ROGERS CORPORATION

TC600™ Laminates Data Sheet

Enhanced Thermal Conductivity Ceramic Filled PTFE/Woven Fiberglass Laminate for Microwave Printed Circuit Boards

TC600™ woven fiberglass reinforced, ceramic filled, PTFE-based composite for use as a printed circuit board substrate is designed to provide enhanced heat-transfer through "Best-In-Class" thermal conductivity, while reducing dielectric loss and insertion loss. Lower losses result in higher Amplifier and Antenna Gains/Efficiencies. Mechanical robustness is also greatly improved for the 6.15 dielectric constant market.

The increased thermal conductivity of TC600 laminate provides higher power handling, reduces hot-spots and improves device reliability. This higher heat transfer within the substrate complements designs using coins, heat sinks or thermal vias to provide designers additional design margin in managing heat. In designs with limited thermal management options, TC600 laminate significantly improves heat transfer where the primary thermal path is through the laminate. This results in reduced in junction temperatures and extends the life of active components, which is critical for improving power amplifier reliability, extending MTBF and reducing warranty costs. In addition, lower operating temperatures and chip-matching thermal expansion characteristics provide better reliability for component attachment prone to solder fatigue, solder softening and joint failure.

TC600 laminate has "Best-In-Class" Dielectric Constant Stability across a wide temperature range. This helps Power Amplifier and Antenna designers maximize gain and minimize dead bandwidth lost to dielectric constant drift as operating temperature changes. Dielectric constant stability is also critical to phase sensitive devices such as network transformers utilized for impedance matching networks utilized in power amplifier circuitry.

TC600 laminate has low Z-Direction CTE. This feature provides unsurpassed plated through hole reliability. TC600 laminate is a "soft substrate" and irrelatively insensitive to stress from vibration. Its robust nature overcomes the brittleness of thermoset ceramic loaded hydrocarbons or ceramics (such as alumina or LTCC) through suspension of micro-dispersed ceramics in a relatively soft, woven fiberglass reinforced PTFE-based substrate. This gives RF designers the advantage of low loss, without sacrificing mechanical robustness required to fulfill the needs of shock, drop and impact testing requirements of electronics. It is preferred by board manufacturers, as it can be easily cut, drilled, and routed without being sensitive to cracking.

Features:

- "Best in Class" Thermal Conductivity(1.1 W/m·K) and Dielectric Constant Stability across Wide Temperatures (-75 ppm/ºC)
- Very Low Loss Tangent provides Higher Amplifier or Antenna Efficiency
- Mechanically Robust; replaces brittle laminates that cannot withstand processing, impact, or High G forces
- Priced Affordably for Commercial Applications
- High Peel Strength for Reliable Narrow Lines

Benefits:

- Heat Dissipation and Management
- Replace Ceramic in Some Applications
- Improved Processing and Reliability
- Large Panel Sizes for Multiple Circuit Layout for Lowered Processing Costs

Typical Applications:

- Power Amplifiers, Filters and Couplers
- Microwave Combiner and Power Divider Boards in Avionics Applications
- Small Footprint Antennas
- Digital Audio Broadcasting (DAB) Antennas (Satellite Radio)
- GPS & Hand-held RFID Reader Antennas

Typical Properties:

