CPL Technology: An Overview

The CPL is the first, two dimensional (planer), commercially viable compound antenna that is simple to manufacture using conventional PCB processes. CPL Antenna Elements can be embedded into existing applications, directly on an existing substrate or be mounted externally with or without a ground plane. Contained herein is an overview of the capabilities of the antenna and the advantages the CPL has over other, conventional antenna designs.

Conventional Antenna designs come in a variety of sizes, modes and constructs. However, most antennas have one thing in common; they are constructed using a single element to generate a TE wave that propagates electronic energy into free space at a certain resonate frequency. They are electrically fed with voltage and the pattern, efficiency and gain are determined by a number of properties of the antenna design including it physical size, the type of materials used to make the radiating element, the substrate the antenna is mounted on, etc.

A CPL element is constructed of two different types of antennas which excite both the TE and TM modes. In its most basic form, a single CPL element is comprised of a single loop antenna, electrically fed with current from a single point and grounded by the same feed line. When the loop is fed and grounded in this manner, the loop becomes a natural magnetic radiator (TM Mode). Attached to the loop and electrically fed from the loop itself, is an electric field radiator (E Field Radiator), which excites the TE mode. When the two are properly position together in an orthogonal relationship, they will resonate and radiate together to form a more powerful wave at the desired frequency, adding together the power of each radiator. Hence where either antenna on its own may produce 0-2 dbi of gain in an omni-directional pattern, together they will produce 3-5 dbi of gain in an omni-directional pattern, depending on the size, frequency, substrate, etc.

Another quality of using two radiators and exciting both the TE and TM modes is that a CPL Antenna Element, in its optimal size, exhibits very high radiation efficiencies, often above 90%. The optimal size of most CPL Elements is usually less than ½ the height of a ½ wave dipole antenna of a similar frequency range. For instance, a typical 900 MHz ½ wave dipole antenna is about 7 inches in height and requires a similar size ground plane to achieve 40%-50% efficiency and 2.11 dbi of gain. A 900 MHz CPL Antenna element is 3 inches in height, achieves 94% efficiency and produces over 3.5 dbi of gain -and yet requires no ground plane.

As previously mentioned, CPL elements may also include a self contained counterpoise and balun built directly into the artwork. With a self contained counterpoise, no ground plane is required, allowing more freedom in the placement of the antenna within the application. It also reduces the effect that other components may have on the CPL itself and the CPL element is less susceptible to the negative effects when placed in close proximity to human body parts.

The self contained counterpoise, when used in conjunction with the built-in balun, makes tuning the CPL element inside the application much simpler. All that is required from the RF source is an unbalanced 50 ohm trace line. Any tuning that may be required is done within the constructs of the CPL element itself; no changes to the board layout are required and no external discrete components are required.

The advantages of a CPL antenna element are:

- Greater Efficiency in their optimal size
- Higher Gain values from a smaller size
- Physically small size
- Integrated tuning elements
- Reduced cost of manufacturing
- Easy to manufacture using common PCB techniques
- Omni-directional patterns from a planer antenna design
- Able to produce on a number of substrates including FR4, PKF, LDS, etc.
- Ease of integration into applications

Recently, there have been advances in materials and designs that allow antennas to be physically smaller while appearing to be electrically larger. While these methods will allow an antenna to be smaller and produce more gain (depending on a user supplied ground plane), they are usually difficult to manufacture and require the use of expensive and exotic materials and manufacturing techniques. Therefore, because of the specialized manufacturing, these antennas are usually produced by a single manufacturing source and can only be purchased from a single source supplier. Most of these types of antennas require large, user supplied ground planes that demand a great deal of tuning and network matching skills, which can slow development cycles and consume large amounts of real estate while requiring very careful planning when designing the application.

CPL Elements on the other hand can be manufactured as a discrete component, mounted externally or internally or printed directly on to application's substrate using common PCB manufacturing techniques from standard Gerber file format. Because a CPL is able to produce an omni-directional pattern with greater gain without the use of a user supplied ground plane, integrating the antenna into an application is easier than most conventional types of antennas, especially for very small applications were a large ground plane is often unavailable. If minor tuning is required, the CPL can be tuned within itself, requiring no changes to other components within the application.

