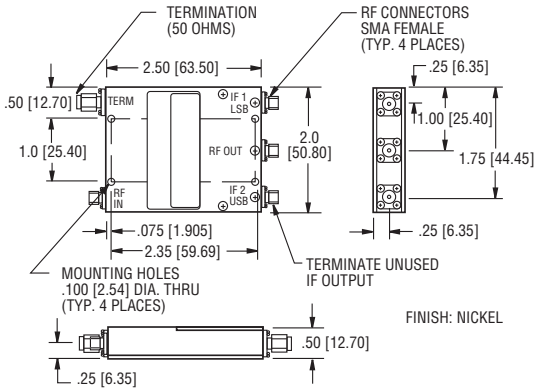
*3. Available part numbers: SM0218LC1CD ★

A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

NOTE: Test data supplied at 25°C; insertion loss, phase and amplitude balance per spectrum table.

OUTLINE DRAWING

SM0218LC1CDA, B and C

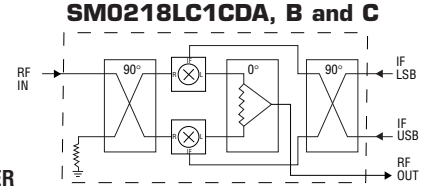


NOTE: All dimensions shown in brackets [ ] are in millimeters.

BLOCK DIAGRAMS

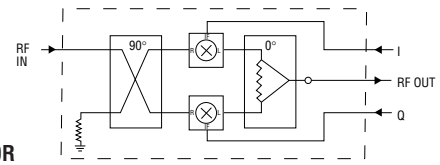
SM0218LC1CDA, B and C

SSB UPCONVERTER



SM0218LC1CDQ

I/Q MODULATOR

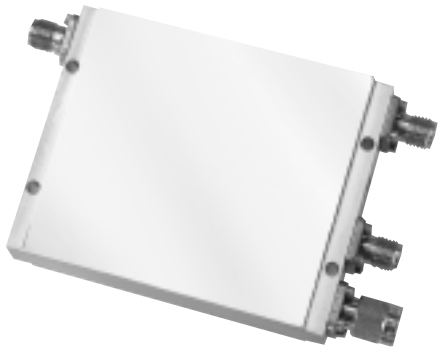


6 TO 18 GHz SINGLE-SIDEBAND ENHANCED UPCONVERTER

MODEL: SME0618LI1CD_* (Carrier Driven)

FEATURES

- **RF output/carrier input ..... 6 to 18 GHz**
- **IF bandwidth ..... DC to 500 MHz (Q)**
- **Linear IF input..... Up to +5 dBm**
- **Carrier input power ..... +10 to +16 dBm**
- **Sideband suppression..... 30 dB**
- **Carrier rejection..... 25 dB**
- **IF options:**
  Single sideband..... A, B and C (internal hybrid)
  Multioctave IFs ..... Q (separate inputs)



All SSB upconverters require that at least one of the input frequency bands (carrier or IF) has sufficient power to turn on the semiconductors. This model employs carrier drive. SSB upconverters, however, employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) upconverters have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. Greater output power can be achieved by using higher level diodes with proportional increases in carrier power. This carrier driven unit is used when the IF input to RF output must be linear (low harmonics). Enhanced sideband rejection (30 dB typ.) is obtained by using a multiple 90° cancellation circuit which is unique to MITEQ's design.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	6		18
RF VSWR (RF = +13 dBm, IF modulation = 0 dBm)	Ratio		1.5:1	
RF power (low-level diodes)	dBm	+10	+13	+16
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (total I/Q)	dBm	Noise		+5
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		9	13
Carrier suppression (RF = +13 dBm, IF modulation = +3 dBm)	dBc	15	25	
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	25	30	
Carrier ±2 IF, 4 IF, etc.	dBc		50	
Carrier ±3 IF	dBc		40	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	6		18
RF VSWR (RF = +13 dBm, IF modulation = 0 dBm)	Ratio		2.5:1	

SME0618LI1CDA CARRIER DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = +13 dBm, IF = 0 dBm total, IF= 60 MHz)

Frequency (GHz)	f_0 + IF (I.L., dB) Note 1	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
5	-10.8	-27.5	-15.4	-53	-44.8	-55.3	-46.2
5.5	-10.8	-29.6	-19.4	-52.4	-45.2	-52.4	-45.6
6	-11.3	-30.2	-19	-53.3	-44.5	-50.7	-46.6
6.5	-10.3	-34	-19.2	-58.1	-42.5	-51.7	-45.5
7	-9.4	-57.1	-20.9	-55.6	-43	-51.6	-45.7
7.5	-6.7	-36	-24.7	-56.5	-42.4	-57.6	-45.5
8	-8.1	-36	-26.1	-53.5	-43.6	-52.4	-46.5
8.5	-8	-34.7	-31.5	-51.6	-43.5	-49.8	-44.8
9	-7.6	-31.3	-32.9	-49.2	-43	-49.6	-42.3
9.5	-7.8	-36.4	-34.3	-49.9	-43.7	-48.6	-46.3
10	-8	-37	-31.8	-50	-44.4	-45.1	-45.1
10.5	-7.8	-36.8	-33.8	-48.7	-44.4	-42.5	-44.8
11	-7.7	-33.3	-30.3	-51.5	-44.5	-42.1	-45
11.5	-6.9	-29.5	-26.7	-50.7	-44.8	-39.7	-47.6
12	-6.3	-26.3	-25.8	-50.2	-44.8	-40	-45.8
12.5	-6.1	-26.5	-23.3	-52.7	-42.4	-42.8	-50.7
13	-7.3	-26.7	-21.3	-51.7	-42	-44.2	-48.2
13.5	-8	-27.8	-23.1	-49.7	-41.3	-45.2	-46.5
14	-8.6	-31.5	-25	-51.5	-41.1	-46	-45.4
14.5	-9.1	-30.9	-19.9	-49.2	-40.8	-46.3	-44.6
15	-9.7	-34.8	-17.4	-46.7	-40.7	-47.1	-46.2
15.5	-9.5	-31.8	-16.6	-44.7	-39.3	-43.1	-43
16	-9.3	-29.3	-16.5	-45.9	-38.5	-44.6	-44
16.5	-8.2	-30.9	-18	-46.3	-40	-45.8	-43.8
17	-8.8	-30.6	-18.4	-46.3	-40.5	-44.6	-43.3
17.5	-9.4	-30	-17.4	-44.2	-39.8	-42.3	-42.9
18	-9.2	-31.1	-17.8	-44.9	-39.2	-40.7	-43.2
18.5	-11.1	-32.2	-18.6	-43.7	-38.9	-34.3	-41.1
19	-11.7	-27.4	-19.6	-40.8	-37.6	-29.5	-40.8
19.5	-11	-30.6	-21.1	-39.6	-37.5	-32	-39.3
20	-11.9	-37.7	-24.9	-40.2	-40.9	-33.1	-40.1

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

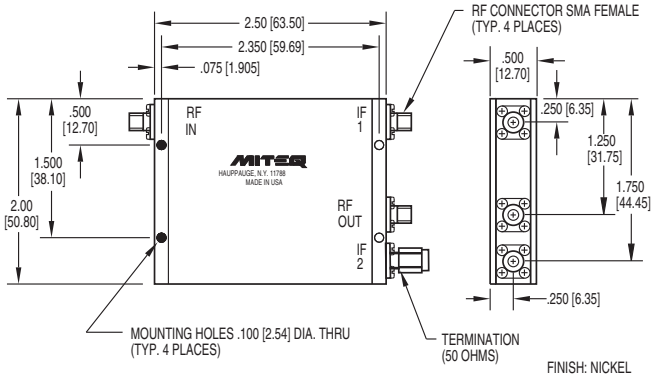
GENERAL NOTES

1. Insertion loss relative to 0 dBm IF input. All other outputs, including f_o, are relative to the desired upper (f_o + f_m) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

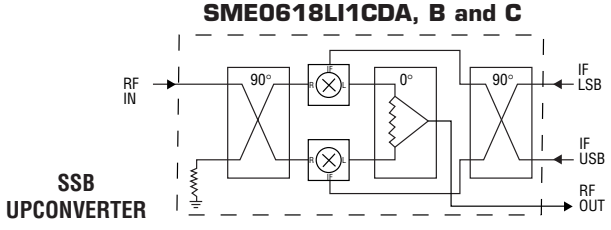
*3. Available part numbers: SME0618LI1CD_*
A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

NOTE: Test data supplied at 25°C; per spectrum table.

OUTLINE DRAWING



BLOCK DIAGRAM



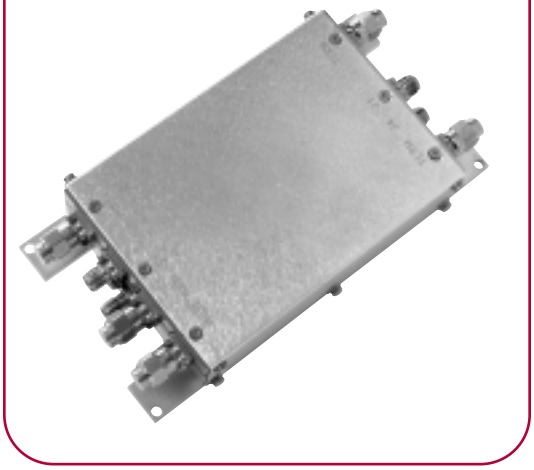
NOTE: All dimensions shown in brackets [ ] are in millimeters.

6 TO 18 GHz QPSK OR QAM MODULATOR

MODEL: SMC0618LI1CD__* (Carrier Driven)

FEATURES

- **RF output/carrier input ..... 6 to 18 GHz**
- **Linear modulation input ..... Up to +10 dBm**
- **Carrier input power ..... +15 to +18 dBm**
- **Sideband suppression..... 30 dB**
- **Carrier rejection..... 35 dB**
- **Modulation options:**
  Single sideband..... A (internal hybrid)
  I/Q modulator..... Q (separate inputs)



All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or modulation) has sufficient power to turn on the semiconductors. This model employs carrier drive. All modulators yield a frequency spectrum that utilizes both sidebands on either side of the output suppressed carrier. SSB upconverters, however, employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) modulators have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. Greater output power can be achieved by using higher level diodes with proportional increases in carrier power. This carrier driven unit is used when the modulation input to RF output must be linear (low harmonics). A typical application is for digital QPSK with cosine shaped pulses (for minimum bandwidth). Many SSB upconverters also require input-to-output signal linearity, thus requiring LO drive.

