



Model Description

- Automatic Self-Balancing
- Current Comparator Technology
- Lead Compensation Circuit
- Range Extension Option with 7020
- Overall Ratio Accuracy < 15 ppm
- Low and High Voltage capacitance measurements
- Potential Transformer Calibration
- Inductance Measurements
- Reactor Loss Measurements

Model 7010C AccuLoss®



Model 7010C AccuLoss® Automatic Capacitance Bridges

The 7010C is a microprocessor controlled, current comparator based, automated capacitance bridge with metrology capabilities. However, it can also be used to measure inductance, reactor loss, AC resistance and the calibration of MI CTs. When used to measure capacitance the ratio of two capacitors (C_x/C_s) or the value of the capacitor C_x in capacitance units (pF to uF) or both are displayed along with the dissipation reading of the measurement. The minimal voltage that can be applied is 100 V when measuring a 1000 pF capacitor. To display the value of C_x the value of the reference capacitor C_s must be known and entered through the touch screen before measurements start.

When it is used to measure inductance it displays either the ratio of 2 reactances (X_l/X_c , where X_l is the reactance of L_x , and X_c is the reactance of C_s) or the value of an unknown inductor in (mH to H). When measuring reactor loss, it displays Inductance and various calculated parameters, such as power, power factor, input voltage and frequency. To display the value of L the value of the reference capacitor C_s must be known and entered through the touch screen before measurements start.

A large touch screen display presents relevant measuring quantities such as capacitance (C_x) and dissipation factor ($\tan \delta$). Easy to use touch screen menus allows the operator to set up the measurements including the number of readings for statistical analysis of uncertainty calculations at the 95% (2 s) level. The touch screen display can display a table of values or a graph or both. All measured parameters related to capacitance and inductance measurements can be transmitted over the IEEE488 interface for storage to a computer. The 7010C measures and displays the current through the standard capacitor (C_s) and the applied input voltage and frequency of measurement. A USB slot is provided on the front panel for saving measurement set ups and data.

The principle of the 7010C is based on the two-stage-compensated current comparator. The automatic self-balancing feature facilitates the use of the bridge for accurate load loss measurements of large high voltage inductive loads. This is a major advantage over the manual capacitance bridges which have difficulty in following frequency changes.

The model 7010C has the following ratios: 1:1, 2:1, 5:1, 10:1, 20:1, 50:1, 100:1, 200:1, 500:1 and 1000:1 with an overall accuracy is < 15 ppm in magnitude and 1% of reading \pm 10 ppm in dissipation. The dissipation (loss tangent) has a range of 0 to 10% with a resolution of 1 ppm making it ideal for both low and high voltage applications.

To accommodate capacitance ratios larger than 1000:1 an additional two stage range extender, model 7020, may be added to increase the ratio to 2,000,000:1. All connections are made on the rear of the instrument. The effect of lead and winding impedance on the measurement accuracy has been reduced by means of a built-in lead compensation circuit. An optional shielded rack on castors are available for portability on the test floor.

Applications for the 7010C include:

Shunt Reactor Loss Measurements	Power Transformer Measurements
Calibration of Potential Transformers	Calibration of Low Voltage Std. Capacitors
Calibration of High Voltage Dividers	Calibration of High Voltage Power Capacitors
Inductance Measurements	Measurement of Low Loss, High Voltage Power
Loss Tangent Measurements to 10%	Corona Loss Measurements
Insulator and Dielectric Testing	





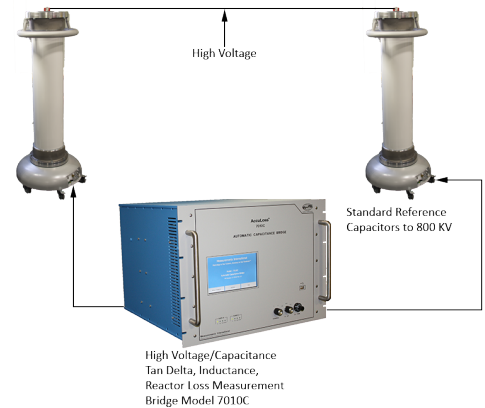
Model 7010C AccuLoss® Automatic Capacitance Bridges

