mtiinstruments

A WORLDWIDE LEADER IN PRECISION MEASUREMENT SOLUTIONS

How-to Guide

Non-Contact Thickness Measurement of Most Insulating Materials

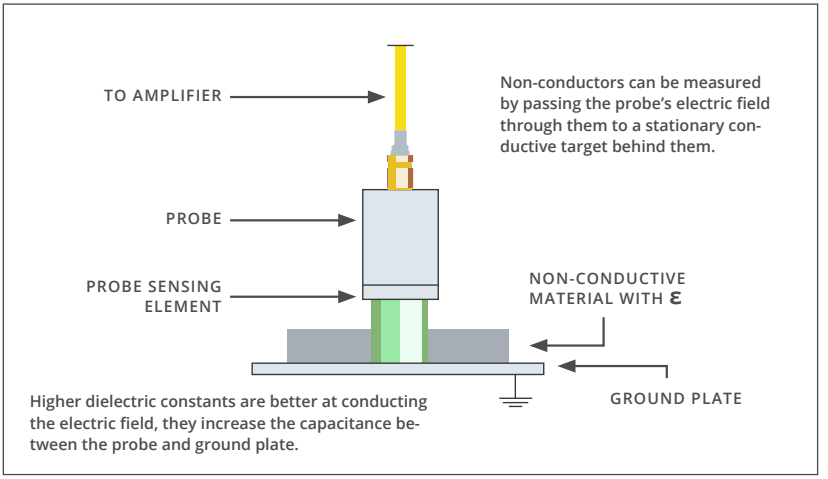
How to achieve accurate thickness measurements of thin, non-conductive materials such as Glass, Sapphire, Plastic, and other Polymers using MTI capacitance amplifiers and capacitance probes.

CAPACITANCE SENSORS

Capacitance sensors are known for their ability to precisely measure thickness and position of conductive targets.

However, it is less known that capacitance sensors can also measure the thickness of non-conductive materials such as sapphire, glass, foams, many plastics and even semi-insulating semiconductor materials such as GaAs and silicon nitride.

It was possible to measure thickness with older analog capacitance probes and amplifiers, but the necessary calibration and thickness calculations were daunting and confusing when dealing with uncalibrated analog signals.



DIGITAL ACCUMEASURE

Now there's a better way. The Digital Accumeasure takes the guess work out of what used to be a complex measurement.

The built-in measurement and computing capability of MTI's Digital Accumeasure system can measure and digitally calculate the thickness of non-conductive targets after performing a simple calibration procedure. The Accumeasure amplifier and computer compensates for the dielectric constant of the target material and the overall gap.

MTI's capacitance probe emits an electric field that passes through the insulating material, and the dielectric constant of this insulating material modifies that field. In order for the capacitive system to measure thickness, it must account for different dielectric constants by going through a calibration with the material to be tested. As long as the dielectric constant of the material doesn't change, the calibration will remain consistent and even non-conductive sheets, webs and other moving non-conductive targets can be measured for process control.

For best results, the ground target area should be circular and the same diameter as the probe. A square ground return that is approximately the same diameter as the probe is also suitable. A large ground plate many times the size of the probe will also work with slightly reduced accuracy. When making thickness measurements, it's best to stay a half-probe diameter away from the edge of the dielectric material in order to avoid measurement errors caused by field warping between the dielectric target and the ground plate below the target. Non-contact measurement of clear plastic or glass materials is difficult or impossible to measure with laser triangulation sensors. The Digital Accumeasure is a suitable method to make these thickness measurements because in most cases clear glass and plastic do not provide enough reflection for a laser triangulation sensor to work when in diffuse mode of operation. Most of the laser energy goes right through the clear target. It is possible to get a displacement reading if a specular laser head is used but many times this is undesirable because the laser spot changes location based on distance.

Additionally, MTI's Digital Accumeasure can be used to calculate/monitor the density of non-conductive materials if used in conjunction with external thickness sensors. Contact MTI if you have a density application.