ELECTRICAL SPECIFICATIONS

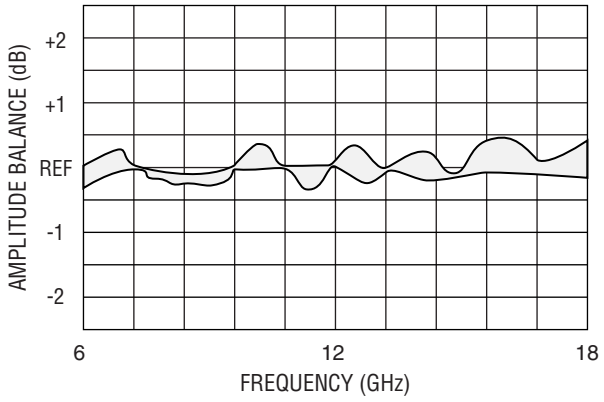
INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	6		18
RF VSWR (RF = +13 dBm, IF modulation = 0 dBm)	Ratio		1.5:1	
RF power (low-level diodes)	dBm	+15	+16	+18
IF modulation frequency range (Note 4)	MHz	DC		500
IF modulation power range (total I/Q)	dBm	Noise	+13	+16
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		16	19
Carrier suppression (Note 3)	dBc	25	35	
Sideband suppression (Note 2)				
Undesired sideband (Note 3)	dBc	23	32	
Carrier ±2 IF, 4 IF, etc.	dBc	35	40	
Carrier ±3 IF	dBc	30	40	
Quadrature phase deviation, I/Q mode (see Graph Key)	Degrees		±10	
Quadrature amplitude deviation	dB		±1.5	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	6		18
RF VSWR (RF = +13 dBm, IF modulation = 0 dBm)	Ratio		2.1:1	

SMC0618LI1CDQ CARRIER DRIVEN TYPICAL TEST DATA

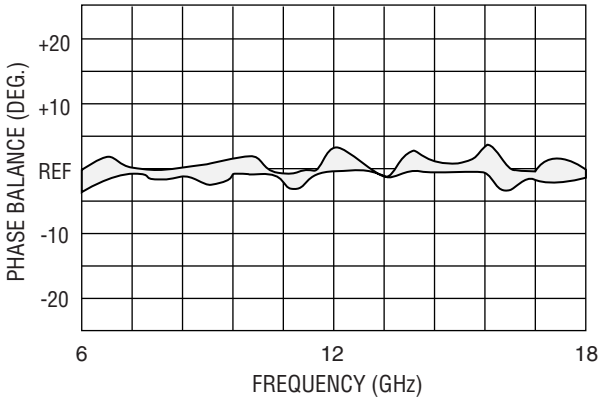
RF Phase (Deg.) I/Q	Graph Key 0 +/+	+90 -/+	-90 +/-	+180 -/-

I/Q MODE (RF = +16 dBm, I/Q = +10 dBm each input (1 volt peak across 50 ohm load)

QUADRATURE AMPLITUDE ERROR (MAX./MIN.)



QUADRATURE PHASE ERROR (MAX./MIN.)



SMC0618LI1CDA CARRIER DRIVEN SPECTRUM TABLE

SSB UPCONVERTER (RF = +16 dBm, IF = +13 dBm total, IF = 20 MHz)

Frequency (GHz)	f_O + IF (I.L., dB) Note 1	f_O - IF (dBc)	f_O (dBc)	f_O - 2 IF (dBc)	f_O + 2 IF (dBc)	f_O - 3 IF (dBc)	f_O + 3 IF (dBc)
6	15.4	39	66	55	56	41	76
8	16	38	43	67	65	46	70
10	16	53	39	64	62	61	65
12	15	28	41	65	63	52	66
14	16	32	35	64	66	66	66
16	16	29	31	63	62	62	61
18	15.8	31	36	62	63	51	63

MAXIMUM RATINGS

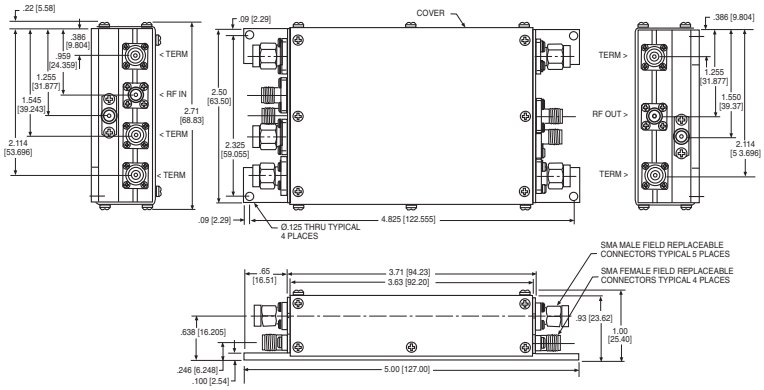
Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Insertion loss relative to +13 dBm combined I/Q inputs. All other outputs, including f_O, are relative to the desired upper ($f_O + f_M$) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.
3. Greater phase accuracy and rejection possible over narrower bandwidths.
*4. Available part numbers: SMC0618LI1CD *****
   A = 20–40 MHz
   B = 40–80 MHz
   C = 100–200 MHz
   Q = DC–500 MHz

NOTE: Test data supplied at 25°C; insertion loss, phase and amplitude balance per spectrum table.

OUTLINE DRAWING

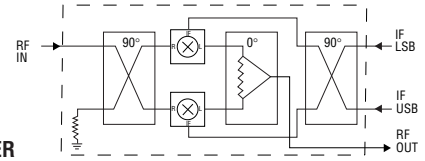


NOTE: All dimensions shown in brackets [ ] are in millimeters.

BLOCK DIAGRAMS

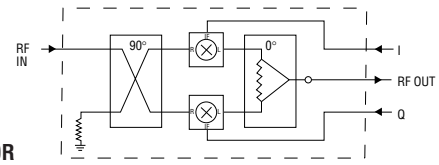
SMC0618LI1CDA, B and C

SSB UPCONVERTER



SMC0618LI1CDQ

I/Q MODULATOR



18 TO 26 GHz SINGLE-SIDEBAND UPCONVERTER (OR I/Q) MODULATOR

MODEL: SM1826NI7CD* (Carrier Driven)

FEATURES

- **RF output/carrier input ..... 18 to 26 GHz**
- **IF bandwidth ..... DC to 500 MHz (Q)**
- **Linear IF input..... Up to +5 dBm**
- **LO input power..... +17 to +20 dBm**
- **Sideband suppression..... 30 dB**
- **Carrier rejection..... 30 dB**
- **IF options:**
  Single sideband..... A (internal hybrid)
  I/Q modulator ..... Q (separate inputs)

SM1826NI7CDQ

All modulators and SSB upconverters require that at least one of the input frequency bands (carrier or modulation) has sufficient power to turn on the semiconductors. This model employs carrier drive. All modulators yield a frequency spectrum that utilizes both sideband on either side of the output supppressed carrier. SSB upconverters, however, employ an internal IF 90° hybrid to yield only one RF sideband output. This is offset above or below the input LO by the IF frequency (test data is recorded for the upper sideband only). Schottky diode (standard) modulators have the greatest speed and bandwidths, but yield RF output powers of typically less than 0 dBm. Greater output power can be achieved by using higher level diodes with proportional increases in carrier power. This carrier driven unit is used when the modulation input to RF output must be linear (low harmonics). A typical application is for digital QPSK with cosine shaped pulses (for minimum bandwidth). Many SSB upconverters also require input-to-output signal linearity, thus requiring LO drive.

ELECTRICAL SPECIFICATIONS

INPUT PARAMETERS	UNITS	MIN.	TYP.	MAX.
RF carrier	GHz	18		26
RF VSWR (RF = +17 dBm, IF modulation = 0 dBm)	Ratio		2:1	
RF power (high-level diodes)	dBm	+17	+18	+20
IF modulation frequency range (Note 3)	MHz	DC		500
IF modulation power range (total I/Q)	dBm	Noise		+5
TRANSFER CHARACTERISTICS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
Conversion loss (Note 1)	dB		9	12
LO Leakage	dBm		-5	0
Sideband suppression (Note 2)				
Carrier – fundamental IF	dBc	20	30	
Carrier ±2 IF, 4 IF, etc.	dBc		40	
Carrier ±3 IF	dBc		40	
Quadrature phase accuracy, I/Q mode (see Graph Key)	Degrees		±6	
Quadrature amplitude accuracy	dB		±0.6	
OUTPUT PARAMETERS	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range	GHz	18		26
RF VSWR (RF = +17 dBm, IF modulation = +5 dBm)	Ratio		3:1	

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Revised: 03/03/14

SM1826NI7CDB CARRIER DRIVEN OUTPUT SPECTRUM TABLE

SSB UPCONVERTER (RF = +17 dBm, IF = 0 dBm total, IF = 60 MHz)

Frequency (GHz)	f_0 (dB) Note 1	f_0 + 1 IF (dBc)	f_0 - 1 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 2 IF (dBc)	f_0 + 3 IF (dBc)	f_0 - 3 IF (dBc)
17	-25.8	-22.3	-8.7	-35	-40	-37.8	-47.2
17.5	-27.3	-24.2	-10.2	-37.5	-40.2	-40.7	-45.5
18	-26.7	-26.2	-8.7	-45.2	-44.2	-43.5	-48
18.5	-27.7	-26.8	-9.8	-44.3	-44.7	-45.5	-47.5
19	-27.7	-29.3	-9.5	-46.3	-43	-47.8	-48
19.5	-30.3	-32	-10.8	-39.8	-41.7	-42.2	-46.5
20	-30.3	-36.7	-9.5	-45	-43.2	-46	-46.3
20.5	-31.3	-43.5	-9.8	-46.8	-46	-46.5	-46.2
21	-31.5	-41.8	-10.2	-45.8	-45.5	-46.2	-46.5
21.5	-33.8	-38.8	-10.2	-46.3	-46.2	-44.7	-46.8
22	-33.7	-35	-9.8	-46	-44.7	-46.3	-44.7
22.5	-32.5	-35.5	-10.3	-45.3	-44.3	-45.3	-45.7
23	-35.5	-30.5	-11	-43.8	-45	-43.8	-44.3
23.5	-37.5	-30.5	-10.8	-43	-42.7	-42.7	-44.5
24	-44.7	-28.3	-10.5	-41.3	-41.8	-43.2	-42.3
24.5	-37.2	-25.7	-11.3	-38	-41	-40.2	-43
25	-38.2	-25.2	-10.2	-40.5	-39.5	-41.5	-42.2
25.5	-34.7	-28.5	-10.3	-41.2	-42.5	-41.2	-43.5
26	-33.7	-26.8	-8.3	-43.2	-43.3	-46	-43
26.5	-36	-31	-9.8	-45.3	-44	-44.7	-44.8
27	-32.5	-25.2	-9.2	-48.5	-48.5	-46.7	-49

MAXIMUM RATINGS

Specification temperature..... +25°C
Operating temperature ..... -54 to +85°C
Storage temperature ..... -65 to +125°C

GENERAL NOTES

1. Insertion loss relative to +3 dBm RF input. All other outputs, including f_0, are relative to the desired upper (f_0 + f_m) output.
2. Standard SSB units with IF hybrids are aligned for upper sideband operation. For lower sideband or selectable sideband, contact MITEQ.

