Series 73 12 Bit Digital and Series 74 Analog High Dynamic I-Q Vector Modulators

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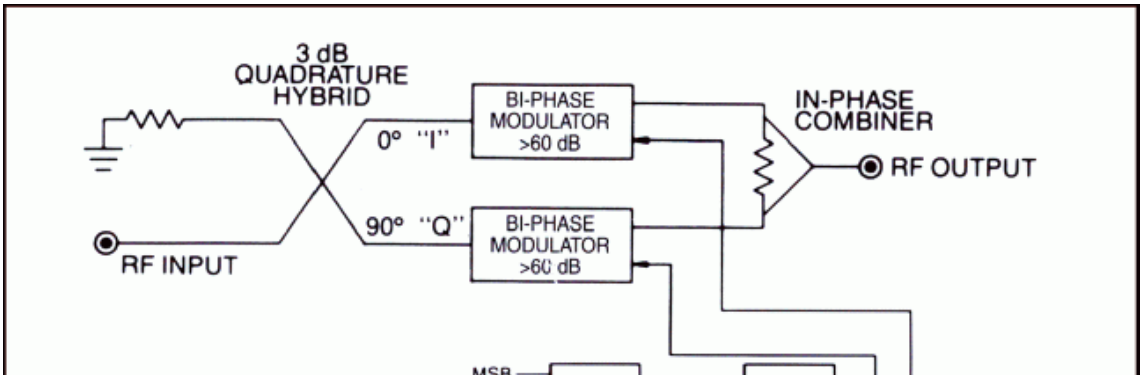
How to Buy Application Notes for Microwave Phase Shifter

The new Series 73/74 represents the latest addition to General Microwave's existing line of PIN Diode I.Q. Vector Modulators. Their performance has been enhanced to provide a higher dynamic range of attenuation for today's more demanding system applications.
All models incorporate multiple bi-phase modulator sections to provide in excess of 60 dB attenuation range at any frequency. All models are also capable of a full 360° range of phase shift. The series covers a frequency range of 2 GHz to 24 GHz in three bands: 2 GHz to 6 GHz, 6 GHz to 18 GHz, and 16 GHz to 24 GHz. A simplified block diagram is shown in Fig. 1.

- **Simultaneous control of amplitude and phase over a 60 dB dynamic range**
- **2 to 24 GHz in three bands:**
  - **2 to 6 GHz**
  - **6 to 18 GHz**
  - **16 to 24 GHz**
- **12 Bit digitally programmable (Series 73)**
- **Analog control (Series 74)**
- **High speed**
- **Guaranteed monotonicity**