Dielectric Constant of Common Materials

ACRYLIC (PLEXIGLASS)	2.7 to 4.5
ACRYLONTIRILE BUTADIENE STYRENE (ABS)	2.87
ACETAL RESIN (DELRIN)	3.6
AIR	1.000585
ALUMINA	9.3 to 11.5
ASBESTOS	3.0 to 4.8
BAKELITE	3.5 to 5.0
BEESWAX	2.6 to 3.0
CELLULOID	3.3 to 11
EPOXY RESIN (CAST)	3.6
FORMICA	3.6 to 6
FR-4	4.3 to 5.0
MICA	5.4
MICARTA	3.2 to 5.5
NEOPRENE	6 to 9
NYLON	4.0 to 5.0
PAPER (CLEAN)	3
PARAFFIN WAX	2.1 to 2.5
PHENOL RESIN	4.9
POLYAMIDE	2.5 to 2.6
POLYCARBONATE (LEXAN)	2.9 to 3.0
POLYESTER FILM (MYLAR)	2.8 to 4.5
POLYETHYLENE	2.27 to 2.5
POLYPROPYLENE	2.25
POLYSTYRENE	2.4 to 2.6
POLYVINYL CHLORIDE (PVC)	2.8 to 3.4
PORCELAIN	5.1 to 6.0
PYREX GLASS	4.3 to 5.0
QUARTZ	4.2
RUBBER CEMENT	2.7 to 2.9
SILICON	11.0 to 12
SILICONE OIL	2.2 to 2.9
SILICONE RUBBER	3.2 to 9.8
SILK	2.5 to 3.5
STYRENE (ABS)	2.8
TEFLON (PTFE)	2.1
TEFLON (GLASS WEAVE)	2.2 to 2.8
WATER (DISTILLED)	76.5 to 80
WAX	2.4 to 6.5
WOOD, DRY	2 to 6
WOOD, WET	10 to 30

What is needed for up to 1µm accuracy

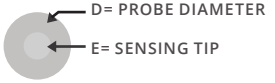
Opaque, translucent, or clear materials.

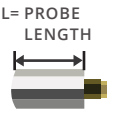
Forms a complete thickness measuring system. System calibration made easy with built-in calibration software. Thickness data can be viewed on a PC or stream data directly to a file.

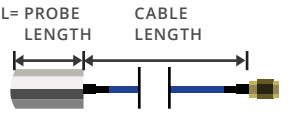
What you need

Unit	Product Model	Product #
1	Digital Accumeasure D100	8000-6454-100
1	Dielectric Probe	Selections Below
1	Oponal 24VDC Power Supply	8000-6925
1	Oponal Micro USB Cable	8000-6929

Product Model	Product #	Min. Range to Target at x1 Range		Normal Range at x1		Max Range Extension[1]	E		D		L	
		µm	*mils*	µm	*mils*		mm	*Inch*	mm	*Inch*	mm	*Inch*
ASP-250M-ILA	8100-2013-410	12.5	.49	250	9.8	4x	3.53	0.139	5.59	0.220	11.79	0.464
ASP-300M-CTA	8100-0013-000	15	.59	300	11.8	4x	3.81	0.150	12.00	0.472	36.00	1.4
ASP-400M-ILA	8100-2012-410	20	.78	400	15.7	4x	4.29	0.169	13.59	0.535	10.84	0.427
ASP-2500M-CTA	8100-0009-000	125	4.9	2500	98.5	3x	11.25	0.443	25	0.984	63.5	2.5
ASP-5000-CTA	8100-0010-000	250	9.8	5000	197	3x	15.93	0.627	38	1.5	63.5	2.5
ASP-5000-ILA	8000-6324-002	250	9.8	5000	197	7x	15.93	0.627	114	4.5	159	6.25







Measurement principles for up to 1µm accuracy

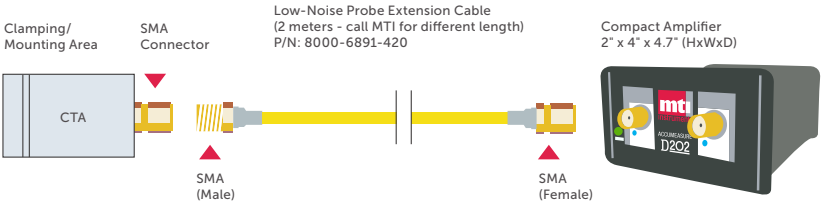
Opaque, translucent, or clear materials.