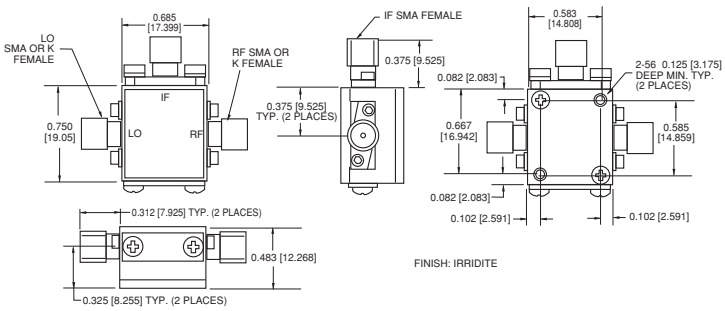
3. Available part numbers: SM1826LI7CD__
A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz
Q = DC–500 MHz

4. LO amplifier option:
Order Part Number SMA1826NI7CD* (contact MITEQ for outline).

NOTE: Test data supplied at 25°C; per spectrum table.

OUTLINE DRAWING

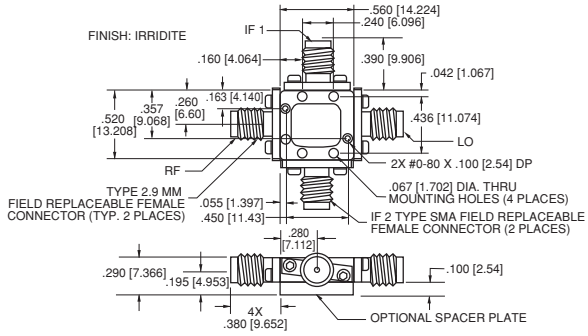
SM1826NI7CDA, B and C



SSB UPCONVERTER

BLOCK DIAGRAM

SM1826NI7CDQ



I/Q MODULATOR

NOTE: All dimensions shown in brackets [ ] are in millimeters.

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34.5 TO 35.5 GHz SINGLE-SIDEBAND CONVERTER

MODEL: SM3435LI7CD_* (Carrier Driven)

FEATURES

- **RF/LO Coverage..... 34.5 to 35.5 GHz**
- **IF operation ..... 20 to 200 MHz**
- **LO power ..... +2 to +10 dBm**

ELECTRICAL SPECIFICATIONS

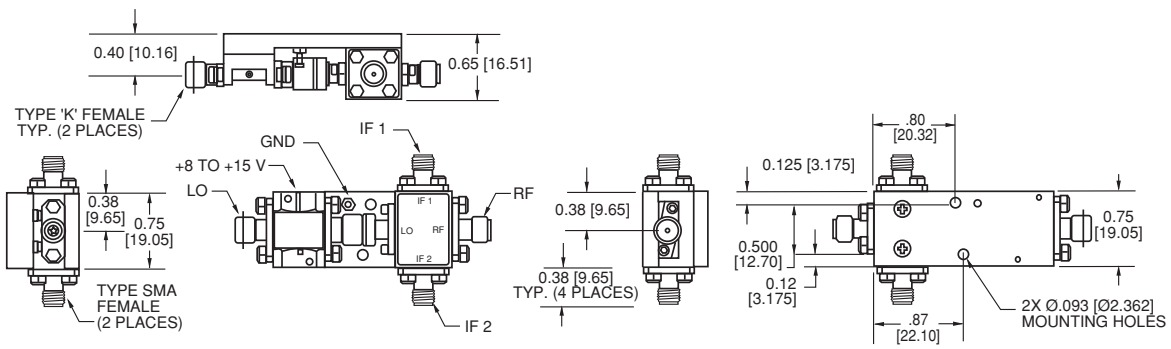
INPUT PARAMETERS	CONDITION	UNITS	MIN.	TYP.	MAX.
LO frequency range		GHz	34.5		35.5
LO VSWR	50 ohm reference	Ratio		2:1	
LO power		dBm	+2		+10
IF frequency range (Note 1)		MHz	20		200
IF VSWR	50 ohm reference	Ratio		1.5:1	
IF power range		dBm	Ø±2		
Bias (+8 volts min./+15 volts max.)		mA			200
TRANSFER CHARACTERISTICS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
IF-to-RF conversion loss		dB			10.5
Sideband suppression		dB	20	25	
LO Leakage		dBm			-15
Intermodulation suppression	F – LO, ±2F – IF F – LO, ±3F – IF	dB dB		25 25	
OUTPUT PARAMETERS	**CONDITION**	**UNITS**	**MIN.**	**TYP.**	**MAX.**
RF frequency range		GHz	34.5		35.5
RF VSWR	50 ohm reference	Ratio		2:1	

MAXIMUM RATINGS
Specification temperature ..... +25°C
Operating temperature ..... -10 to +50°C
Storage temperature ..... -65 to +95°C

GENERAL NOTE
*1. Available part numbers: SM3435LI7CD_*
A = 20–40 MHz
B = 40–80 MHz
C = 100–200 MHz

NOTE: Test data supplied at 25°C; conversion loss, sideband supression and LO leakage.

OUTLINE DRAWING



NOTE: All dimensions shown in brackets [ ] are in millimeters.

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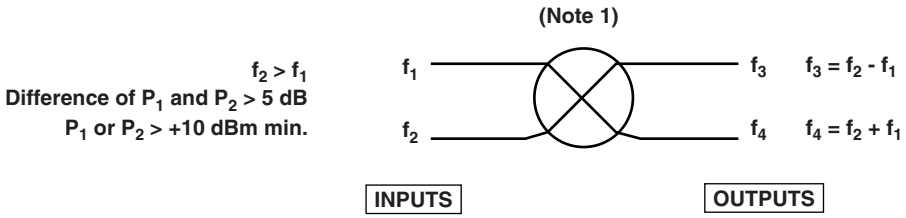
Revised: 09/10/13

MIXER TERMINOLOGY

The subject of mixers is often confused by the variety of different technical terms that often describe the same piece of hardware. For example, the common double-balanced mixer is useful as a downconverter, demodulator, upconverter or modulator. Other adjectives are also used to further subdivide each category such as linear, saturated, double sideband, etc. Ultimately, it is the relationship between the two input and desired output frequency bands and powers that uniquely specify each device classification. During our discussion, we will refer to the two input signal bands of any mixer as f_1 and f_2 (in increasing frequency) with respective powers P_1 and P_2. In this manner, any confusion defining the IF, RF, LO for up- and downconversion is avoided. The two output bands are $f_3 = (f_1 - f_2)$ or difference frequency and $f_4 = (f_1 + f_2)$ or sum frequency. In general, downconverters and demodulators are separated in classification from upconverters and modulators by the obvious fact that the output frequency (f_3, f_4) of the latter group is always greater than f_1, whereas f_3 is less than f_2 and f_1 for downconverters/demodulators. These two groups are further subdivided into either single- or double-sideband responses. An example of a single-sideband downconverter would be the image rejection mixer. A single-sideband upconverter rejects either output upper or lower sideband (i.e., $f_2 + 1$ or $f_2 - f_1$). The figure and table below show how all of our mixer products are defined in this catalog.



MIXER MODEL SELECTION GUIDELINE

1. Double-Sideband Mixers	❑	No image or sideband rejection
Upconverter	❑	$f_2/f_1 > 2$ using f_3, or f_4 = output
Downconverter	❑	f_3 min. > 0 and $f_2/f_1 < 2$
Demodulator	❑	f_3 min. = DC (i.e., $f_2 = f_1$)
2. Single-Sideband Downconverters	❑	Image rejection required
Image Rejection	❑	f_3 min. > 0 and $f_2/f_1 < 2$
I/Q Demodulator	❑	f_3 min. = DC (i.e., $f_2 = f_1$)
3. Single-Sideband Upconverters	❑	$f_2/f_1 > 2$
I/Q Modulator	❑	f_3 and f_4 required and $f_1 = 0$
Modulation Driven	❑	$P_2 < P_1$
Carrier Driven	❑	$P_2 > P_1$
SSB Upconverter	❑	f_2 or f_4 required and f_1 min. is not = 0
4. Low-Noise / Millimeter Subsystems	❑	f_1 or f_2 or f_2 or f_4 > 30 GHz
Low Noise	❑	SSB noise figure < 5 dB

Note 1. When f_2 or f_1 is each a range or a frequency, use their midband values in the table formulas above.

MODULATOR CIRCUIT DESCRIPTION IN ORDER OF COMPLEXITY

BASIC MIXER CIRCUITS

There are several basic mixer circuits discussed within this catalog. While there appear to be many similarities, there are subtle circuit differences that can greatly improve performance or reduce cost for a given receiving system application.

We will first clarify the definitions of the basic circuits in order of their complexity (cost), with lowest first.

SINGLE-BALANCED MIXER CIRCUITS

use only 2 semiconductors and, therefore, requires the least LO power. They are frequently made on a common substrate with the necessary 90 or 180° hybrid offering lowest input VSWR or highest isolation respectively.

DOUBLE-BALANCED MIXER CIRCUITS

offer high LO-to-RF isolation over multioctave bandwidths. The back-to-back semiconductor ring quad provides immunity to high peak input voltage burn-outs. Even harmonic output intermodulation products of both LO and RF inputs are suppressed.

TRIPLE-BALANCED MIXER CIRCUITS

provide high RF input-to-output isolation over overlapping bandwidths. The 6 dB greater LO input compared to the single-balanced mixer yields proportional increases in compression and intercept points. Most triple-balanced mixers do not have an IF response down to DC and, therefore, are not suitable for modulator or demodulator applications.

SUBHARMONIC MIXERS

offer only 1 dB higher conversion loss than single or triple designs, but require 1/2 the LO frequency (cheaper). They also provide 50 to 60 dB rejection of input LO power appearing at the input/output of the desired RF frequency. This makes this circuit useful for accurate BPSK or QPSK modulators.

MESFET MIXERS

made in single- and double-balanced circuits offer the highest ratio of IP^3 to LO power, thus making them suitable for up- or downconversion in crowded communication bands.

