# Electrometers

## General-Purpose Electrometer with Built-In Programmable Power Supply

## TR8652

- **High Impedance of $10^{13}$ Ω or More**
- **Single Unit Allows Measurement of DC Voltage, Micro Current, High Resistance, and Charges**
- **4 1/2-Digit Display**
- **VSIM and VSRM Measurement**


## TR8652
## Digital Electrometer

The TR8652 is a 4-1/2 digit digital electrometer which employs a DC amplifier with an input impedance of $10^{13}\Omega$ and is capable of measuring DC voltage, micro currents, high resistance and charges. It features a built-in programmable power supply, enabling its use in VSIM (voltage source current measurement) and VSRM (voltage source resistance measurement) applications. Thus making it widely usable in diverse fields such as basic materials research, evaluation, testing and selection of semiconductors and other electronics components and even in biological applications. The TR8652 leaves nothing to be desired in terms of easy operation and accuracy. In addition to the previously available auto ranging, it provides the following advanced features. High speed sampling (approx. 13 and 15 readings/second at 50 Hz and 60 Hz line frequency respectively) Auto-zero to perform zero adjustment automatically Null function to suppress leakage current, offset voltage or contact resistance Automatic calibration function that ensures high accuracy and long-term stability Shield drive system that provides measurement with high response, even for measurements of voltages having a high source resistance and for resistance measurements Preamplifier output function usable for impedance conversion and in expanding the electrical charge measurement range Comparator function checks measured values against set limit values to perform a Go/No-Go test. Calculation functions include maximum value, minimum value, average value and current integration over a set number of times. In addition to all these features, for the high-sensitivity ranges which tend to be susceptible to external noise, leading to unstable measurements, the TR8652 offers the following measurement approach. The A/D converter integration time can be set at any of three steps.

A smoothing function is used which takes a walking window average of varying data. An internal battery power supply is used to completely eliminate the effect of AC line induced noise, thus providing measurement with the minimal influence of external disturbance.

The charge measurement range can be expanded by connecting the R12601 Coulomb range extender. The TR8652 features a GPIB interface and BCD output as standard and a variety of other easy-to-use functions, making it a highly versatile systems instrument, as well.

### ■ Built-In Programmable Power Supply for VSIM and VSRM Applications

The TR8652 features a built-in ±20-V programmable power supply, ensuring its use in voltage source current measurement (VSIM) and voltage source resistance measurement (VSRM).

### ■ Measurements with Minimal Influence from Noise

While the high input impedance of an electrometer enables the measurement of micro currents and high resistances, it makes the instrument inherently susceptible to noise and externally induced signals. The TR8652 A/D conversion section uses variable integration time. In addition, a smoothing function may be used to process measured data, providing a display of the continuously moving average of a set number of measured values. An internal rechargeable battery is used to power the TR8652, making it immune to noise induced in the power line. The TR8652's power-efficient design also has minimized the influence on measurements of external disturbances, thus ensuring highly stable measurements. A double-coaxial (triaxial), low-noise cable of soft construction is used as the input cable.

### ■ High-Speed Measurement of High Signal Source Impedance Voltages and Resistances Using a Shield Drive Function

In the TR8652, to improve the response speed under these conditions, a shield drive (active guarding) technique is use to drive the input cables inner shield with a voltage which is the same as the input voltage, so that the impedance appears to be zero as seen from the Lo terminal. Also, since the leakage current flowing through the cable and connectors from the Hi to the Lo terminals is decreased, the apparent insulation resistance increases. The result of using this technique is a ten-fold or greater improvement in response speed.