Capacitance Measurement and Calibration

The 7010C is capable of performing both 2 and 3 terminal capacitance measurements. 3 terminal measurements (lead compensation) are typically performed when very large capacitors are to be measured to remove the lead impedance. For capacitance measurements the 7010C has a ratio of 1000:1 for measurement of capacitance and a C_s range of 10 pF to 10,000 pF. To extend the ratio of the 7010C an additional range extender model 7020 with a ratio of up to 2000:1 can be added extending the C_x range from 10 pF to 10,000,000 pF. A large touch screen display on the 7010C is used to setup and display the measurements. Several high voltage capacitors are also available ranging from 50 kV up to 800 kV with values of 50 pF and 100 pF.

Voltage Transformer Calibration

Voltage transformers can be calibrated using the 7010C and two high voltage standard capacitors. The ratio of the capacitors is first measured at the voltage that the transformer is measured at. The high voltage supply is then used to feed both the voltage transformer and the two high voltage standard capacitors. During the calibration of the voltage transformer the two high voltage capacitors are interchanged and the voltage ratio can be calculated and the dissipation reading on the 7010C is the loss of the voltage transformer. Below table shows possible combination of ratios and capacitors but not limited to these values.



Voltage Transformer Ranges

Transformer Ratio	C_{s1}	C_{s2}	MAX C_{s2} VOLTS	BRIDGE RATIO 1	BRIDGE RATIO 2
1	1000 pF	1000 pF	26 kV	1	1
100	1000 pF	1000 pF	26 kV	1	100
10	1000 pF	100 pF	260 kV	10	1
1000	1000 pF	100 pF	260 kV	10	100
100	5000 pF	50 pF	520 kV	100	1
10000	5000 pF	50 pF	520 kV	100	100

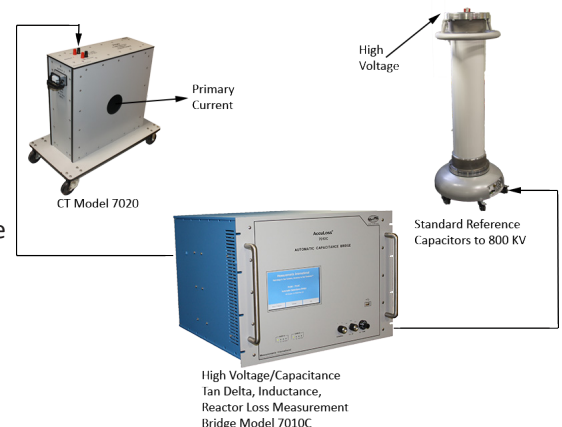
Note: The same specifications for accuracy of the 7010C Capacitance Bridge apply to each of the two measurements required for voltage transformers. Any voltage coefficient of the C_{s1} capacitor should be taken into account when calculating the voltage ratio.

Inductance Measurement

The Capacitance Bridge is capable of measuring inductors by automatically reversing the primary winding. This reactive component of current when reversed is in phase with the current through the standard capacitor and a bridge balance can be obtained with the display reading in terms of equivalent inductance ratio.

NOTE: The accuracy of the bridge in the measurement of capacitance ratio does not depend essentially on the accuracy of the frequency. However, in measuring inductance, the frequency of the supply can be the dominating factor.

The 7010C handles frequency changes by measuring the frequency and updating the display. Several transformer manufacturers use the MI 7010C, 7020 and an MI high voltage capacitor combination for measuring inductance and reactor losses. Systems as high as 600 kV have been built. The range of the 7010C can be extended for the measurement of inductance using the 7020 Two-Stage Compensated Current Transformer which has a single ratio up to 2000:1. The combined ratio of the 7010C and 7020 is 2,000,000:1. See inductance measurement range table for a complete range of inductance measurements.





