

dw T c l y A PLITRON White Paper

Abstract

Narrow Bandwidth Technology (NBT) reduces line distortion within isolation or power transformers. NBT transformers restrict electromagnetic energy to a very narrow passing frequency band. This patented technology gives the transformer the ability to dampen distortion on the line due to harmonics and spikes. It is very effective for attenuating high and very high frequency signals whether the origin is on the line or generated due to asymmetrical loads. NBT can be adapted to most transformer-based power applications.

An NBT transformer performs as a low pass filter with a selected corner frequency. The system is based on two principles, which involve an increase of the internal series inductance, as well as the phase cancellation principle. Phase cancellation is obtained by connecting a bifilar control winding in contraposition through a capacitor. At low frequencies the capacitor acts as an open switch allowing the power frequency (50/60 Hz) to freely cross the transformer. At high frequencies, the capacitor behaves as a closed switch. Therefore, the magnetic flux of the two windings cancel one another and full deletion of high frequency signals occurs. By adjusting the series inductance and the capacitor, the passing bandwidth of the transformer can be controlled.

Introduction

Power lines not only contain pure undistorted 50 or 60 Hz sine wave voltages, but other signals as well. The sine wave is distorted, and consequently harmonics of the 50/60 Hz fundamental are found up to 10 kHz. At higher frequencies, switching transients appear from rectifiers, motor drives, etc. At frequencies above 50 kHz, strong HF signals from radio, TV, and computers are superimposed on the line and appear across the primary winding of a transformer.

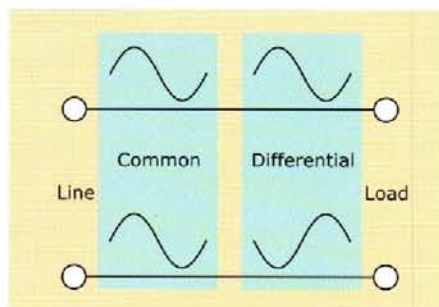


Figure 1. Common and differential noise

All these extra signals, called noise or distortion, appear in two ways on the power lines. At frequencies above one MHz, noise is mostly common mode - which refers to both line and neutral containing an equal amount of amplitude and phase distortion. For frequencies below 1 MHz, the major component of the noise is typically differential mode - lines where the noise on both sides' amplitudes are equal and the phase reversed. Differential mode noise generates a real noise voltage difference between line and neutral.



NBT resolves both differential and common mode noise, with the help of increased series inductance, phase cancellation principle, and a reduction in primary to secondary capacitance.

Electronic equipment is sensitive to noise entering through the power line. This unwanted noise can affect the product in many ways, including performance degradation, and even result in malfunctions. Typically, high frequency filters are applied to remove the noise before the line voltage enters the power transformer that supplies the electronic equipment. However, with NBT the power transformer becomes an effective noise rejection filter and the external components to remove the high frequency component are not longer required.

The elimination of components has many advantages including reduced parts count and cost. Also, the reduction of primary circuit components will expedite safety agency and approvals certifications. Improved leakage current results by eliminating line-to-ground components.

Comparing Other Technologies

Effective noise rejection filters should pass the 50/60 Hz fundamental, and remove all higher frequencies. However because the line source impedance, combined with the impedance of the actual load, is low (between 1 to 100 Ohms at 50/60 Hz), for optimum attenuation, the impedance of the filter should be low as well. This would require impractical large and expensive capacitors and inductors.

A less costly approach is to start filtering noise at frequencies above 1 kHz, where most of the unwanted noise is found and which causes malfunction of electronic equipment. The filter should be of the low-pass type with second or higher order slopes. The internal capacitance and inductance inside the transformer are the tools to create the desired filter.

