

# ELECRAFT CP1 DUAL DIRECTIONAL COUPLER

Rev A, September 26, 2005

The Elecraft CP1 is a dual directional coupler that provides high directivity, can be internally or externally terminated and can be constructed with a coupling loss of either 20 dB or 30 dB. It can be used to sample a transmitter's forward and reflected power output. For example, it can be used as tap point for IMD measurements in conjunction with the Elecraft 2T-gen (2-tone generator).

## Specifications

Frequency Range	1 MHz to 30 MHz
Coupling Loss	20 dB or 30 dB (29.8) +/- 0.25 dB
Directivity	30 dB typical
Power Rating	30 dB coupler, 250 watts; 20 dB coupler, 25 watts

## Parts List

	(1)	CP1 Printed Circuit Board	E100191
R1, R2	(2)	Resistor, 51-ohm, 3W Resistor	E500178
S1, S2	(2)	Miniature slide switch	E640009
J1-J4	(4)	BNC Connector	E620020
See text	(2)	Toroid Cores, FT50-43	E680008
	(2)	Toroid Cores, FT50A-61	E680025
	(4)	Self-adhesive mounting feet	E700024
	(6 ft.)	#26 red magnet wire	E760002
	(3 in.)	#18 gray insulated wire	E760021

## Assembly

- Before winding the toroid inductors, decide whether you want to construct the CP1 as a 20 dB coupler or a 30 dB coupler. For power levels of 25 watts or less, a 20 dB coupler will result in greater useful measurement range with commonly-used detectors. With power levels higher than 25 watts, a 30 dB coupler will be more useful.
- Use a permanent marker to write the coupling loss in the space provided on the printed circuit board. See the photographs on page 3.
- If you are constructing a 20 dB coupler, 10 turns will be wound on each toroid core. If the coupling is to be 30 dB, then 31 turns will be used. For 10-turn windings, cut two 10 inch (25.4cm) lengths of magnet wire. For 31-turn windings, cut two 30 inch (76 cm) lengths of magnet wire. Note that two types of cores are supplied. The thicker core, E680025 is used for the 30 dB coupler and the thinner core, E680008 is used for the 20 dB coupler.
- Using the photograph as a guide, wind the required number of turns onto the toroid cores. Make sure that the direction of the winding is the same as in the photograph. Turns are counted by the number of times the red enamel wire passes through the *inside* of the toroid. The photograph shows a 10-turn inductor; the 31 turn inductor is identical except for the number of turns. The wire should be evenly spaced around the core and will occupy about 90% of the core.
- Remove the enamel insulation from the ends of the wires. A hot soldering iron, can be used or sandpaper can be used. When the insulation is removed, the ends of the wire should be tinned with a

light coating of solder. The insulation should be removed to within about 1/8 inch (3.2mm) of the core.

- Mount each inductor in its indicated position. When wound and mounted correctly, the enamel wire will emerge from the top of each core and connect to the top hole at each inductor location.
- Cut two 1.5 inch (3.8cm) lengths of the red #18 insulated wire.
- Remove enough insulation from each end so that 5/8 inch (1.6cm) of insulation remains in the center of each wire for a 20 dB coupler or 3/4 inch for a 30 dB coupler.
- Form the wire into a loop, then connect the wire from the pad in the center of each core, over the top of the core and to the pad centered between the enamel wire connections. The wire insulation should rest on the top of the printed circuit board with no bare wire exposed. See the photograph.
- Install R1 and R2 in their indicated positions. The resistors should be spaced about 1/16 (1.6mm) above the printed circuit board.
- Install S1 and S2 in their indicated positions. The switches can be mounted in either direction.
- Install the 4 BNC connectors in their indicated positions.
- Install 4 mounting feet on the back side of the board as shown in the photo.

*This completes assembly of the CP1.*

## **Circuit Description**

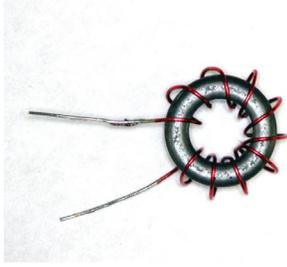
The coupling circuit used in the CP1 is very simple and requires no adjustment. It provides predictable coupling loss and very high directivity. Power flowing from J1 to J2 is sampled by the transformers so that it adds in phase at J3 and cancels at J4. Power flowing from J2 to J1 behaves identically, but in this case adds in phase at J4 and cancels at J3. A more detailed treatment of this circuit can be found in most recent ARRL Handbooks; for example, see the Tandem Match construction article by John Grebenkemper, KI6WX.