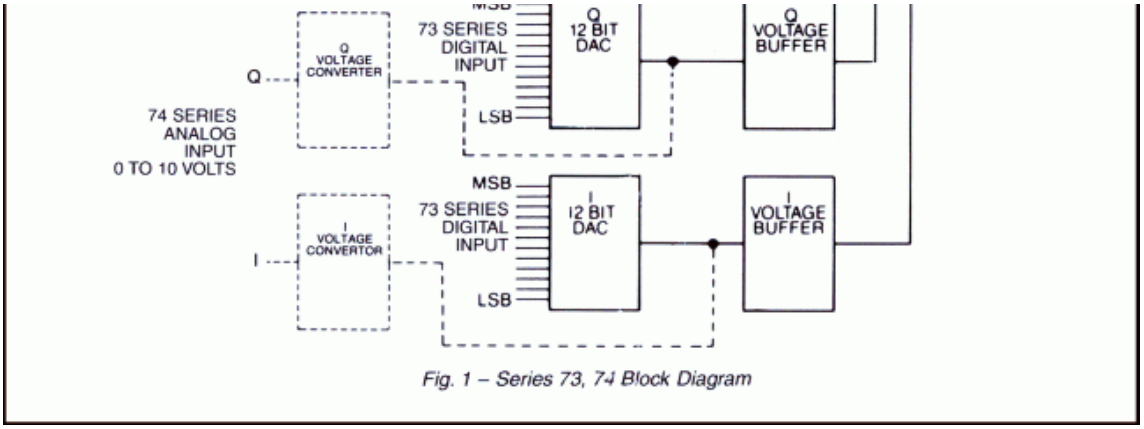


Fig. 1 – Series 73, 74 Block Diagram

THEORY OF OPERATION

The block diagram of the I-Q Vector Modulator is shown in Figure 1. An RF signal incident on a 3 dB quadrature hybrid is divided into two equal outputs, with a 90° phase difference between them. The in-phase, or 0°, channel is designated the I channel and the Quadrature, or 90°, channel is designated the Q channel. Each signal passes through a biphase modulator which sets the 0° or 180° state and the attenuation level for both the I and Q paths. The outputs of the I and Q path are combined to yield the resultant vector which may fall anywhere within the bounded area shown in Figure 2. Any signal applied to the I-Q Vector Modulator can be shifted in phase and adjusted in amplitude by applying the following relationships:

1. Let the desired attenuation level = X dB and the desired phase shift = θ° (with respect to 0 dB and 0° reference states).
2. The normalized output voltage magnitude is given by: $|V| = 10^{-(x/20)}$.
3. The values of the I and Q attenuator control inputs are then expressed as:

$$I = V \cos \theta$$

and

$$Q = V \cos \theta$$

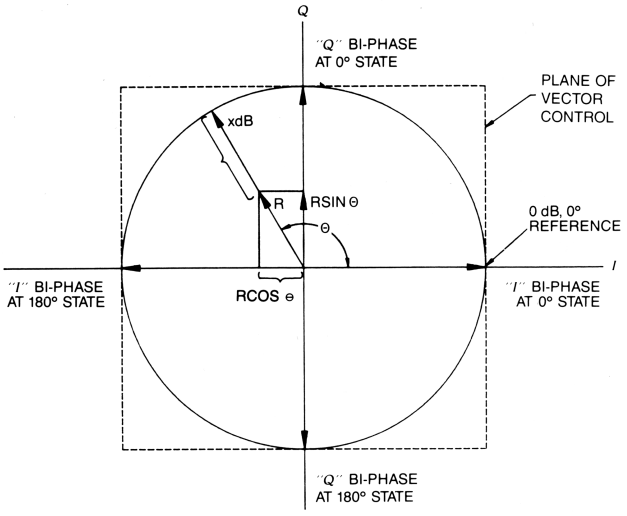


Fig. 2–I-Q Phase Relationship

Figure 3 shows the nominal value of I and Q vs. either digital word (Series 73) or analog voltage (Series 74). Thus, to achieve an attenuation level of 3 dB with a phase offset of 112.5° (with respect to 0 dB and 0° reference states) the values of I and Q can be calculated as follows:

$V = 10^{-(3/20)} = 0.707$
$I = 0.707 \cos (112.5°) = -0.027$
$Q = 0.707 \sin (112.5°) = +0.65$

From Figure 3, the control inputs to yield the desired amplitude and phase are approximately:

Analog Units (73 Series)	Digital Units (74 Series)
I = 7.81 volts	110010000000
Q = 1.50 volts	001010000000

While these values for I and Q will yield an output signal whose amplitude and phase are close to the nominal values over the entire operating frequency range of the vector modulator, the use of an iterative measurement procedure will determine the I and Q inputs which exactly deine the desired parameter at any selected frequency.

