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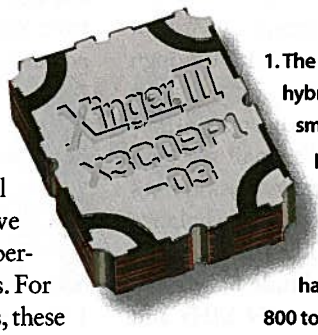
SMT Couplers Build On Legacy

The third generation is a charm for the Xinger lines of surface-mount couplers, which boast improved loss and power-handling characteristics than their equivalent-sized predecessors.

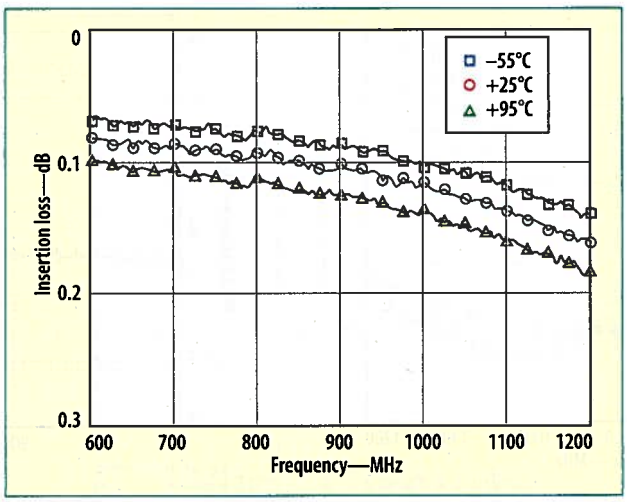
Generational improvements in product lines are often incremental in nature, especially for passive components. But for the third generation of Xinger hybrid and directional couplers from Anaren (www.anaren.com), the improvements from the first- and second-generation products are dramatic, with significantly less insertion loss and greatly improved power-handling capability per square inch. The new patent-pending Xinger-III surface-mount-technology (SMT) products include seven hybrid couplers and five directional couplers for applications from 600 to 2900 MHz.

Introduced in 1993, the original Xinger passive components are still in use today. These multilayer stripline components were impressive then for their low loss and power-handling capabilities in small surface-mount packages. Performance improvements were evident in the second generation, the Xinger-II components, introduced in 2004, and with the evolution of smaller versions of the passive components, such as the Pico Xinger components in packages measuring only 0.25 x 0.20 in.

Based on proprietary multilayer stripline technology, the third-generation Xinger components take advantage of improving materials technologies, such as high-frequency laminates with enhanced thermal capabilities and excellent z-axis coefficient of thermal expansion (CTE), to achieve improved levels of coupler performance in smaller packages. For the Xinger-III hybrid couplers, these improvements translate into as much as 66 percent lower insertion loss than current Xinger hybrid couplers with the same size footprint, and more than 5 times the power-handling capability of current Xinger hybrid couplers of the same size. In fact, compared to older Xinger hybrid couplers of equivalent power-handling capability, Xinger-III hybrids are just one-quarter their size. The new Xingers also boast more than 25 percent higher isolation when compared to first- and second-generation Xingers of the same size, and significantly better amplitude balance compared to any of the older Xinger hybrid couplers. The new Xinger-III hybrid couplers measure 0.250 x 0.200 in.



1. The X3C09P1-03S 3-dB hybrid coupler is one of the smaller of the Xinger-III passive components, measuring just 0.25 x 0.20 x 0.04 in. but providing generous power-handling capabilities from 800 to 1000 MHz.



2. The specified insertion loss for the X3C09P1-03S 3-dB hybrid coupler is 0.22 dB from 800 to 1000 MHz.

The new Xinger-III directional couplers provide the same directivity as older Xinger directional couplers, but at a fraction of the size. They have less than 37 percent the insertion loss of their precessors, with about 50 percent more power-handling capabilities for components that are one-quarter the size of their precessors. The new Xinger-III directional couplers measure just 0.250 x 0.200 in. for 30-dB models and

0.560 x 0.20 in. for 20-dB models.

