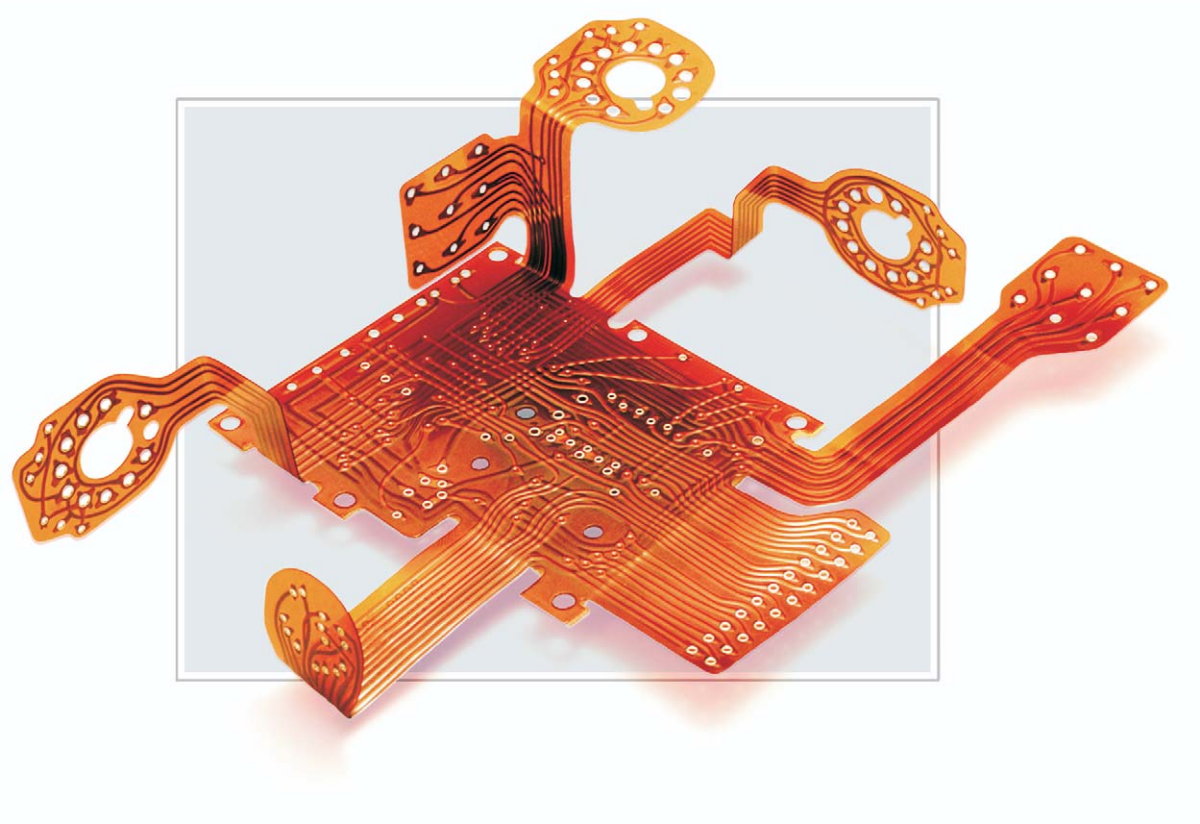
BULLETIN FC-301(A)

FLEX·CIRCUITS



MINCO
PRODUCTS, INC.

Minco:
The preferred source for precision flex-circuits

Minco is a leading supplier of precision flex-circuitry for critical MIL/aerospace and medical devices. We specialize in fine lines, tight tolerances, and exacting quality requirements—the very features you need for today's high-density, high reliability electronics. On many difficult circuit designs, Minco can produce results where others produce rejects.

Our comprehensive capabilities put the full potential of flex-circuit design within your reach. We can furnish single-sided, double-sided, multilayer, and rigid-flex circuits with up to 16 layers. Stiffeners, pins, and connectors are optional. More importantly, we furnish confidence—in quality, in long-term performance, and in adherence to your specifications.

