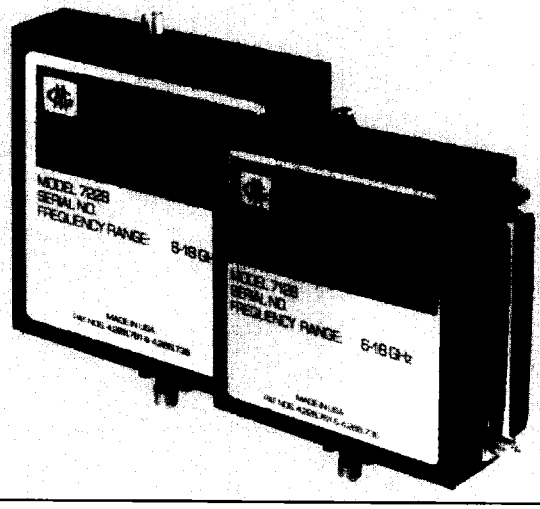
Series 71, 12 Bit Digital and Series 72 Analog I-Q Vector Modulators

Both Series comprise a family of four solid-state PIN diode I-Q Vector Modulators covering the frequency range from 0.5 to 18 GHz in four bands; 0.5 to 2 GHz, 2 to 6 GHz, 4 to 12 GHz and 6 to 18 GHz. See Fig. 1.

All models provide a full 360° range of phase shift and a minimum of 20 dB attenuation range at any frequency.

- **Simultaneous control of amplitude and phase**
- **0.5 to 18 GHz in four bands: 0.5 to 2 GHz; 2 to 6 GHz; 4 to 12 GHz; 6 to 18 GHz**
- **12 Bit digitally programmable (Series 71)**
- **Analog control (Series 72)**
- **High speed**
- **Guaranteed monotonicity**



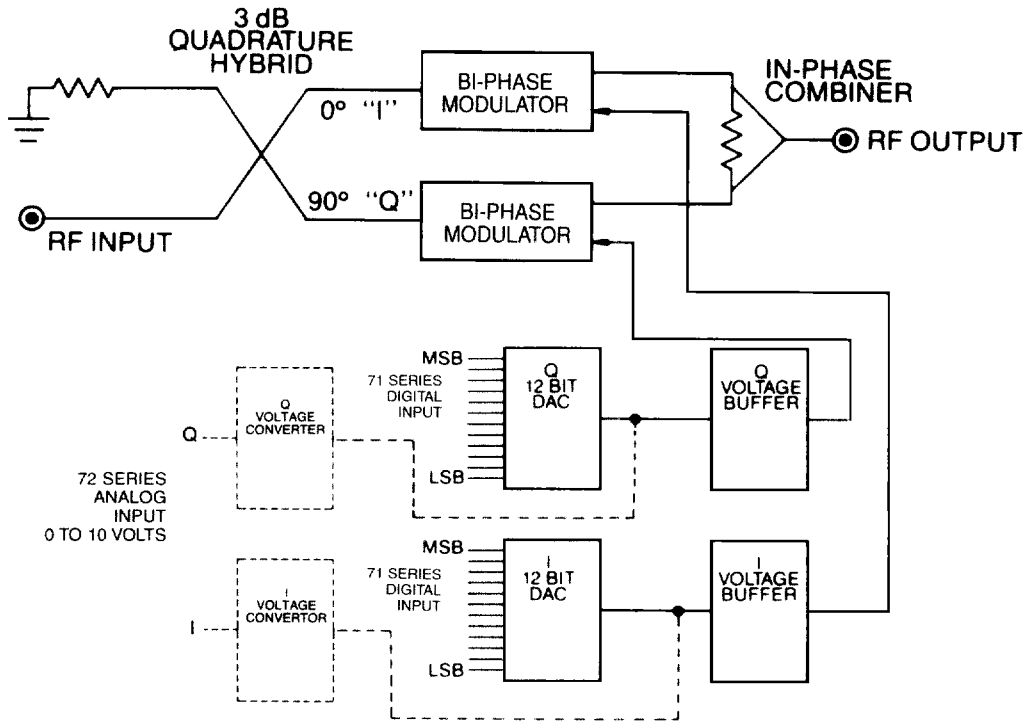


Fig. 1–Series 71, 72 Block Diagram

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 bi-phase 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 O° 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

$$Q = V \sin \theta.$$

Figure 3 shows the nominal value of I and Q vs. either digital word (Series 71) or analog voltage (Series 72). 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:

$$V = 10^{-(3/20)} = 0.707$$
$$I = 0.707 \cos (112.5°) = -.027$$
$$Q = 0.707 \sin (112.5°) = +0.65$$

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

Analog Units (72 Series)	Digital Units (71 Series)
I = 5.78 volts	100101000000
Q = 2.84 volts	010010001011

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 define the desired parameter at any selected frequency.