Leakage inductance between the primary and secondary windings in all transformers already functions as a first order low pass filter. Its corner frequency is high, 20 kHz for EI-transformers and 200 kHz for toroidals (due to the toroid's inherently low leakage inductance). Previously, leakage inductance and interwinding capacitance were viewed as simply a bi-product of the design of line frequency transformers, a function of spacings and dielectrics. NBT exploits these characteristics to attenuate all unwanted frequencies. PLITRON has developed the means to accurately calculate specifications, and to construct transformers to meet specified corner frequencies.

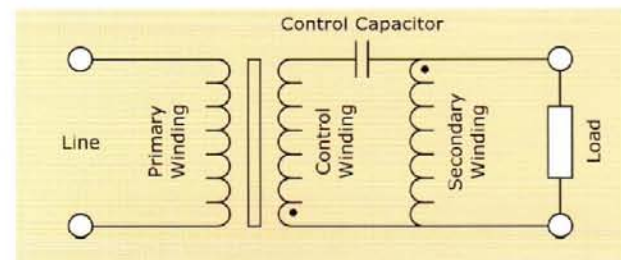


Figure 2a. Phase Cancellation Principle

Principle

Figures 2a and 2b give the essentials of the NBT filter technique. Figure 2a shows the secondary winding being extended with an extra winding (control winding), with equal number of turns, connected in reverse phase to the existing secondary winding through a capacitor (control capacitor). At low frequencies, the impedance of the control capacitor is high, the capacitor acts as an open switch, only one secondary winding functions and the 50/60 Hz is free to cross the transformer. At higher frequencies (above 1 kHz), the control capacitor begins to act as a closed switch. Both secondary windings now generate magnetic flux in the transformer core, however, with 180 degrees phase difference. Therefore the magnetic flux of the two windings cancel one another and full cancellation of high frequency signals occurs. Then there is no magnetic transfer of energy through the core to the secondary.

Figure 2b shows the equivalent circuit of a NBT transformer. The increased leakage inductance, L, is the prime factor in the performance of the NBT design, C is the transformed capacitance from secondary to primary and R is the Primary DC-resistance.

The combination of L, C and R react as a second order low pass filter. The corner frequency of the filter is determined by the combination of the values of these elements along with the load impedance ZL.

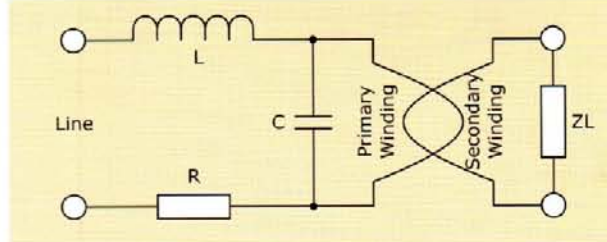


Figure 2b. Equivalent circuit (from primary side)

One of the advantages of this approach is the large impedance of L at high frequencies. Noise from the line will not be reflected at the input terminals of the transformer, but absorbed in L. At high frequencies, the NBT transformer will deliver no load to the power lines.

Distributed phase cancellation

When the control winding is used to deliver energy to an extra secondary load, more efficient use of copper (winding wire) is made, see Figure 3.

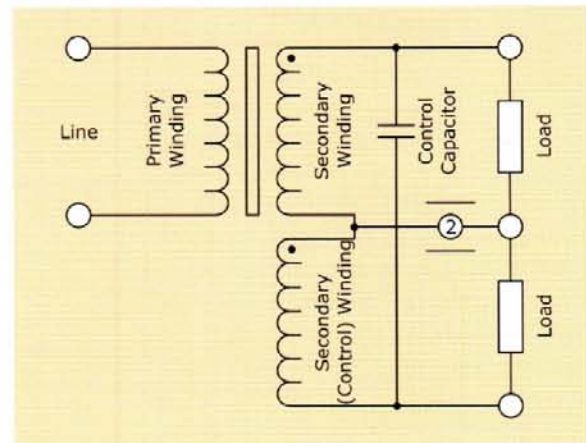


Figure 3. Control winding delivering power

When the loads are equal, the total effective current through connection (2) becomes zero (Phase cancellation). When connecting (2) to ground, a clean ground reference is created without high frequency noise.



