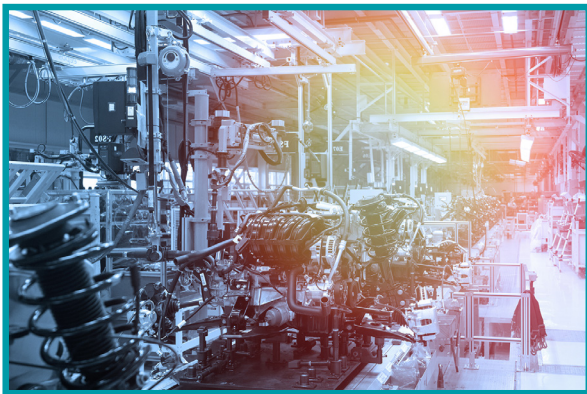


PULSECHIP™ - ETHERNET TRANSFORMERS

Introduction to Ethernet Networking

Computer networking has been in existence since the 1950's. Initially designed for U.S. military, Ethernet networking became more of a reality for consumers in the 1980's, with network speeds of 10Mbps. Throughout the years, the data rate improved with advancements in manufacturing technology and introduction of efficient coding schemes. Today's Ethernet networks can deliver up to 40Gbps over copper and 100Gbps on fiber optic networks. It should be noted engineering communities did actively develop competing technologies to support different protocols such as Token ring, launched by IBM in 1985 and Star-Lan, by AT&T in 1983. However, these alternates are no longer viable due to the slower progress in finalizing their protocol standards. As a result of Ethernet's wide deployment, it is now the lowest cost solution. This cost advantage has allowed it to expand into new areas, such as communication function in hardware design which traditionally used serial or bus configurations, and this expansion in turn has continued to reduce Ethernet network cost.

In today's world the vast majority of end-use electronic devices (for consumer, transportation, communication and industrial markets) are interconnected through some form of communication network and the Ethernet networking protocol is employed in a multitude of common applications that we are exposed to in our daily lives.



Industrial

4.0, Security | Infrastructure and Tools



Communication

Switches | Routers | Data Modems
Servers | 5G Applications



Consumer

Computers | Televisions
Household Appliances and
Smart Home Solutions



Transportation

ICE/EV/HEV Vehicles | Charging Stations
and Light Rail

Network Link Block Diagram

A critical component used in Ethernet networks is the transformer. It provides galvanic isolation between digital circuitry represented as MAC “Media Access Controller” in the block diagram below which provides the data link layer for Ethernet systems and PHY “Physical layer” which converts digital signal to analog to transmit over data lines.

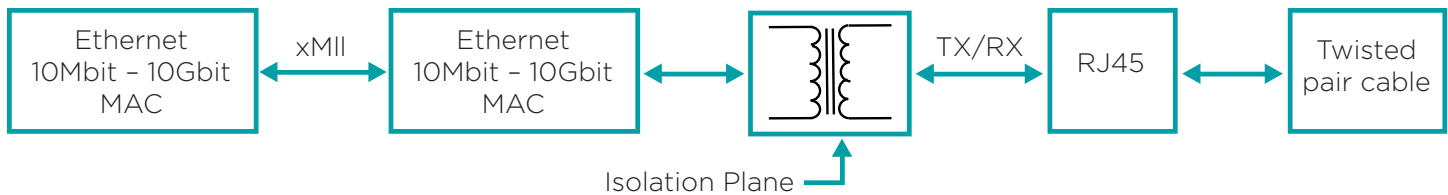


Figure 2, below, is a representation of the electrical schematic for a transformer used in local area networks. The transformer consists of four windings of which two windings are used on the primary side, digital Interface, and the other two windings on the secondary side connected to twisted pair wires via the RJ45 connector. The transformer which provides 1500Vrms or 2250Vdc electrical isolation as specified by IEEE. 802.3X derived from IEC62368-1 eliminates potential high voltage exposure caused by electrical shorts in building wiring and it accomplishes that by magnetic coupling which allows transfer of electrical signals from primary to secondary side while provides required safety function.