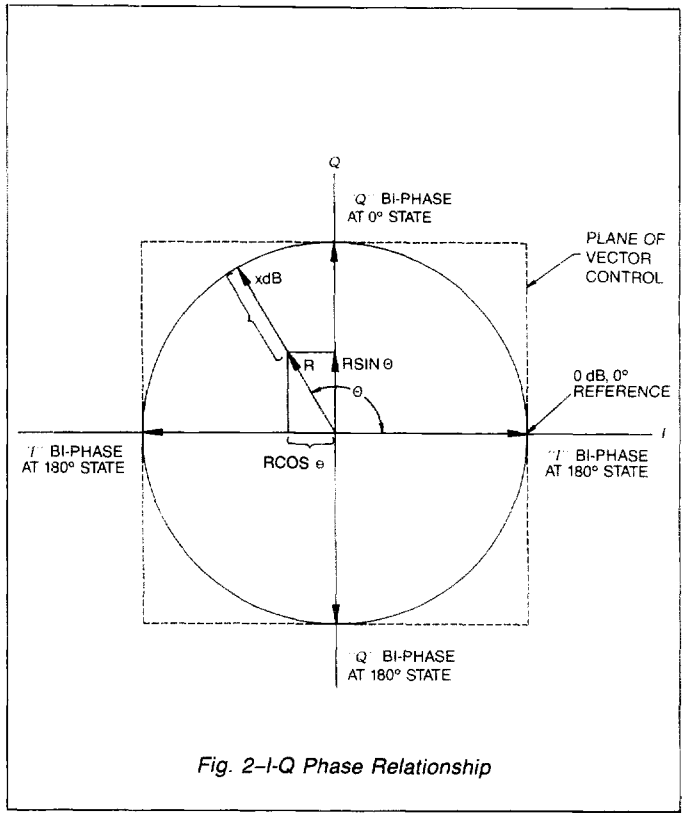


Fig. 2–I-Q Phase Relationship

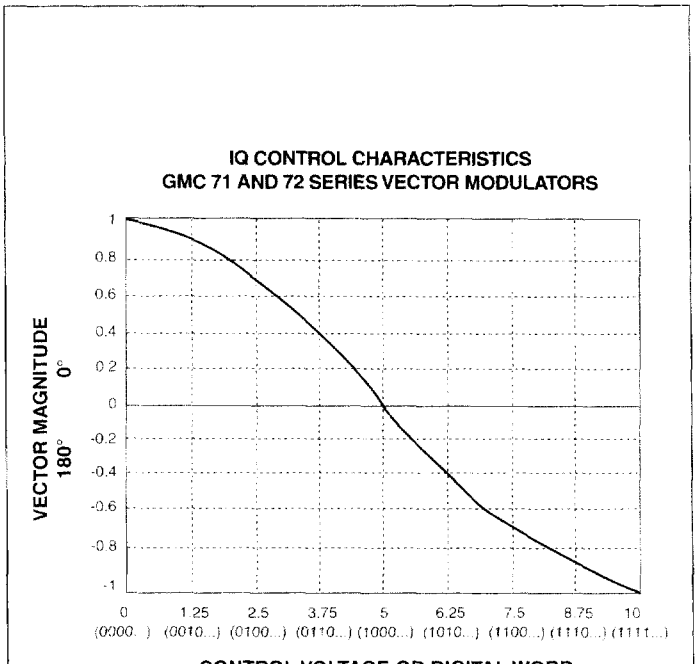


Fig. 3 – I-Q vs. Control Input (Typical)

