



# Quad Plus®



## Terahertz Gauging Solutions

**Quad Plus: Terahertz - The Future of Online QCS Metrology**

Thickness • Basis Weight • Density • Multilayer Structures

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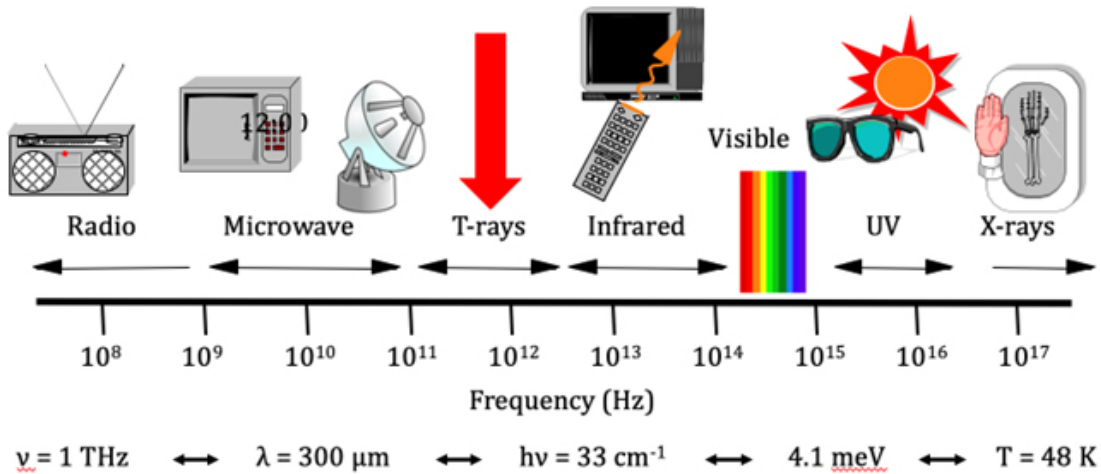


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# What is Terahertz (THz)?

Terahertz is the electromagnetic spectrum between far infrared and microwave. Due to historically limited propagation capabilities, this spectrum area is called the Terahertz Gap. This “gap” offers precision radar-like sensing options at frequencies ranging from 30GHz to 10THz and wavelengths from 1mm to 0.03 mm.



## Quad Plus THz Background

Terahertz is an early adoption phase disruptive technology. It offers improved quality, material savings, and increased process utilization. Quad Plus integrated the first time-domain THz sensor to a factory floor multilayer QSC system ten years ago. In just a decade, we have adopted and innovated an increasing array of applications now spanning more THz process integrations than other QCS providers combined.

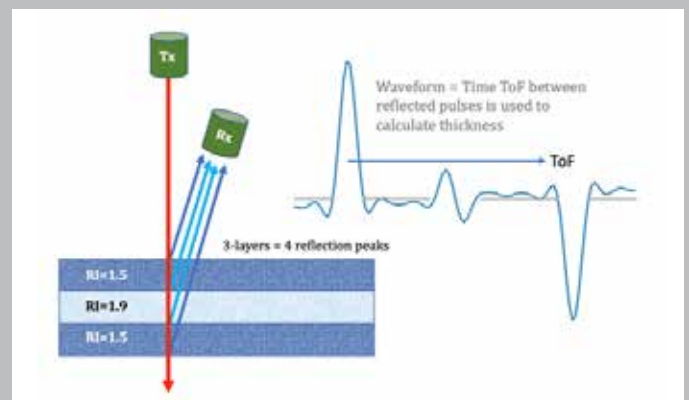
The terahertz gap spectral range enables an array of differing propagation designs. Quad Plus currently deploys time-domain TD/THz (when application parameters allow).

Quad Plus is headquartered in New Lenox, Illinois, and is ranked 3rd in the Global System Integrator database. Unlike many QCS manufacturers who sell what they have, we offer our clients metrology solutions open to global innovation. A suite of innovative products and services is delivered directly from Quad Plus to support customers' gauging measurement and control requirements. Regional sales and service resources are available throughout the USA and Europe.

