Millimeter Wave Components,
18-40 GHz

**SPST & SP2T F90 SERIES SWITCHES**
General Microwave millimeter wave switches are available in SPST and SP2T models in a variety of topologies and configurations, e.g., with current-controlled switching, or with integrated TTL-compatible voltage drivers, and in both low insertion loss and high isolation models.

All switch models in the series operate over the frequency range from 18-40 GHz; each is capable of handling cw or peak powers up to 1W without performance degradation, and features rise and fall times of less than 10 ns.

**CURRENT, DIGITAL & VOLTAGE CONTROLLED ATTENUATORS**
General Microwave wideband millimeter-wave attenuators are available in three configurations. Model 1959 is current-controlled, while the Model D1959, which incorporates a hybrid driver, is voltage-controlled with a linearized transfer function of 10 dB per volt.

The digitally-controlled Model 3499 provides 0.03 dB resolution (11 bits) and switching speed of less than 500 nsec.

Each of the three models operates over the full frequency range from 18-40 GHz with a dynamic attenuation range of 50 dB.

**QUADRATURE COUPLER**
The Model 7050 3-dB Quadrature Coupler is a 4-port single-section Hopfer coupler which operates over the frequency range from 18-40 GHz. It features low insertion loss, high isolation, and excellent amplitude and phase balance.
Models 1959, D1959
Millimeter Wave PIN Diode Attenuator/Modulator

MODEL 1959
The Model 1959 is a current-controlled attenuator/modulator that provides a minimum of 50 dB of attenuation over the frequency range of 18 to 40 GHz. As shown in figure 1 below, the RF circuit uses two shunt arrays of PIN diodes and two quadrature hybrid couplers. The quadrature hybrids are of a unique GMC microstrip design which are integrated with the diode arrays to yield a minimal package size.

MODEL D1959
The Model D1959 voltage-controlled linearized attenuator/modulator is an integrated assembly of a Model 1959 and a hybridized driver circuit which provides a nominal transfer function of 10 dB per volt. (See figure 2 below.)

• Absorptive
• Current or voltage controlled
• 18 to 40 GHz frequency range
• High performance MIC quadrature hybrid design
• High speed

Fig. 1–Model 1959, RF schematic diagram

Fig. 2—Model D1959, block diagram

Fig. 3—Model 1959, typical effects of temperature on attenuation.
PERFORMANCE CHARACTERISTICS

<table>
<thead>
<tr>
<th>MODEL</th>
<th>FREQUENCY RANGE (GHz)</th>
<th>MAX. INSERTION LOSS (dB)</th>
<th>MAX. VSWR</th>
<th>FLATNESS (± dB) AT MEAN ATTENUATION LEVELS UP TO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10 dB</td>
</tr>
<tr>
<td>1959</td>
<td>18-26.5</td>
<td>3.6</td>
<td>2.2</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>26.5-36</td>
<td>4.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>36-40</td>
<td>4.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1959</td>
<td>18-26.5</td>
<td>4.1</td>
<td>2.2</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>26.5-36</td>
<td>4.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>36-40</td>
<td>5.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ENVIRONMENTAL RATINGS AND AVAILABLE OPTIONS

See page 175.

COMMON TO BOTH MODELS 1959 AND D1959

Mean Attenuation
Range..........................50 db
Monotonicity ..................Guaranteed
Power Handling Capability
Without Performance
Degradation...................10 mW cw or peak
Survival Power.................0.2W average, 5W peak
(1 µsec max. pulse width)

MODEL 1959
Rise and Fall Times
Rise Time ....................75 nsec max.
Fall Time ....................20 nsec max(1)
Bias Current for Maximum
Attenuation ...................15 to 70 mA
Temperature Effects ...........See figure 3

MODEL D1959
Accuracy of Attenuation
0 to 30 dB ....................±0.5 dB
30 to 50 dB ....................±1.0 dB
Temperature Coefficient ......±0.025 dB/°C
Switching Characteristics
ON Time ........................300 nsec
OFF Time ........................30 nsec max(1)
Nominal Control Voltage Characteristics
Operating .....................0 to +5V
Transfer Function .............10 dB/volt
Input Impedance ................10 Kohms
Modulation Bandwidth
Small Signal .................5 MHz
Large Signal ..................2 MHz
Power Supply
Requirements ..................+12V ±5%, 100 mA
-12V ±5%, 20 mA
Power Supply
Rejection ......................Less than 0.1 dB/Volt change in either supply

(1) For attenuation steps of 10 dB or more

DIMENSIONS AND WEIGHTS

Dimensional Tolerances, unless otherwise indicated: .XX ±.02; .XXX ±.005
The Model 3499 Millimeter Wave Digitally Controlled Attenuator provides greater than octave-band performance and wide programming flexibility in a compact rugged package.