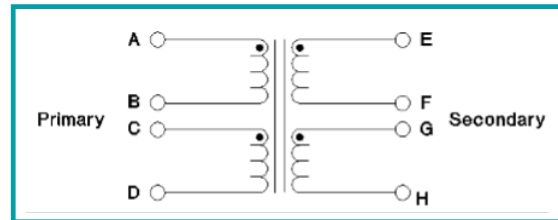


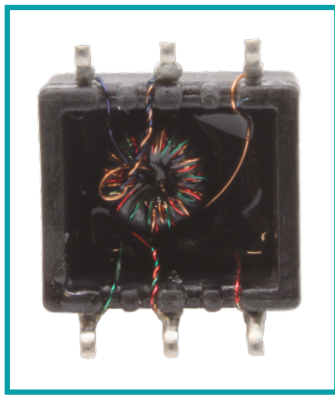
Figure 2

Construction

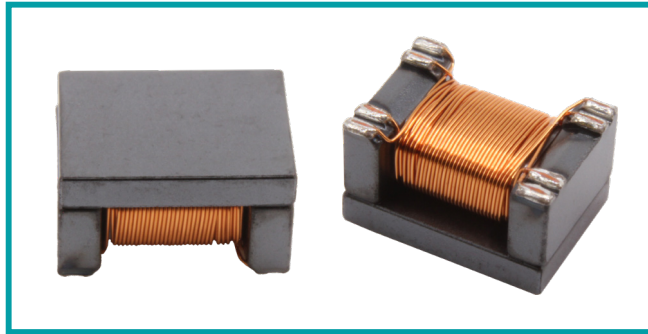
Up until the recent past, transformers for Ethernet applications were manufactured using magnet wires that were hand wound on ferrite toroidal cores. Due to increased labor costs and the pursuance of higher product yields with lower cost, Pulse Electronics invested in automated transformer winding equipment, thereby improving yield and quality associated with manual winding process. Additionally, this also resulted in cost reduction during the time when labor and material rates were rising. Adoption of automated winding technology allowed for the removal of a visual inspection step, which was been practiced for over three decades to insure winding correctness.

Based on the increasing landscape of adopted applications and large volumes of products needed to support the demand, especially driven by Automobile market. Pulse Electronics utilizing its core competencies, designed, and launched fully automated manufacturing lines to produce wound magnetics. This new fully automated transformer series offer lower cost by means of shortened manufacturing time and improved production yield. This new line of transformers was released to engineering communities after extensive product qualification and reliability testing. Increased automation level allowed a 70% reduction in manufacturing steps by decreasing human intervention. The new process requires involvement of humans in two stages: one for loading raw material in the system, and a second stage to pack and ship finished products. Figure 3a reflects a legacy transformer wound on a ferrite toroidal core using automated winding equipment with manual operation for wire termination to pins. Figure 3b is the new fully automated transformer wound on a bobbin shaped core with plated terminal pads for wire terminations. Figure 4 shows the typical process flow used to manufacture legacy type transformers, and figure 5 is representative of the processes involved for fully automated line. The simplicity of manufacturing process for the new line of transformers allows even greater opportunities to reduce cost and increase production volume due to automation and reduction of direct labor force.