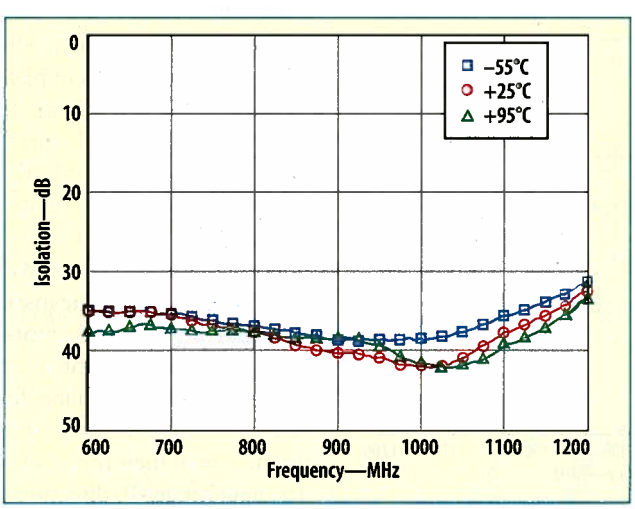
As an example of the Xinger-III hybrid 3-dB couplers, model X3C09P1-03S can be used for power combining and dividing in UMTS applications from 800 to 1000 MHz (***Fig. 1***). It exhibits 0.22 dB maximum insertion loss over its full frequency range and at temperatures from -55 to +95°C (***Fig. 2***), with 0.14 dB maximum insertion loss from 869 to 894 MHz and from 925 to 960 MHz. The tiny 90-deg. hybrid coupler achieves 23 dB minimum isolation from 800 to 1000 MHz, with 25-dB minimum isolation from 869 to 894 MHz and 25 dB minimum isolation from 925 to 960 MHz (***Fig. 3***). The maximum VSWR is 1.15:1 from 800 to 1000 MHz, with maximum VSWR of 1.12:1 from 869 to 894 MHz and maximum VSWR of 1.12:1 from 925 to 960 MHz. Although measuring just 0.25 in. in length, it handles 110 W CW power at all frequencies. The hybrid's small size and carefully controlled transmission lines result in worst-case amplitude balance of ±0.22 dB from 800 to 1000 MHz, with worst-case amplitude balance of ±0.14 dB from 869 to 894 MHz and worst-case amplitude balance of ±0.14 dB from 925 to 960 MHz. The phase balance is within ±4 deg. of 90 deg. from 800 to 1000 MHz, within ±2 deg. of 90 deg. from 869 to 894 MHz and within ±2 deg. of 90 deg. from 925 to 960 MHz (***Fig. 4***). The Xinger-III hybrid coupler is compatible with a wide range of printed-circuit-board (PCB) materials, including FR-4, G-10, and RO4003 laminates from Rogers Corporation (***www.rogerscorp.com***).

Table 1. Xinger-III hybrid couplers at a glance.

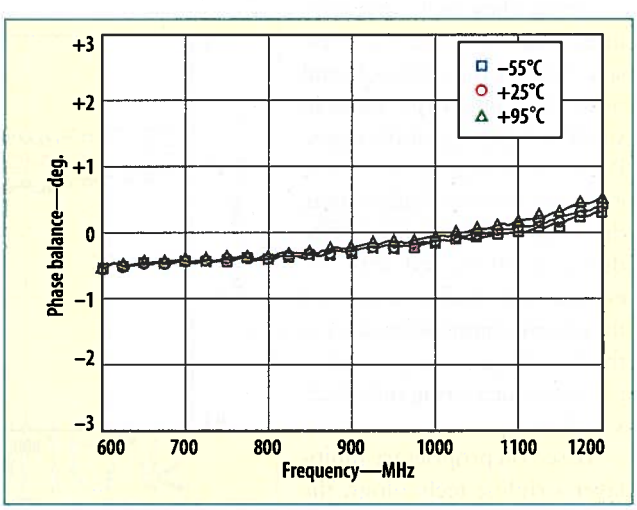
MODEL	FREQUENCY RANGE (MHz)	INSERTION LOSS, MAX. (dB)	ISOLATION, MIN. (dB)	POWER-HANDLING CAPABILITY, CW (W)
X3C07P1-03	600 to 900	0.20	23	130
X3C09P1-03	800 to 1000	0.22	23	110
X3C09P2-03	800 to 1000	0.20	23	187
X3C19P1-03	1700 to 2000	0.22	23	100
X3C19P2-03	1700 to 2000	0.22	23	176
X3C21P1-03	2000 to 2300	0.22	23	100
X3C21P2-03	2000 to 2300	0.20	23	150

The company also offers the X3C09P2-03S hybrid coupler with slightly less insertion loss (0.20 dB) from 800 to 1000 MHz and increased power-handling capability of 187 W (***see Table 1***). It also measures only 0.25 x 0.20 in. For higher-frequency applications, the model X3C19P2-03S 3-dB 90-deg. hybrid coupler can handle 176 W CW input power, for UMTS frequencies from 1700 to 2000 MHz. It features maximum insertion loss of 0.22 dB from 1700 to 2000 MHz, with only 0.12 dB insertion loss from 1805 to 1880 MHz and from 1930 to 1990 MHz. It achieves 23 dB minimum isolation from 1700 to 2000 MHz, with minimum isolation of 25 dB from 1805 to 1880 MHz and from 1930 to 1990 MHz. The maximum VSWR is 1.15:1 across the full 300-MHz operating bandwidth, and no worse than 1.12:1 in the UMTS transmit and receive bands. The full-band amplitude balance is ±0.22 dB, with performance of ±0.10 dB from 1805 to 1880 MHz and from 1930 to 1990 MHz. The full-band phase balance is within ±4 deg. of 90 deg. from 1700 to 2000 MHz, and within ±2 deg. of 90 deg. from 1805 to 1880 MHz and from 1930 to 1990 MHz.