The Model 3499 is an integrated assembly of a balanced PIN diode attenuator and a driver circuit consisting of a PROM, a D/A converter and a current-to-voltage converter, as shown in Figure 1. This arrangement provides a high degree of accuracy and repeatability and also preserves the inherent monotonicity of the attenuator.

The Model 3499 offers a 50 dB attenuation range, 0.03 dB resolution and switching speed of no more than 500 nanoseconds. It is available with either a strobe/latch or a non-linear current or voltage controlled attenuation capability. Refer to the Available Options and the Notes on page 175.

- Frequency range: 18-40 GHz
- 50 dB attenuation range
- 500 nsecond switching speed
- 11 Bit binary programming
- Guaranteed monotonicity
- Absorptive
Model 3499
Specifications

PERFORMANCE CHARACTERISTIC

<table>
<thead>
<tr>
<th>MODEL</th>
<th>FREQUENCY RANGE (GHz)</th>
<th>MAX. INSERTION LOSS (dB)</th>
<th>MAX. VSWR</th>
<th>FLATNESS (± dB) AT MEAN ATTENUATION LEVELS UP TO</th>
</tr>
</thead>
<tbody>
<tr>
<td>3499</td>
<td>18-26.5</td>
<td>4.1</td>
<td>2.2</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>&gt;26.5-36</td>
<td>4.6</td>
<td>2.2</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>&gt;36-40</td>
<td>5.2</td>
<td></td>
<td>3.4</td>
</tr>
</tbody>
</table>

Mean Attenuation Range ....50 db
Accuracy of Attenuation
0 to 30 dB.................±0.5 dB
30 to 50...................±1.0 dB
Monotonicity ..............Guaranteed
Temperature Coefficient ....±0.03 dB/°C
Power Handling Capability
Without Performance
Degradation..................10 mW cw or peak
Survival Power (from –40°C to +25°C; +25°C; see Figure 2 for higher temperatures) .............0.2W average, 5W peak (1 µsec max. pulse width)
Switching Time..................0.5 µsec max.
Programming ..................Positive true binary. For complementary code, specify Option 2. To interface with other logic families, please contact factory.

Minimum Attenuation Step ..................................0.03 dB (1)
Logic Input
Logic “0” (Bit OFF) ..........–0.3 to +0.8V
Logic “1” (Bit ON) ..........+2.0 to +5.0V
Logic Input Current ..........1 µA max.
Analog Input ..................0 to 6.4V
Power Supply Requirements ..................+12V to +15V, 120 mA
                                  −12V to −15V, 50 mA
Power Supply Rejection .................Less than 0.1 dB/volt change in either supply

ENVIRONMENTAL RATINGS
Operating Temperature
Range ...................... −40°C to +85°C
Non-Operating Temperature
Range ...................... −54°C to +100°C
Humidity .................... MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)
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.)

(1) See note (1) on page 169
**ACCESSORY FURNISHED**
Mating power/logic connector

**AVAILABLE OPTIONS**

<table>
<thead>
<tr>
<th>Option No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Complementary programming (logic “0” is Bit ON)</td>
</tr>
<tr>
<td>4</td>
<td>Strobe latch for data input. Attenuator responds to data input when logic “0” is applied, Attenuator latched to data input when logic “1” is applied.</td>
</tr>
<tr>
<td>7</td>
<td>Two type K male RF connectors</td>
</tr>
<tr>
<td>10</td>
<td>One type K male (J1) and one type K female (J2) RF connector</td>
</tr>
</tbody>
</table>

**DIMENSIONS AND WEIGHTS**

**NOTES:**

1. The Model 3499 attenuator is an 11-bit digital attenuator. In order to use this device with a lesser number of bits (lower resolution), the user may simply ground the logic pins for the lowest order unused bits. For example, when operated as an 8-bit unit, the Model 3499 would have Pin 15, Pin 1 and Pin 2 connected to ground. All other parameters remain unchanged.

2. Normally supplied as an Analog input. Optionally available as a strobe latch function for input data.

3. Pin 3 is available to apply a current or voltage to control the attenuator in a non-linear fashion. Leave pin open circuited if not using.

**ACCESSORY FURNISHED**

Mating power/logic connector

**AVAILABLE OPTIONS**

<table>
<thead>
<tr>
<th>Option No.</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>2</td>
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</tr>
<tr>
<td>4</td>
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</tr>
<tr>
<td>7</td>
<td>Two type K male RF connectors</td>
</tr>
<tr>
<td>10</td>
<td>One type K male (J1) and one type K female (J2) RF connector</td>
</tr>
</tbody>
</table>

**NOTES:**

1. The Model 3499 attenuator is an 11-bit digital attenuator. In order to use this device with a lesser number of bits (lower resolution), the user may simply ground the logic pins for the lowest order unused bits. For example, when operated as an 8-bit unit, the Model 3499 would have Pin 15, Pin 1 and Pin 2 connected to ground. All other parameters remain unchanged.