TC600 Laminates

Property	Units	Value	Test Method
1. Electrical Properties			
Dielectric Constant (may vary by thickness)			
@1.8 MHz	-	6.15	Resonant Cavity
@10 GHz	-	6.15	IPC TM-650 2.5.5.5
Dissipation Factor			
@1.8 GHz	-	0.0017	Resonant Cavity
@10 GHz	-	0.0020	IPC TM-650 2.5.5.5
Temperature Coefficient of Dielectric	-		
TCεr @ 10 GHz (-40-150°C)	ppm/ºC	-75	IPC TM-650 2.5.5.5
Volume Resistivity			
C96/35/90	MΩ-cm	$1.6x10^9$	IPC TM-650 2.5.17.1
E24/125	MΩ-cm	$2.4x10^8$	IPC TM-650 2.5.17.1
Surface Resistivity			
C96/35/90	MΩ	$3.1x10^9$	IPC TM-650 2.5.17.1
E24/125	MΩ	$9.0x10^8$	IPC TM-650 2.5.17.1
Electrical Strength	Volts/mil (kV/mm)	850 (34)	IPC TM-650 2.5.6.2
Dielectric Breakdown	kV	62	IPC TM-650 2.5.6
Arc Resistance	sec	>240	IPC TM-650 2.5.1
2. Thermal Properties			
Decomposition Temperature (Td)			
Initial	°C	512	IPC TM-650 2.4.24.6
5%	°C	572	IPC TM-650 2.4.24.6
T260	min	>60	IPC TM-650 2.4.24.1
T288	min	>60	IPC TM-650 2.4.24.1
T300	min	>60	IPC TM-650 2.4.24.1
Thermal Expansion, CTE (x,y) 50-150ºC	ppm/ºC	9, 9	IPC TM-650 2.4.41
Thermal Expansion, CTE (z) 50-150ºC	ppm/ºC	35	IPC TM-650 2.4.24
% z-axis Expansion (50-260ºC)	%	1.5	IPC TM-650 2.4.24
3. Mechanical Properties			
Peel Strength to Copper (1 oz/35 micron)			
After Thermal Stress	lb/in (N/mm)	10 (1.8)	IPC TM-650 2.4.8
At Elevated Temperatures (150ºC)	lb/in (N/mm)	10 (1.8)	IPC TM-650 2.4.8.2
After Process Solutions	lb/in (N/mm)	9 (1.6)	IPC TM-650 2.4.8
Young's Modulus	kpsi (MPa)	280 (1930)	IPC TM-650 2.4.18.3
Flexural Strength (Machine/Cross)	kpsi (MPa)	9.60/9.30 (66/64)	IPC TM-650 2.4.4
Tensile Strength (Machine/Cross)	kpsi (MPa)	5.0/4.30 (34/30)	IPC TM-650 2.4.18.3
Compressive Modulus	kpsi (MPa)		ASTM D-3410
Poisson's Ratio	-		ASTM D-3039
4. Physical Properties			
Water Absorption	%	0.03	IPC TM-650 2.6.2.1
Density, ambient 23ºC	g/cm^3	3.0	ASTM D792 Method A
Thermal Conductivity (z-axis)	W/mK	1.1	ASTM E1461
Thermal Conductivity (x, y)	W/mK	1.4	ASTM E1461
Specific Heat	J/gK	0.94	ASTM E1461
Flammability	class	V0	UL-94
NASA Outgassing, 125ºC, $\leq 10^{-6}$ torr			
Total Mass Loss	%	0.02	NASA SP-R-0022A
Collected Volatiles	%	0.00	NASA SP-R-0022A
Water Vapor Recovered	%	0.00	NASA SP-R-0022A

**Dielectric Constant may vary by test method or based on specific metal plate or composite constructions. Contact your Rogers' representative with any specific questions.*

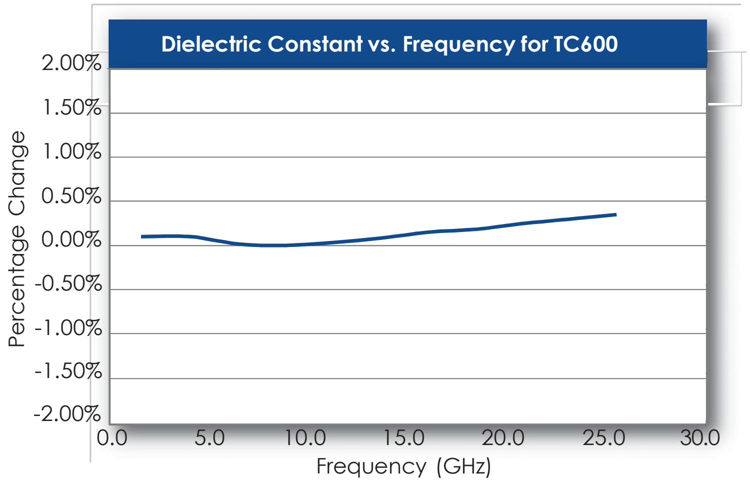

Figure 1

Demonstrates the stability of dielectric constant across frequency. This information was correlated from data generated by using a free space and circular resonator cavity. This characteristic demonstrates the inherent robustness of Rogers' laminates across frequency, thus simplifying the final design process when working across EM spectrum. The stability of the Dielectric Constant of TC600 laminate over frequency ensures easy design transition and scalability of design.