Series 71/72 Specifications

PERFORMANCE CHARACTERISTICS

MODEL	7120/7220	7122/7222	7124/7224	7128/7228
FREQUENCY	0.5-2.0 GHz	2.0-6.0 GHz	4.0-12.0 GHz	6.0-18.0 GHz
INSERTION LOSS	13 dB	11 dB	12 dB	12 dB
VSWR (MAX)	1.6:1	1.8:1	1.8:1	2.0:1
POWER HANDLING WITHOUT PERFORMANCE DEGRADATION	+7 dBm	+20 dBm	+20 dBm	+20 dBm
SURVIVAL POWER (MAX)	1W			
ABSOLUTE INSERTION PHASE ACCURACY VS. FREQUENCY (MAX)	±15°			
FINE GRAIN PHASE RIPPLE (50 MHz) (MAX)	2° pk-pk			
VARIATION OF PHASE VS. TEMPERATURE (MAX)	±0.1 deg./ °C			
ATTENUATION RANGE (MIN)	20 dB			
VARIATION OF AMPLITUDE VS. TEMPERATURE (MAX)	0.02 dB/ °C			
RESPONSE TIME (MAX)	0.5 µsec			
POWER SUPPLY	-12 to -15V @ 70 mA +12 to +15V @ 70 mA			
CONTROL INPUT 71 SERIES 72 SERIES	12 bit TTL for both I and Q inputs 0 to +10V dc for both I and Q inputs			
CONTROL INPUT IMPEDANCE 71 SERIES 72 SERIES	40 µA max 10 K ohms			

ENVIRONMENTAL RATINGS

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

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

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

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

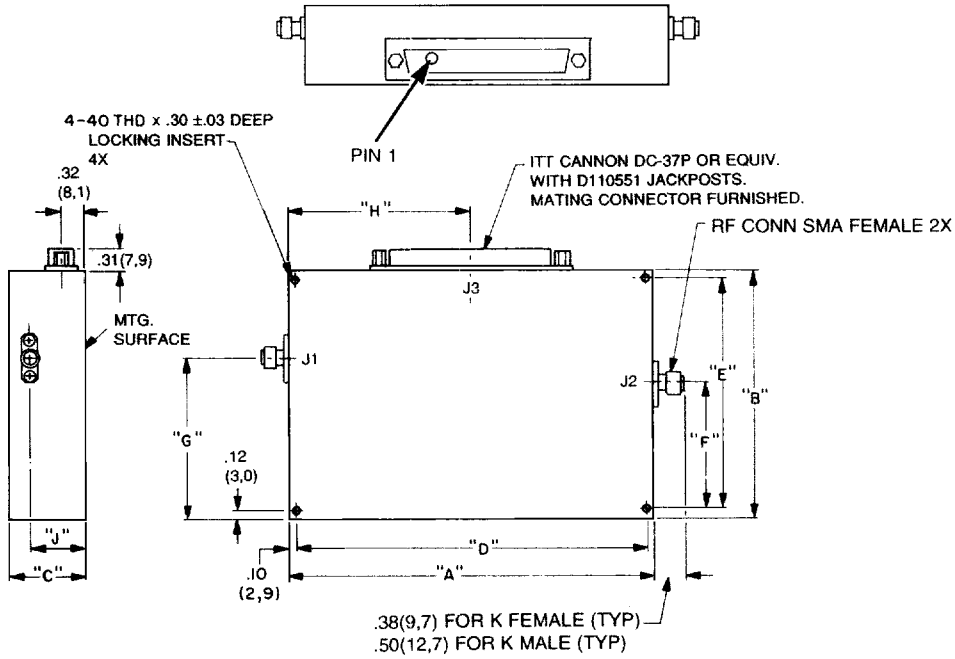
ACCESSORY FURNISHED

Mating power/control connector (Series 71 only)

AVAILABLE OPTIONS

Option No.	Description
7	Two SMA male rf connectors
10	One SMA male (J2) and one SMA female (J1) rf connector

DIMENSIONS AND WEIGHTS



MODEL	A	B	C	D	E	F	G	H	J
7120	4.95±.03 (125,7)	3.38±.03 (85,9)	1.02 (25,9)	4.75±.01 (120,7)	3.12±.01 (79.2)	1.68 (42,7)	.75 (19,1)	2.48 (62,9)	.73 (18,5)
7122	3.25±.03 (82,6)	3.25±.03 (82,6)	.85 (21.6)	3.05±.01 (77,5)	3.00±.01 (76,2)	1.63 (41,4)	1.99 (50,5)	1.63 (41,4)	.64 (16,3)
7124							1.83 (46,5)		
7128	3.00±.03 (76,2)	3.00±.03 (76,2)	.96 (24,4)	2.80±.01 (71,1)	2.75±.01 (69,9)	1.50 (38,1)	1.63 (41,4)	1.50 (38,1)	.76 (19,3)