Figure 3 Transformer Manufacturing Methods



a. Hand or Semi-automated



b. Fully Automated

Figure 4 Process steps for Manual/Semi automated line

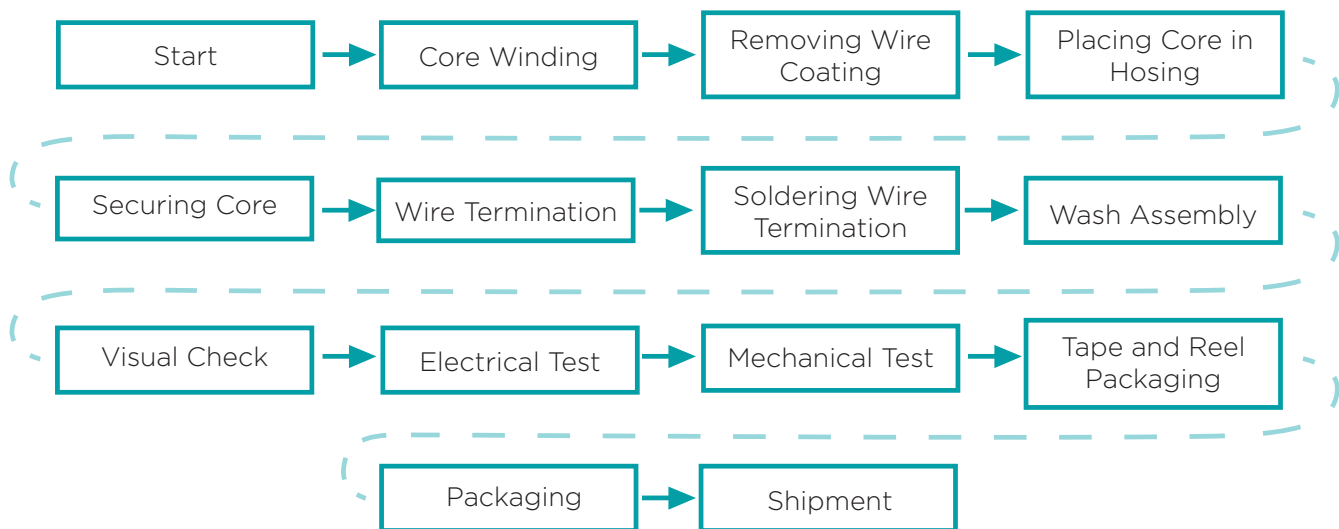
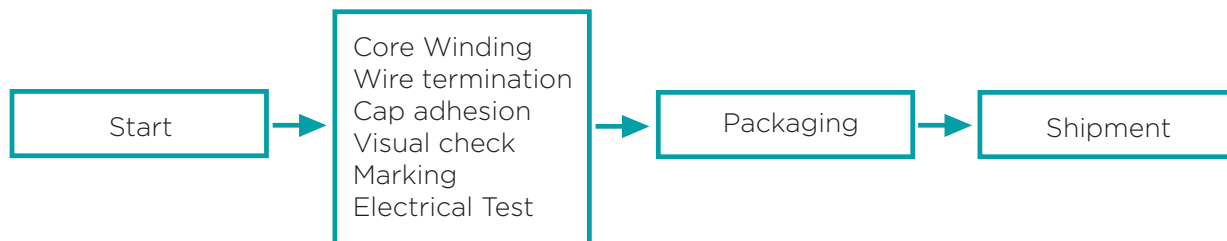


Figure 5 Process steps for Fully automated line



Comparison

Table 1 lists a few distinctive differences between transformers manufactured with semi-automation (toroidal designs) versus fully automated methods (henceforth called T-chip). In general, T-chip transformers designed for Ethernet applications can support the same data rates as toroidal designs and they exceed the IEEE802.3xx specifications and have lower part to part performance variation.

Transformer type	Electrical performance	Performance variation	Wire Termination	Testing	Label & Packaging	Product yield	Mechanical Size
Toroidal	Good	Good	Manual	Manual	Manual	Good	Large
T-chip	Better	Better	Automated	Automated	Automated	Better	Small

Table 1

The automated T-chip technology integrates the mechanical package and ferrite core eliminating the need for plastic housing and enabling a lower weight and smaller size compared to legacy toroidal designs.

Figure 6 below is the mechanical dimensions for the first group of released transformers using the T-chip platform, they comply to IEEE802.3xx standards for data transmission rates of 100Mbps to 10Gbps with ability to supply up to 600mA of PoE current to power up remote terminal equipment.