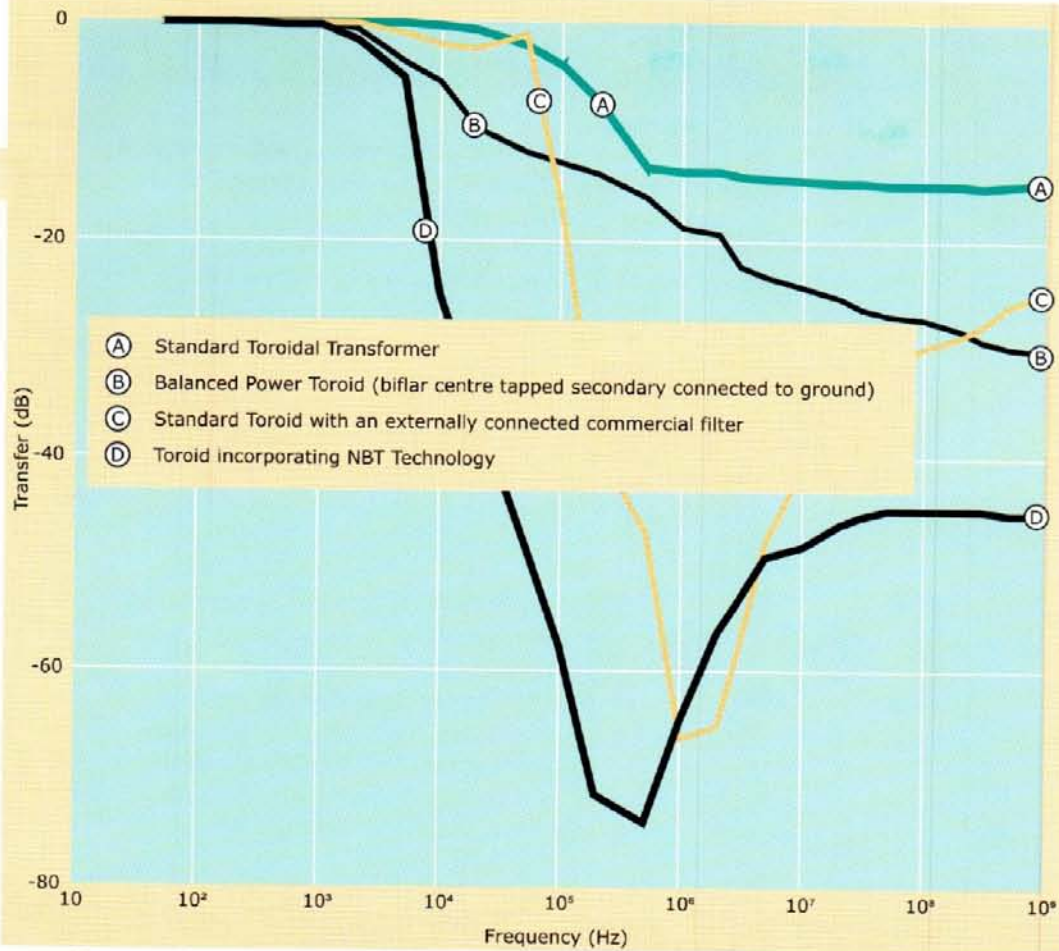


Figure 4 Performance comparisons

Frequency Response Measurements

To verify the performance of the NBT transformer and observe its advantage over other transformer designs, frequency response tests were carried out and the results are shown in Figure 4. The primary of the transformers are fed by an oscillator and the voltages of the primaries and the loaded secondaries are measured at frequencies, ranging from 50Hz to 1GigaHz. The ratio of the secondary to primary voltage, in decibels, versus frequency is plotted for each transformer.

Four different toroidal transformer constructions were compared;
 a) Standard toroidal transformer,

b) Balanced Power, (biflar centre tapped secondary connected to ground), c) Standard Toroid with an externally connected commercial filter* d) Toroid incorporating NBT Technology.

