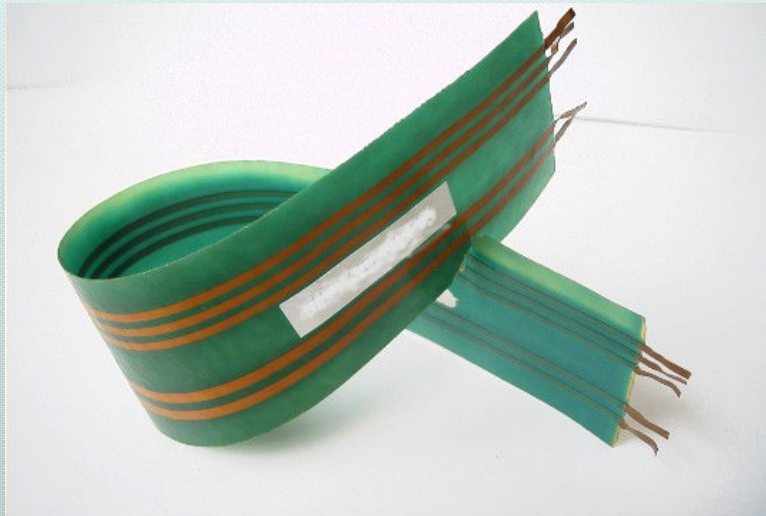


VER3

ALL FR4

XRIGID/BENDFLEX
PRINTED CIRCUIT MANUFACTURING



Robert Tarzwell

January 2009

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The information in this book is current to January 2009. As material specifications and manufacturing practices change and evolve, please ensure you are using up to date information.

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Written by Robert Tarzwell

FOREWORD

The concept of an all epoxy FR4, style bendable circuit has been around for a long time, but until now the product was very fragile and limited as to the number of bends and a minimum radius of those bends. The main problem was the ease at which the FR4 material would tear.

After many experiments and tests, I found a new method to manufacture the material so it would be quite flexible, bend at a smaller radius and be resistant to tearing. The glass cores are smaller than normal printed circuit 7628 glass, and they are laid up at different angles providing substantially more tear resistance while improving the flexibility. The material is considered bendable not flexible, which relates to the number of times and the diameter of the radius that it can repeatedly, move through. To that end, we call our product **Bendable**, so as not to confuse it with flex material. The bendable material is available in .002 to .008 thick single sided or double-sided copper.

If we combine our bendable material with rigid FR4 boards, the result is an inexpensive rigid/ flex type product, called rigid/bendflex. Although not as flexible as Kapton, it will repeatedly bend through a 1/2 inch radius. It is, also able to be twisted. The limitations to the rigid/bendflex product are that it cannot be folded over on itself flat and the voltage dielectric rating of bendflex is not as high as kapton.

The rigid/bendflex circuits are excellent as prototypes and test samples of a new rigid/flex design as our setup and manufacturing costs are less than a flex PCB shop. The rigid/bendflex circuit is, typically used where the base rigid board is attached to a chassis, the second rigid board is also attached to a chassis, and the bend legs attach the two together.

Chapter 1

Overview of Rigid/Bendflex FR4 Circuits

By combining a very particular property of epoxy and a certain thin weave of fiberglass, it results in a very bendable printed circuit board. It is, however, not flexible. By the term bendable, I mean that the circuit can conform to certain shapes, mostly in one plane. A bendable circuit can withstand a reasonable number of flex cycles. However, it is not designed to flex repeatedly. A properly designed and manufactured bendable circuit can bend as far as 360°, in as little as one inch in diameter. Some mechanical attachment device is needed to keep the circuit in the desired shape. Very heavy copper bendable circuits (greater than 6 oz.) will retain a given shape, due to the mechanical retention nature of copper.

Bendable circuits are used in applications where a flat, stiff circuit board will not fit. Typically, bendable circuits are single or double-sided circuits, with simple open designs. Crowded, highly populated circuits do not bend well because the components do not bend. When designing a bendable board, consideration must be given to the placement of the components. All components must be kept clear of the bend lines. If only a small bend is required, some components such as capacitors will only allow a very small radius.

Multi-layers are possible but with limits on layer counts and the amount of bendability desired. As a multi-layer is a composite construction consisting of many layers, it imparts stiffness in the inability of adjoining layers to move in relation to each other. Fingers of bendflex material can be designed in a rigid/bendflex application. One redeeming feature of bendable circuits is their low cost compared to a typical double-sided Kapon flex board. The particular laminate system and processing are considerably less expensive. Typical uses of a bendable circuit are the curved dash in an automobile, round sonar buoys, or connecting two power supplies of different heights.