2. Normally supplied as an Analog input. Optionally available as a strobe latch function for input data.

3. Pin 3 is available to apply a current or voltage to control the attenuator in a non-linear fashion. Leave pin open circuited if not using.
Series 90
Millimeter Wave SPST Switches

- 18 to 40 GHz frequency range
- Low VSWR and insertion loss
- Up to 75 dB isolation
- Less than 10 nsec rise and fall times

**SERIES 90**

Series 90 switches provide high performance characteristics over the frequency range of 18 to 40 GHz. These miniature switches measure only .75" x .95" x .42".

The series uses an integrated circuit assembly of up to four PIN diodes mounted in a microstrip transmission line. The circuit configuration is shown in Fig. 1, below.

Application of a positive current to the bias terminal switches the unit OFF since the diodes are biased to a low resistance value. With zero or negative voltage at the bias terminal, the diodes are biased to a high resistance and the unit is switched ON.

**SERIES F90**

The Series F90 switches are the same as the corresponding Series 90 models except the units are equipped with integrated drivers as shown in Fig. 2.

The proper current required to switch the unit ON or OFF is provided by the integral driver which is controlled by an external logic signal. Maximum rise and fall times are less than 10 nsec.

---

**Fig. 1—Series 90 SPST schematic diagram.**

**Fig. 2—Series F90 SPST schematic diagram.**
### PERFORMANCE CHARACTERISTICS

<table>
<thead>
<tr>
<th>MODEL NO.(1)</th>
<th>CHARACTERISTIC</th>
<th>FREQUENCY (GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>18-26.5</td>
</tr>
<tr>
<td>9012, F9012</td>
<td>Min. Isolation (dB)</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Max. Insertion Loss (dB)</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>Max. VSWR (ON)</td>
<td>2.0</td>
</tr>
<tr>
<td>9013, F9013</td>
<td>Min. Isolation (dB)</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Max. Insertion Loss (dB)</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Max. VSWR (ON)</td>
<td>2.0</td>
</tr>
<tr>
<td>9014, F9014</td>
<td>Min. Isolation (dB)</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Max. Insertion Loss (dB)</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>Max. VSWR (ON)</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Rise and Fall Times .......... 10 nsec max.
Switching Time................ 20 nsec max.
Repetition Rate ............... 20 MHz max.

**POWER SUPPLY REQUIREMENTS**

**Driverless Units**
- For rated isolation .......... +35 mA
- For rated insertion loss .... −10V

**Units With Integrated Drivers**
- +5V ±2%, 65 mA
- −12 to −15V, 20 mA

(1) Models prefixed with “F” are equipped with integrated TTL-compatible drivers; models without the “F” prefix are current-controlled units and are furnished without drivers.

### CONTROL CHARACTERISTICS

**Control Input Impedance**
- TTL, advanced Schottky, one unit load. (A unit load is 0.6 mA sink current and 20 µA source current.)

**Control Logic**
- Logic “0” (−0.3 to +0.8V) for switch ON and Logic “1” (+2.0 to +5.0V) for switch OFF.

### ENVIRONMENTAL RATINGS AND AVAILABLE OPTIONS

See page 175.

### DIMENSIONS AND WEIGHT

Dimensional Tolerances, unless otherwise indicated: XX ±.02; XXX ±.005
Series 90
Millimeter Wave SP2T Switches

REFLECTIVE SP2T SWITCHES

Series 90 SP2T switches use an integrated assembly of PIN diodes mounted in a microstrip transmission line in a series-shunt arrangement as shown in Figure 1.

When applying positive current (by the driver), the associated port is OFF since the corresponding shunt diodes are biased to a low resistance and the series diode to a high resistance. With negative current at the bias terminal converse conditions are established and the port is ON. All models are supplied with integrated drivers. Standard units are supplied with logic that turns a port ON with the application of a logic “0” control signal. Maximum rise and fall times are less than 10 nsec.