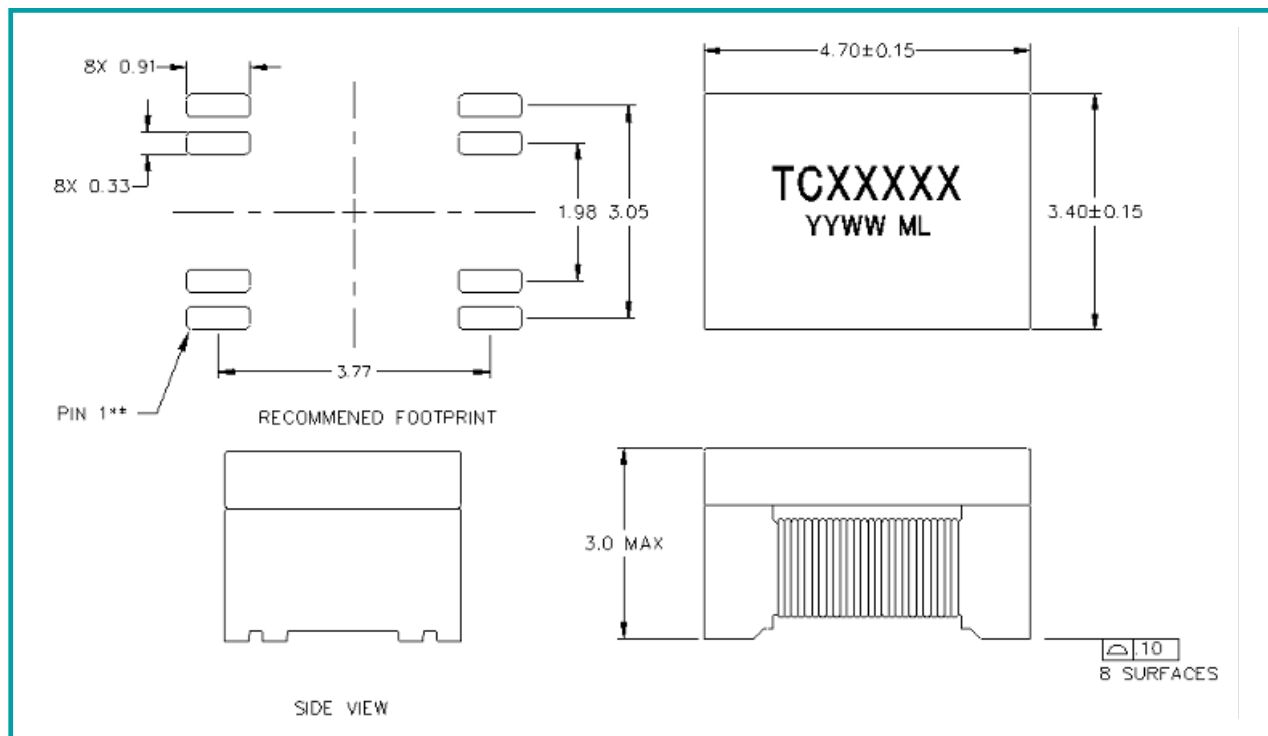
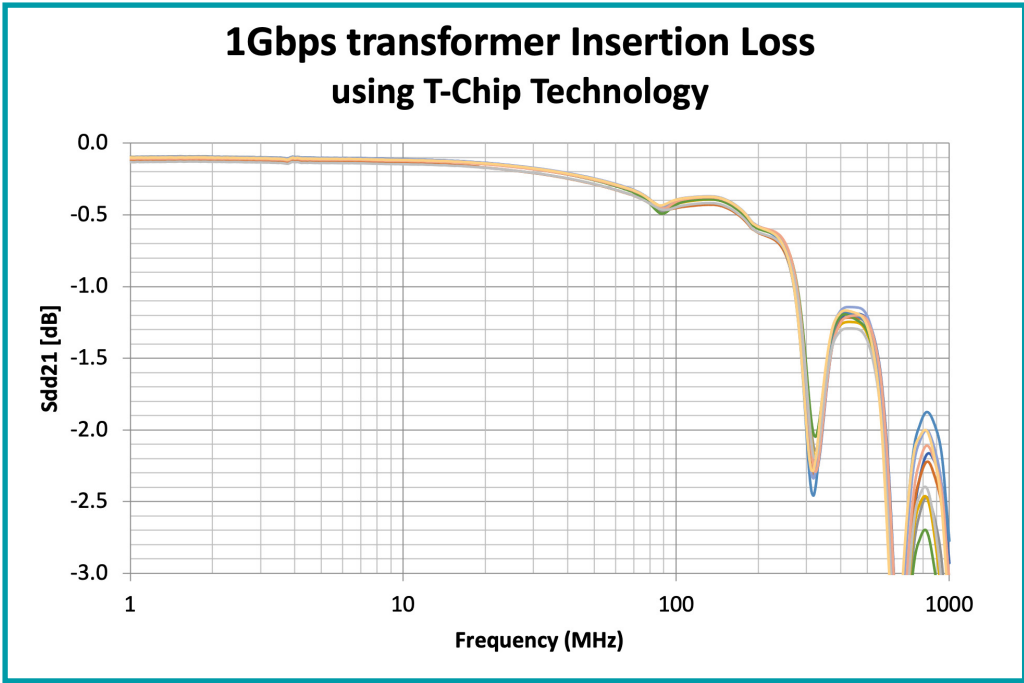