Modern facilities

All engineering and manufacturing of flex-circuits take place at Minco's Minneapolis location. Our facilities include a spacious plant dedicated to flex-circuit fabrication with the stated goal of making our facilities equal to any in the world.

We continually update the plant with precision equipment for drilling, plating, laminating, and trimming circuits. Our engineers and architects design all aspects of the facility, from chemical systems to material handling, to provide you clean, consistent, and cost-effective circuits.

Automation and statistical process control keep productivity high and rejects low. A computerized job scheduling system tracks your order through all phases of production. Computers also link design with production. Minco was one of the first manufacturers to accept CAD-generated artworks on disk or tape, and we now have an extensive CAD network for artwork modification, inspection, and plotting. The same system controls drilling and tooling. Because your circuit stays in digital format from your CAD to our production floor, conductor patterns and dimensions maintain their accuracy.

Minco invites you to tour our plant and see our commitment to state-of-the-art flex-circuit production.

Quality Assurance

Minco circuits excel in applications where quality is the primary consideration. We define quality as conformance to customer requirements; we specialize in accepting and meeting the most difficult of requirements.

You'll find our circuits in:

- Space shuttle engine controls
- Cardiac pacemakers
- Implantable defibrillators
- Trident II missile
- SINCGARS radio
- Mark 46 torpedoes
- Laser gyros
- In-the-ear hearing aids
- Nerve stimulators

Minco's policy is to document, monitor, and verify all processes. We visually inspect all circuits. When required, we also check their dimensions, microsection them, perform first-article inspection, subject circuits to thermal shock and stress, test solderability, check conductor continuity, measure flexibility and peel strength, simulate rework, and determine moisture resistance and dielectric strength. All these tests are performed in-house.

We welcome your quality audits and have special area set aside for inspection.

Minco's Quality Management system is certified to ISO 9001: 2000.

Listed below are specifications which may apply to Minco circuits:

MIL-P-50884C Types 1-5	IPC-MF-150
MIL-Q-9858	IPC-FC-231
MIL-I-45208	IPC-FC-232
MIL-STD-2118	IPC-FC-241
MIL-C-14550	IPC-RF-245
MIL-P-45662	IPC-FC-250
MIL-P-46112	IPC-TM-650
MIL-P-81782	IPC-S-804

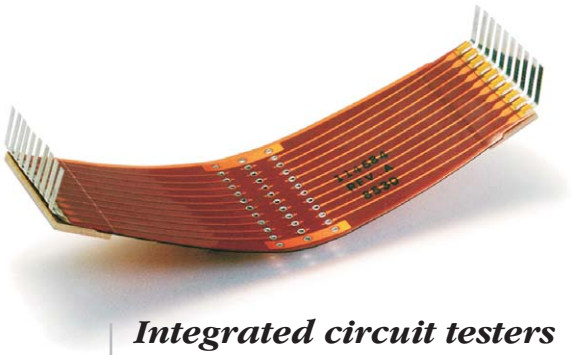
NHB5300.4 (1C and 1B)

FDA Regulation Part 820: Good Manufacturing Practices for Medical Devices

Solving interconnect problems with flex-circuits

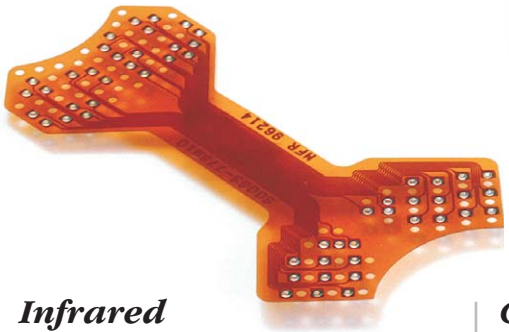
Cardiac pacemakers

As pacemaker functions have grown more sophisticated, many manufacturers have added remote telemetry for two-way communications with the pacemaker's electronics. Mating coils inside and outside the body exchange the signals. This Minco circuit has an integral wire-wound antenna coil in addition to the etched conductors. The package is compact, rugged, and reliable.