## How Does THz Work?

An easy way to understand THz is by comparison to radar. Time-domain THz functions as a high-precision radar sensor that measures time-of-flight (ToF). The ToF principle can be understood as follows: it detects the time for a pulse to interrogate the target, reflects from interfacial layer structures, and returns to the sensor. This is accomplished by using a femtosecond [10-15] laser to generate picosecond [10-12] pulse terahertz waves. Waveform data streams are typically at kilohertz [1000k/second], enabling rapid web scan speeds and large data arrays >175,000/ scan and >35,000/layer without averaging. Quad Plus optimizes performance by integrating the digital THz kHz sensor with a Beckhoff multicore processor to host a maximum 4,294,967,295 element high-resolution array (32-bit, 4.29 billion).

Simplified illustration of ToF principle:



# Application Considerations

Terahertz sensors are 100% human-safe, non-nuclear, non-ionizing and widely applicable to web processes. We can safely apply Terahertz sensors to multilayer plastic sheet or foam extrusion, aseptic and EVOH barrier packaging, converting, laminating, and lithium battery electrode coating/calendering. Additionally, tire body-ply calendering, tread extrusion and many building product applications offer unique THz benefits.

## Features:

- ✓ THz unique capabilities are not feasible with any single sensor
- ✓ Simultaneous measurement of thickness, basis weight, and density
- ✓ Precision & gauge R&R better than beta gauges
- ✓ Range <math>10\mu\text{m}</math> – 10cm

- ✓ Can reduce system complexity – fewer scanners and sensors
- ✓ Non-contact single-layer or multilayer thickness measurement
- ✓ Multilayer measurement without product-specific calibration
- ✓ Single-sided, reflection sensor – convenient low-space profile
- ✓ Temperature stable sensor 50C without external cooling
- ✓ Linear calibration to time – no inverse exponential curve fit dependency
- ✓ Immune to web flutter, dust, dirt, fumes
- ✓ Small measurement spot size ~2mm
- ✓ Speed = 1000hz or 100hz applications dependent

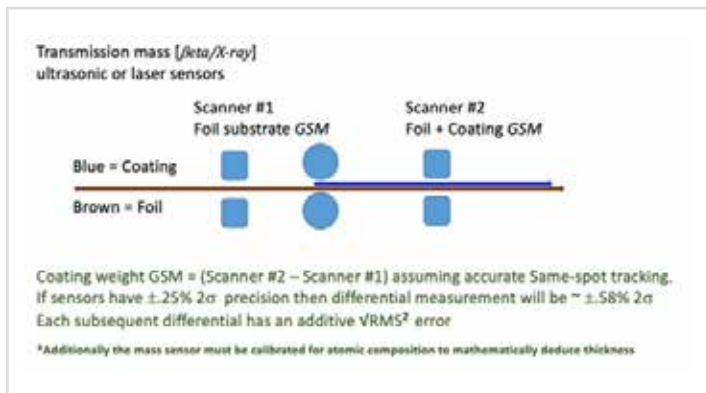
# Typical THz converting application examples

The common processes for packaging, battery electrodes and medical laminations often require flat die extrusion, reverse roll or calendered application of coatings to a substrate such as foil, film, paper or nonwovens.

## Example #1

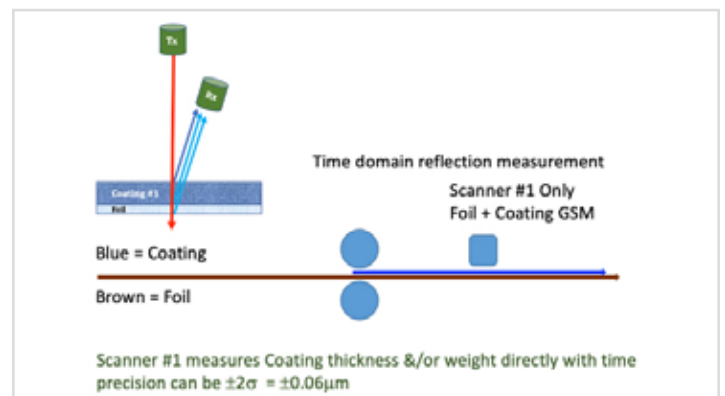
The QCS systems are typically configured with two scanner/sensor pairs aligned with same-spot tracking to enable a differential coat-weight measurement. This method requires a precision O-frame scanner to sustain a ~1cm web pass line.

