# Face Electronics, LC

## *Frequently Asked Questions about Power Transoner*

## 1. What is the Power (Resonant Mode) Transoner?

The Power Transoner is a patented piezoelectric transformer (PT)… an electro-mechanical… not an electromagnetic device. Useful in applications involving power conversion and power switching, **the Transoner is not a "drop-in replacement" for any other product.** Before the attractiveness of Transoner can be assessed in any specific application, it is important to understand how Transoner's unique behavior can favorably impact the design, complexity and cost of the circuit in which it may be used.

## 2. Why would I want to use a Power Transoner instead of the device I'm already using for power conversion?

The answer depends on your application. Like any technology, Power Transoner is more attractive to use in some applications than in others. With the advances made to date, various Power Transoners might be used in applications up to 80 watts and up to four amps. In many cases, the Transoner can be more attractive than magnetic transformers because of the Transoner's:

- lower price
- more rugged construction
- much lower emission of magnetic fields
- smaller size
- flatter profile
- simpler circuitry

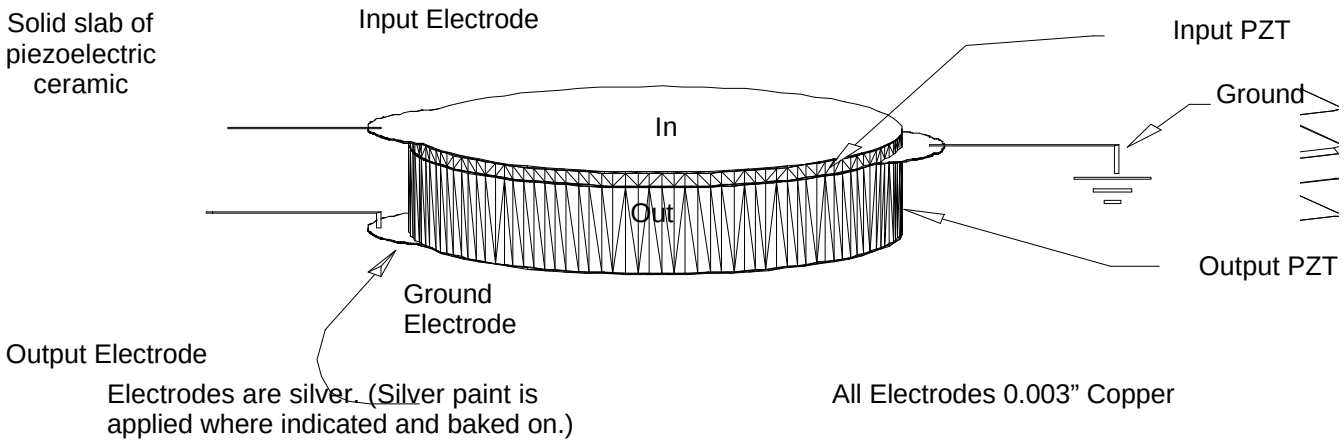
## 3. I've tried to use "Rosen type" piezoelectric transformers before and they didn't prove useful in my application; isn't this just another version of the Rosen?

No. Although Transoner and the Rosen transformer are both made of piezoelectric ceramics, the Transoner takes advantage of different and often simpler design, construction and poling than the Rosen. In fact, the Transoner is so different that it has received broad patent coverage in the United States — and essentially the same patent is pending worldwide.

## 4. Other than the way it's made, how else is the Transoner different from the Rosen PT?

**The biggest difference is power.** Because of their low power transmission capabilities, Rosen type PTs are generally considered for applications that require 4 watts or less. Certain Transoners, however, have been shown to handle as much as 20 times that much power — even more power capacity is expected as Transoner development continues.

Other differences are: • lower cost • more rugged construction • simpler mounting & circuitry




*Rosen Transformer (4 watts)* *Power Transoner (15 W design)*

## 5. Can a Power Transoner be used just like other transformers?

An engineer who was one of the first to see the Power Transoner outside of Face Electronics labs remarked:

*"The Transoner innovation versus conventional power conversion devices parallels the technological leap from the vacuum tube to the transistor."*

Transoner can be used in many applications that use other transformers, but in most applications the circuitry must be different due to Transoner's novel operation. Just as no one would have considered pulling a vacuum tube out of a circuit and plugging a transistor in its place, developers of Transoner-based circuits need to rethink how they design their products. In some applications, these new circuits can apparently be less complicated and expensive than the transformer-based circuits they replace.

## 6. The leap from vacuum tube to transistor was pretty substantial; is Transoner really that big a departure from the older technologies?

Independent electronics experts have described Transoner as a quantum leap. But there are more parallels to the vacuum tube/transistor comparison than just relative importance. When the transistor replaced vacuum tubes, the electronics industry had to adjust its designs so it could replace a voltage driven device with a current driven device. And, maybe even more significant, the world went from a glass tube to a solid-state device. Similarly, wirewound transformers are inductive devices dating from the 19th century… while Transoners are solid state current capacitive devices.