The standard Toroid (a) has a high corner frequency of about 50kHz and low attenuation rate. Balanced power (b) has better performance with reasonably low corner frequency of about 3kHz, attenuation of about -15db around 100kHz and -30db close to 1GHz. The standard toroid with an external commercial filter* (c) performs much better in the range of 50kHz to 40MHz in comparison with the balanced power, but it has poor corner frequency of about 60kHz.

* Corcom P/N 20VV1

NBT (d) clearly out-performs other designs in terms of both corner frequency and attenuation. It has a low corner frequency of about 1kHz, which can be design-adjusted to any reasonable value, with db attenuation in excess of 60db around 1MHz and 35db at 1GHz.

Applications

The applications of NBT in power supply transformers are various. A clear example is audio applications, where it is important that differential high frequency noise not enter the sensitive audio equipment. A second application is found in general power supply transformers in any electronic equipment, where differential noise filtering is mandatory. The choice for an NBT-transformer is then based on the balance of costs for a NBT transformer compared to a standard power transformer with external differential mode filters.

In IT applications with uninterrupted data transport over long distances, the advantages of clean power lines are obvious. Medical applications, especially safety-critical patient connected devices, NBT transformers with electrostatic shields, provide clean power with low leakage currents. In large power applications, NBT can remove the higher harmonics, starting with the 5th up to the 50th - with no external filters.

Summary

Power lines can contain electromagnetic noise. Noise appears in differential (below 1 MHz) or common (above 1 MHz) mode. NBT effectively removes differential mode noise up to 1MHz. It also reduces the common mode noise considerably between 1MHz and 1GHz. The control capacitor and the internal leakage inductance between primary and secondary windings of the power transformer determine the frequency at which the reduction of noise starts.

References

This paper describes a portion of the inventions and research performed at PLITRON Manufacturing by the team of Francisco de Leon, Brian Gladstone, Menno van der Veen, and Val Tatu from 1999 to 2001, and Henry Pajooman who joined in late 2001. Written by Francisco DeLeon, Menno Vanderveen and Brian Gladstone in 2001. Edited and updated by Henry Pajooman in 2002.

Francisco de Leon, Menno Van der Veen, Brian Gladstone, "Transformer Based Solutions to Power Quality Problems" Power Quality Proceedings, Vol. 14, pp 303-314, September 2001.
Menno van der Veen, Francisco de Leon, "Narrow Bandwidth Transformer (NBT): A clean- Power Technology" Power Quality Proceedings, Vol. 14, pp 754-758, September 2001.

Technical Inquiries

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PLITRON R&D

PLITRON has a research team dedicated to improving and expanding toroidal technology. We engage in fundamental research and have developed new methods to quantify transformer performance. In addition to NBT, here are some of the other projects we have introduced for use in standard and custom toroidal applications.



LOW INRUSH TECHNOLOGY

PLITRON's Imin technology reduces in-rush currents to the level of load currents. This eliminates the need for soft-start circuits, relays, PTCs or large breakers.



LOW NOISE TECHNOLOGY

LONO technology from our research program effectively eliminates any audible noise in the power transformer regardless of line conditions, including DC offset and overvoltage. PLITRON can quantify and specify noise performance to NC (noise criterion) standard curves.



LOW STRAY FIELD TECHNOLOGY

Toroidal transformers are typically 1/10th the magnetic field of standard EI transformers. Yet another research output, PLITRON's LoSTRAY technology further reduces magnetic emissions from the transformer without the use of shields, or "belly-bands".

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General Terms and Conditions of Sale

The terms and conditions set forth herein constitute a binding agreement between Plitron Manufacturing Inc. ("Plitron") and the customer ("Customer").

Customer Purchase Orders and Plitron Acknowledgement form binding contract

Customer Purchase Orders to Plitron shall be placed or confirmed in writing, signed by an authorized Customer representative or officer. Facsimiles and E-mail may be accepted at the discretion of Plitron.