Integrated circuit testers

A high speed IC handler must make repeated electrical connections to chip leads as they pass through its test site. The answer is a Minco circuit with welded fingers for contact and shielding for controlled impedance and crosstalk. The circuit can withstand millions of flexures as it opens and closes on IC's.



Infrared detector modules

Forward-looking infrared lends night vision to aircraft, tanks, and foot soldiers. High density signal lines in the sensing module terminate through a fine-line circuit with 0.005" lines and spaces.

Clinical analyzers

A diagnostic chemical analyzer must keep body fluid at a constant temperature during test operations. A Minco heater/sensor/flex-circuit does the job singlehanded. An etched-foil heater warms the sample, a wire-wound resistance thermometer senses temperature, and a flex-circuit provides the link to control electronics.

Military radio

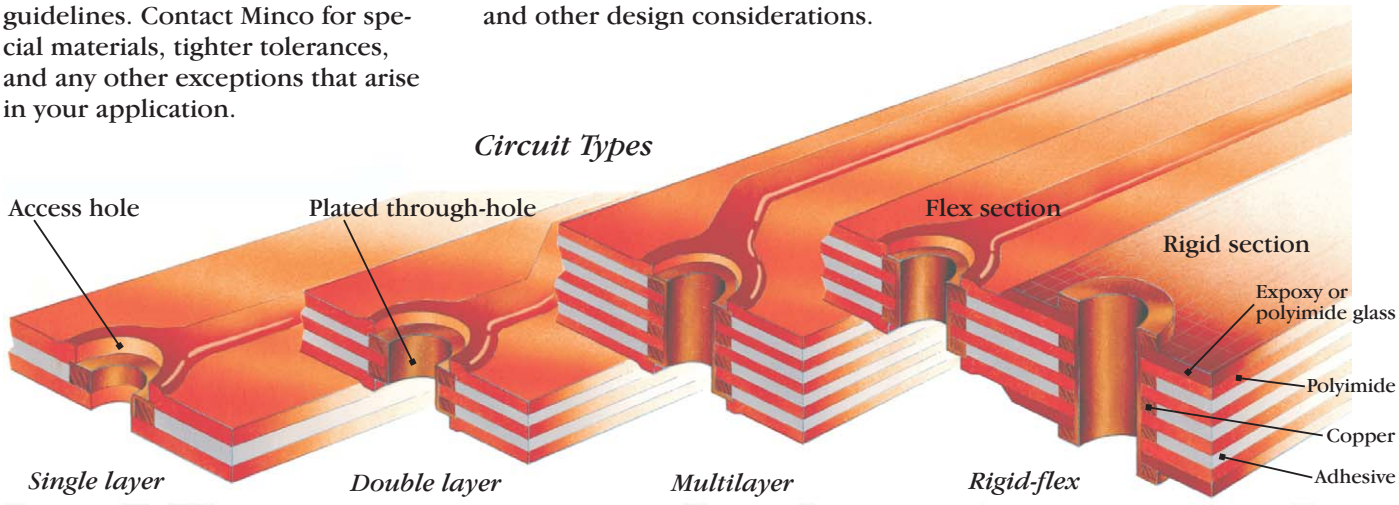
The latest generation of all-purpose military radios have advanced features, compact size, and nearly indestructible construction. State-of-the-art packaging makes it all possible. An example is this Minco circuit, which has two 3-layer arms mated at a single connector.

Capabilities

Listed below are Minco's standard materials and specifications for flex-circuits. These serve only as guidelines. Contact Minco for special materials, tighter tolerances, and any other exceptions that arise in your application.

Minco Application Aid #24, "Flex-Circuit Design Guide," fully specifies dimensional tolerances and other design considerations.

Circuit Types



1. Materials

Substrate:

Polyimide film 0.0005", 0.001", 0.002", 0.003", 0.005" thick.

Teflon 0.001" and 0.002".

Cover insulation:

Same as substrate, or optional UV-cured liquid cover.

Adhesive:

Modified acrylic, epoxy, epoxy prepreg, or phenolic butyral.