Model X3C09P2-30S is one of the Xinger-III directional couplers (***see Table 2***), designed for AMPS cellular applications from 700 to 1000 MHz. It has a 30-dB coupling factor and maximum insertion loss of only 0.1 dB across its full 300-MHz bandwidth. The maximum insertion loss is only 0.075 dB from 869 to 894 MHz and from 925 to 960 MHz. The component maintains minimum directivity of 20 dB from 700 to 1000 MHz with mean coupling within ±1.5 dB of 30 dB. The maximum VSWR is 1.15:1, with VSWR of only 1.12:1 from 869 to 894 MHz and from 925 to 960



3. The specified isolation for the X3C09P1-03S 3-dB hybrid coupler is at least 23 dB from 800 to 1000 MHz.



4. The phase balance of the X3C09P1-03S 3-dB hybrid coupler is specified as within ±4 deg. of a nominal 90 deg. from 800 to 1000 MHz.

MHz. The 30-dB coupler is rated for 225 W maximum CW power from -55 to +95°C and measures 0.25 x 0.20 in.

For higher-frequency use, model X3C19E2-20 is a Xinger-III 20-dB directional coupler that can handle 225 W CW input power from 1400 to 2700 MHz in a package measuring just 0.56 x 0.20 in. The mean coupling is 20.3 ± 1.00 dB across the full frequency range, with maximum insertion loss of 0.1 dB and maximum VSWR of 1.22:1. The minimum fullband directivity is 20 dB, with directivity of 25 dB and insertion loss of only 0.05 dB from 1805 to 1880 MHz and from 1930 to 1990 MHz.

All of the Xinger-III components are noteworthy for their good power-handling capabilities for such small parts, although this capability is truly the residue of design. Achieving such high power-handling capabilities requires a thorough understanding of the materials used in the Xinger-III components as well as the thermal mechanisms of passive components subjected to high input power levels. For example, the average or continuous-wave (CW) power-handling capability of a Xinger-III coupler is a function of the internal circuit temperature of the component, the temperature of the mounting interface (to a PCB), the thermal resistance of the component's materials, and the amount of power dissipated within the coupler. A high thermal resistance will yield an excessive temperature rise at high input power levels, and high internal or mounting temperatures can lead to reliability problems. All must be controlled to deliver reliable operation at high average power levels. All of the Xinger-III coupler designs have been studied with finite-element (FE) electromagnetic (EM) simulation software to better understand the thermal mechanisms at high power levels, and to calculate the unit thermal resistance based on material properties, circuit geometry, the mounting interface temperature, and the thermal load (the dissipated power). The dissipated power (P_{dis}) within a Xinger-III coupler (in Watts) can be found from

$$P_{dis} = \Delta T/R = P_{in}(1 - 10^{IL_{therm}/10})$$

where

R = the thermal resistance,

ΔT = the change in temperature,

P_{in} = input power, and

IL_{therm} = the thermal insertion loss.

Because the different Xinger-III models incorporate a number of different material combinations and bonding techniques to optimize electrical performance, the maximum allowable circuit temperature will vary from model to

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Table 2. Xinger-III directional couplers at a glance.

MODEL	FREQUENCY RANGE (MHz)	COUPLING FACTOR (dB)	INSERTION LOSS (dB)	DIRECTIVITY (dB)	POWER-HANDLING CAPABILITY (W)
X3C09E2-20	700 to 1000	20±1.0	0.07	20	225
X3C19E2-20	1400 to 2700	20±1.0	0.010	20	225
X3C19P2-30	1400 to 2700	30±1.5	0.10	20	150
X3C09P2-30	700 to 1000	30±1.5	0.10	20	225
X3C26P1-30	2300 to 2900	30±0.8	0.10	20	120

(continued from p. 100)

model. The mounting interface is also critical to achieving maximum power-handling performance, since changes in mounting interface temperature can effect the power-handling capabilities of a Xinger-III coupler.

In addition to the EM simulations, the Xinger-III couplers are fully tested by means of microwave vector network analyzers (VNAs) and specialized test circuit boards. The test circuit boards are fabricated from 0.032-in.-thick RO4003 circuit laminate from Rogers. The laminate has a dielectric constant of 3.38 at 10 GHz and low loss (a dissipation factor of 0.0027 at 10 GHz). It is formed of glass-reinforced hydrocarbon/ceramic material with dielectric constant and physical properties that are stable with frequency and temperature. These microstrip test boards are designed with trace impedances within 50 ± 1 Ω, with discontinuities at the SMA connector to microstrip interface required to be less than an equivalent return loss of 35 dB. The insertion phase of the test board must be less than ±0.50 deg. from the median value of the four signal paths. The average insertion loss of the test board at +25°C is about 0.064 dB from 869 to 894 MHz and 0.136 dB from 2110 to 2170 MHz.

To de-embed the effects of the test board from the Xinger-III under test, a second test board is constructed with a thru microstrip transmission path. It is characterized and subtracted from the test results of the first fixture.

The Xinger-III products are available with an immersion tin finish and can be supplied in tape-and-reel format for automated assembly equipment. They are manufactured on circuit materials with CTE in the x- and y-axis from 17 to 25 PPM/°C to minimize solder joint stress with most PCB substrates. **Anaren Microwave, Inc., 6635 Kirkville Rd., E. Syracuse, NY 13057; (315) 432-8909, (800) 544-2414, FAX: (315) 432-9121, Internet: www.anaren.com.** MRF