QUADRATURE COUPLED MIXERS (TIM)

single- or triple-balanced mixer circuits offer similar advantages as 90° coupled amplifier circuits (i.e.; excellent input/output VSWR with enhanced LO-to-RF isolation and further rejection of even harmonic spurious products).

QPSK MODULATORS

accept two independent channels of digital or video information and vary the RF carrier phase in proportion to these signals. When spectral spreading is not important, (no raised cosine input filter) the diodes are driven by the I/Q signals.

QAM MODULATORS

are similar to I/Q modulators except that amplitude variations of the modulation are also superimposed on the carrier as an envelope. Linear modulation is achieved by driving the diodes with the carrier and using high-isolation mixers.

RAISED COSINE FILTERS

are used to limit the spectrum of digital modulation and eliminate the fundamental and harmonic responses of the sampling frequency. For most applications active ICs are employed; but when high sampling rates are used, tapped delay networks are useful.

QUADRATURE QPSK CIRCUITS

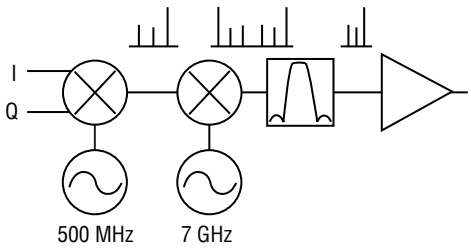
produce highest carrier suppression and, therefore, accurate phase states. The SMC0618LI1Q typically has 50 dB carrier to output isolation and permits modulation rates in excess of 1 Gbps.

MODULATORS AND UPCONVERTERS

In our earlier discussion on downconverters and demodulators, we referred to the two input signal bands of any mixer as f_1 and f_2 (in increasing frequency) with respective powers P_1 and P_2. The two output bands are $f_3 = (f_1 - f_2)$ or difference frequency and $f_4 = (f_1 + f_2)$ or sum frequency. In general, downconverters and demodulators are separated in classification from upconverters and modulators by the obvious fact that the output frequency (f_3, f_4) of the latter group is always greater than f_1 whereas f_3 is less than f_2 and f_1 for downconverters/demodulators. Furthermore, upconverters and modulators are distinguishable from each other by the range of frequency at the lower or f_1 terminal. For the modulator, f_1 always contains baseband or low-pass video or digital frequencies whereas for the upconverter f_1 is usually a bandpass spectrum of already modulated IF information. A further difference is that both upper and lower output sidebands are needed to preserve modulation. For upconversion, however, only one output sideband is selected. An example of these two modes of operation is shown next by the current design trend of direct microwave modulation using newer high-isolation mixers.

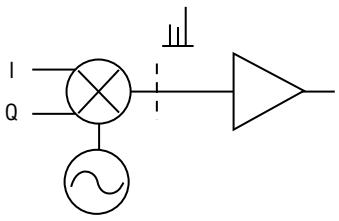
Microwave biphase and QAM signals are traditionally generated by linearly mixing or modulating a VHF or UHF carrier oscillator with band limited I and Q information. The resulting phase and/or amplitude states of the carrier are then multiplied or upconverted by another mixer, local oscillator and sideband filter to the actual transmitted frequency. I/Q modulation has traditionally been done in this manner because lower frequency high-isolation mixers tend to yield the best carrier and sideband rejection. The latter qualities are most important for accurate I/Q phase states or transmitted signal constellations. As a result of now having microwave mixers with the same balun quality as lower frequency torroidal units, one can directly modulate at high frequencies without the costly extra frequency conversions. Furthermore, greater modulation rates are also possible.

CONVENTIONAL MODULATOR UPCONVERTER



I/Q BW= 50 MHz

LOWER COST DIRECT MODULATOR



I/Q BW= 500 MHz

Modulators are further subclassified by the use of fundamental or subharmonic carrier operation ($2f_2 + f_1$), ($3f_2 + f_1$). In general, a lower cost design results because the carrier is frequently generated by subharmonic sources anyway, thus eliminating system multipliers and amplifiers. In addition, the core advantage of even-harmonic mixers, is ultra-high carrier isolation.

Most important, all modulators require that at least one of the input frequency bands, modulation (f_1) or carrier (f_2), has sufficient power to always turn on the semiconductors used in the various designs (i.e., Schottky diodes or PIN diodes). Schottky diode (standard) modulators have greatest speed and bandwidths, but yield RF output powers of typically less than +5 dBm. PIN diode designs can only be driven at modulation rates at less than 30 MHz, but will yield output RF powers exceeding +5 dBm. All modulators should be tested in either the carrier or modulation driven mode, as specified by the customers needs. In general, most manufacturers show modulator phase/amplitude accuracy in either the carrier or modulation driven modes. However, caution is necessary when observing the better accuracy data of the modulation driven mode that a trade-off in output spectrum harmonic levels results.

In the next section, we will attempt to define the proper modulator circuit for a given application in a step-by-step sequence. More information needed to answer the questions, is available following the data sheet section.

Questions and Answers about...

MODULATORS

Q1. What are the major differences between modulators and upconverters?

A1. A modulator commonly varies some aspect (amplitude, phase or frequency) of an RF carrier (f_o, in proportion to a much lower frequency video or digital input signal (f_m). In general, the input frequency components of the modulation typically extend from DC to 100 MHz, except for fast data links. In order to preserve the information content superimposed on the RF carrier, one must insure that the output system bandwidth is adequate to pass both upper and lower sidebands (i.e., $f_o \pm f_m$) without distortion. In fact, system amplifier and channel distortion often will add residual AM or PM modulation to an otherwise clean transmitter.

Upconverter and modulator circuits are very similar except that in the upconverter case one is usually only interested in transmitting one of the output sidebands (upper or lower) and suppressing the other. In this manner all input information at the f_m port is preserved but shifted in frequency to only one RF transmitted sideband. SSB converters usually employ an input 90° hybrid to accept octave bandwidth signals in the 30 to 500 MHz range. DSB upconverting mixers often use a double-balanced mixer circuit with a high-frequency IF input that produces a large separation between upper and lower output sidebands that are filtered further in the system.

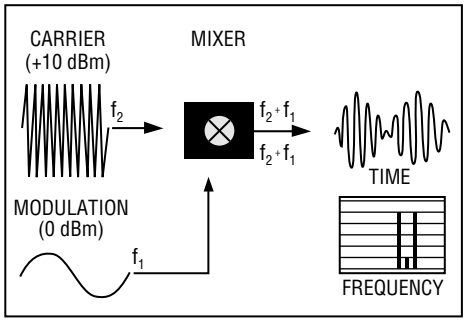
A vector modulator is commonly used to vary only RF carrier phase in a linear fashion with time so that no RF amplitude variations occur. A shift in the RF carrier frequency will occur in direct proportion to the time rate of change of RF output phase ($\Delta\emptyset / \Delta t$). This device is sometimes known as a phase shifter or frequency offset generator (FOG). Both output sidebands can be utilized to simulate forward or reverse movement of a variable amplitude RF source (i.e.; Doppler generation or corrections). More recently, digital-controlled vector phase-shifting circuits are being used with linear amplitude compensation to adaptively cancel an unwanted RF echo signal. This circuit provides the unusual property of nearly linear operation at the modulation and RF input ports, although the rate of modulation is restricted.

Q2: Should the diodes be switched or driven by the carrier (CD) or by the modulation (MD)?

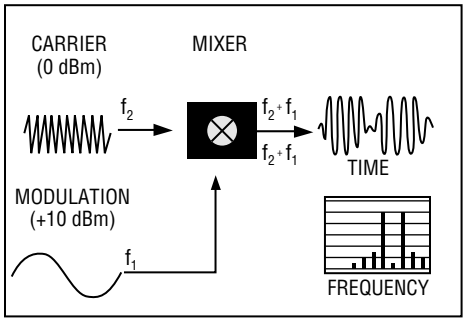
A2: A carrier or LO diode switching power of +10 dBm to +13 dBm is used when any amplitude variation or pulse shape at the IF or modulation port must be accurately transferred to the RF output envelope. A communication example would be directly modulating a microwave carrier with Gaussian shaped I/Q digital pulses to minimize the channel bandwidth required. A linear IF SSB upconverter would also use this mode with an internal hybrid. In this mode, the modulation or IF upconverter port is linear and therefore, will operate from the 1 dB compression point (approximately 5 dB below P_m) down to the noise level. The IF modulation power (typically 0 dBm) is usually selected to minimize output spectrum harmonics ($f_o \pm Nf_m$) but still be greater than the fixed carrier power leakage that exists at the output of any mixer.

A modulation or IF drive of +10 dBm or ±10 mA is used when the RF input power varies over a wide dynamic range such as for military EW and commercial Doppler frequency-shift generation or corrections. The linear RF input range while desirable for these applications would of course, not turn on the modulator diodes at low input powers. Consequently, the modulation must always be high power. In many cases the high and nonlinear modulation power is adequate for biphase and QPSK with only 2 or 4 output spectrum states using saturated output amplification. However, many phase and frequency modulators require continuous and linear control of the RF output phase and amplitude in small steps. The modulation input can be linearized for these applications by converting the input control voltage to the required mixer Schottky or PIN diode current with the aid of analog RDS (resistance, diode sources) or digital ROM (read only memory) waveshaping techniques. The MITEQ-AVC and -DIQ Model Series modulators employ these circuits. The penalty for this linearization is lower modulation rates particularly when PIN diodes are used.

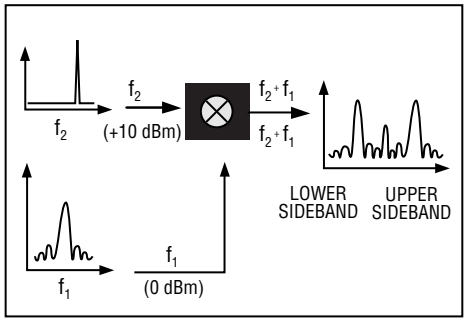
CARRIER DRIVEN BIPHASE MODULATOR (LINEAR BASEBAND INPUT)



MODULATION DRIVEN BIPHASE MODULATOR (LINEAR CARRIER INPUT)



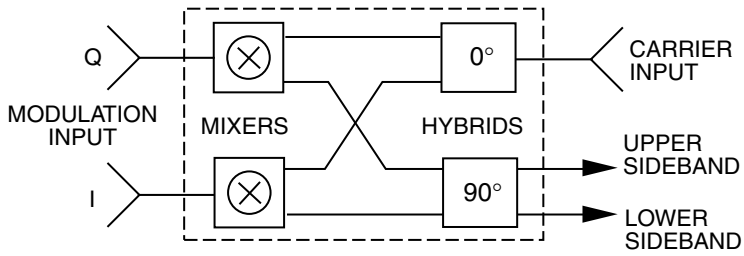
DOUBLE-SIDEBAND (DSB) UPCONVERTER (LO DRIVEN WITH LINEAR IF INPUT)



Q3: How does a single-sideband modulator or upconverter work?