Conductors:

Electrodeposited or rolled/annealed copper:
0.5 oz. (0.0007"), 1 oz. (0.0014"), 2 oz. (0.0028"), 3 oz. (0.0042"), or thicker.

Beryllium copper: 0.003" and thicker.

Cupronickel and other metals for special applications.

Stiffeners:

Epoxy-glass (FR-4), polyimide-glass, polyimide, or aluminum.

Hardboards:

Polyimide-glass or epoxy-glass.

Plating:

Copper: To desired thickness. May be applied to entire circuit or terminal areas only (selective plating) for better flexibility.

Solder: To desired thickness. Normally applied by selective coating; plating optional.

Nickel: To desired thickness.

Gold: To desired thickness.

2. Physical Properties

Maximum size:

Standard 10½" × 22" for more than 2 layers

Other sizes available; please inquire.

Tolerance:

See Application Aid #24 for complete dimensional tolerances.

Flexibility:

Single layer circuits: Minimum bend radius 6 times circuit thickness.

Double layer: Minimum bend radius 12 times circuit thickness.

Multilayer: Minimum bend radius 24 times circuit thickness.

One-time bends with sharp creases are possible. Ask Minco about factory forming.

Thickness is approximately 0.006" per circuit layer.

Temperature:

-65 to 150°C (-85 to 302°F). Will withstand a 5 second solder immersion at 260°C (500°F) without blistering, delamination, or discoloration.

Chemical resistance:

No detrimental loss of physical properties when immersed for 15 minutes in acetone, methyl alcohol, toluene, or trichloroethylene.

3. Electrical characteristics

Insulation resistance:

100 megohms minimum at 25°C (77°F), (0.010" minimum conductor spacing.)

Dielectric strength:

1000 VRMS at 60 Hz for 30 seconds, one milliamp maximum leakage current.

Wire coils:

Circuits may contain wire-wound coils for use as antennas or inductors. Typical inductance values range from 10 microhenries to 30 millihenries. Circuit cover encapsulates coils, etched conductors, and coil connections. See Bulletin FC-1 for details.

Shielding:

Specify shield layers in solid or grid patterns. Copper or screened conductive ink.

4. Connections

Interlayer:

Plated through-holes standard.

Components:

Either leaded or surface-mount components acceptable. Large component areas usually require stiffeners. Locating components in flexible areas is permissible if solder joints will not be stressed.

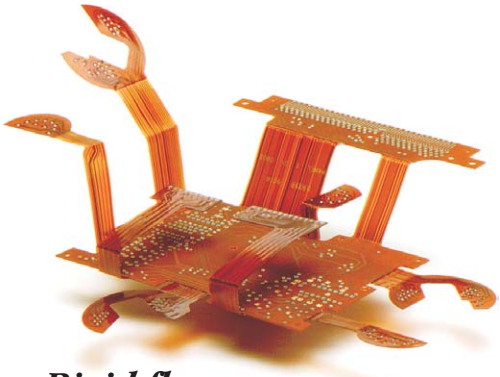
Pins:

Minco can assemble pins to circuits either at right angles (through holes) or in line with conductors at the circuit's edge. Attachment method is swaging/soldering, or brazing for higher temperature rating.

Connectors:

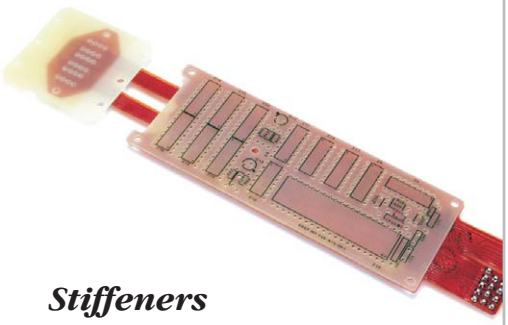
Minco can furnish complete circuit/connector assemblies. Epoxy potting is optional.