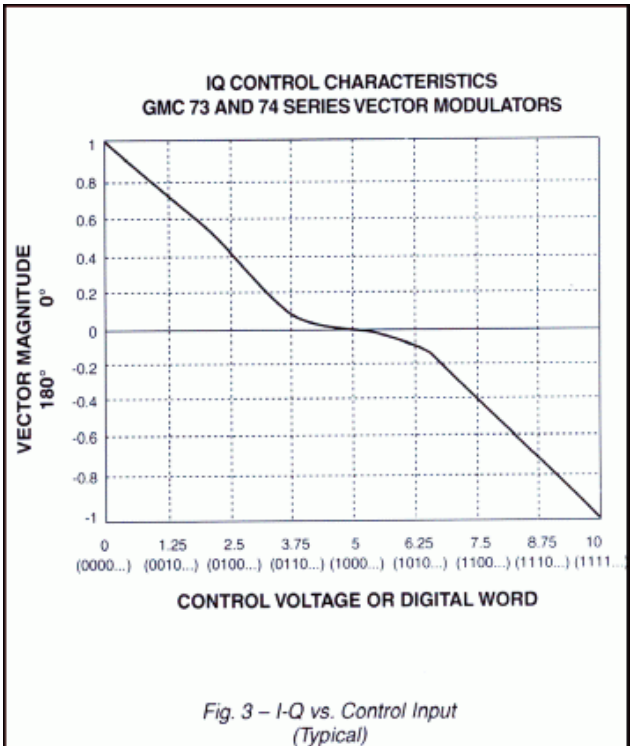


Fig. 3 – I-Q vs. Control Input (Typical)

PERFORMANCE CHARACTERISTICS

MODEL	7322/7422	7328/7428	7329/7429
Frequency	2.0-6.0 GHz	6.0-18.0 GHz	16.0-24.0 GHz
Insertion Loss (max)	14 dB	16 dB 6-16 GHz 17 dB > 16-18 GHz	16 dB 16-22 GHz 18 dB > 22-24 GHz
VSWR (max)	1.8:1	2.0:1	2.0:1 16-22 GHz 2.2:1 > 22-24 GHz
Power Handling Without Performance Degredation	+20 dBm		
Survival Power (max)	1W		
Absolute Insertion Phase Accuracy vs. Frequency (max)	±15°		±15° 16-22 GHz ± 20° > 22-24 GHz
Fine Grain Phase Ripple (50 mhz)	2° pk-pk		
Variation of Phase vs. Temperature (max)	± 0.2 deg./ °C		
Attenuation Range (min)	60 dB		
Variation of Amplitude vs. Temperature (max)	0.04dB/ °C		
Response Time (max)	1.0 µsec		
Power Supply	-12 to -15V @ 100 mA +12 to +15V @ 100 mA		
Control Input **73 Series** **74 Series**	12 bit TTL for both I and Q inputs 0 to +10V DC for both I and Q inputs		
Control Input Impedance **73 Series** **74 Series**	40 µA max 10 K ohms		

ENVIRONMENTAL RATINGS

Operating Temperature Range..... -54°C to + 100°C

Non-Operating Temperature Range ... -65° to + 125° C

Humidity.....MIL-STD-202F, Method 103B, Cond. B (96 hrs at 95%)

Shock.....MIL-STD-202F, Method 213B, Cond. B (75 G, 6 msec)

Vibration..... MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)

Altitude.....MIL-STD-202F, Method 105C Cond. B (50,000 ft.)