CPL antenna element comparisons

It is important to understand that a while a CPL antenna element may be physically smaller than a ½ wave dipole antenna, a CPL element is a two dimensional planner antenna that does not require a ground plane and will naturally produce an omni-directional pattern in free space, much like a standard dipole antenna. The combined effects of the two radiating elements and the near perfect impedance matching internally to the design, a CPL will commonly achieve radiation efficiencies in excess of 90% in their optimal size.

In this section, we will compare a CPL antenna element to some embedded and external antennas commonly in use today in various applications.

CPL vs. Patch

It is easy to mistake a CPL Element for a common patch antenna. Both can be easily and inexpensively manufactured onto most substrates in a 2 dimensional configuration using common PCB manufacturing techniques. However, where the patch antenna typically radiates only in one direction, the CPL can be either omni-directional or directional with the application of a rear reflector. In addition, most patch antennas require a much larger surface area to create an antenna with any amount of gain and cannot be scaled down to a smaller size. For instance, a 900 MHz patch antenna on FR4 (4.4 dielectric constant) would be about 8 inches square to produce a peak gain of about 7dbi in a directional pattern. (see figure 1.) The radiation efficiency of this antenna would be approximately 50%.

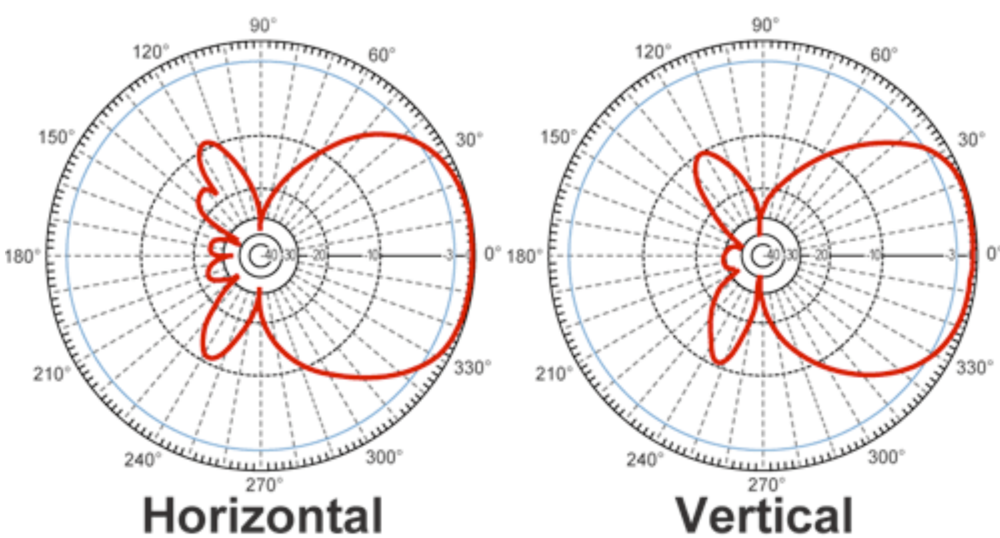


Figure 1

A 915 MHz CPL Element on FR4 would measure about 3 inches square and generate a peak gain of about 3 dbi in an omni-directional pattern. (See figure 2)

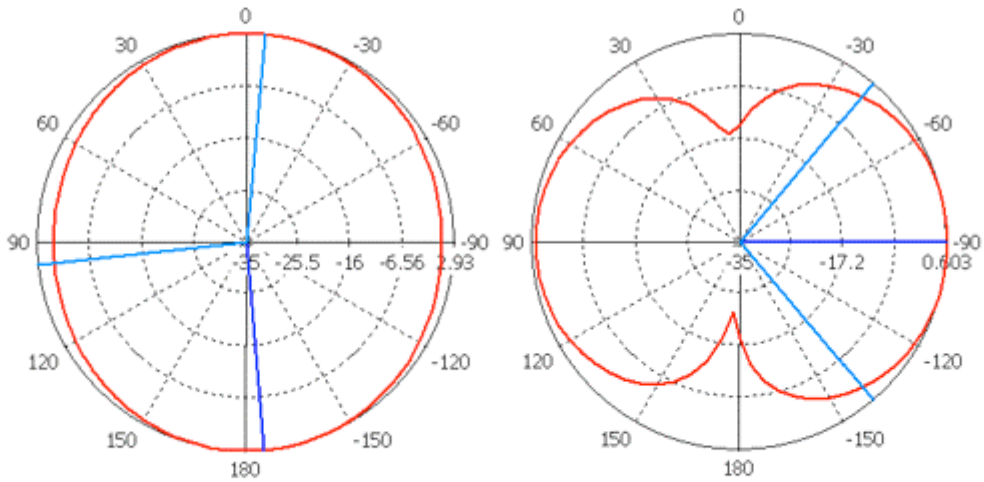


Figure 2

By using a reflector to convert the Omni-direction pattern to directional, the peak gain value of the CPL would be about 5 dbi, still from a single 3 inch square CPL antenna element and adding about 1.5 - 2 inches to the depth of the antenna structure.