Design options



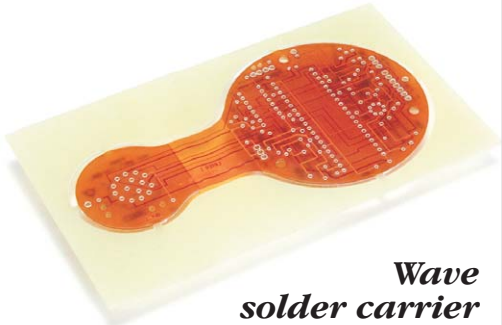
Rigid-flex

Hybrid hardboard/flex-circuits can have up to 16 layers.



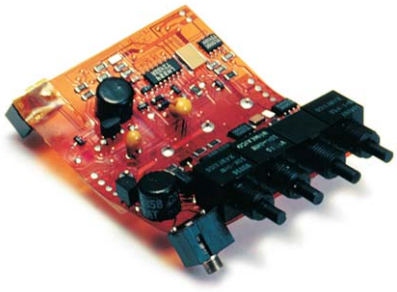
Stiffeners

An inexpensive alternative for rigidizing component areas.



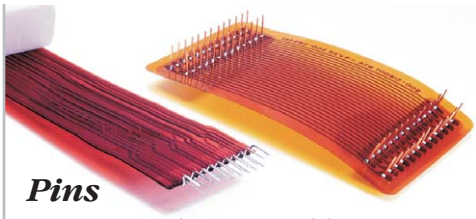
Wave solder carrier

Stiffener material frames the circuit to hold it flat during wave solder. After soldering, just clip out and fold.



Surface mount

Combine the space and weight savings of surface mounting with those of flex-circuits for the ultimate in high-density packaging.

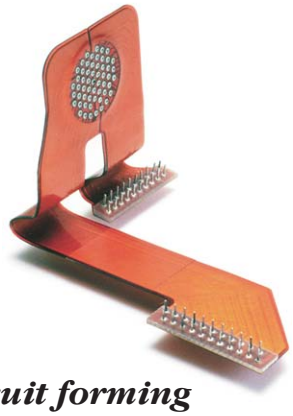


Pins

Minco can braze or solder pins to circuits, either through holes or as extensions to conductors.

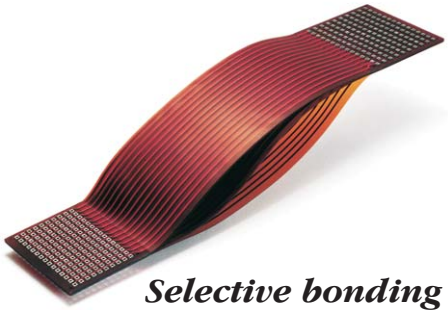
Connectors

Built-in connectors speed your assembly. Optional epoxy potting seals between the circuit and connector.



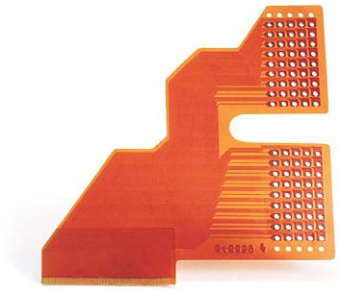
Circuit forming

Factory formed circuits follow tight curves to save space.

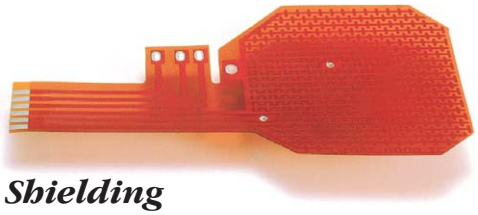


Selective bonding

For better flexibility along circuit arms, individual layers are unbonded and allowed to flex freely. Each layer has its own substrate and cover.

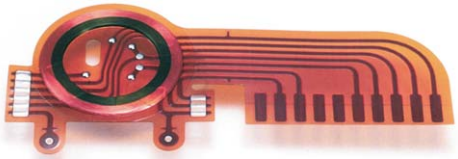


0.003" conductors and spaces are possible.