### ■ Versatile Data Processing Functions

### ■ Diverse System Functions Including the GPIB Interface and BCD Output

## General-Purpose Electrometer with Built-In Programmable Power Supply

# TR8652

## Specifications

### DC Voltage Measurement

| Measurement range | | 200 mV | 2 V | 20 V |
|---|---|---|---|---|
| Maximum display | | 199.99 | 1.9999 | 19.999 |
| Resolution | | 10 µV | 100 µV | 1 mV |
| Measurement accuracy | Auto-zero ON | 0.06 + 2 | 0.06 + 2 | 0.06 + 2 |
| | Auto-zero OFF | 0.06 + 12 | 0.06 + 3 | 0.06 + 2 |
| Temperature coefficient | Auto-zero ON | 0.005 + 0 | 0.005 + 0 | 0.005 + 0 |
| | Auto-zero OFF | 0.005 + 2 | 0.005 + 0.2 | 0.005 + 0.1 |

The measurement accuracy is expressed as ± (% of reading + digits) and applies at a temperature of 23˚C±5˚C and a humidity of 70% or less over six months.

The temperature coefficient is expressed as ± (% of reading + digit)/˚C over a temperature range from +5 to +35˚C and at a humidity of 70% or less.

**Input resistance:** $1 \times 10^{13}$ Ω or more.
**Input capacitance:** 30 pF or less.
**Settling time:** 2.5 ms max. (Time required for the value to reach within ±1% of the full scale, with a signal source resistance of 1 MΩ or less, excluding the range switching time)
**Maximum allowable applied voltage:** 200 V peak (1 min).
**Noise rejection:** NMR Approx. 60 dB (50/60 Hz ±0.1%)
Effective CMR (1 kΩ unbalanced resistance) 120 dB min.(50/60 Hz ±0.1%, DC)

### DC Current Measurement

| Measurement range | | | 200 pA | 2 nA | 20 nA | 200 nA | 2 µA | 20 µA | 200 µA | 2 mA |
|---|---|---|---|---|---|---|---|---|---|---|
| Maximum display | | | 199.99 | 1.9999 | 19.999 | 199.99 | 1.9999 | 19.999 | 199.99 | 1.9999 |
| Resolution | | | 10 fA | 100 fA | 1 pA | 10 pA | 100 pA | 1 nA | 10 nA | 100 nA |
| Measurement accuracy | 24 hour after | Auto-zero ON | 0.35+5 | 0.35+2 | 0.2+2 | 0.15+2 | 0.15+2 | 0.15+2 | 0.1+2 | 0.1+2 |
| | CALL ON | Auto-zero OFF | 0.35+6 | 0.35+2 | 0.2+3 | 0.15+2 | 0.15+3 | 0.15+2 | 0.1+3 | 0.1+2 |
| | CALL OFF | Auto-zero ON | 0.7+5 | 0.7+2 | 0.3+2 | 0.3+2 | 0.15+2 | 0.15+2 | 0.1+2 | 0.1+2 |
| | | Auto-zero OFF | 0.7+6 | 0.7+2 | 0.3+3 | 0.3+2 | 0.15+3 | 0.15+2 | 0.1+3 | 0.1+2 |
| Temperature coefficient | | Auto-zero ON | 0.04+0.3 | 0.04+0 | 0.03+0 | 0.03+0 | 0.01+0 | 0.01+0 | 0.01+0 | 0.01+0 |
| | | Auto-zero OFF | 0.04+0.5 | 0.04+0.1 | 0.03+0.2 | 0.03+0.1 | 0.01+0.2 | 0.01+0.1 | 0.01+0.2 | 0.01+0.1 |
| Input bias current (23˚C±1˚C, 50% RH max.) | | | 20 fA | 20 fA | 20 fA | 20 fA | 20 pA | 20 pA | 20 pA | 20 pA |
| Feedback resistance | | | 10 GΩ | 10 GΩ | 100 MΩ | 100 MΩ | 1 MΩ | 1 MΩ | 10 kΩ | 10 kΩ |

The measurement accuracy is expressed as ± (% of reading + digits) and applies at a temperature of 23˚C±5˚C and a humidity of 70% or less over six months.

The temperature coefficient is expressed as ± (% of reading + digit)/˚C over a temperature range from +5 to +35˚C and at a humidity of 70% or less.