However, this solution is costly and assumes sustained calibration and same-spot tracking of multiple sensing units. Furthermore, it has dependencies for ambient temperatures, dirt compensation and coating consistency.



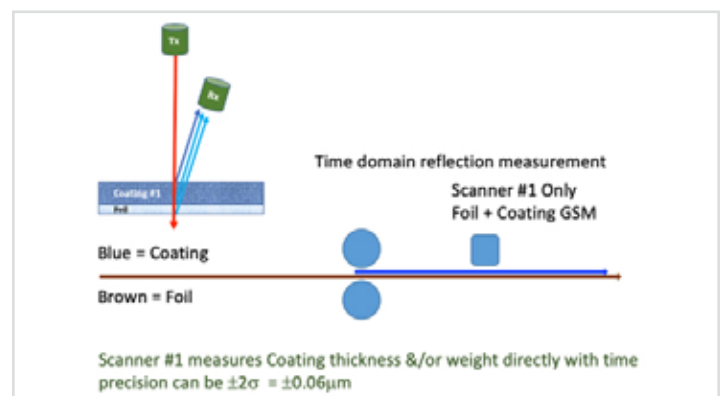
## Example #2

A single THz sensing unit with inherent same-spot measurement, linear-to-time calibration without z-axis, thermal, and dirt dependencies. This single rail scanner is equipped with reflection probe 75-150mm optical pass line.



## Example #3

A single TCU with dual-THz probes. This application produces high-efficiency process metrology results, which include previous benefits and low-marginal costs for the second THz probe.





## Application Dependent Performance Specifications:

Parameter	Specification	Units	Comments
Type of Measurement	Time Domain THz		
Typical Measurement Period	0.25	sec	Minimum periods of 0.001 sec or 0.01 sec depending on TCU
Pass line tolerance	±3 ±6 ±12 ±40	mm	80 ps width 160ps 320ps 700ps Value is dependent on TCU scan window
Measurement Rate	100 / 1000	meas/sec	1000 Hz - 80ps and 160ps      100 Hz - 320ps and 700 ps
Basis Weight Range	3 to > 20000	gsm	
Basis Weight Precision	0.2 to 1	gsm	Low gsm limit to high gsm limit
Caliper Range	0.025 to 8 0.025 to 17 0.05 to 40 0.05 to 100*	mm mm mm mm	80 ps 160 ps 320 ps 700 ps* extended range is possible * Slightly
Caliper Precision	±0.1 to ±0.5	µm	Filter selection - Low Bandwidth to UltraHigh Bandwidth
Measurement Footprint	2	mm	Average focus spot size
CD Streak Resolution	0.5	mm	
Z-Axis Tolerance	±6 ±9 ±12 ±18	mm	Values listed are for 3 inch standoff sensor For 1 inch standoff sensor, divide values by 4 For 6 inch standoff sensor, multiple values by 2
Operating Temperature	0 to 50	C	Environmental enclosure available for operation outside this range
% Moisture			Application specific, please contact

## Product Maintenance:

We based our service offering on corrective and preventative maintenance that reduces downtime and helps you improve the process.

At Quad Plus, our support agreements offer

- ✓ System calibrations
- ✓ Preventative maintenance
- ✓ On-site repair

Complete package options are available with all travel and labor included.

## Education and Training:

Our training, included with the sale of each system, helps you increase productivity by optimizing the use of your instruments and expanding the skills of your operators.

Training topics covered:

- ✓ Basic Operation
- ✓ Calibration
- ✓ Routine Maintenance
- ✓ Troubleshooting

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