900 mHZ CPL Compared to a Patch Antenna on FR4

Antenna	Dockon CPL	Patch
Size	3 inches square (over 7 times smaller)	8 inches Square
Pattern	Omni or Directional	Directional only
Construction	PCB	PCB or Metal Plate
Gain	3dbi omni / 5dbi directional	8dbi directional
Efficiency	92%	>50%
Application placement	Internal, printed on same planer board, no ground plane required or external	Internal – requires a ground plane board behind antenna or external
Tuning	Internal to CPL	External Components

CPL vs. Planer Inverted F Antenna (PIFA)

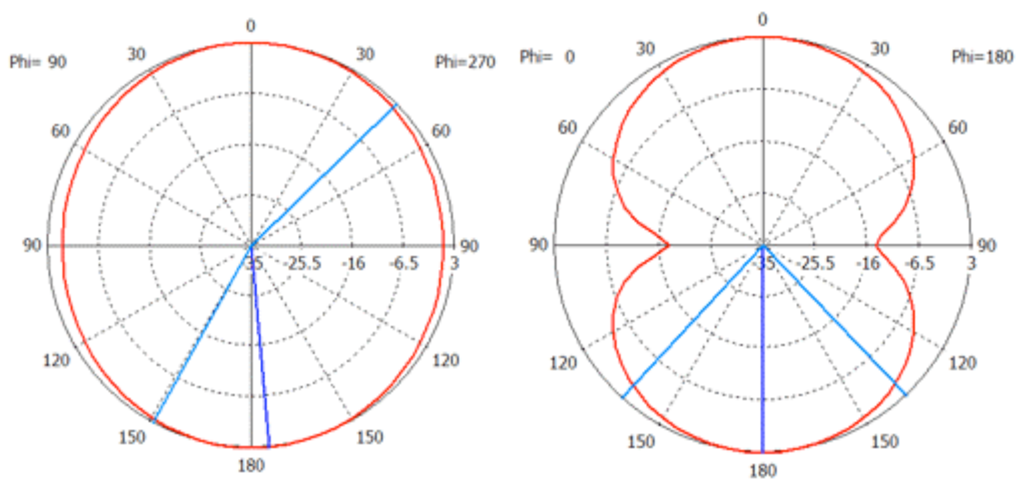
Many mobile applications use PIFA antennas. They are simple and inexpensive to manufacture, can be installed as either a discrete component or printed directly onto the application's planner board. While a PIFA must usually be elevated above the application's planer board for optimal performance, they can usually be made physically small depending on the desired frequency and the amount of ground plane provided by the application. For example, a quarter wave PIFA at 2.4 GHz measures approximately 1 inch long and will require at least 3 inches of ground plane positioned directly below the antenna. In this configuration the PIFA will produce about -2 to 1 dbi of gain with an efficiency of 50% - 60%. The PIFA may be manufactured on a variety of substrates and may be tuned by shorting the PIFA itself and/or by using external tuning components.

The radiation patterns tend to be fairly omni-directional in free space, but are greatly effected by the size and location of the ground plane provided.

A 2.4 GHz CPL element is 1.2 inches high and can be produced directly on the applications planner board. In this size, the CPL does not require ground plane or an external matching network. The CPL will produce over 3 dbi of gain in an omni-directional pattern and have an efficiency of about 94%.

2.4 gHZ CPL Compared to a PIFA Antenna on FR4

Antenna	Dockon CPL	PIFA
Size	1.2 inch square	1.1 inches plus ground plane
Pattern	Omni	Omni
Gain	+3 dbi	-2 to 1 dbi
Construction	PCB	PCB
Efficiency	94%	>60%
Application placement	Internal, printed on same planer board, no ground plane required or as a separate component	Internal – requires a ground plane below antenna and a copper free area below
Tuning	Within the CPL	Internal to PIFA and external components



CPL Radiation Patterns
Figure 2