

Application Note on

DO IT YOURSELF LOW-COST DIRECTIONAL COUPLERS

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Do it yourself low-cost Directional Couplers

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Introduction:

Ever expanding applications of RF and Microwaves for Wireless and Cable applications have revived the development efforts of components at these frequencies. There is a continuing demand to reduce the cost and increase the performance and quality at the same time. Mini-Circuits is working to satisfy these goals and has introduced a new Directional Couplers series to satisfy the demands of the market. These couplers are designed to need only commercially available low-cost off-the-shelf chip resistors as external components, and are designed for automated manufacturing to achieve low overall cost.

What Constitutes a Directional Coupler :

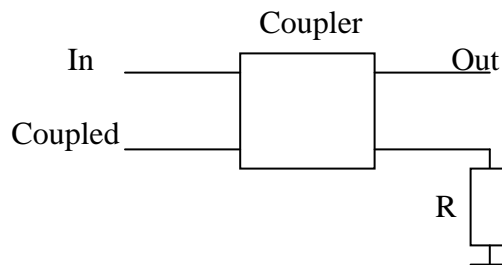


Fig.1 Block Schematic of a Directional Coupler

Fig 1 is the block schematic of a Directional Coupler. The heart of the coupler is supplied by Mini Circuits as a component. When used with one external chip component a resistor **R** a complete coupler is realized. Mini-Circuits has released a series of couplers for both 50 and 75 ohm operation. These couplers have prefix “TCD” in their model number.

Construction of the "TCD" device

TCD-series couplers use one ferromagnetic core transmission line transformer to realize a directional coupler. The base of the device is made of plastic with embedded leads, which makes the construction very rugged. The leads are solder plated for excellent solderability. All connections from the transformers to the header are made by welding. This helps to ensure preciseness of the assembly, with resulting high performance repeatability, as well as preventing any disconnection during reflow.

Performance of the Coupler

Mini-Circuits has introduced 9 couplers, covering the frequency range of 5 to 1000 MHz. TCD-13-4 is designed for 50 ohm and TCD-13-4-75 is a 13 dB coupler for 75 ohm characteristic impedance. **Fig 2** is a photograph of the coupler and **Table I** gives the specifications. Also shown in Table I are the specifications for couplers of other coupling values. **Fig 3** shows the insertion loss of TCD-13-4-75. The insertion loss of the coupler is typically 0.9 dB over the band. **Fig 4** shows the directivity vs. frequency, which is typically 15 dB over the band. **Fig 5** shows the coupling vs. frequency, which is typically 13 dB over the frequency. **Fig 6** shows return loss vs. frequency at all three ports, which is typically 20 dB (VSWR, 1.22:1). Circuit board layout plays an important part in the performance of the coupler. In order to minimize parasitic effects, the suggested layout shown in **Fig 7** should be used. This series needs only an external resistor of 0805 size. The chip resistor should have a nominal value of 75 or 50 ohms for TCD-13-4-75 and TCD-13-4 respectively. Actual data of other couplers shown in table I can be viewed instantly at <http://www.minicircuits.com>

Conclusion

Nine couplers have been introduced to operate over 5-1000 MHz. Due to all-welded connections the couplers are very rugged. The product has been designed to be manufactured in automated set-ups which helps lower the cost. Further cost reduction is obtained by designing the unit to work with a low-cost off-the-shelf chip resistor used as external component. These units are designed for automated pick and place manufacturing.

**Table I
ELECTRICAL SPECIFICATIONS**

MODEL NO.	FREQ. RANGE (MHz)	COUPLING (dB)		MAINLINE LOSS (dB)						DIRECTIVITY (dB)						VSWR (:1)	POWER INPUT, W		RESIS-TOR (Ω)	
		Nom.	Max. Flatness	L		M		U		L		M		U			Typ	L Max.		MU Max.
				Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Min.	Typ.	Min.	Typ.	Min.					
TCD-9-1W	5-750	8.9±0.5	±0.5	1.2	2.1	1.2	1.8	1.5	1.9	21	17	17	10	15	-	1.30	0.5	1	50	
TCD-9-1W-75	5-500	8.9±0.5	±0.5	1.3	2.1	1.2	1.8	1.3	1.9	21	17	17	10	12	-	1.30	0.5	1	75	
TCD-10-1W	10-750	10.3±0.5	±0.8	1.3	2.1	1.2	1.6	1.4	2.0	22	17	18	14	15	-	1.30	0.5	1	50	
TCD-10-1W-75	10-750	10.5±0.5	±0.7	1.6	2.1	1.4	1.9	1.5	2.0	22	17	18	14	14	-	1.30	0.5	1	75	
TCD-13-4	5-1000	13.0±0.5	±0.6	0.7	1.3	0.7	1.3	0.8	1.5	21	17	18	12	15	-	1.20	0.5	1	50	
TCD-13-4-75	5-1000	13.0±0.5	±0.9	1.0	1.8	0.8	1.3	1.1	1.5	22	17	15	-	12	-	1.20	0.5	1	75	
TCD-18-4	5-1000	17.9±0.5	±0.6	0.7	1.3	0.7	1.1	1.0	1.4	22	11	20	15	18	-	1.20	1	1	50	
TCD-18-4-75	10-1000	18.0±0.5	±0.9	0.9	1.3	0.7	1.2	0.8	1.3	20	15	22	15	18	-	1.20	1	1	75	
TCD-20-4	5-1000	20.0±0.5	±0.8	0.3	0.9	0.4	0.8	0.7	1.1	20	11	21	15	15	-	1.20	1	1	50	