Model 7010C AccuLoss® Automatic Capacitance Bridges

Inductance Measurement Range

Capacitor Cs (pF)	Max Voltage @50 Hz (V)	Bridge Ratio	Extender Ratio	Max Inductance (H)	Max Inductor Current (A)
10000	3180	723	2	0.7	14.46
10000	3180	723	20	0.07	144.6
10000	3180	723	200	0.007	1446
10000	3180	723	2000	0.0007	14460
1000	31800	723	2	7	14.46
1000	31800	723	20	0.7	144.6
1000	31800	723	200	0.07	1446
1000	31800	723	2000	0.007	14460
100	318000	723	2	70	14.46
100	318000	723	20	7	144.6
100	318000	723	200	0.7	1446
100	318000	723	2000	0.07	14460
50	636000	723	2	140	14.46
50	636000	723	20	14	144.6
50	636000	723	200	1.4	1446
50	636000	723	2000	0.14	14460
10000	2650	1005	1	0.7	10.04
10000	2650	1005	10	0.07	100.4
10000	2650	1005	100	0.007	1004
10000	2650	1005	1000	0.0007	10041
1000	26500	1005	1	7	10.04
1000	26500	1005	10	0.7	100.4
1000	26500	1005	100	0.07	1004
1000	26500	1005	1000	0.007	10041
1000	26500	1005	2000	0.0035	20083
100	265000	1005	1	70	10.04
100	265000	1005	10	7	100.4
100	265000	1005	100	0.7	1004
100	265000	1005	1000	0.07	10041
100	265000	1005	2000	0.035	20083
50	530000	1005	1	140	10.04
50	530000	1005	10	14	100.4
50	530000	1005	100	1.4	1004
1000	26500	1005	2000	0.0035	20083
100	265000	1005	1	70	10.04
100	265000	1005	10	7	100.4
100	265000	1005	100	0.7	1004
100	265000	1005	1000	0.07	10041
100	265000	1005	2000	0.035	20083
50	530000	1005	1	140	10.04
50	530000	1005	10	14	100.4
50	530000	1005	100	1.4	1004



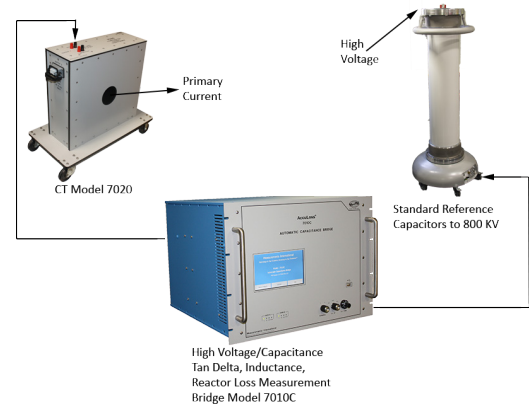


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Reactor Loss Measurements

Reactor Loss mode makes the same measurements as Inductance mode, but performs additional calculations to determine and display power factor (PF), impedance (Z), apparent power (S), active power (P), and reactive power (Q).

For Reactor Loss mode measurements all values are displayed in engineering notation throughout. Units are indicated in the headings, fields and labels see Extended Reactor Testing screen. The bridge will display the Cs current immediately, during the balancing phase, and once it reaches balance it will display the rest of the parameters. The 7010C will alert the user when applied voltage on the capacitor is within 90% of the rated value. Pressing the "Hold" button freezes the display, but the measurements will continue. When "On Hold", a snapshot of the displayed values can be saved to USB by pressing the "Save" button. Pressing the "On Hold" button again unfreezes the display.



Cabling

The 7010C comes equipped with a voltage cable to connect the high voltage capacitor and a current cable to connect the output of the 7020 to the current input on the rear of the 7010C. Custom Cables Available.

Optional Shielded Rack

The 7010C can be supplied as a laboratory bench top instrument or a Test Floor unit on castors for portability allowing the user to move it about the test floor. All inputs are located on the rear of the rack. Locking BNC connectors are used to connect the high voltage capacitors. Two current inputs are provided. The current input of the 7010C has both a locking connector on the output of the 7020 Range Extender and a locking connector on the input of the 7010C as well as a five way binding post input for connecting other manufacturers current transformers.