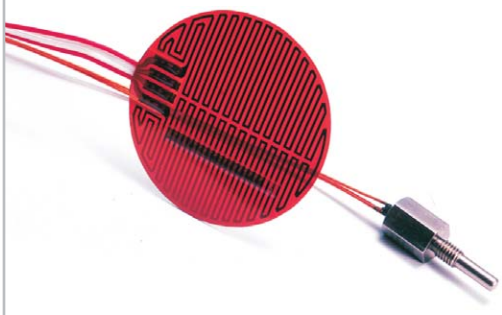
Shielding

Solid or patterned shield planes reduce noise and control impedance of signal lines. Photo etching ensures repeatability.



Coils

Minco has the unique ability to wind flat inductive coils and laminate them within flex-circuits. Applications include pacemaker antennas and eddy current generators.



Minco's other major products are temperature sensors and etched-foil heaters. We can integrate them with flex-circuits for unified temperature control.

Why flex-circuits instead of conventional wiring?

Flex-circuits represent an advanced approach to total electronics packaging. They occupy a niche between ordinary printed circuit hoards and round wire, and take on many of the uses and benefits of each. In essence, flex-circuits give you unlimited freedom of packaging geometry while retaining the precision density, and repeatability of printed circuits.

Flex-circuits have these advantages over wire:

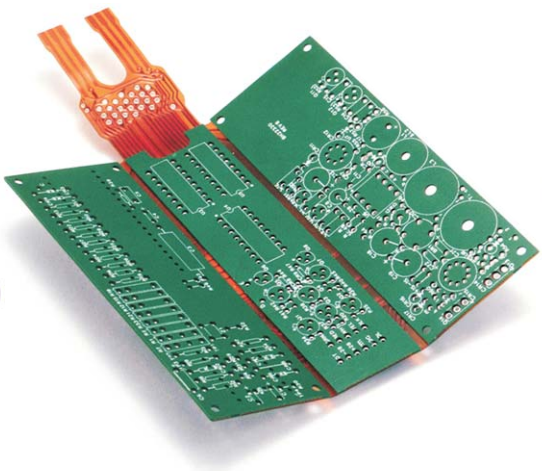
- Because they fit only one way, flex-circuits eliminate wire routing errors. You save testing time, rework, and rejects.
- Flex-circuit conductor patterns maintain uniform electrical characteristics. You can predict and control noise, crosstalk, and impedance.
- Flex-circuits can save 75% on space and weight. A single flex-circuit can replace several hardboards, cables, and connectors.
- Flex-circuits reduce the chance of assembly rejects and in-service failures. Total installed costs are lower, especially with volume production.
- The flat foil conductors of flex-circuits dissipate heat better and carry more current than round wires of the same cross-sectional area.
- Flex-circuits simplify assembly and give a better appearance. There's no need to color code and wrap bundles of wire.

Your answer to common design dilemmas

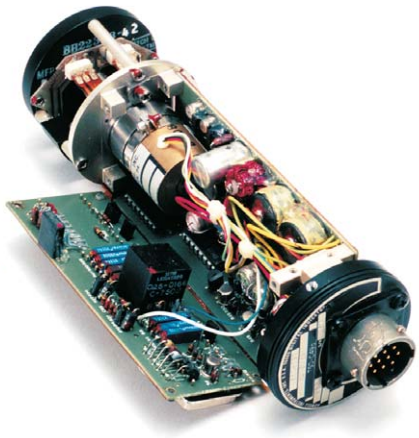
Have you considered all the possible uses for flex-circuits? Here are some ideas:

- Substitute flex-circuits for bulky wire harnesses.
- Replace hardboard/connector/cable assemblies with rigid-flex or flex with stiffeners.
- You can mount components directly to flexible areas in many cases. You can then bend flex-circuits to fit where even the smallest hardboards can't go.
- Use circuits as flexible shields or groundplanes to reduce noise. You can design conductor patterns to block specific types of electrical interference.
- Enhance high-speed signal integrity with matched-impedance flex-circuits.
- Use flex-circuits as miniature jumpers on circuit boards.

Before: A tangle of wires connects four circuit boards in this aircraft gauge.



The flex-circuit solution: A single circuit with three stiffeners provides all the necessary interconnects. Insert components into the flat circuit, solder, and fold.