L = low range [f_L to $10 f_L$] M = mid range [$10 f_L$ to $f_U/2$] U = upper range [$f_U/2$ to f_U] Price: \$5.95 (Qty.10-19)

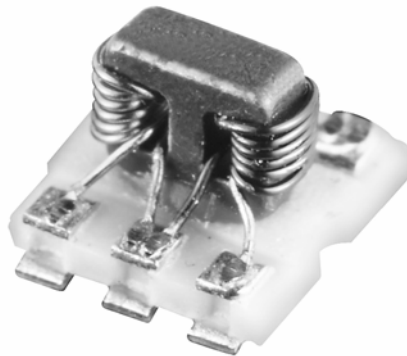


Fig. 2

**TCD-13-4-75
INSERTION LOSS**

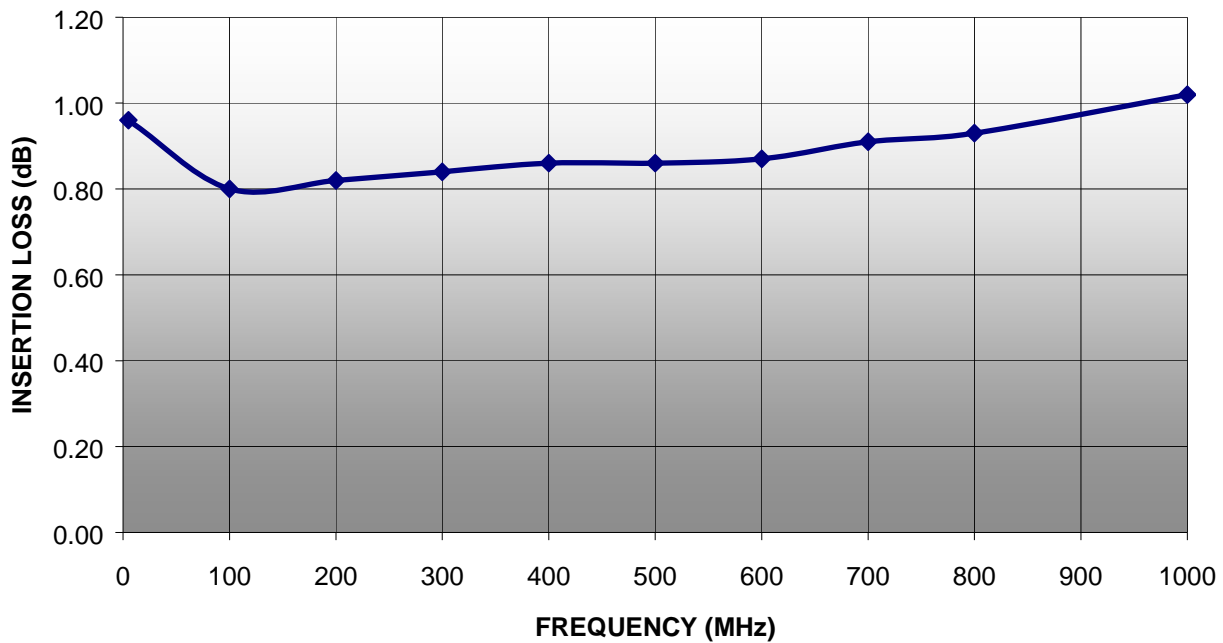


FIG. 3

**TCD-13-4-75
DIRECTIVITY**

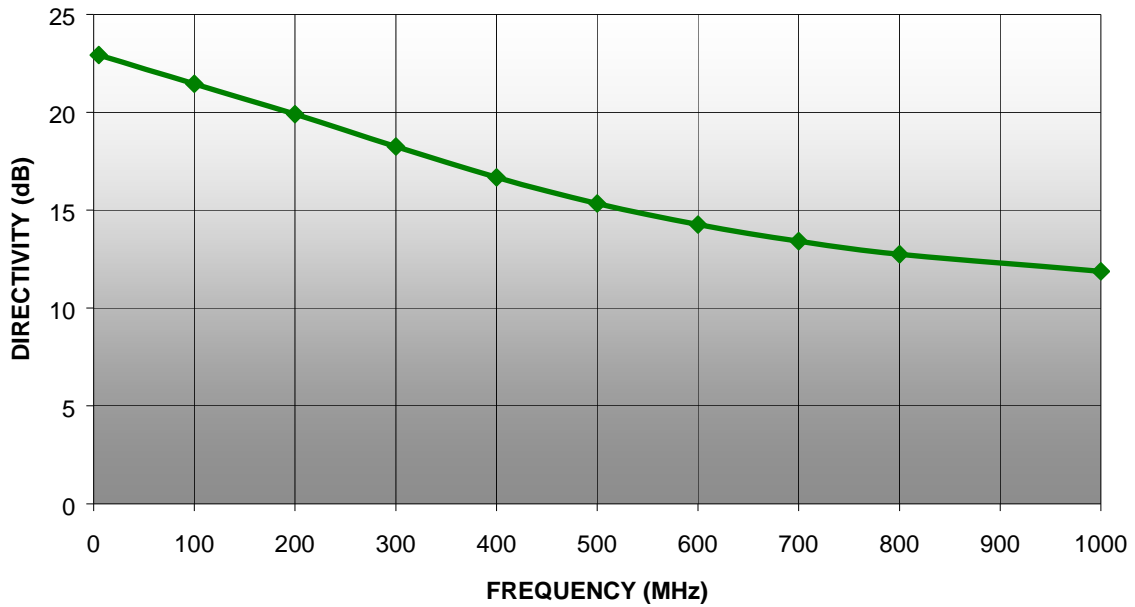


FIG.4

**TCD-13-4-75
COUPLING**

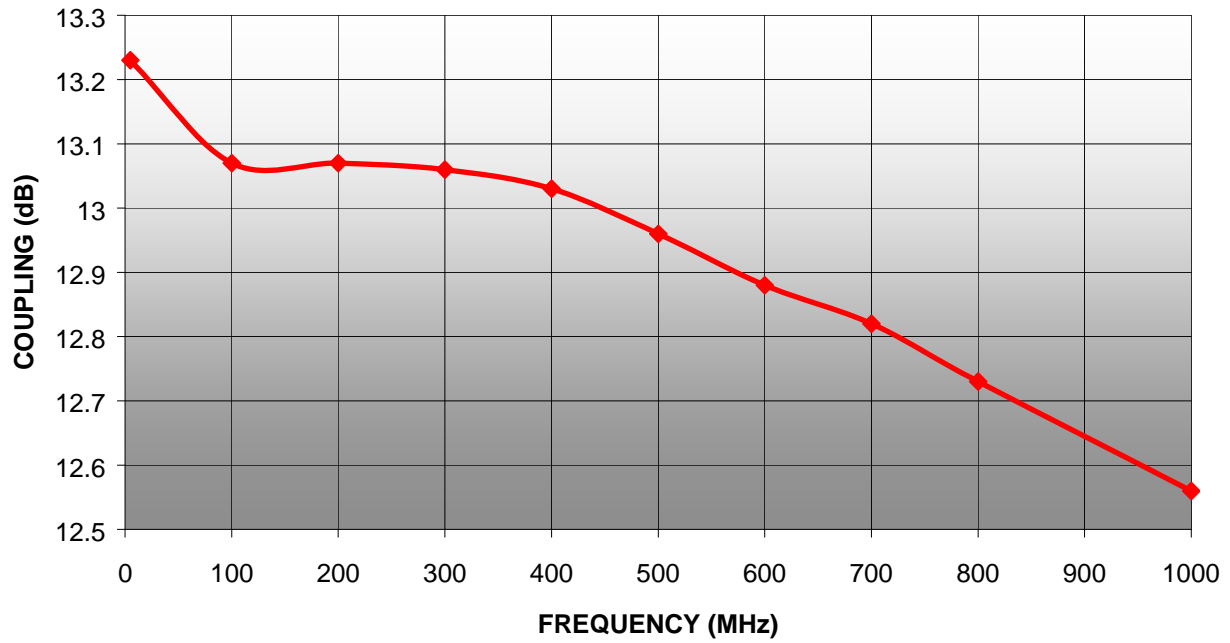


FIG.5