## **Application**

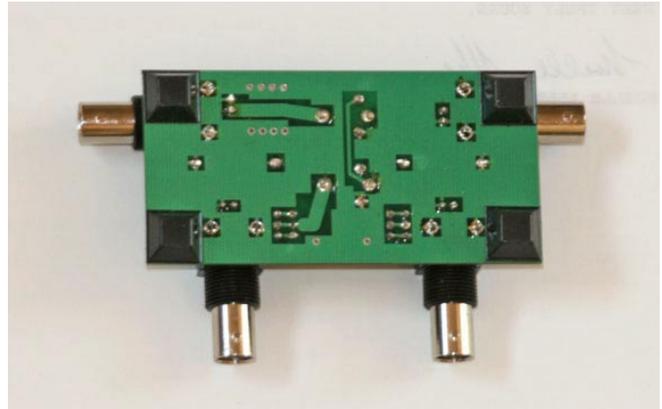
The CP1 is a very useful tool in the ham shack, especially that of a homebrew enthusiast. The CP1 separates the power flowing in each direction on a transmission line. With the two switches in the down position, the power from each direction flows to the connector indicated by the silkscreened arrows. By measuring the power at each connector, an accurate measurement of forward and reflected power can be made. This is very useful when matching an antenna, the input to an amplifier, or other devices. (SWR bridges and power meters use a similar coupler, often with inferior performance, driving a diode detector.)

An ordinary oscilloscope may be connected to the forward power connector and used as a monitor scope. When used with a spectrum analyzer, the CP1 can be used at either port to observe the transmitted spectrum, including IMD if used with the Elecraft 2T-gen or other 2-tone generator. If a sweeper is substituted for the transmitter, then swept-frequency measurements can be made.

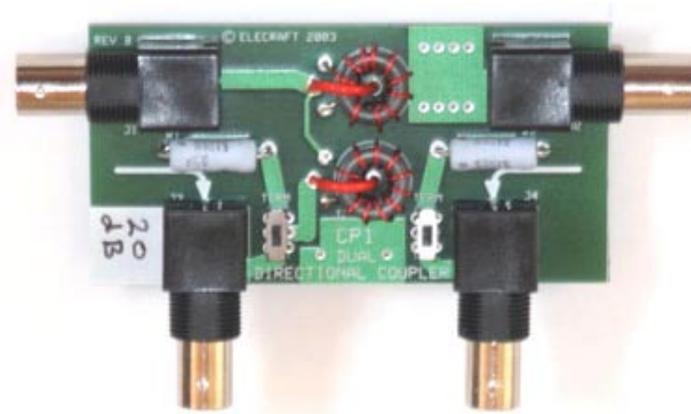
The two switches allow 3-watt 50-ohm terminations to be connected to either RF sampling port. This is useful when simultaneous forward and reverse measurements are not required. For accurate readings when either J3 or J4 is NOT connected to a piece of test equipment, the switch next to the unused BNC connector should be in the UP position to use the internal 50-ohm resistor.



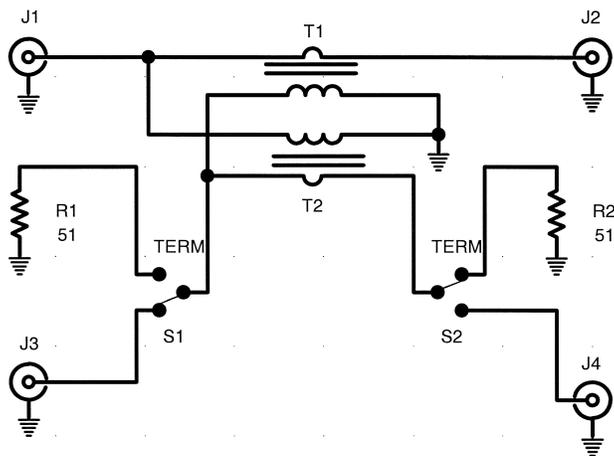
Toroid Wound With 10 turns.



Installation of Mounting Feet



Completed CP1 (20 dB version shown)



CP1 Schematic, rev. A