Information must include (at minimum): Plitron part number and/or Customer part number, revision level of part (if applicable), quantity ordered, delivery schedule, FOB point, price, and terms of payment. Plitron will issue an Acknowledgement of Purchase Order.

When a Purchase Order has been Acknowledged by Plitron, there is a Binding Contract established between the parties.

Price Quote validity.

Price Quotes to customers are normally valid for 60 days from date of issue. Prices will be held firm for up to 12 months when Customer places a Blanket Order.

Blanket Orders and Applicable Prices

Prices are based on individual order release size, and not total order quantity or volume, except as outlined in the Blanket Order Release Table below.

Plitron is prepared to accept Customer Blanket Orders and extend quantity pricing according to the following table. Blanket orders must be accompanied by customer schedule of releases over a maximum 12 month period.

Should changes to the release schedule be required, such changes will be accepted according to the Terms specified in this agreement.

Blanket Order Release Table

Total Quantity Ordered	Min. Release Qty	Applicable price
1000	100	1000
	50	500
500	100	500
	50	250
250	100	250
	50	100
100	100	100

Special Charges

Minimum quantities for release sizes may be quoted when special materials not normally stocked by Plitron are required. Tooling charges, set up charges, and other special charges will be quoted when applicable.

FOB Point and Currencies.

Unless otherwise specified or agreed between the parties, the following are the applicable currency of transaction and FOB points:

*USA shipments

Prices are quoted in US dollars. Shipments are FOB Buffalo New York.

*Canadian shipments

Prices are quoted in Canadian dollars. Shipments are FOB Toronto Ontario.

*International shipments

Prices can be quoted in Canadian dollars or US dollars at option of Customer. Shipments are FOB Toronto.

Shipping lead-time

Shipment lead-time is specified for each product quoted, and is typically 4-6 weeks after receipt of order (except for items with special materials or sourced offshore which are necessarily longer). Lead-times will be confirmed upon placement of order and may vary from time to time.

Shipment Accuracy and Guarantee

Unless otherwise specified, Plitron delivery will be considered on time within 7 business days of the target date (5 days early, 2 days late).

Plitron guarantees to meet its acknowledged delivery commitment for OEM customers. Plitron acknowledged FOB dates are guaranteed accurate within our stated delivery commitment. For every business day outside of that window, Plitron will deduct 2% from the unit price, to a maximum 10% discount. Exclusions of this guarantee may be made by Plitron at time of Order Acknowledgment.

Plitron strives to ship all orders on-time. However, production and shipments by Plitron to Customer may occasionally be delayed beyond acknowledged shipping date(s) due to unforeseen circumstances. In such instances, Plitron will notify the Customer as early as possible of the delay and use its best efforts to minimize the delay. Plitron will advise Customer of new schedule ship dates as early as possible

Shipping insurance

Plitron insures all prepaid shipments from the FOB point with a US\$500 deductible. Insurance up to \$500 is the responsibility of the Customer.

Damaged Shipments

Claims for damage should be reported immediately in writing to the carrier and Plitron with specific details. No verbal claims can be accepted. All claims made to Plitron for hidden damage must be made within 5 days of receipt of shipment.

Terms of payment

Terms of payment are 1%- 15 days, Net 30 days to approved accounts, unless other terms are specifically agreed in writing.

Customer to provide D&B rating, or banking and three trade references to apply for an account.

Plitron reserves the right to charge interest costs on overdue accounts based on established banking rates + 3%.

Plitron does not ship COD orders.

Personal checks must be certified, or shipment will be held until check can clear through banking channels. Where an account cannot be opened, Customer may choose option of full prepayment of order.

Payment by Credit Card

Credit cards (Visa, Mastercard, and American Express) may be accepted. Charges for credit card orders will be pre-authorized before orders are accepted by Plitron. Customers need to be aware that orders placed with Plitron Manufacturing Inc may not be cancelled.