- 18 to 40 GHz frequency range
- Rise and fall times less than 10 nsec
- Low VSWR and insertion loss
- Up to 65 dB isolation
PERFORMANCE CHARACTERISTICS

<table>
<thead>
<tr>
<th>MODEL NO.</th>
<th>CHARACTERISTIC</th>
<th>FREQUENCY (GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>18-26.5</td>
</tr>
<tr>
<td>F9021</td>
<td>Min. Isolation (dB)</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Max. Insertion Loss (dB)</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Max. VSWR (ON)</td>
<td>2.1</td>
</tr>
<tr>
<td>F9022</td>
<td>Min. Isolation (dB)</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Max. Insertion Loss (dB)</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>Max. VSWR (ON)</td>
<td>2.2</td>
</tr>
<tr>
<td>F9023</td>
<td>Min. Isolation (dB)</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Max. Insertion Loss (dB)</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Max. VSWR (ON)</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Rise and Fall Times ............ 10 nsec max.
Switching Time .................. 25 nsec max.
Repetition Rate .................. 20 MHz max.

Power Handling Capability
Without Performance
Degradation ......... 1W cw or peak
Survival Power .......... 1W average, 75W peak
(1 µsec max. pulse width)

Power Supply
Requirements .......... +5V ±2%, 75 mA
                      −12 to −15V, 50 mA

CONTROL CHARACTERISTICS
Control Input
Impedance .......... TTL, advanced Schottky, one unit load. (A unit load is 0.6 mA sink current and 20 µA source current.)

Control Logic .......... Logic “0” (−0.3 to +0.8V) for port ON and Logic “1” (+2.0 to +5.0V) for port OFF.

ENVIRONMENTAL RATINGS AND AVAILABLE OPTIONS
See page 175.

DIMENSIONS AND WEIGHT

SERIES F90
Wt. 1 oz. (28 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ±.02; .XXX ±.005
The 3 dB Quadrature Coupler is a four port device covering the frequency range of 18 to 40 GHz. The coupler design is a single section Hopfer coupler which has been optimized to perform in the millimeter frequency range. See Fig. 1. It offers excellent amplitude and phase balance as well as low loss and high isolation. The 3 dB Quadrature Coupler utilizes removable connectors for easy integration into coaxial millimeter wave systems.

### SPECIFICATIONS

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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<tbody>
<tr>
<td>Frequency (GHz)</td>
<td>18-40</td>
</tr>
<tr>
<td>Min. Isolation (dB)</td>
<td>14</td>
</tr>
<tr>
<td>Max. Insertion Loss (dB)</td>
<td>1.5</td>
</tr>
<tr>
<td>Max. VSWR</td>
<td>1.8</td>
</tr>
<tr>
<td>Amplitude Balance (dB)</td>
<td>±1.7</td>
</tr>
<tr>
<td>Phase Balance deg.</td>
<td>±10</td>
</tr>
<tr>
<td>Power Handling, operating and survival, cw or peak</td>
<td>2W</td>
</tr>
</tbody>
</table>

Environmental Rating see page 175.
ENVIRONMENTAL RATINGS
 Operating Temperature Range

Series 90
 With Drivers ........... –65°C to +110°C
 Without Drivers .... –65°C to +125°C

Model 1959 ............... –54°C to +125°C
 Model D1959 ............. –54°C to +110°C
 Model 7050 ............... –65°C to +125°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

AVAILABLE OPTIONS

<table>
<thead>
<tr>
<th>Option No.</th>
<th>Description</th>
<th>MODEL(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Option No.</td>
<td>1959</td>
</tr>
<tr>
<td>3</td>
<td>SMA female bias/control connectors</td>
<td>✓</td>
</tr>
<tr>
<td>7</td>
<td>Type K male RF connectors</td>
<td>✓</td>
</tr>
<tr>
<td>7A</td>
<td>J1 type K male; J2 and J3 type K female</td>
<td>✓</td>
</tr>
<tr>
<td>7B</td>
<td>J1 type K male; J2 and J3 type K male</td>
<td>✓</td>
</tr>
<tr>
<td>9</td>
<td>Inverse control logic; logic “0” for port OFF and logic “1” for port ON</td>
<td>✓</td>
</tr>
<tr>
<td>10</td>
<td>One type K male (J1) and one type K female (J2) RF connector</td>
<td>✓</td>
</tr>
<tr>
<td>27</td>
<td>Single-port toggle control; logic “0” connects J1 to J2</td>
<td>✓</td>
</tr>
<tr>
<td>33</td>
<td>EMI filter solder-type bias/control terminals</td>
<td>✓</td>
</tr>
<tr>
<td>61</td>
<td>20 dB/volt transfer function with 0 to +3V control signal input</td>
<td>✓</td>
</tr>
<tr>
<td>62</td>
<td>±15 volts operation</td>
<td>✓</td>
</tr>
<tr>
<td>64</td>
<td>SMC male bias/control connectors</td>
<td>✓</td>
</tr>
<tr>
<td>64A</td>
<td>SMB male bias/control connectors</td>
<td>✓</td>
</tr>
</tbody>
</table>

(1) See page 167 for Model 3499 digital attenuator.
(2) Not applicable for units without drivers.