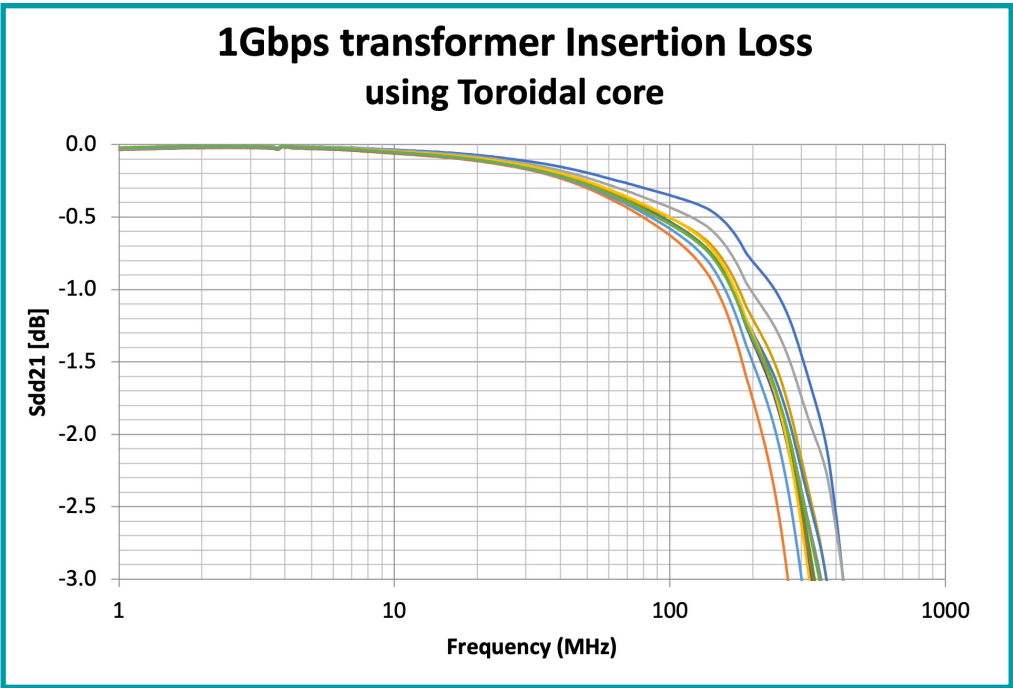
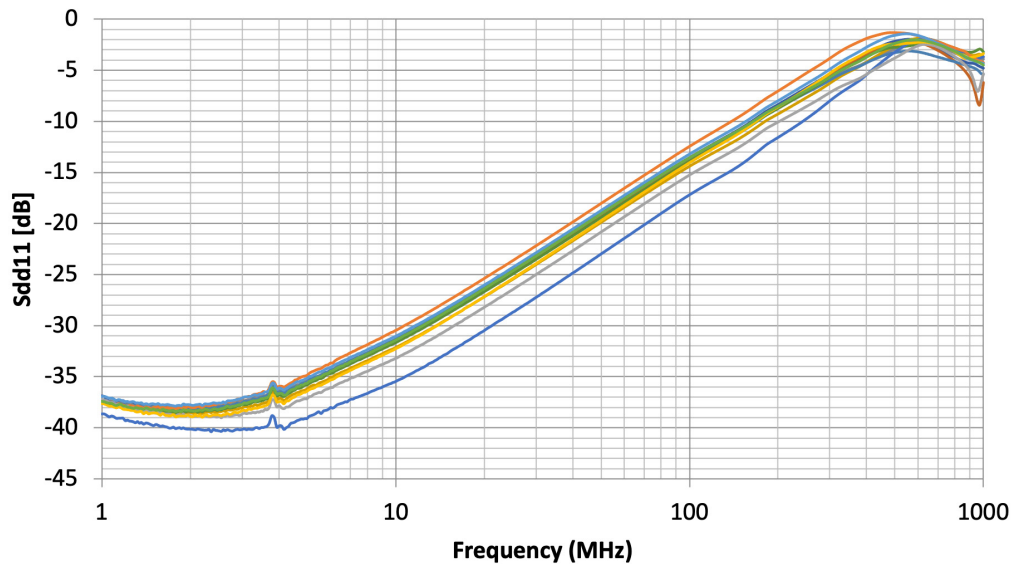