Temp. Cycling.....MIL-STD-202F, Method 107D Cond. A, 5 cycles

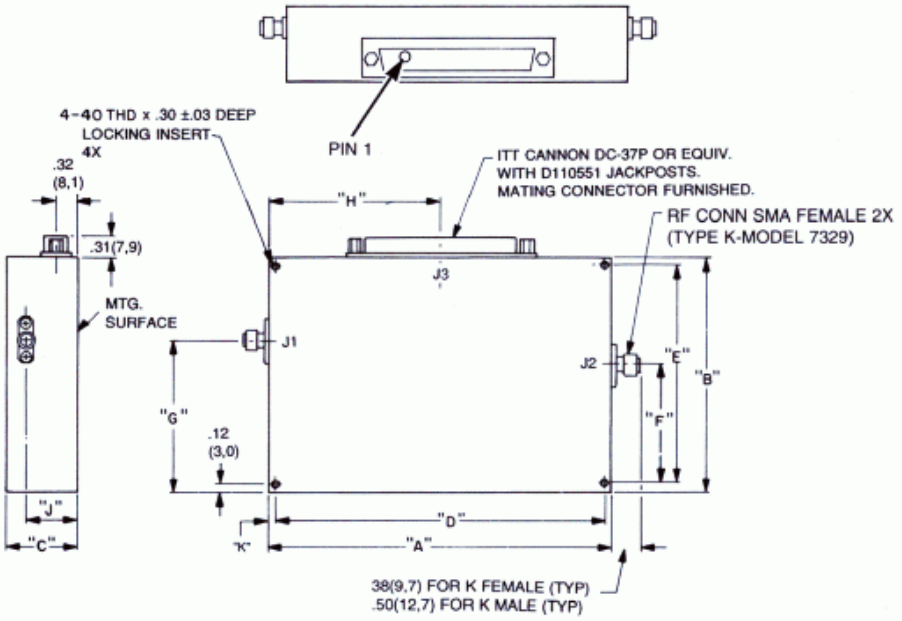
ACCESSORIES FURNISHED

Mating power/control connector (Series 73 only)

AVAILABLE OPTIONS

Option no.	Description
7	Two SMA (Type-K Model 7X29) male RF connectors
10	One SMA (Type-K Model 7X29) male (J2) and one SMA (Type-K Model 7X29) female (J1) RF connector

DIMENSIONS AND WEIGHTS



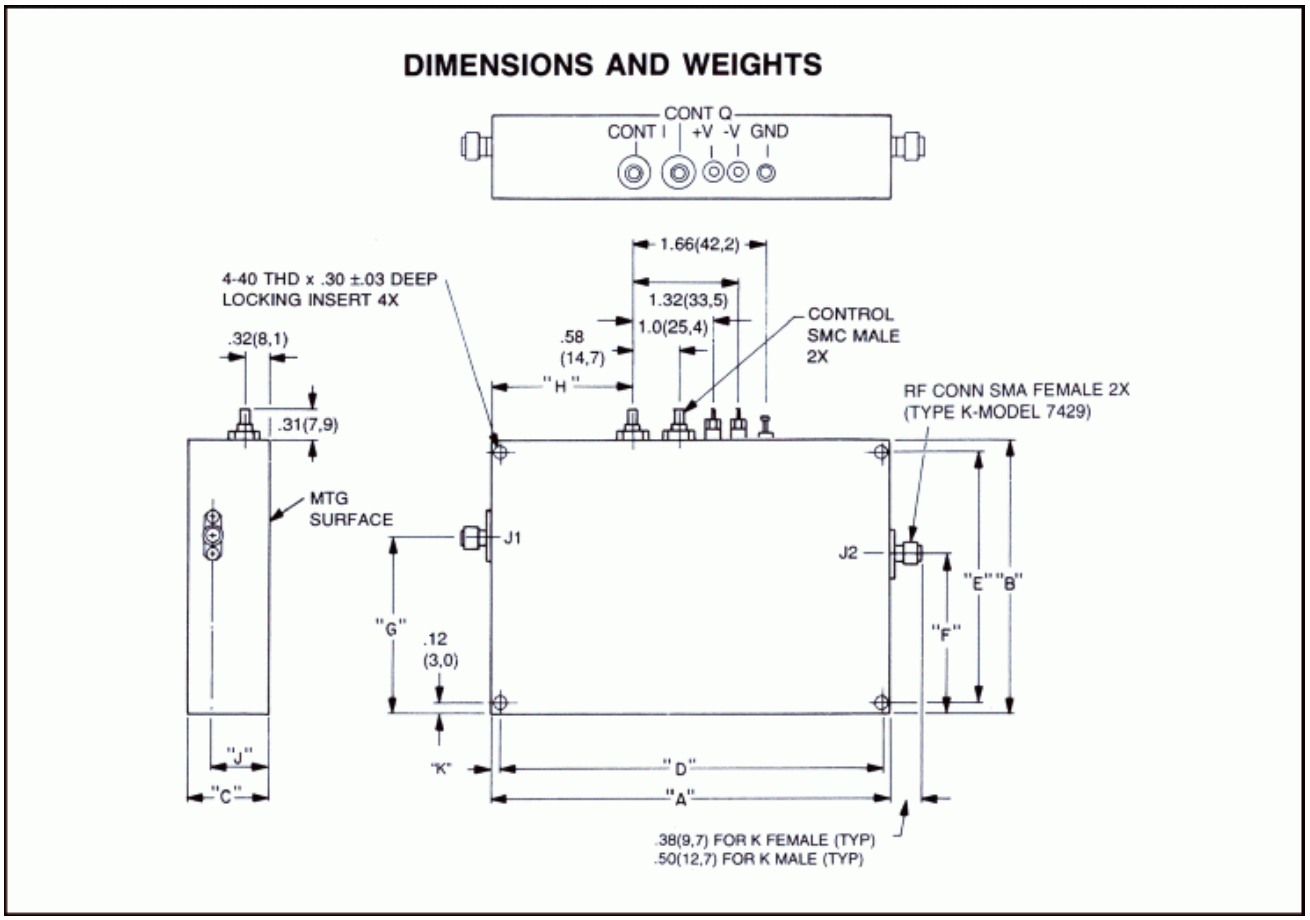
MODEL	A	B	C	D	E	F	G	H	J	K
7322	4.00 ± .03 (101,6)	3.00±.03 (76,2)	.88 (22,4)	3.80±.01 (96,5)	2.75± .01 (69,9)	1.50 (38,1)	1.90 (48,3)	2.00 (50,8)	.68 (17,3)	.10 (2,9)
7328	3.12 ± .03 (79,2)	3.00 ± .03 (76,2)	.88 (22,4)	2.92 ± .01 (74,2)	2.75 ± .01 (69,9)	1.50 (38,1)	1.82 (46,2)	1.56 (39,6)	.68 (17,3)	.10 (2,9)
7329	3.25 ± .03 (82,6)	3.00 ± .03 (76,2)	.82 (20,8)	3.00 ± .01 (76,2)	2.75 ± .01 (69,9)	1.50 (38,1)	1.69 (42,9)	1.62 (41,1)	.65 (16,5)	.12 (3,0)