MTI's Digital Accumeasure amplifier is a multichannel digital (up to 4 channels) capacitance gauge. A single Digital Accumeasure can be configured to monitor three thickness points across a web or sheet of material at up to a 20,000 samples sec.

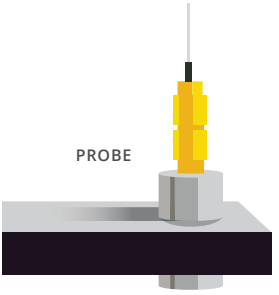
Placing a dielectric (non-conducing) material between a capacitance probe and grounded target creates a three capacitor equivalent circuit. The greater the dielectric constant of the target, the lower the impedance of the gap appears to the probe. You can measure the thickness of the non-conductive material by placing it between a probe and a ground plate that is grounded back to the capacitance amplifier.

The target material should not be thicker than the probe range (select probe from previous page) since it then would not be possible to calibrate the probe. The supplied software includes the development kit (SDK), DLL, .NET, C++ and LabView. Quadrature encoder inputs can synchronize the probe position with a moving platform (scanning a target) or a conveyor belt.

Do not let the insulating material get too close to the probe face. A quarter-gap distance from probe face is recommended.



NOTE: NOT RECOMMENDED FOR TARGETS THAT ABSORB MOISTURE SUCH AS PAPER



Dielectric thickness measurements work best with materials that have good control over their dielectric content.

If batch-to-batch variance exists, recalibrate the probe with a sample of known thickness to show the system the dielectric constant and probe gap when the batch composition changes.

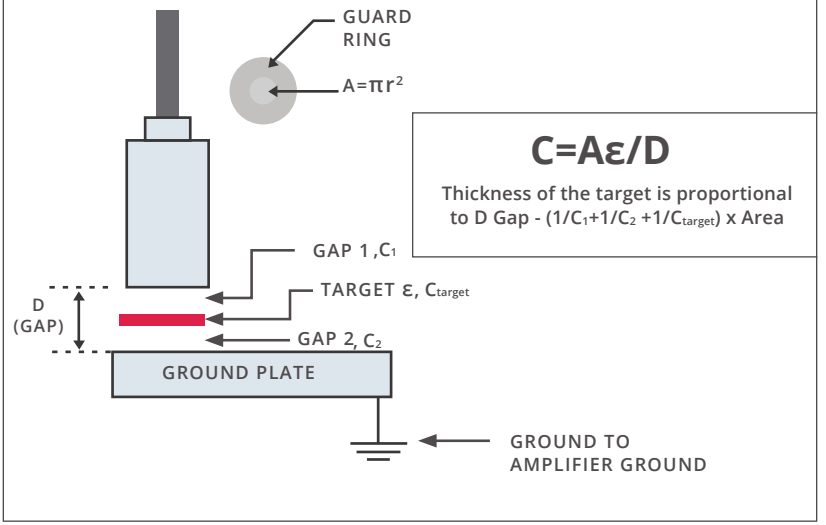
The Accumeasure D Series Amplifier

A revolutionary design

The Accumeasure D Series Amplifier uses the latest technology to convert a highly reliable capacitive electric field measurement directly into a highly precise 24 bit thickness reading.

WHERE

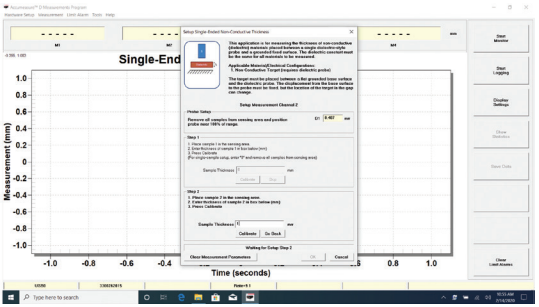
- **C** is capacitance
- **Ɛ** Dielectric constant of the gap medium, typically air
- **D** Gap distance between the probe and grounded target
- **A** Probe sensing area



Our new capacitance amplifier measures and converts the multiple gap capacitances C_1, C_2 and the capacitance of the target C_{target} directly to a digital target thickness. This direct conversion approach eliminates errors that traditional analog amplifiers have due to analog filtering, linearization, range extension and the calculations of the target capacitance/ dielectric constant. There is no actual need to know the dielectric constant of the target material as the software calibrates for the dielectric constant. The only limitation is that the dielectric constant of the target must remain the same during the measurement and that the constant should be greater than 1 (air); however, some lightweight open cell foams have a ε so close to air that they make poor targets.