**TCD-13-4-75
RETURN LOSS**

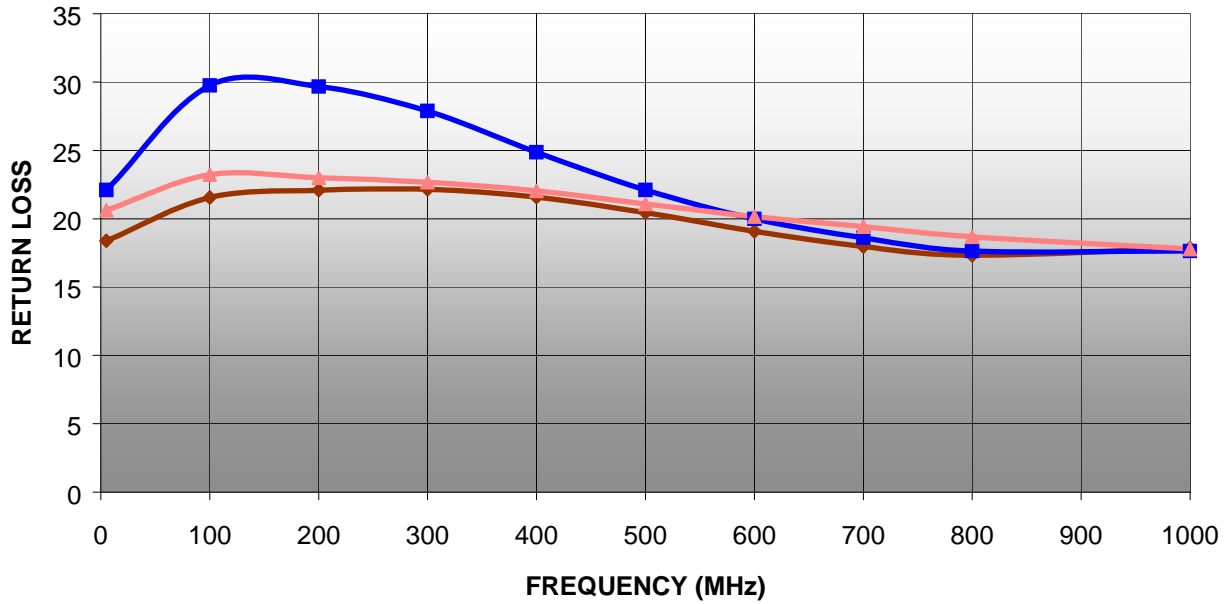


FIG. 6

—◆— IN —■— OUT —▲— CPL

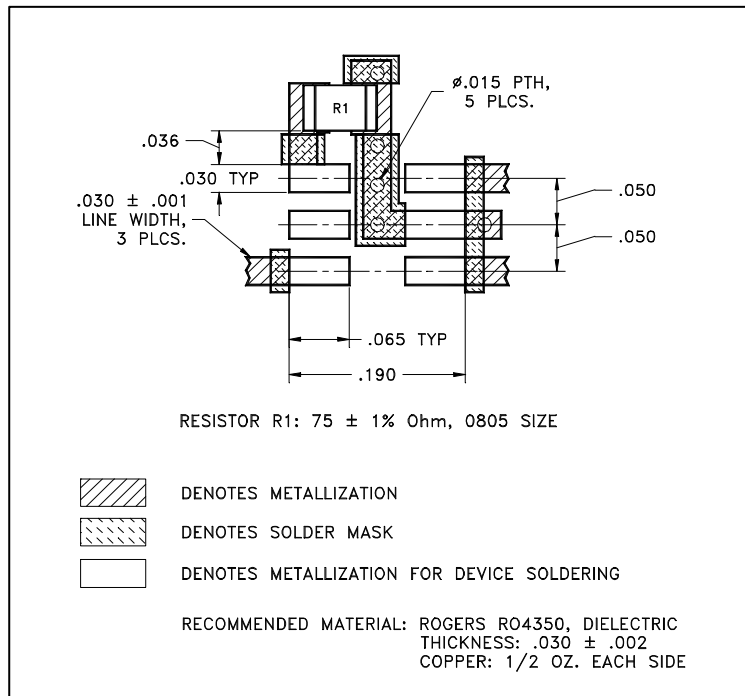


FIG. 7

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