Figure 6

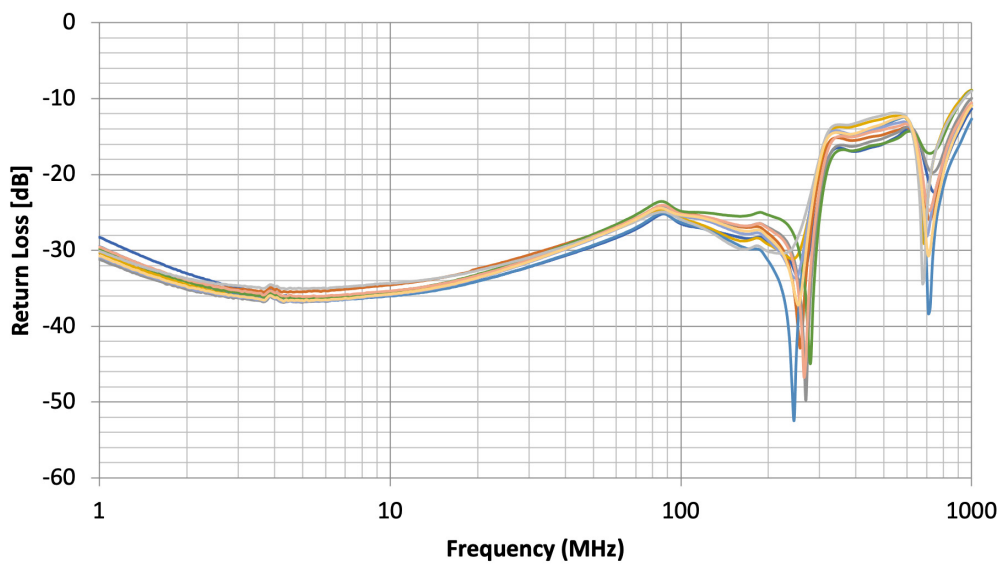
Plots below are from 1Gbps transformers manufactured using Toroidal and T-chip technologies. They reflect the performance enhancement and reduced variability achieved using in T-chip design concepts and manufacturing.



**1Gbps transformer Return Loss
using Toroidal core**



**1Gbps transformer Return Loss
using T-Chip Technology**



Part numbers released to production

Part Number	Date Rate Mbps	Maximum PoE Current 600mA	Primary Inductance uH Minimum
TC1000	100	-	250
TC1000P	100	✓	180
TC2500	2500	-	180
TC2500P	2500	✓	180
TC5000	5000	-	180
TC5000P	5000	✓	180
TC10000	10000	-	120
TC10000P	10000	✓	120

Conclusion

T-chip technology enables large volume manufacturing of high-quality magnetic component for ever increasing market for Ethernet networking while reducing the implementation cost by removing dependability to human workforce.

Written By: Hamlet Abedmamoore

SEARCH PRODUCT FINDER

GET A QUOTE