A3. In general, when the phase of the input IF signal of a double-sideband modulator or upconverter is shifted by +90°, the output upper RF sideband phase will also shift by +90°, but the lower RF sideband will have a conjugate or -90° shift. Therefore, if two such identical mixers are driven by an in phase LO and a 90° IF input coupler, one will observe leading and lagging 90° output sideband RF phases. An additional 90° output RF coupler can then be used to separate the lower and upper sidebands at different output ports of the same coupler (see figure below).

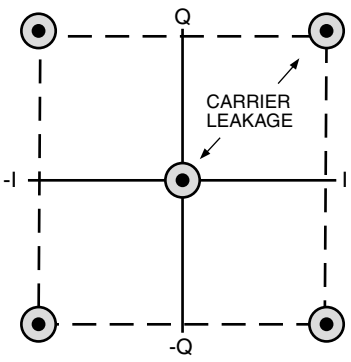
MITEQ SM SERIES



Q4. What is meant by the term signal constellation and why are I/Q modulators used?

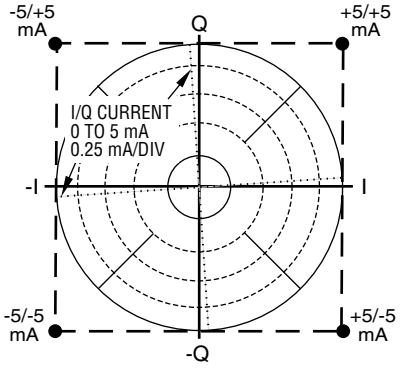
A4. Basically one can transmit more information in a given fixed RF bandwidth by first dividing the modulation into two path streams, each with 1/2 the BIT rate of the original stream. If these two data streams (I and Q) are then orthogonally modulated on the RF carrier, they remain uncoupled until added back together after demodulation at the receiver. By simultaneously using quadrature phase and several amplitude stages (QAM), greater data-rate reductions are possible, but at the cost of increased intersymbol interference or poorer signal-to-noise ratio. The output amplitude and phase states of a modulator are most easily described in polar form with two orthogonal planes or I/Q axis, as shown on page 361. Diagram (A) shows the ideal phase states of quadrature modulation, which should have no amplitude variations and a perfect quadrature relation between the two I/Q data streams. However, the small and random vectors from carrier leakage, together with 3 IF diode currents resulting from high- level I/Q switching currents, quickly degrade output orthogonality. When good baseband amplitude linearity and I/Q orthogonality is required, the mixers employed must have very high LO-to-RF isolation and must use low IF switching power to prevent LO ±3 IF currents. High LO-to-RF isolation ensures that small I/Q amplitude steps, see Diagram (B) x/y axis current steps, will not be phase or amplitude shifted by carrier leakage, particularly at the center of the chart. Linear modulators are required for the digital communications format of 8 QAM, reference Diagram (C) plot on right. In this mode of operation the AM and PM noise becomes more important to minimize intersymbol interference, since the modulation states are closer to each other. The signal constellation is also a useful way of observing interference or channel coupling in the time domain, because the noise dots become small circles which should not touch each other. Alternatively, an “eye-diagram” is another useful way of observing I/Q output errors on a fast oscilloscope.

DIAGRAM A



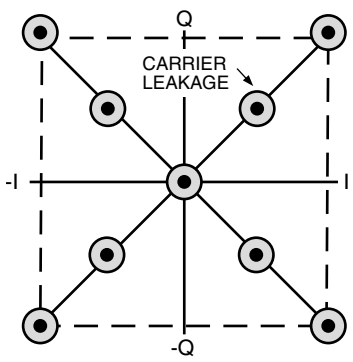
TTL NONLINEAR I/Q DRIVE (HIGH-LEVEL RF SHOWING CARRIER LEAKAGE ERRORS)

DIAGRAM B



LINEAR I/Q QUADRATURE DRIVE (LOW-LEVEL IF POWER/ CURRENT, HIGH-LEVEL RF CARRIER +10 dBm)

DIAGRAM C



LINEAR I/Q QUADRATURE AM (LOW-LEVEL IF, HIGH-LEVEL RF SHOWING INTERSYMBOL NOISE)

Q5. What mixer and quadrature coupler characteristics are necessary for linear I/Q modulation with accurate phase and amplitude states?

A5. One of the most important mixer characteristics for linear IF (AM) or saturated IF (PM) modulator applications is high LO-to-RF isolation, because this limits the output carrier rejection. Residual carrier leakage will produce unwanted amplitude or phase deviations from the ideal signal constellation states of either biphase or quadraphase modulators. Thus, for biphase or double-sideband modulators, one tries to achieve at least 20 dB carrier rejection for biphase accuracy of ±11°. For accuracies of ±2° and ±0.25 dB, one requires all common spectral lines to be rejected by at least 30 dB. Recently, MITEQ developed a new balun design (DM and SM Series) that consistently achieves greater than 40 dB LO-to-RF isolation over octave bandwidths (patent pending).

During SSB or QPSK modulation, the quadrature and in phase couplers (and mixers of course) all must have closely controlled phase and amplitude tracking since ±0.5 dB, and/or ±10° is required for 25 dB sideband rejection. However, the interaction of coupler isolation, mixer reflections and the modulator's source and load VSWR can also cause sideband rejection ripples to occur. Certain types of single-sideband modulator's employing multiple 90° couplers, including the recent MITEQ SME enhanced sideband rejection circuits, are more load and source termination insensitive than the conventional 90°/0° hybrid configurations.

Q6. What relative input RF and IF power levels are necessary for linear modulation?

A6. When Schottky diode mixers are used as modulators, one must first decide whether to use the RF or IF (baseband) as the higher power level that will switch the diodes on and off, thus producing multiplication or modulation action. Typically, the lower frequency signal is selected, since this will allow a lower power RF carrier, which is further rejected by the mixer LO-to-RF isolation. Unfortunately, the diode nonlinear voltage current relation will produce high (-10 dBc) odd-order harmonics of the baseband signal in the output RF spectrum, particularly if an odd-harmonic or double-balanced mixer is employed. These harmonics are hard to filter, since they are in close proximity to the desired output frequency, particularly when low modulation frequencies are used. Alternately, one could use the RF input carrier as the higher level diode switching signal and apply the IF at -5 to -10 dB lower power to produce a linear or harmonic-free output spectrum. Harmonics of the high-level RF carrier are usually ignored since they are easily filtered at twice the RF. The major difficulty with this mode of operation is that microwave mixers typically only have -25 dB RF to LO or carrier isolation and, therefore, will produce output carrier rejection or suppression that is the difference in converted IF power and LO leakage. For an input LO and IF power difference of 10 dB and conversion loss of 6 dB, the resulting carrier rejection is only (25-10-6=-9 dBc.) Since

this leakage is common to both I and Q spectrums, it represents a severe degradation in channel-to-channel isolation or dynamic I/Q phase/amplitude accuracy. The advantages of a higher LO-to-RF isolation mixer (45 dB typical), such as the MITEQ DM or SM Series, is obvious in this mode.

Q7: What determines the output power limits of an upconverter or modulator?

A7: Ordinary Schottky diode ring mixers have an input 1 dB compression power of about 5 dB below the LO power. Assuming a 7 dB modulator or converter conversion loss for the lower input level signal, we conclude that the maximum output power is about (7+5) 12 dB less than the LO power. Assuming the mixer employs 2 high-level GaAs quads requiring +23 dBm, the expected output power is +11 dBm. For many applications, a low-gain power amplifier is used at the modulator or upconverter output and has the additional advantage of isolating load mismatch from the mixer.

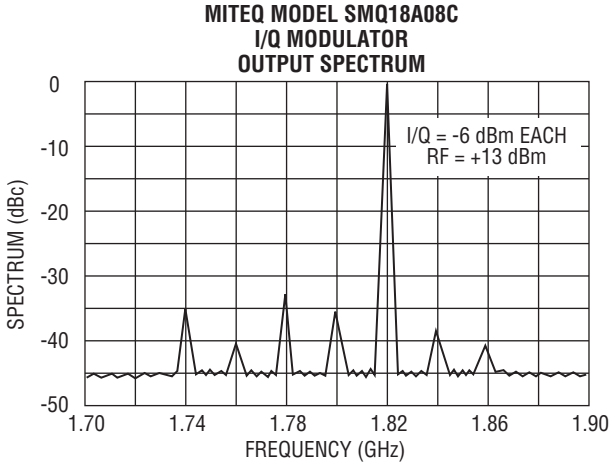
Alternately, a more LO efficient balanced MESFET modulator with +23 dBm switching power would yield an output power of +15 dBm. PIN diodes are also used in modulators as the switching semiconductor. In this case, the silicon charge carrier's lifetime is long and, therefore, will be unaffected by high RF input powers (except for heat dissipation). The main limitation of this device is that the carrier's lifetime also affects the maximum IF drive signal frequency (typically 30 MHz or less). Output powers of +20 dBm have been obtained from TTL or ECL driven QPSK PIN modulators.

Q8: Are there techniques to further enhance carrier rejection?

A8: Yes, one of the most common is to use an even-harmonic mixer. This circuit will typically achieve 30 to 40 dB output to carrier rejection, but is limited to upconverter usage where the LO is the higher power level and is set at 1/2 the normal frequency. The main disadvantage of this technique, besides needing 1/2 LO frequency, is that the phase noise of the LO is also doubled. This technique, when combined with an SSB circuit, is popular for communication link transmitters.

Q9: How much RF bandwidth and sideband rejection at MITEQ is available from current single-sideband modulators and upconverters being marketed today?

A9: Rejection is limited by the RF quadrature coupler phase and amplitude balance and how well the two required mixers track. For combined phase/amplitude errors of ±5°/±0.5 dB the expected rejection is 24 dB. This is achievable over a 20 percent bandwidth, whereas an octave 3 to 1 bandwidth unit will seldom exceed 20 dB (2 to 18 and 2 to 26 GHz units are available with 18 and 15 dB typical rejection). The table below shows the output spectrum of a MITEQ linear modulator with an optimized 90° coupler.



Q&A MODULATORS (CONT.)