J3 PIN FUNCTIONS			
PIN	FUNCTION	PIN	FUNCTION
1	I-5	20	I-4
2	I-6	21	I-7
3	I-8	22	I-3
4	I-9	23	I-2
5	I-10	24	I-1 (LSB)
6	I-11	25	I-12 (MSB)
7	N/C	26	N/C

8	+12 to + 15V	27	N/C
9	GND	28	GND
10	GND	29	N/C
11	-12 to -15V	30	N/C
12	Q-3	31	N/C
13	Q-2	32	Q-4
14	Q-1 (LSB)	33	N/C
15	Q-5	34	N/C
16	Q-6	35	Q-12 (MSB)
17	Q-7	36	Q-11
18	Q-8	37	Q-10
19	Q-9		

MODEL	WEIGHT (APPROX)
7322	12 oz. (341 gm)
7328	11 oz. (312 gm)
7329	11 oz. (312 gm)

Dimensional Tolerances, unless otherwise indicated .XX±.02; .XXX±.005



MODEL	A	B	C	D	E	F	G	H	J	K
7422	4.00 ±.03 (101,6)	3.00±.03 (76,2)	.88 (22,4)	3.80 ±.01 (96,5)	2.75±.01 (69,9)	1.50 (38,1)	1.90 (48,3)	1.28 (32,5)	.68 (17,3)	.10 (2,9)
7428	3.12±.03 (79,2)	3.00 ± .03 (76,2)	.88 (22,4)	2.92±.01 (74,2)	2.75±.01 (69,9)	1.50 (38,1)	1.82 (46,2)	.83 (21,1)	.68 (17,3)	.10 (2,9)
7429	3.25 ± .03 (82,6)	3.00 ± .03 (76,2)	.82 (20,8)	3.00±.01 (76,2)	2.75±.01 (69,9)	1.50 (38,1)	1.69 (42,9)	0.90 (22,9)	.65 (16,5)	.12 (3,0)

MODEL	WEIGHT (APPROX)
7422	12 oz. (341 gm)
7428	11 oz. (312 gm)

7429