Rush Orders ("Gold Service")

Plitron will try to accommodate customer requests for deliveries with shorter than normal lead-times, or beyond Plitron's available production capacity at time of order. An expedite fee known as a "Gold Service" (typically 30% of the order cost) charge will be quoted to the Customer. Should customer wish to utilize this service, a Purchase Order should be supplied to Plitron by the Customer. All other terms and conditions are applicable.

Offshore Pricing and Production

Plitron has established offshore facilities and subcontractors to produce toroidal transformers. Lead-time for offshore production orders is typically 14-16 weeks (including sea-shipment) after first article/prototype approval. Lead-time may be reduced at additional expense by using air shipments. Orders may not be cancelled, or deliveries changed, within acknowledged lead-time.

Applicable price and terms of sale : Domestic and Offshore Manufacture

When Plitron has quoted prices from both domestic manufacturer and off-shore sources, and Customer has placed Purchase Order, the price invoiced to Customer will be based on factory of origin. Products supplied to Customer by Plitron, wherever manufactured, are sold under the terms and conditions, and covered by the warranty defined in this document.

Suitability of Products for Application is Customer's responsibility

The Customer is responsible for ensuring Products ordered from Plitron meet electrical, mechanical, safety and any other requirements

Custom Products

Custom Transformers are designed and manufactured to meet the unique and specific requirements of the Customer. As purpose-built components, there is no other application or market available to Plitron. Customer is responsible to ensure the fulfillment of their commitments for Acknowledged Purchase Orders.

Designs, Customer Responsibility and Acceptance

Custom Products are manufactured by Plitron, based on Customer supplied specifications and /or designs, and Plitron's design, quality control, and manufacturing capability and expertise.

Plitron provides transformer designs as part of its service to our customers to assist in specifying a suitable transformer for Customer application. Nonetheless it is the responsibility of the Customer to ensure the suitability of the product for the intended application.

Plitron will supply preliminary transformer specifications at the same time as price quotation. Such specification may change during the ongoing product development cycle, particularly when the design is proven by building/supplying a prototype transformer.

Prototype Development and Approval

When a quotation and preliminary specification is acceptable to a Customer, the typical next step is a Customer request for a sample/ prototype transformer. The prototype is the opportunity for Plitron and the Customer to "prove" the design, and develop electrical, mechanical, and manufacturing data to ensure smooth integration into the manufacturing cycles of both companies.

Plitron can often provide prototypes in two weeks, however depending upon the complexity of the product, and changes introduced by either company, delays may be introduced into the development process.

Due to the nature of prototype development, anticipated delivery dates for prototypes are subject to change. Plitron will keep customer informed of any changes in dates.

Plitron will supply a "Prototype Approval Form" with samples of custom products. Such form, when signed by Customer representative and returned to Plitron, indicates the acceptance by the Customer of the products supplied by Plitron.

A "Prototype Approval Form" or similar signed information must be provided to Plitron before Purchase Orders for Custom products can be accepted by Plitron.

Prototypes are for the exclusive use of the customer to determine suitability to their product, and may not be copied or given to a third party.

Pilot Production Runs

In certain circumstances, it will be in the Customer's best interest to purchase additional samples (i.e. a Pilot Production run) before committing to volume orders to confirm the acceptability of the product to the application. Products ordered by Customer for Engineering evaluation and development are warranted to meet published specifications, but may not be returned to Plitron for reason of unsuitability in Customer's application.

Standard Products

Plitron Standard Products are designed to meet general industrial standards and requirements. Plitron warrants that Standard Products will meet the published specifications. It is the Customer's responsibility to determine the suitability of Standard Products for their applications.

Changes requested by Customers to Standard products will normally result in a new part number and designation as a Custom product.

"Prototype Approval" is not applicable for orders for Standard Products.

Consumer and Retail Orders for Standard Products

Plitron Standard Products may be sold via telephone, e-mail, or mail order to end user customer. A written purchase order and acknowledgement to Customer may not be practical. Customer accepts responsibility for reviewing the product specifications in advance of ordering.