Optional High Voltage Capacitors - CG Series



The high voltage capacitors consist of a low voltage measurement electrode which is isolated from the high voltage electrode by a dielectric gas (SF₆). A guard electrode or grounding technique can be used to eliminate parasitic capacitance. Grounding or connecting the guard circuit are specific to the installation and application.

- | | |
|------------------------|---|
| CG 100 - 100 pF 100 kV | - Voltage range : 50 kV ta 500 kV |
| CG 200 - 100 pF 200 kV | - Tangent delta (Tan δ) : < 1.10-5 |
| CG 300 - 100 pF 300 kV | - Nominal capacitance : 5 pF to 1000 pF |
| CG 400 - 100 pF 400 kV | - Voltage coefficient : < 30 ppm (Typically < 10 ppm) |
| CG 500 - 100 pF 500 kV | - Stability / year : < 0.05 % |

Note: For higher voltages please contact MI
Note: 50 pF Capacitors also available





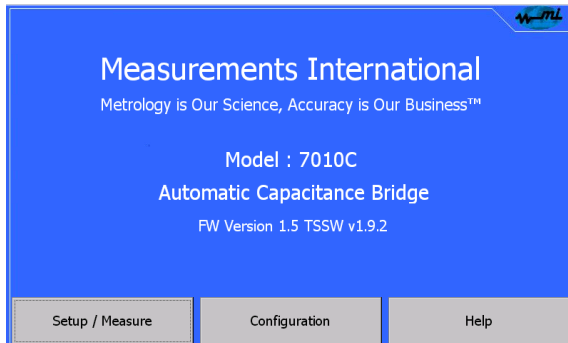
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Touch Screen Operation

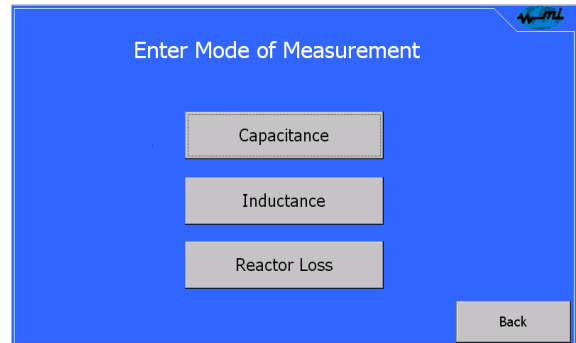
When 7010C power switch is turned on - the touch screen will automatically load the program and the bridge will perform initialization routines, calibrate its A/D converters, etc.

From the touch screen panel it is possible to fully operate the bridge performing the capacitance, inductance and reactor loss measurements.

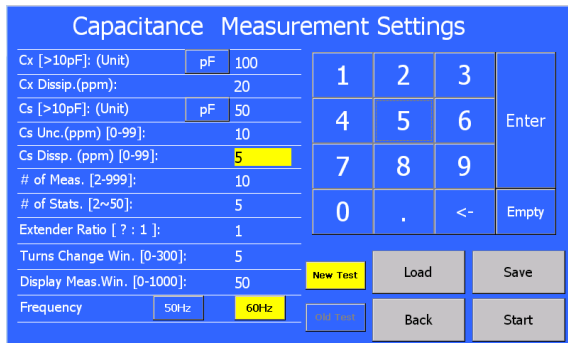
For each measurement the user will be prompted to enter parameter setting page.