## 7. Why might a Power Transoner circuit be simpler and less expensive than some existing circuits?

Because of the way the Transoner works. In the simplest circuits, the Transoner's gain automatically responds to the load imposed on it. This means that — in a lighting ballast for instance — the Transoner will produce a higher voltage for ignition… and then automatically reduce its gain to achieve the lower operating voltage required by the lamp. This natural behavior of the Transoner means that several components required in some ballast circuits might be eliminated.

## 8. Speaking of gain, how much can a Power Transoner step up or step down voltage?

In the product prototypes developed to date, certain Transoners have exhibited step-up of up to 1:60 and step down of 4:1.

## 9. What would be the size of a 40 - 50 Watt Power Transoner?

Generally, the higher the volume of the ceramic in the Transoner, the higher the power capacity of the device. A typical Transoner for operation in the 40 to 50 watt range would be 3/4 to 1 inch in diameter and 1/4 of an inch or less thick. Naturally, the application requirements (e.g., frequency, voltage, etc.) would define the specific size and structure.

## 10. Other than power, what determines the size of a Transoner?

Many variables enter into the design of a Power Transoner: operating frequency, voltage, output, maximum current, step-up/step-down ratios, desired profile, desired "footprint", target cost, efficiency, operating environment, mounting requirements, isolation (if desired) and other factors.

## 11. How does the Transoner work?

The basic operation of the Power Transoner is very simple. Its design takes advantage of two basic performance characteristics of piezoelectric materials: 1) when an electric field is established, the material moves or deforms, and 2) when the material is moved, an electrical charge is created. In the operation of the Transoner, the input side of the device is excited with an AC signal. The input side is bonded to the output side. Thus, when the input side moves, so does the output side. When the output side moves back and forth, it generates an AC signal.

**So, Transoner converts electrical energy to mechanical energy and then back to electrical energy.** By adjusting the number, size, material, electroding and wiring of the input and output layers, the performance of the Transoner can be tuned to the desired application, step up/step down, isolation, etc.

## 12. What factors influence the step-up/step-down ratios?

The most important factor in the construction of Transoner that affects voltage step-up and step-down ("gain") is the relative size and number of the input and output layers. In step-down devices, the input layers are typically thicker than the output layers. In step-up devices, the input layers are typically thinner than the output layers.

The most important factors in the operation of Transoner that affect voltage gain are the magnitudes of 1) the voltage input to the Transoner and 2) the resistance of the load that is connected to the output of the Transoner.

## 13. What factors influence the Transoner's power capacity?

The most important factor in the power capacity of a Transoner is its volume. Power capacity is directly related to how much piezoceramic material is in the device and the dissipation characteristics of the specific piezoceramic material chosen. So, generally speaking, the larger the Transoner, the higher its power capacity.

## 14. What is the power capacity of a Power Transoner?

Relatively large experimental Transoners (a 1.28" disk, 0.235" thick) have been manufactured that can operate at 80 watts, although higher power capacity is under development. Smaller Transoners, of course, have lower power capacity.

## 15. What factors influence the Transoner's current capacity?

In order to increase Transoner's current capacity (to decrease its impedance), the combined surface area of the layers of the Transoner must be increased. The surface area can be increased by increasing the diameter of the Transoner and/or by increasing its number of piezoceramic layers.

## 16. How much current can a single Transoner handle?

Again, it is a matter of how the Transoner is constructed. Many Transoners have been made for use in lighting ballasts, which have relatively low current demands (less than 0.25 amp). In an application demanding small size and high current capacity, a compact (less than 0.25" thick) Power Transoner circuit was built which had an output of @50 watts at 12 volts (approximately 4 amps). Higher current capacity devices are expected as R & D continues.

## 17. It sounds like there are many variables that can be adjusted.

That's right. Among the variables are:

| **This Variable** | **Most Affects** |
|---|---|
| **Total Volume of Ceramics** | *1) Power Capacity 2) Cost* |
| **Diameter (or Length/Width)** | *1) Operational Frequency 2) Current Capacity 3) Efficiency* |
| **Relative Thickness of Layers** | *1) Voltage Gain 2) Voltage Output* |
| **Total Number of Layers** | *1) Current Capacity 2) Power Capacity 3) Cost 4) Efficiency* |
| **Total Transoner Thickness** | *1) Power Capacity 2) Voltage Output 3) Efficiency* |
| **Isolating Layer** | *1) Breakdown Voltage 2) Efficiency 3) Cost* |
| **Design of Ceramic Material** | *1) Efficiency 2) Operational Frequency 3) Current Capacity 4) Gain* |

## 18. How efficient is the Transoner itself?

In product prototypes developed to date, Transoners have operated at a maximum of 95% to 98% efficiency. But again, Transoner performance cannot be measured separately from its application circuit. **Each Transoner must be matched to its application circuit to achieve optimized results.**

## 19. How does the ambient temperature affect performance?

Transoners can generally be operated up to 150°C with minimal apparent affect on performance. However, as operating temperature increases, gain decreases.