After: The package is neat, lightweight, and less susceptible to connection failure.

Designing your flex-circuit

1. Gather the necessary literature

Request these guides before starting your design process:

Application Aid #24, "Flex-Circuit Design Guide," contains general design tips, dimensional tolerances, detailed capabilities lists, conductor design data, and artwork layout and submission guidelines.

Bulletin FC-1, "Flex-Coils," offers design assistance and specifications for flex-circuits with integral inductive coils.

2. Determine circuit outlines and conductor routing

The first step in flex-circuit design is to translate schematics and package geometry into flex-circuit outlines and artworks. Paper cutouts are one way to achieve this.

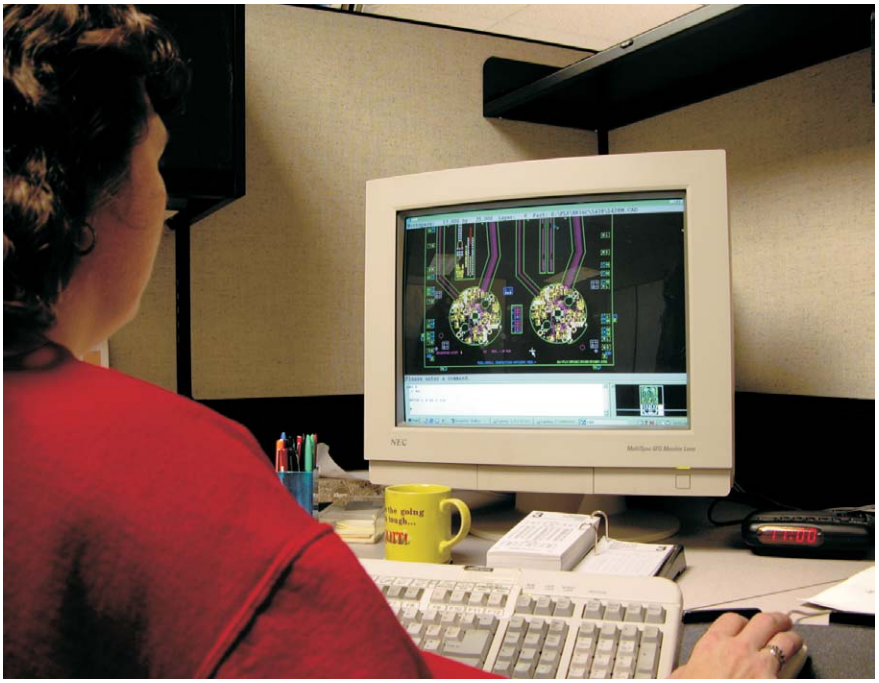
First, cut out a piece of paper which can be folded to reach all points which the circuit will connect. Then lay the paper flat and trace conductor routing between connection points. Make additional cutouts to represent extra layers.

Specify foil thickness and conductor widths to match current requirements. See Application Aid #24 for a chart relating conductor cross sections, current, and temperature rise.

For assistance with artwork layout, see Minco Application Aid #24, or let Minco prepare the artwork for you, working from your point-to-point drawings and conductor current ratings. Minco can also provide assistance in creating your original CAD part from schematic.

Hints for lower cost:

- Keep the number of layers to a minimum. In particular, do not exceed two layers unless packaging density is more important than economy. Consider using several small simple circuits instead of one large complex one.



Send us your CAD-generated data. We'll reproduce it with digital precision.

- Rigid-flex is an expensive option. Specify stiffeners instead, if you can.
- Design the overall circuit outline so multiple copies will nest together on panels. Avoid material waste.
- Try to design conductors at least five times wider than they are thick.
- Do not overspecify tolerances or quality provisions. Make reference to standard MIL, IPC, and Minco specifications whenever possible.
- Allow looser dimensions than you would with a hardboard. Flex-circuits have enough "give" to correct for minor misalignments with mating parts.
- Take advantage of Minco's CAD/CAM system. If you design your artwork on a CAD system, we can import your standard photoplotter code into our system via disk, e-mail, or FTP. We can then correct minor artwork flaws, step off multiples, design tooling, and program CNC production equipment—all from one digital master. You save time and money while avoiding the errors of manual methods.