With the Accumeasure D series, filter frequency response, sample rate, linearization and probe are all digitally controlled. This ensures the most accurate data capture, lossless processing and the freedom from having to purchase additional acquisition hardware. Additionally, range extension operation (bigger gap with the same probe) is permitted as long as a calibration is run after changing the extension.

The Accumeasure D Simple Calibration



The easy-to-use calibration program prompts the user to enter the known thickness of a sample.

This is a two-step entry. You can use two different thickness samples, or enter 0 in step 1 for no sample, and the sample thickness in step 2 with a sample of known thickness.

Accumeasure Amplifier Specifications

Measurement Range	0 to 12.5mm
Noise	.000001% FSR at 50Hz
Repeatability	0.000085% FSR (at a fixed point, 1 Hz bandwidth)
Minumum System Resolution	0.100 nm
Long Term Stability/Drift	20ppm/month or better at (±1°C)
Linearity Accuracy	±0.01% FSR
Frequency Response	5kHz
Output Data Rate	100 min. to 20,000 max. (samples per second)
Temperature Stability	100ppm digital (over 0 to 40°C)
Butterworth Filter	50, 100, 500, 1kHz, or 5kHz
Range Extension	1x and 2x Default. Up to 10x max. optional (see probe charts for max probe range extension permissable)
ADC Bit Count	24-bits
Exponential Filter	No filtering, 0.1, 1, or 10Hz
Basic Interface	Command-Response, ASCII commands
Digital Output	Micro USB or RJ-45 Ethernet 10/100/1000

Analog Output Scan	0-5V (14 bit resolution), 0-10V (15 bit resolution), -10V to +10V (16 bit resolution), -5V to +5V (15 bit resolution)
Analog Output Impedance	50Ω, 5kHz, 5 pole Butterworth Low Pass Filter Limited
Encoder Input	0-24VDCmax, Threshold ~1.2V, 32 bit, Z input/ reset input
Included Software	MTI Basic Software, LabVIEW, .NET, and DLL Drivers
Operating Temperature	0-40°C, 95% non-condensing (designed) 20°C, 100kPa, 50%RH (nominal)
Operating Environment	IP40 (particles to 1mm/no water protection)
Power Requirements	24VDC±1V 50mV ripple, switching speed >60kHz. <8W estimated
Target Ground Return	Integrated with Power Connector
Input Protection	Reverse Polarity (Over Volt to 35VDC)
ESD Protection	±4kV Contact and ±8kV Air
Case Dimensions	2"(53mm) H x 4"(103mm) W x 4.7" (120mm) D
Case Mount	DIN Mount Kit
Probe Connectors	SMA Female

[1] Measurement range is determined by probe selected and amplifier gain (Range Extension)
[2] Actual resolution is a function of measurement range and frequency response. Please refer to probe brochures for specifications.
[3] 0.00000180 x Frequency Response vHz x FSR

Basic Measurement Software

(Includes DLL, .NET and NI LabVIEW™ Driver)

Easy user interface allows exporting data to image files, Excel® CSV files, or data logging for data analysis and reports. The user settings tab allows adjustment of range, filter, data rate and other items.

Optional Accessories

Description	Product #
Special Low Noise Probe Extension Cables - SMA male to SMA female	
1 meter	8000-6891-410
2 meters	8000-6891-420
4 meters	8000-6891-440
24VDC Power Supply	8000-6925
KD-CH-4D Calibration Fixture	8000-6952
Ethernet Cable (2.1 meters)	8000-6887
USB-A to Micro USB-B (1 meter)	8000-6929
DIN rail (to mount aplifier)	8000-6882

mtiinstruments

A WORLDWIDE MANUFACTURER OF PRECISION MEASUREMENT SOLUTIONS