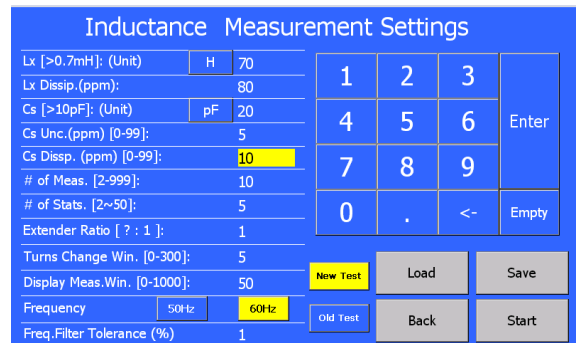
Main Screen



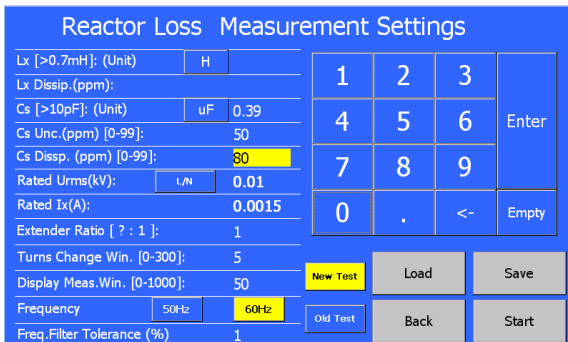
Enter Mode of Measurement



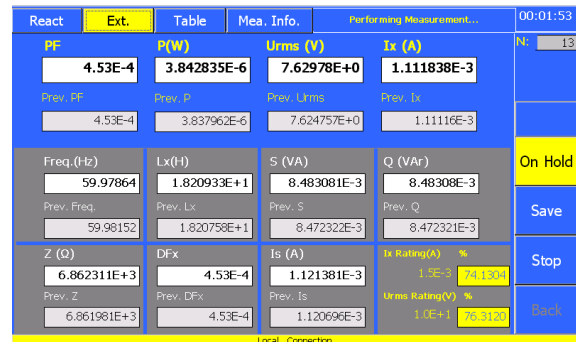
Capacitance Measurement Settings



Inductance Measurement Settings



Reactor Loss Measurement Settings



Extended Reactor Testing





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Optional Range Extenders

The 7010C can be supplied with several optional Extenders, both passive and electronically aided. Higher ratios like 1000:1 or 2000:1 are passive. For ratios below 1000:1 (e.g. 600:1 or 200:1) the CT's are electronically aided.



The **MI 7020** is a low voltage precision two-stage-compensated current transformer with phase and magnitude errors less than 10 ppm. It is mounted on casters for portability where the typical application is extending the range of the 7010C Reactor loss bridge in the calibration of shunt reactor losses on the test floor.

- Passive Two-Stage-Compensated Current Transformer.
- Compensation and Secondary windings
- Ratios 2000:1 or 1000:1
- High-quality core and proprietary windings.
- Magnitude and phase errors < 10 ppm
- Does not drift over time
- 4-inch (102 mm) window
- A Range Extender for reactor loss reactor measurements, inductor measurements, capacitor measurement, high voltage transformer measurements.

Nominal Ratio	Primary Current	Ratio Error	Phase Error
2000 : 1 (1000 : 1)	2000	< ± 20 PPM	< ± 20 PPM
2000 : 1 (1000 : 1)	1000	< ± 20 PPM	< ± 20 PPM
2000 : 1 (1000 : 1)	500	< ± 20 PPM	< ± 20 PPM
2000 : 1 (1000 : 1)	200	< ± 20 PPM	< ± 20 PPM
2000 : 1 (1000 : 1)	100	< ± 20 PPM	< ± 20 PPM
2000 : 1 (1000 : 1)	50	< ± 20 PPM	< ± 20 PPM
2000 : 1 (1000 : 1)	20	< ± 20 PPM	< ± 20 PPM
2000 : 1 (1000 : 1)	10	< ± 20 PPM	< ± 20 PPM

Dimensions: 635 x 330 x 584 mm

Weight: 64 kg

Optional Range Extenders for the calibration of MI current transformers



Model 7200ACC

The Model 7200ACC, consisting of high quality cores and proprietary windings, is a passive two-stage-compensated Current Transformer/Comparator with applications as a reference standard for calibrating precision CTs. The 7200ACC has a compensation, secondary and detector winding with a 2-inch (51 mm) primary window. The detector/comparator output is a BNC connector as shown on the bottom left of the unit. The detector output is used to connect to an electronic detector or oscilloscope. The 7200ACC can be supplied with a ratio of 2000:1 or 1000:1. Magnitude and phase errors are < 10 ppm. A handle is mounted on the top for portability.



Model 7201ACT

An Electronically Aided Current Transformer with Multiple Ratios. Used for the 7201ACT CT test set.