Payment is required in advance by certified check or credit card. Charges to credit cards are pre-authorized before the order is entered into Plitron's manufacturing schedule. Orders for standard products are non-cancelable and non-refundable.

Products may not be returned for reasons of unsuitability.

Changes to Acknowledged Purchase Orders

Plitron will use all reasonable efforts to accommodate the Customer, but is under no obligation to change Acknowledged Purchase Orders. Plitron will use its

best efforts to minimize the costs related to changing the Acknowledged Purchase Order, but Customer is responsible for all related costs. All requests to change the Acknowledged Purchase Order must be in writing. Plitron will respond in writing and advise whether the request(s) can be accommodated, and on what terms, in accordance with the following guidelines.

Classes of Changes to Purchase Orders.

Customer requests cancellation of Purchase Order not started in production [C1]

When Plitron has not ordered or committed raw materials, nor committed manufacturing resources, or otherwise incurred costs, Plitron will agree to cancel order. Customer will be responsible for any extra or special costs incurred by Plitron in the cancellation.

*Customer requests order "in process" be placed "on hold" or re-scheduled, or change implemented [C2]

Circumstances may arise (such as pending engineering change, or change in customer delivery requirement), where the Customer requests a change in delivery schedule, orders be placed "on hold", or a production change implemented. Plitron will use every effort to accommodate the Customer request, but is under no obligation to do so.

Placing of orders on "hold" or requests for Engineering changes by Customer, even temporarily, may disrupt Plitron's manufacturing and delivery schedules, with financial consequences. The Customer agrees to be responsible for Plitron's expenses in such cases.

Customer agrees that resolving such matters is of the utmost urgency and will use all possible efforts to provide new schedules, resolve engineering issues, and the like.

If Plitron is able to place Customer orders "on hold", re-schedule deliveries, or implement the requested Engineering change Plitron will notify Customer in writing of the costs of providing such service. The Customer will issue a Purchase Order to authorize such charges. Should Customer not provide the Purchase Order to Plitron for the requested changes, Plitron will complete and ship the order according or as close as possible to the Acknowledged Customer Purchase Order.

Placing of orders "on hold" by Customer and Plitron's agreement to accept such requests, in no way releases the Customer from the obligations of fulfilling the contract agreed with Plitron by the Acknowledged Purchase Order.

* Customer requests cancellation on work "in process" or finished product [C3]

Orders where Plitron has committed materials and/or labour may not be cancelled. Customer is responsible to accept delivery and make payments as agreed between the parties in the Acknowledged Purchase Order.

*Customer changes quantity of products ordered [C4]

When Customer reduces the quantity of products ordered on a purchase order, the Customer agrees to also change the pricing and modify the Purchase Order to reflect the actual quantity of products ordered and/or delivered, and/or accept additional billing from Plitron to adjust the price accordingly.

*Order placed on hold by Plitron [C5]

Plitron may place customer orders "on hold" for example for reasons of late payment or non-payment by the Customer. In such cases, Plitron will notify

Customer that orders are "on hold" and that delivery schedules may be affected. Placing of orders on hold by Plitron does not release Customer from the obligations of the Acknowledged Purchase Order.

Twenty Year Warranty

All Plitron Transformers come with a 20 YEAR WARRANTY. The terms of the warranty are as follows:

This Warranty only applies to the original purchase of the transformer. This Warranty ONLY applies to repair or replacement of the transformer. The transformer must be used only in the equipment for which it was designed.

The warranty covers materials and workmanship. This Warranty does not apply to any ancillary installation expenses.

Plitron is not liable for any personal injury or consequential damage of any kind resulting from malfunctions, defects, misuse, or improper installation of the transformer.

Plitron reserves the right to determine if the Warranty will apply if in the course of its inspections it reasonable determines that the transformer has been modified.

Operating or using the transformer under conditions not suitable for the transformer, or attempting to service or modify the transformer, will render this Warranty void.