In addition, special enhanced rejection SSB upconverters manufactured at MITEQ yield 35 dB typical upper or lower sideband suppression over 3 to 1 RF bandwidths. The table below shows data achieved with external I and Q inputs at 60 MHz from MITEQ Model SME0208LI1Q:

			f_o = 0 dBm		I/Q = 60 MHz (+10 dBm)		
Frequency (GHz)	CL (f_0 + IF) (Note 1) (Typ.)	f_0 - IF (Typ.)	f_0 (Typ.)	f_0 - 2 IF (Typ.)	f_0 + 2 IF (Typ.)	f_0 - 3 IF (Typ.)	f_0 + 3 IF (Typ.)
2	-8.6	-34.4	-42.9	-43.5	-52.9	-14.7	-33.8
2.5	-8.3	-40	-29.4	-50	-46.3	-15	-32.4
3	-7.6	-44.1	-28.2	-43.9	-51	-16.6	-31.8
3.5	-6.5	-37.8	-30.8	-42.5	-43.9	-15.8	-34.6
4	-8	-30.3	-28.8	-49.3	-43.8	-14.9	-35.8
4.5	-8.1	-29.9	-31.6	-47.8	-47.8	-17.7	-32.9
5	-8.2	-35.3	-33.3	-51.9	-45.8	-15.7	-30.9
5.5	-8.8	-44.5	-27.6	-42.2	-48.1	-14.2	-33.2
6	-8.6	-38.8	-38.7	-40.4	-40.6	-15.1	-35.5
6.5	-9.1	-33.8	-22.8	-41.7	-37.3	-15.5	-36.5
7	-9.8	-31.5	-22.7	-44.1	-36.8	-14.7	-32.9
7.5	-7.2	-42.4	-32.5	-39.9	-31.4	-15.7	-34.3
8	-9.1	-32	-28	-33.3	-42.8	-17.8	-29.9
Worst case	-9.8	-29.9	-22.7	-33.3	-31.4	-14.2	-29.9

Note 1: Conversion loss (CL) is relative to lowest power input (f_o or f_f). All other outputs (including f_o) are relative to the desired upper ($f_o + f_{IF}$) output.

TECHNICAL APPLICATION

HIGH-ISOLATION MODULATORS AND HIGH-LEVEL MIXERS FOR COMMUNICATION LINKS

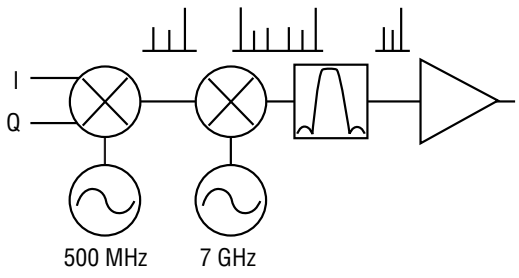
From September 1995 Wireless Convention paper

Microwave QAM signals are traditionally generated by linearly mixing or modulating a VHF or UHF carrier oscillator with band limited I and Q information. The resulting phase and/or amplitude states of the carrier are then multiplied or upconverted by another mixer, local oscillator and sideband filter to the actual transmitted frequency. I/Q modulation has traditionally been done in this manner because lower frequency high-isolation mixers tend to yield the best carrier and sideband rejection. The latter qualities are most important for accurate I/Q phase states or transmitted signal constellations. More recently at MITEQ, the electrical and physical symmetry of microwave baluns have been improved to yield mixers with LO-to-RF isolations of 45 dB up to 18 GHz. In addition, test data measured on quadrature coupled enhanced isolation double-balanced I/Q modulators show 50 to 60 dB carrier isolation in the 2 to 8 GHz frequency range. Consequently, high carrier rejection, biphase and QPSK linear modulators for manufacturing or testing of receivers are now possible directly at higher wireless frequencies, without extra frequency conversions. Another technique for designing linear I/Q modulators and demodulators, is to exploit the properties of even-harmonic mixers. When these mixers are used, a lower cost up- or downconverting receiver results because the required LO is at half the normal frequency. The core advantage of the even-harmonic mixer is again very high (55 dB typical) input LO to output 2 LO isolation. In the downconverter case, this also often eliminates the need for an input isolator or filter to stop receiver LO reradiation, again saving cost.

In addition to I/Q modulators, we will also review the advantages of Schottky diode and MESFET mixers for receiver designs. As the density of signals in a receiver increases, the input IP^3 rather than noise figure of the front end begins to limit the dynamic range. This is particularly true for the newer fixed tuned LO wideband RF “block” downconverters that utilize digital IF circuits to separate and demodulate each user of the channel. The digital filters can often process closely spaced signals that are 60 or 80 dB different in power thus requiring similar rejection of spurious mixer outputs. At MITEQ, we have explored the advantages of fundamental, harmonic and sampling mixers using MESFETs instead of Schottky diodes. The result is often a lower cost LO while still maintaining high receiver dynamic range. The principles of operation for the three common type mixers (fundamental, harmonic and sampling) are reviewed and data is presented to show the performance obtainable with the newer MESFET equivalent circuits. Sampling mixers can further lower the cost or receiver design by utilizing a UHF oscillator to downconvert microwave signals up to 20 GHz.

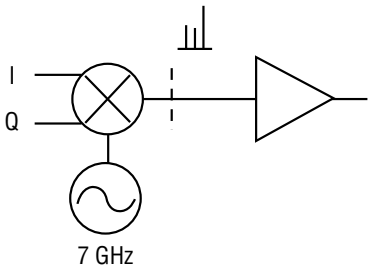
CONVENTIONAL DOUBLE CONVERSION AND DIRECT WIDE I/Q BANDWIDTH MODULATOR ARCHITECTURES

CONVENTIONAL UPCONVERTER MODULATOR



I/Q BW= 50 MHz

LOWEST COST DIRECT MODULATOR



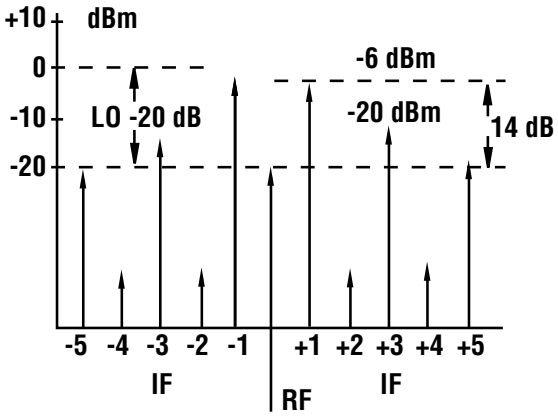
I/Q BW= 500 MHz

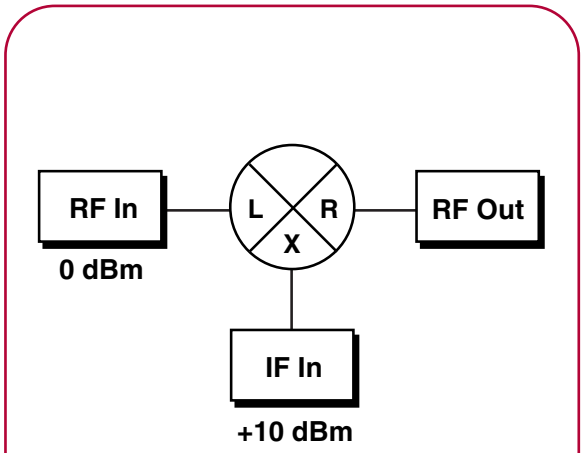
TECHNICAL APPLICATION

OUTPUT SPECTRUM OF TYPICAL DOUBLE-BALANCED MIXER MODULATOR USING HIGH POWER RF AND LOWER POWER IF COMPARED TO REVERSE POWER RELATION

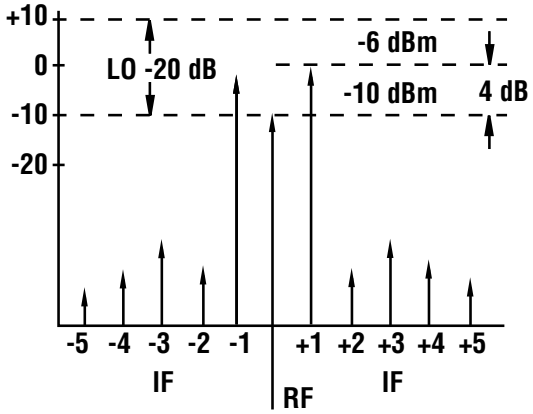
Note: Carrier suppression limited by use of mixer with 20 dB LO-to-RF isolation (conversion loss of 6 dB).

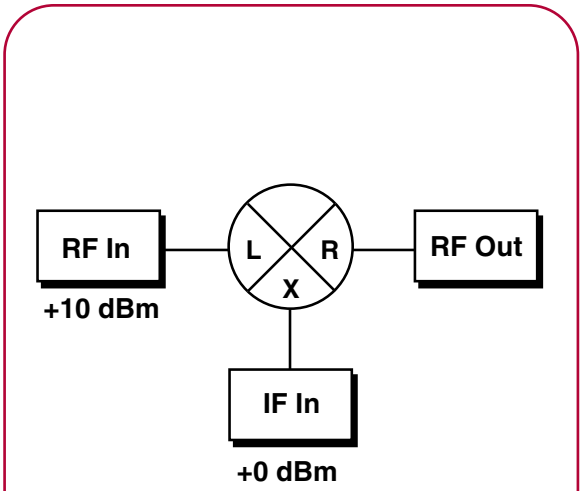
LINEAR RF MODULATOR (RF POWER < IF POWER)





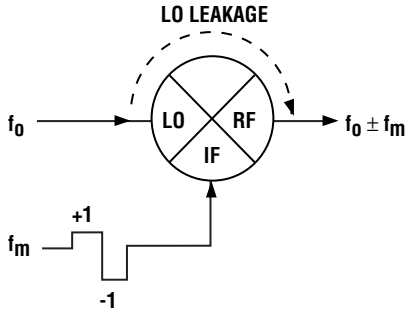
LINEAR IF MODULATOR (RF POWER > IF POWER)