## 20. What is the typical frequency of operation?

Power Transoners are designed to operate at or near their resonant frequencies. The resonant frequency is most affected by the Transoner's dimensions, but typical devices operate between 80 kHz and 250 kHz. (Using advanced microelectronic manufacturing techniques, operational frequencies in the megahertz or gigahertz range are anticipated.) The operating frequency is roughly inversely proportional to the radius of a circular Power Transoner. The operating frequency does affect the overall power capability.

## 21. Is there a required input waveform?

A sine wave is preferred, but Transoner can also use a square wave.

## 22. What output waveform does Transoner produce?

Because the signal is produced mechanically, Transoner generates a pure sine wave. Naturally, the output waveform is influenced by the input waveform. (Surrounding circuitry can be used to modify waveforms).

## 23. Are there preferred load characteristics for Transoner?

Resistive loads are best. Capacitive loads of 2 to 5 nanofarrads are okay. Highly capacitive loads of 5 nanofarrads or more will reduce effective voltage gain — however, this can often be compensated for in the design of the Transoner.

## 24. Aren't piezoceramics very fragile?

Some ceramics are extraordinarily fragile — like potato chips. But Transoner's unique design results in an extremely rugged product when compared to the Rosen PT.

## 25. With the trillions of vibrations that a Transoner may experience over its life, what's the chance of mechanical failure?

The actual range of motion of an operating Transoner is extremely minute… typically a maximum of 0.00024 of an inch (six microns). A mechanical failure within the ceramic of the Transoner (due to operational vibrations) is extremely unlikely — and the adhesive used is even stronger than the ceramic.

## 26. What assurance is there that Face will have the Transoner manufacturing capacity that I need, when I need it?

Face's Transoner manufacturing joint venture with Maida Development Corp. of Hampton, VA, marries Transoner's revolutionary technology with Maida's more than 50 years of exacting manufacture of electronic components. Maida manufactures more than 250 million ceramic components a year, with the capacity to produce nearly 800 million pieces. Almost a third of Maida's current product line is sold to Pacific Rim clients, who demand top quality at competitive prices.

## 27. What is Face doing to assure the highest quality standards?

In its effort to remain at the cutting edge of PT development, Face is forming a team of experienced employees, partners and consultants from around the world. As to product quality assurance, Face is working with one of the top US product evaluation labs, which specializes in accelerated life testing. This lab will test not only Transoners, but also entire Transoner circuits, which includes the critical mounting and electrical connections.

## 28. How much might performance vary among Transoners of the same design — in other words, what is the repeatability?

Even Transoners made by hand in the laboratory exhibit high repeatability. For instance, operating frequency varies only 1% or 2%. When manufacturing is automated, even higher degrees of repeatability are expected. Maida Development Corp. achieves a very high degree of repeatability in their current product lines.

## 29. What factors affect the cost of making a Transoner?

As with most products, the direct cost of manufacturing a Transoner is affected by the price of materials and the cost of assembly — and both factors are greatly affected by quantity. In small, simple (two-layer) Transoners, the cost of the product is about 50% material and 50% assembly. If a Transoner is simple but very large, the materials cost is the major factor. If the design becomes more complicated (for instance, having many different-thickness layers), assembly becomes the larger expense.

## 30. Where is the Transoner patented?

The first United States patent for Transoner issued to Face on November 10, 1998. Essentially the same patent is pending worldwide. Favorable office action on this patent has been received from Patent Cooperation Treaty (PCT) officials, who represent 100 countries. Face has many additional Transoner patents pending.

## 31. Is there a reference book on Power Transoner?

It's being written right now. The National Science Foundation Center for Power Electronics Systems (CPES) at Virginia Tech began a characterization study of Transoner early in 1999. Funded in part by a grant from Virginia's Center for Innovative Technology, the first published findings of the CPES project are now available (CPES papers on Radial Vibration Mode Piezoelectric Transformers).

## 32. What about design software?

A program to develop software to design both Transoner and Transoner circuitry is being developed by Face Electronics, CPES and software designer Magsoft. This software should also be available in the year 2000.

## 33. How does my company get an early advantage in the new Transoner market?

The small number of companies that will learn about Transoner this year have the chance to gain a significant advantage over their competition. The broad announcement of the development of the Transoner to the electronics industry won't happen until late 1999 or early 2000. Until then, companies such as yours can work with Face Electronics to advance the design of Transoners and Transoner circuits for specific products. This will give your company a head start in the marketplace and a chance to gain patent protection for that specific design.

## 34. How can we work with Face to develop our products?

Face Electronics is currently working with several companies in the development of a number of Power Transoner applications. Although Face has the advantage of being very flexible to meet its Client's preferences, ideally, your company would locate product development personnel in a secure lab set up especially for them in Face's technology incubator facility in Virginia. Your personnel can then have easy "down the hall" access to key Face researchers. Face Electronics hopes to locate as many as ten teams in this incubator in the next few years. The teams would be chosen so that they are not competing to develop the same product. The incubator is being developed with the participation of state and local governments in Virginia.

## 35. What's the next step?

Contact your Face representative and discuss the application(s) you have for Transoner. If it appears that Transoner can meet your performance requirements in the near term, we can start discussing how to move ahead.

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