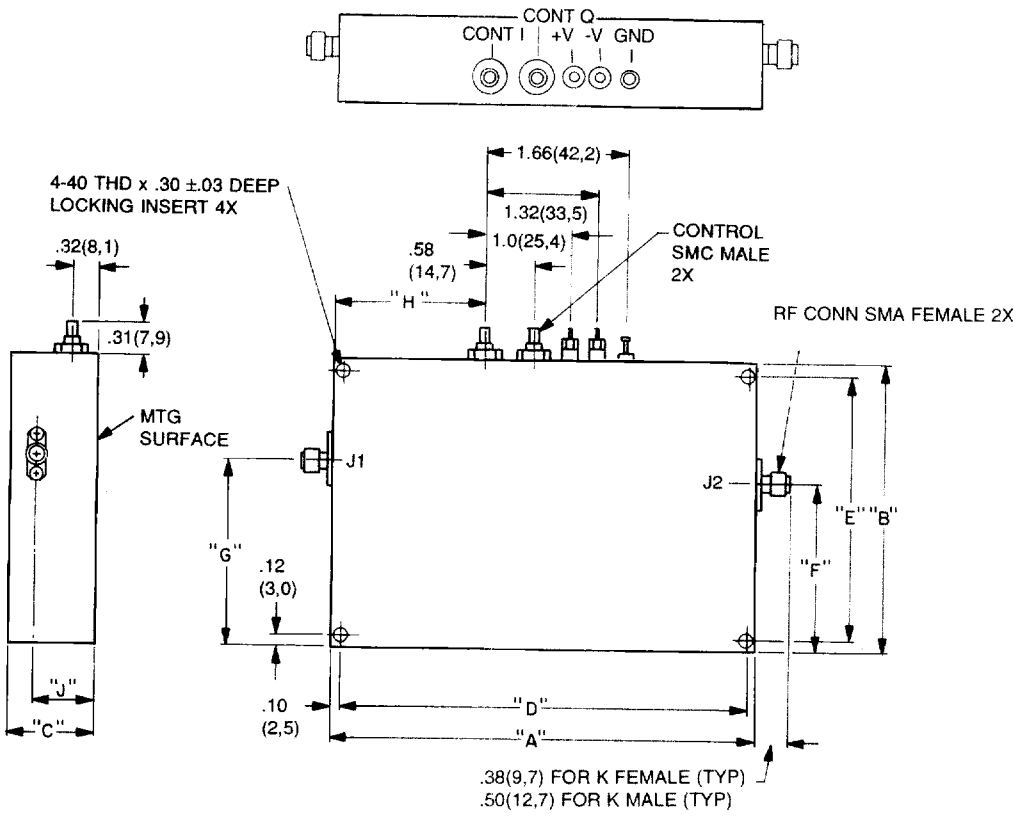
J3 PIN FUNCTIONS			
PIN	FUNCTION	PIN	FUNCTION
1	I-5	20	I-4
2	I-6	21	I-7
3	I-8	22	I-3
4	I-9	23	I-2
5	I-10	24	I-1 (LSB)
6	I-11	25	I-12 (MSB)
7	N/C	26	N/C
8	+12 to +15V	27	N/C
9	GND	28	GND
10	GND	29	N/C
11	-12 to -15V	30	N/C
12	Q-3	31	N/C
13	Q-2	32	Q-4
14	Q-1 (LSB)	33	N/C
15	Q-5	34	N/C
16	Q-6	35	Q-12 (MSB)
17	Q-7	36	Q-11
18	Q-8	37	Q-10
19	Q-9		

MODEL	WEIGHT (APPROX)
7120	13 oz. (369 gm)
7122	10 oz. (284 gm)
7124	10 oz. (284 gm)
7128	9 oz. (255 gm)

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

Series 71/72 Specifications

DIMENSIONS AND WEIGHTS



MODEL	A	B	C	D	E	F	G	H	J
7220	4.95±.03 (125,7)	3.38±.03 (85,9)	1.02 (25,9)	4.75±.01 (120,6)	3.12±.01 (79.2)	1.68 (42,7)	.75 (19,1)	1.75 (44,5)	.73 (18,5)
7222	3.25±.03 (82,6)	3.25±.03 (82,6)	.85 (21.6)	3.05±.01 (77,5)	3.00±.01 (76,2)	1.63 (41,4)	1.99 (50,5)	.90 (22,9)	.64 (16,3)
7224							1.83 (46,5)		
7228	3.00±.03 (76,2)	3.00±.03 (76,2)	.96 (24,4)	2.80±.01 (71,1)	2.75±.01 (69,9)	1.50 (38,1)	1.63 (41,4)	.78 (19,8)	.76 (19,3)

MODEL	WEIGHT (APPROX)
7220	13 oz. (369 gm)
7222	10 oz. (284 gm)
7224	10 oz. (284 gm)
7228	9 oz. (255 gm)

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