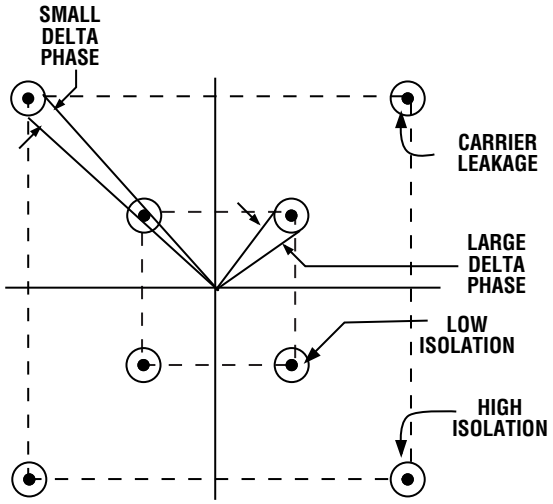


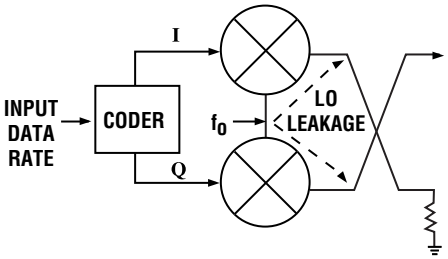


AMPLITUDE/PHASE ERRORS OF BIPHASE AND IDEAL QUADRATURE PHASE MODULATOR FROM POOR MIXER LO-TO-RF ISOLATION

LO-TO-RF ISOLATION	BPSK AMP. ERROR (dB)	BPSK PHASE ERROR (Deg.)
20	0.82	5.7
25	0.47	3.2
30	0.27	1.8
35	0.15	1.0
40	0.08	0.6





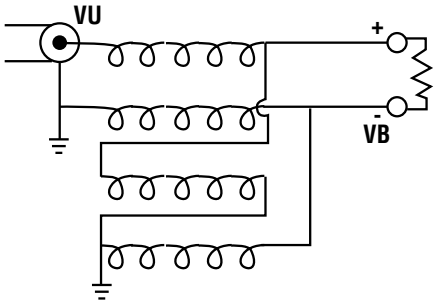


TECHNICAL APPLICATION

POPULAR VHF/UHF AND MICROWAVE BALUNS

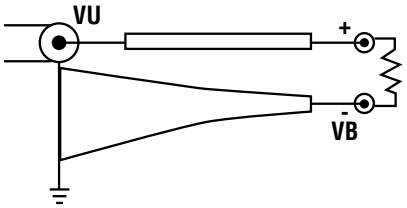
TORRID

Δ = -40 to -50 dB
Frequency = kHz to several GHz
Bandwidth = 100 to 1 Ratio



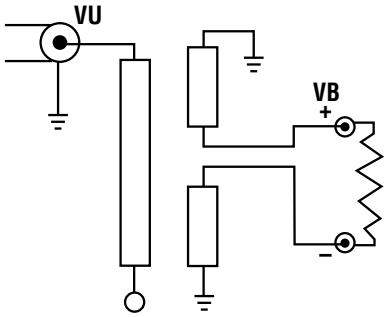
TAPERED

Δ = -20 to -30 dB
Frequency = 1 to 40 GHz
Bandwidth = 20 to 1 Ratio



MARCHAND

Δ = -25 to -35 dB
Frequency = 1 to 20 GHz
Bandwidth = 10 to 1 Ratio

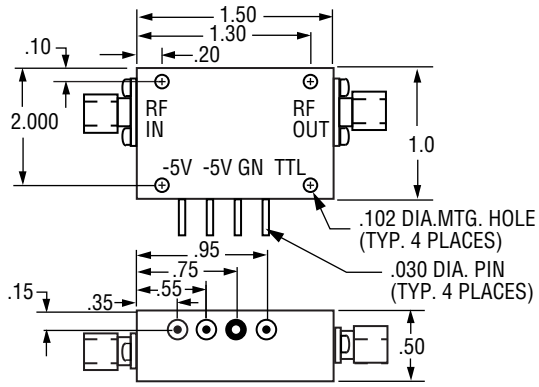


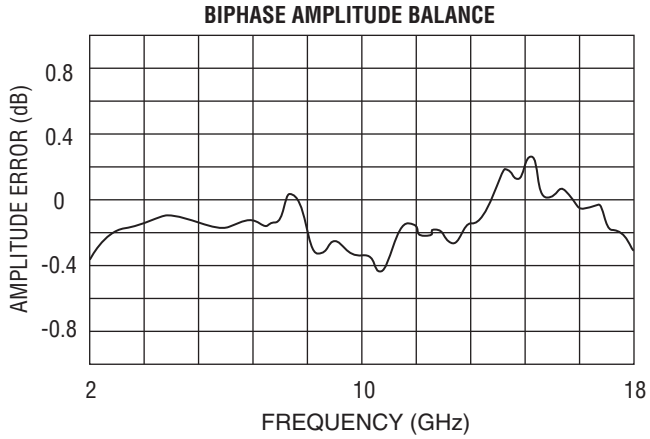
$$\Delta_{dB} = \text{BALANCE ERROR} = 20 \text{ Log } \frac{|+V_B| - |-V_B|}{|+V_B| + |-V_B|}$$

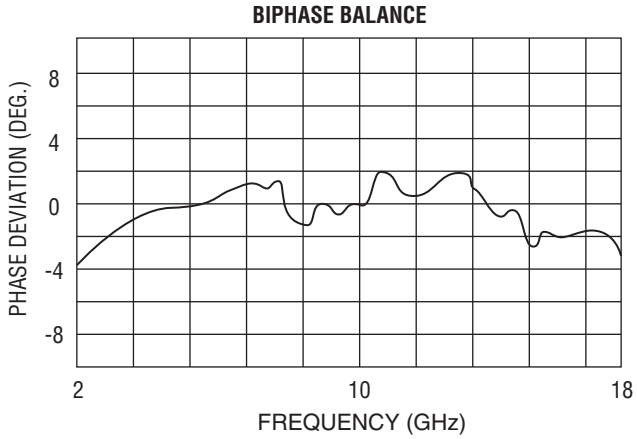
EXAMPLE OF MULTIOCTAVE, LINEAR RF, TTL, BIPHASE MODULATOR USING TAPERED LINE 25 dB BALUNS

MODEL: BMT0218HC10

- RF ..... 2 to 18 GHz
- TTL ..... DC to 20 Mbps
- RF (P1 dBm) ..... +16 dBm
- Degree accuracy ..... ±0.4 dB/4°



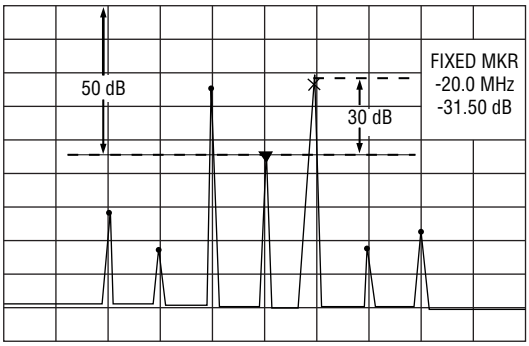




TECHNICAL APPLICATION

EXAMPLES OF BIPHASE AND QPSK MODULATORS THAT USE NEW 45 dB MICROWAVE BALUN DESIGN

IF = -3 dBm (20 MHz) RF = +13 dBm
REF = +13 dBm 10 dB/DIV.



Center 2.5000 GHz SPAN 200.0 MHz

DM0204LA1

BPSK

I/Q = 0 dBm (200 MHz), RF = +10 dBm

Freq. (GHz)	f_0 + IF Spec. 10.5 dB (Max.)	f_0 - IF 18 dBc (Min.)	f_0 18 dBc (Min.)	f_0 - 2 IF 30 dBc (Min.)	f_0 + 2 IF 30 dBc (Min.)	f_0 - 3 IF 18 dBc (Min.)	f_0 + 3 IF 18 dBc (Min.)
2.7	-6.1	-28.8	-29.6	-53	-43.5	-47.4	-51.5
2.8	-5.4	-28.8	-30.3	-51.4	-44.5	-45.4	-52.2
2.9	-5.4	-30.5	-30.3	-49	-45.2	-45.4	-53
3	-5.7	-29.2	-29.4	-48.9	-44.8	-43.7	-50.6
3.1	-5.6	-29.2	-29.6	-48.7	-44.9	-42.5	-50.6
3.2	-5.5	-28.9	-29.4	-48.8	-45.9	-42.4	-51
3.3	-6.3	-28	-28.5	-47.7	-45	-40.4	-51
3.4	-6.3	-28.3	-28.4	-48	-44.4	-40	-50.9
3.5	-6	-28.6	-28.4	-48.2	-45.4	-40.1	-52.5
3.6	-5.3	-29.3	-28.2	-50.1	-45	-39.5	-51.1
3.7	-5.2	-30	-27.1	-53.8	-46.1	-37.8	-50.3
Worst Case	-6.3	-28	-27.1	-47.7	-43.5	-37.8	-50.3

Note: Upper sideband is desired output.

SM2737LI6Q

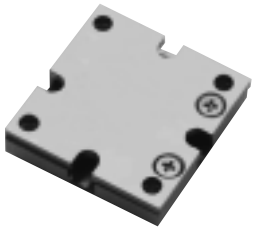
QPSK

TECHNICAL APPLICATION

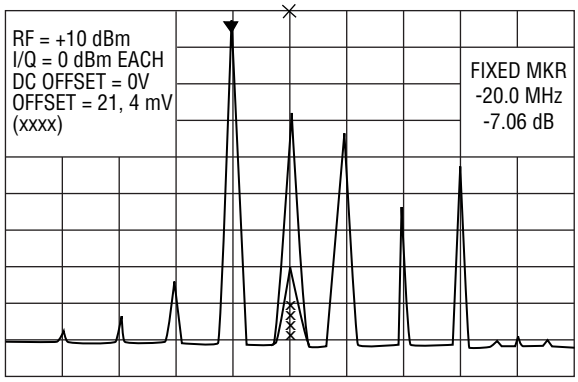
DIRECT MICROWAVE I/Q MODULATOR FOR 7.5/8.2 GHz SATELLITE COMMUNICATION BAND (WITH/WITHOUT DC CARRIER SUPPRESSION VOLTAGE)

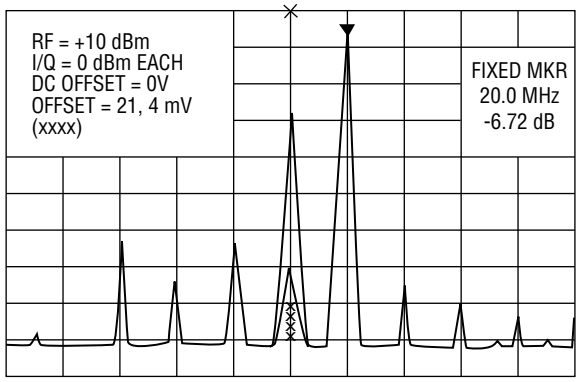
- **RF coverage ..... 7.2 to 8.4 GHz**
- **RF input power ..... +10 dBm**
- **I/Q bandwidth ..... DC to 500 MHz**
- **I/Q input level ..... 0 dBm**
- **Carrier suppression ..... 25 dB**
  (with DC compensation..... 45 dB)