Magnitude and phase errors are < 10 ppm. A 1-inch (25.4 mm) window is available for primary currents. The 7201ACT is portable with carrying handle and is Battery operated. The output is provided by a BNC connector on the front panel.





Model 7010C AccuLoss® Automatic Capacitance Bridges

Specifications: Rev 1

Capacitance Range	Cs: 10 pF to 10,000 pF Cx: 10 pF to 10,000,000 pF (10 µF)
Capacitive Ratio 1:1 to 1000:1	Ns: 0 to 1.11110 in steps of 0.000001 Nx: 1 to 1000 in steps of 1, 2, 5
Primary Current	10 Amp Maximum
Secondary (Cs) Current Range	40 µA to 10 mA
Dissipation Factor Range	0 to 10% in steps of 0.000001
Inductance Range	700 µH to 700000 H (Q factor > 10)
Test Frequencies	50 and 60 Hz
Accuracy	Ratio: ±15 ppm for all Cx Ratios
Loss Angle	±1% of Reading ±10 ppm
Display	7 inch Screen Display
Warm Up Time	< 5 Minutes to Full Rated Accuracy
Operating Environment	18 to 34°C, 10 to 80% RH
Operating Power	100, 120, 220, 240 V - 50/60 Hz

Product Details:

Dimensions	545 x 435 x 355 mm
Weight	41 kg
Shipping Weight	50 kg
Warranty	1 Year Parts & Labor

How to order:

Model 7010C

Options:

CG 100 - 100 pF 100 kV	Model 7020/1000	Custom Cabling Available
CG 200 - 100 pF 200 kV	Model 7020/2000	
CG 300 - 100 pF 300 kV	Model 7200ACC	
CG 400 - 100 pF 400 kV	Model 7201ACT	
CG 500 - 100 pF 500 kV		

Corporate Headquarters

Measurements International
PO Box 2359, 118 Commerce Drive
Prescott, Ontario, Canada K0E 1T0
Phone: (613) 925-5934
Fax: (613) 925-1195
Email: sales@mintl.com
Toll Free: 1-800-324-4988

Worldwide Offices

MI-USA
Phone: (407) 706-0328
Email: sales@mintl.com
Toll Free: 1-866-684-6393

MI-China
Phone: 86-10-64459890
Email: sales@mintl.com

MI-Europe
Phone: +(420) 731-440-663
Email: sales@mintl.com

MI-Japan
Phone: +(81) 72 39 64 660
Email: kaz@mijpn.com

MI-India
Phone: +(91) 98 10 134 932
Email: sales@MILLP.co.in



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1987
Measurements International (MI) is founded.
Develops the Four Terminal Automated Resistance Scanner - Model 4220A

1991
Release of the High-Voltage Divider - Model 2500A

1993
MI USA was founded

1994
MI releases Power Calibration System (PCS) - Model 2100A
Release of Wattmeter - Model 2010A

1996
Release of the Reactor Loss Measurement System
Release of the Capacitance Bridge 100:1 - Model 7010A

1997
Release of the Automated Loss Measurement System (ALMS)
Release of the Capacitance Bridge 1000:1 - Model 7010B

1998
Develops the 20,000 A Direct Current Comparator for the LHC at CERN

2000
Release of the High-Voltage Bushing - Model 7022

2002
Develops the world's first and only portable cryogenic QUANTΩ (QHR) System - Model 6800A

2005
MI Europe was founded

2006
Develops the first self-calibrating Direct Current Comparator Ratio Bridge. Model 6242B with touchscreen display

2009
Release of the Automated Winding Resistance Measurement System - Model AWRMS 50

2010
Release of the Automated Winding Resistance Measurement System - Model AWRMS 200
Release of the Power Calibration System up to 200 A - Model 2100B
MI China was founded

2012
Release of the High-Voltage Capacitance Bridge with touchscreen display - Model 7010C
Release of AccuLoss® Technology
MI India was founded

2015
Release of the Sampling Type Power Analyzer - Model 2020A
MI Japan was founded

2016
Release of the Electronically Aided Current Transformer - Model 7201ACT

2017
Release of the Isolating Current Transformer System - Model ICT200



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www.mintl.com

sales@mintl.com