3. Send us your request for quote

Minco's policy is to identify and correct potential problems with circuits at the quoting stage, not after we accept your order. To evaluate your circuit and quote a firm price we need:

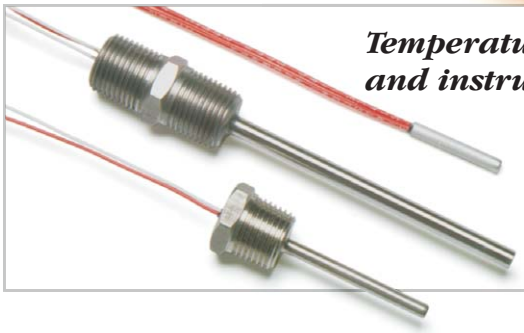
- A circuit drawing with outline dimensions, cutouts, and dimensional tolerances.
- A chart of hole locations, sizes, and access hole diameters with tolerances.
- A material cross section (circuit stackup) specifying insulation thickness, adhesive, conductor thickness, and stiffener type and thickness.
- A photocopy of artwork or CAD data (if available) showing conductor layout and widths, with all applicable tolerances.
- All testing, inspection, and packaging requirements.

Contact Minco early in your design process for assistance and price estimates.

Other Minco products

Thermofoil™ heaters

- Flexible etched-foil heating elements
- Polyimide, polyester, silicone rubber, mica insulation
- Precise heat, uniform or profiled
- UL, NASA qualified models
- Complete subassemblies with heat sinks, temperature sensors, thermostats, and connectors



Temperature sensors and instruments

- Resistance temperature detectors: Platinum, copper, nickel, and nickel-iron.
- Thermocouples: E, J, K, T.
- Probes, HVAC/R, flexible Thermal-Ribbons™, lab standards, ceramic elements.
- Controllers, transmitters, readouts, alarms.

A history of meeting customer needs

Minco was established in 1956 as an engineering firm, manufacturing electromechanical instruments. In 1958, the company began to develop precision wire-wound temperature sensors for aerospace guidance systems, followed by etched-foil heating elements. Flex-circuit production dates to 1972, when Minco built its first circuit in cooperation with a pacemaker manufacturer.

These early efforts established Minco's core technologies—fine wire and precision etching—and marketing strategy—innovative engineering to meet unique application requirements.

Minco today

Minco now has more than 700 employees serving 2500 customers worldwide. Fifty sales representative offices in the U.S. and overseas provide engineering assistance. Three adjacent buildings, totaling 228,000 square feet, contain modern administrative, engineering, and manufacturing facilities. Annual orders have grown to over $60 million. Minco is the nation's leading producer of such diverse products as temperature sensors for machinery protection, heaters for guidance systems, and flex-circuits for cardiac defibrillators.

People who make the difference

Minco's most important investment is in an informed and involved work force. Personnel turnover is low, and the company sponsors both in-plant and outside training programs to foster personal growth and job knowledge. Incentive programs, quality initiatives, and open communications encourage efficiency and continuous improvement of product quality. You'll find that all Minco employees—in customer service, in production, in engineering, and in quality assurance—have the knowledge and desire to serve your needs.

Minco is an equal opportunity/ affirmative action employer.

MINCO
ISO 9001: 2000

Minco Products, Inc.
7300 Commerce Lane
Minneapolis, MN 55432 U.S.A.
Tel: 763-571-3121
Fax: 763-571-0927
www.minco.com

Customer Service/Order Desk:
Tel: 763-571-3123
Fax: 763-571-0942
custserv@minco.com

Minco S.A.
Usine et Service
Commercial, Z.I.
09310 Aston, France
Tel: (33) 5 61 03 24 01
Fax: (33) 5 61 03 24 09

Minco EC
Hirzenstrasse 2
CH-9244 Niederuzwil
Switzerland
Tel: (41) 71 952 79 89
Fax: (41) 71 952 79 90

Form 880802-5