Before returning this product, please call Plitron customer service at 1-800-plitron to obtain a customer authorization number for returns and instructions.

This Warranty gives you specific rights. The provisions of this Warranty are in addition to, and not a modification of, or a subtraction from, the statutory warranties and other remedies contained in any applicable legislation. To the extent that any provision of this warranty is inconsistent with any applicable law, the provision shall be deemed void or amended to comply with such law.

Defective and Returned Goods

Customer should contact Plitron to obtain an "Authorization to Return Goods" and return Products to Plitron prepaid. Products covered by Plitron under warranty will be returned prepaid and insured. In case where no fault is found, goods will be returned to Customer at customer expense. No deduction from payments may be made by Customer until a Test and Inspection Report is provided by Plitron.

Confidentiality of Information

Technical information provided by Customer to Plitron will not be disclosed to any other party. Customer agrees not to supply any technical information provided by Plitron to any other party.

Technical documents prepared by Plitron Manufacturing Inc remain the property of Plitron Manufacturing Inc and may not be copied, transmitted, or used as the basis for manufacturing of apparatus. Prototypes are supplied for the exclusive use of the customer to determine suitability to their product, and may not be copied or given to a third party.

Proprietary information provided by Plitron Manufacturing Inc is valuable intellectual and/or commercial property and revealing it to third parties may cause serious damage.

Representations

There are no representations or warranties made outside this agreement regarding terms of sale. Any changes to this agreement must be made in writing.



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Thanks for stopping by our booth at MD&M / Electronics West 2004.

We have enclosed our brochure, which includes information on our standard products and custom capabilities. We have also included a technical paper that outlines Narrow Bandwidth toroidal Technology.

Please review the information here and on our web site. Contact any of us below. We would appreciate assisting you in your next transformer application.



All transformers for OEM applications are warranted against materials and workmanship defects for 20 years from the date of manufacture when used in the equipment for which they were designed. This applies for all PLITRON OEM toroidal transformers ever produced.



We stand behind our commitments. PLITRON acknowledged FOB dates are guaranteed accurate within 7 business days (-5/+2). For every business day outside of that window we will deduct 2% (up to 10%) from the unit price.



New unique technology from our research team, NBT power transformers substantially attenuate differential and common mode noise, eliminating requirements for external circuits such as low-pass filters.



PLITRON's Imin technology reduces in-rush currents to the level of load currents. This eliminates the need for soft-start circuits, relays, PTCs or large breakers. Another product of our research.



LONO technology from our research program effectively eliminates any audible noise in the power transformer regardless of line conditions, including DC offset and overvoltage. PLITRON can quantify and specify noise performance to NC (noise criterion) standard curves.



Toroidal transformers are typically 1/10th the magnetic field of standard EI transformers. Yet another research output, PLITRON's LoSTRAY technology further reduces magnetic emissions from the transformer without the use of shields, or "belly-bands".

Standard Products

Standard Power Toroidal Transformers

- Broad range
- Approved
- 15VA to 1.5kVA

Toroidal Isolation Transformers for Medical Equipment

- 100VA to 12.5kVA
- International medical approvals

Printed Circuit Mount Toroidal Power Transformers

- Triple output
- Encapsulated
- 20VA to 160VA

Toroidal Audio Transformers

- Tube Output
- Tube Power
- Electrostatic
- Chokes
- LoNo Power for Solid-State
- 70 & 100V Distribution
- Chassis

Custom Capabilities

Power Toroidal Transformers

- Computer aided design solutions
- From 8VA to 30kVA
- Various mechanical mounting arrangements
- Designed to the world's safety approvals

Current Transformers

- High accuracy
- Single or multiple core versions
- Saddle bracket or encapsulated
- High isolation

Inductors

- To 150 mH
- To 300 A
- 1.75" to 18" dia.
- Gapped cores

Other

- Three phase
- Power conditioning
- Packaging / Assembly
- Autoformers
- Connectors
- Cases

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Inside Sales
Applications Engineering

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