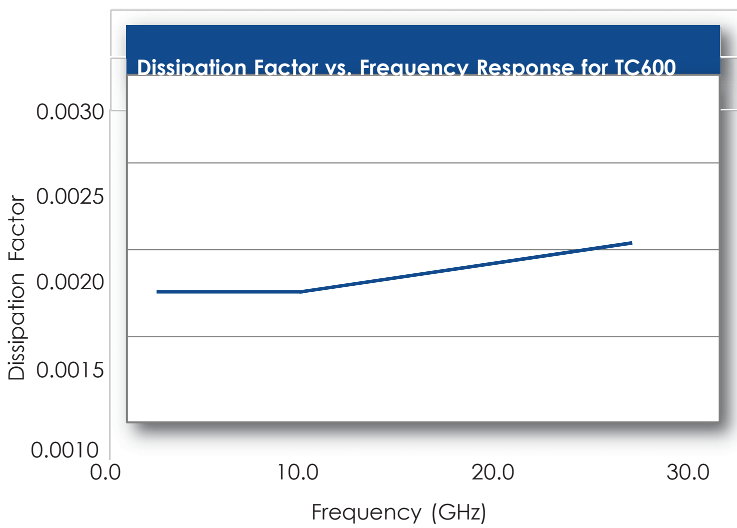

Figure 2

Demonstrates the stability of dissipation factor across frequency. This characteristic demonstrates the inherent robustness of Rogers' laminates across frequency, providing a stable platform for high frequency applications where signal integrity is critical to the overall performance of the application.

Resonant Cavity Methods yielded slightly lower dissipation factor results than IPC 650-TM 2.5.5.5. Df across 1.8 GHz to 25.6 GHz averaged 0.0017 in the Z-Axis. Dielectric loss best correlates with Z-Axis (E-field perpendicular to the board) as the signal propagation down the length of the board maintains the E-Field perpendicular to the plane of the board (right hand rule), such as a microstrip or stripline design.

Top View **Bottom View**

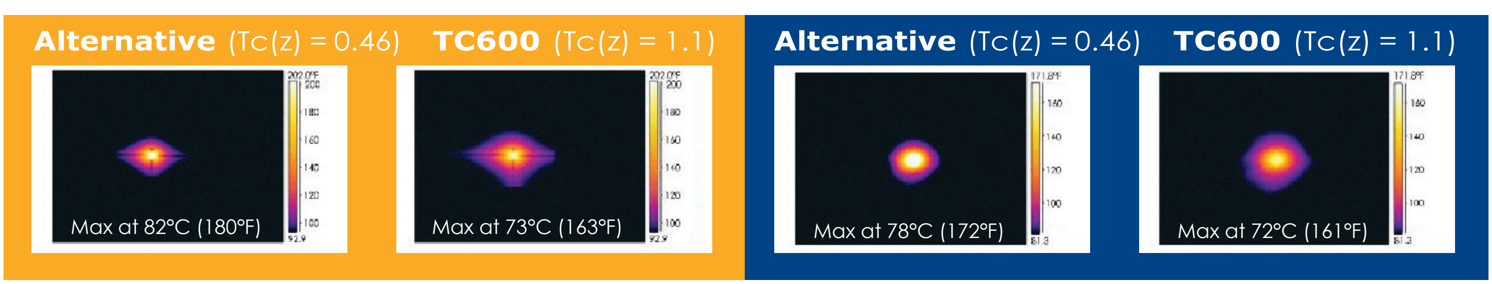

Figure 3 - THERMAL COMPARISON – thermal image of 25 mil laminate test circuit

Results listed above are typical properties; they are not to be used as specification limits. The above information creates no expressed or implied warranties. The properties of Rogers laminates may vary, depending on the design and application.

Material Availability:

Grade	Available Thicknesses	Standard Panel Sizes	Available Cladding
TC600	0.010" (0.25mm) ±0.0007"	18"x12" (457mm X 305mm) 18"x24" (457mm X 610mm)	½ oz. (18µm), 1 oz. (35µm) Reverse Treat electro-deposited copper Foil
	0.020" (0.51mm) ±0.0015" 0.030" (0.76mm) ±0.0020" 0.060" (1.52mm) ±0.0030"	18"x12" (457mm X 305mm) 18"x24" (457mm X 610mm)	½ oz. (18µm), 1 oz. (35µm) electrodeposited copper Foil ½ oz. (18µm), 1 oz. (35µm) Reverse Treat electro-deposited copper Foil