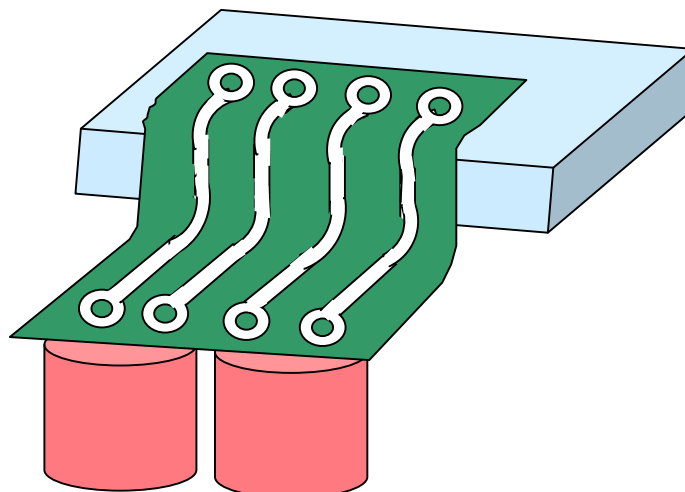


Figure 1: Two power supplies connected together

An additional use of bendable heavy circuit boards is the creation of surface buss bars. By combining the attributes of a bendable board with heavy copper and possibly even designing the fingers to protrude

off the board, a bendable buss bar can snake around the surface, vertically supplying power and carrying heavy currents. The base printed circuit could be a less expensive, 2 oz. or so, board with the bendable power board carrying the current. Thermal dissipation would be increased because the buss bar would be vertical, increasing the thermal shear and airflow. Single, double and multi-layer designs could reduce the clutter and cost of a medium heavy copper circuit.

When designing bendable buss bars, the copper must be thick enough to support the fingers. The fingers would fit into a slot on the baseboard or surface mount by bending the fingers at 90°. The radius of any curve should be at least 50 times the thickness of the substrate. Therefore, a .005" thick buss bar would have a minimum bend radius of $.005" \times 50 = .250"$.

The buss bar can have plated vias, as well as multiple traces and circuitry. Some buss bars have components designed onto the surface, although, they must be placed clear of any bend area. To raise capacitance, the traces can be run parallel to each other on opposite sides of the buss bar. Considerable capacitance can be generated by using thin substrates with wide parallel tracks. To lower the capacitance, run the traces on the same side, or on opposite sides but not directly across from each other.

When a bendable board is used for a buss bar and plated with 10 oz. of copper, it will possess considerable strength. You can bend it into any shape and it will retain the shape, due to the thickness of the copper.



Figure 2: Photo of a typical bendable buss bar

Bendflex circuits can have a reasonable flex cycle life. On the tough .125" mandrel test, a circuit made from a double 106 type prepreg, 1 oz. of RA copper and Kapton cover coat went over 250 cycles before an open stopped the test, more than a double sided Kapton flex circuit. The limiting factor with bendflex FR4 type circuits is that the minimum bend radius is not as small as Kapton flex circuits.

Flex circuits are found throughout electronic devices of all types, makes and operations. The unique problem-solving design capabilities of flex circuits mandates their use in military, automotive, consumer and general electronics. Products that we take for granted in our everyday lives today, would not be possible without the innovative designs that flex circuitry allows. All FR4 bendflex circuits feature many

attributes that are quite usable and can replace many existing and new designs, with a considerably less expensive alternative construction.

Bendflex circuit's most interesting adaptability is in the area of interconnects. The versatility of a bendflex FR4 circuit to fit between and around components while interconnecting many devices still amazes me. Bendflex FR4 circuits provide a cleaner, neater appearance in your assemblies than wire bundles. Designers can think and operate in a true three-dimensional world. With a little imagination, a bendflex FR4 circuit can save an amazing 60% of the space and/or weight, over a conventional rigid board or conventional wiring. In many laboratory tests, bendflex FR4 circuits show greater resistance to the vibration and operation stress of automobiles and airplanes than discrete wiring. Bendflex FR4 circuits offer dependability at a low cost. Recurring tooling costs are quite often lower than many wiring harnesses.

For maximum bendable cycle life, a single sided circuit with thin rolled and annealed copper is used. This very thin circuit is designed to bend many times, when strict rules regarding bend radius and circuit construction are followed. Single sided bendflex circuits are relatively inexpensive because of the few processing steps required and their simple design.

Double-sided circuits can have more conductors and feature plated through holes for interlayer connection but are more expensive and feature reduced bendability. Although, in most situations, the laminated type construction of the double-sided bendflex circuit allows many different types of construction and numerous material/ copper selections. The double-sided bendflex circuit has been widely accepted within the general automotive and commercial electronics marketplace.

Rigid/ flex designs are in the forefront of today's advanced military and space electronic devices. Rigid/flex circuits allow for complete multi board assemblies featuring folded shapes, reliable interconnects, high-speed signal processing, all in one package. Our inexpensive rigid/bendflex can replace many of the existing kapton expensive rigid/flex circuits.

Other new bendflex applications are evolving every day, with ideas such as heavy copper bendflex where part of the circuit features heavy copper for high powered electronics and areas of thin copper for flexibility. Some heavy copper circuits feature fingers that protrude off the board and directly to connectors or other devices.

Bendflex applications in automotive use are now a reality with materials that can bend and retain that shape or can flex a reasonable number of times. Through careful design of the circuit, you can reduce wiring errors in assembly with one way fitting only, applications.

The ability of rigid/bendflex material to withstand harsher environments is enhanced with the addition of our Hi.E.R technology which allows designers new tools for automotive electronics.

Chapter 2

Manufacturing a Bendflex Laminate

To learn the secret how to make bendflex buy this book .