SMO607LE3Q



SDMO708LI3Q

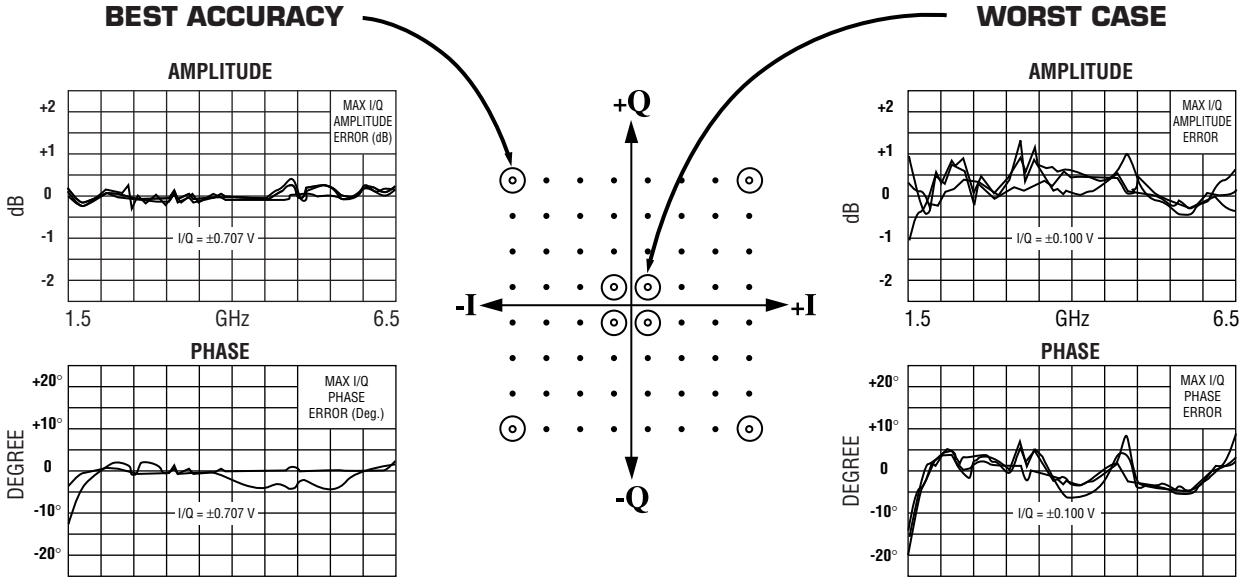




TECHNICAL APPLICATION

FREQUENCY VS. AMPLITUDE AND PHASE ERRORS OF 1.5 TO 6.0 GHz, 64 QAM I/Q MODULATOR CAUSED BY CARRIER LEAKAGE (MODEL SMC0206LI1)

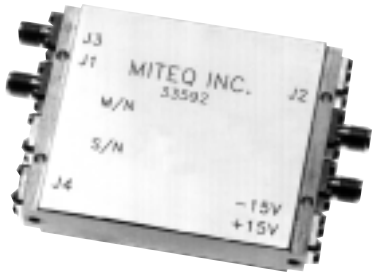
Notes: RF = +16 dBm, ⊙ = carrier leakage



WIDEBAND, HIGH-ISOLATION I/Q TEST MODULATOR

MODEL: SMC0208LI1Q

- Ideal for high fidelity I/Q or QAM Modulation
- Ultra wideband usage ..... 1.5 to 6.5 GHz
- Data rate ..... DC to 500 Mbps
- Input-to-output carrier isolation .... 60 dB
- QPSK amplitude/phase accuracy .. 0.5 dB/5°



OUTPUT SPECTRUM RELATIVE TO UPPER SIDEBAND

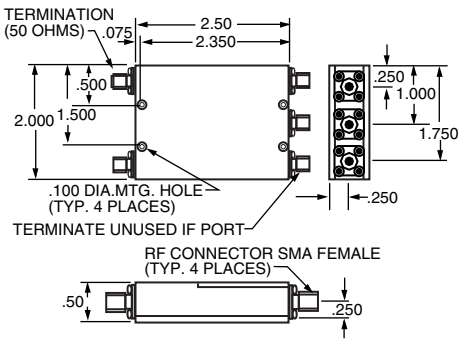
Frequency (GHz)	f_0 + IF (I.L., dB)	f_0 - IF (dBc)	f_0 (dBc)	f_0 - 2 IF (dBc)	f_0 + 2 IF (dBc)	f_0 - 3 IF (dBc)	f_0 + 3 IF (dBc)
1.5	-10.3	-18	-30	-48.7	-48.9	-34.5	-51
2	-7	-25.6	-38.9	-48.8	-49.1	-43.5	-53.8
2.5	-6.7	-34.1	-38.6	-48.5	-50.2	-44.6	-54.2
3	-8.3	-31.2	-41.9	-47.2	-49.5	-47.8	-52.2
3.5	-8	-30.2	-42.2	-48.6	-47.5	-45.9	-50.4
4	-8.6	-24.5	-30.8	-48.2	-48.6	-48.6	-51.8
4.5	-8.8	-24.1	-27.8	-47.8	-48.1	-45.8	-52.2
5	-8.9	-27.6	-28.2	-47.6	-48.9	-42.4	-51.7
5.5	-8	-25	-28.7	-46.7	-48.5	-45.6	-51.7
6	-7.6	-30.2	-28.9	-47	-49	-41	-52.6
6.5	-7.7	-28.2	-34.3	-47.2	-49.4	-42.7	-51.6

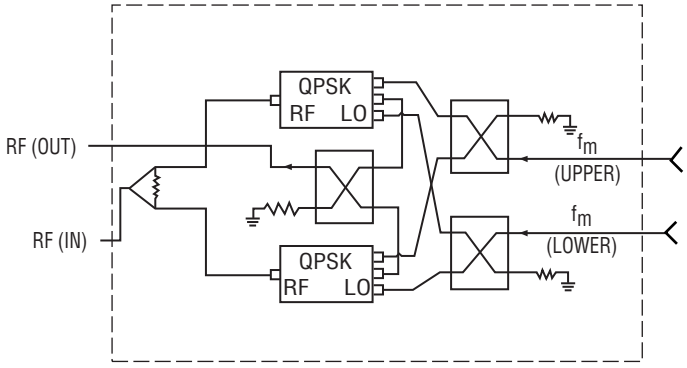
Notes: LO level: +16 dBm
I/Q level: +4 dBm (20 MHz)

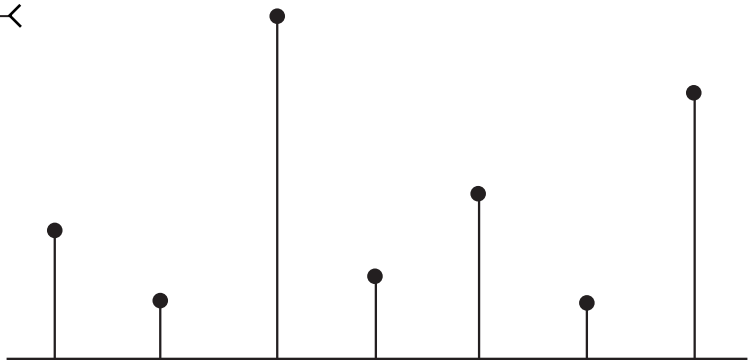
MULTIOCTAVE BANDWIDTH, ENHANCED SIDEBAND REJECTION MODULATOR (TYPICAL PERFORMANCE)

MODEL: SME0104LI1

- RF output/carrier input..... 1 to 4 GHz
- Modulation bandwidth..... DC to 500 MHz
- Modulation input power ..... +10 to +13 dBm
- Sideband suppression ..... 30 dB
- Carrier rejection ..... 25 dB







Frequency (GHz)	f_0 - 3 IF (I.L., dB)	f_0 - 2 IF (dBc)	f_0 - IF (dBc)	f_0 (dBc)	f_0 + IF (dBc)	f_0 + 2 IF (dBc)	f_0 + 3 IF (dBc)
1	-41.2	-44.5	0	-28.7	-20.6	-45.9	-12.4
1.5	-35.5	-47.4	0	-35.4	-30	-63.5	-13.7
2	-35.7	-50.3	0	-29.5	-32.3	-47.1	-12.7
2.5	-32.9	-39.2	0	-26.8	-32.7	-58.2	-14.5
3	-31	-39.2	0	-28.9	-31.7	-46.2	-15.1
3.5	-34.5	-38.9	0	-30	-30.1	-44.1	-13.6
4	-31.8	-44.9	0	-25.3	-25.1	-45.4	-13.7

MODULATOR ORDERING INFORMATION

MODEL NUMBER	LEVEL OPTION (*)	IF FREQUENCY OPTION (**)
BMT65175HC10MD	-	-
BMA0502LA2MD	-	-
BMA0104LA1MD	-	-
BMA0208LW2MD	-	-
BMA0218LA1MD	-	-
BMT0218HC10MD	-	-
BMA0618LA1MD	-	-
SDM0502LC1MD(**)	-	A, B, C, Q
SMT0502(*)C1MD	L, H	-
SDM0102(*)C1MDQ	L, H	-
SDM0104LC1MD(**)	-	A, B, C, Q
SME0104LI1MD(**)	-	A, B, C, Q
SSM0204(*)C2MD(**)	L, M, H	A, B, C, Q
SSM0208(*)C2MD(**)	L, M, H	A, B, C, Q
SME0208LI1MD(**)	-	A, B, C, Q
SSM0408(*)C2MD(**)	L, M, H	A, B, C, Q
SSM0812(*)C2MD(**)	L, M, H	A, B, C, Q
SMT0218(*)C1MD	L, H	-
SM0218LC1MD(**)	-	A, B, C, Q
SSM0618(*)C2MD(**)	L, M, H	A, B, C, Q
SME0618LI1MD(**)	-	A, B, C, Q
SSM1218(*)C2MD(**)	L, M, H	A, B, C, Q
SM0226LC1MD(**)	-	A, B, C, Q
SDM0102LC1CD(**)	-	A, B, C, Q
SM2737LI6CD(**)	-	A, B, C, Q
SDM0104LC1CD(**)	-	A, B, C, Q
SMC0206LI1CD(**)	-	A, B, C, Q
SDM0307LI1CDQ	-	-
SDM0208LC1CD(**)	-	A, B, C, Q
SDM0708LI3CDQ	-	-
SML0711LM8CDQ	-	-
SDM1015LI3CDQ	-	-
SM0218LC1CD(**)	-	A, B, C, Q
SME0618LI1CD(**)	-	A, B, C, Q
SMC0618LI1CD(**)	-	A, B, C, Q
SM1826NI7CD(**)	-	A, B, C, Q
SM3435LI7CD(**)	-	A, B, C