**Input voltage drop:** 500 µV + 0.5 Ω × Ix max. (Ix: current under measurement)
**Settling time:** 2.5 ms max. (2 µA to 2 mA ranges), 5 ms max. (20 nA to 200 nA ranges), 250 ms max. (200 pA to 2 nA ranges) (Time required to reach within ±1% of the full-scale ±1%, excluding the range switching time)
**Maximum allowable applied voltage:**
70 V peak (200 µA, 2 mA ranges)
200 V peak (200 pA to 20 µA ranges)
**Noise rejection:** NMR 55 dB min. (50/60 Hz ±0.1%)

**Maximum allowable input capacitance:** 0.1 µF
(between Hi-Lo terminals of Hi-V SOURCE terminals)

### Resistance Measurement

| Measurement range | | | 20 kΩ | 200 kΩ | 2 MΩ | 20 MΩ | 200 MΩ | 2 GΩ | 20 GΩ | 200 GΩ |
|---|---|---|---|---|---|---|---|---|---|---|
| Maximum display | | | 19.999 | 199.99 | 1.9999 | 19.999 | 199.99 | 1.9999 | 19.999 | 199.99 |
| Resolution | | | 1 Ω | 10 Ω | 100 Ω | 1 kΩ | 10 kΩ | 100 kΩ | 1 MΩ | 10 MΩ |
| Measurement applied current | | | 100 µA | 100 µA | 1 µA | 1 µA | 10 nA | 10 nA | 100 pA | 100 pA |
| Measurement accuracy | 24 hour after | Auto-zero ON | 0.2+2 | 0.2+2 | 0.2+2 | 0.2+2 | 0.2+2 | 0.4+2 | 0.6+2 | 1.6+2 |
| | CALL ON | Auto-zero OFF | 0.2+3 | 0.2+2 | 0.2+3 | 0.2+2 | 0.2+3 | 0.4+2 | 0.6+3 | 1.6+2 |
| | CALL OFF | Auto-zero ON | 0.2+2 | 0.2+2 | 0.2+2 | 0.2+2 | 0.4+2 | 0.6+2 | 1.0+2 | 2.0+2 |
| | | Auto-zero OFF | 0.2+3 | 0.2+2 | 0.2+3 | 0.2+2 | 0.4+3 | 0.6+2 | 1.0+2 | 2.0+2 |
| Temperature coefficient | | Auto-zero ON | 0.015 | 0.015 | 0.015 | 0.02 | 0.03 | 0.03 | 0.05 | 0.1 |
| | | Auto-zero OFF | 0.015+0.2 | 0.015+0.1 | 0.015+0.2 | 0.02+0.1 | 0.03+0.2 | 0.03+0.1 | 0.05+0.2 | 0.1+0.1 |

The measurement accuracy is expressed as ± (% of reading + digits) and applies at a temperature of 23˚C±5˚C and a humidity of 70% or less over six months.

The temperature coefficient is expressed as ± (% of reading + digits)/˚C over a temperature range from +5 to +35˚C and at a humidity of 70% or less.

**Maximum open-circuit voltage:** 32 VDC
**Maximum allowable applied voltage:**
70 V peak (20 kΩ, 200 kΩ ranges)
200 V peak (2 MΩ to 200 GΩ ranges)
**Settling time:** 5 ms max. (measuring a resistance of 2 MΩ or less)
(Time to reach within ±1%of the full-scale excluding the range switching time)

### Charge Measurement

| Measurement range | 200 pC | 2 nC | 20 nC |
|---|---|---|---|
| Maximum display | 199.99 | 1.9999 | 19.999 |
| Resolution | 10 fC | 100 fC | 1 pC |
| Measurement accuracy | 1+50 | 0.5+5 | 0.5+2 |
| Temperature coefficient | 0.05+2 | 0.05+0.2 | 0.05+0.1 |

The measurement accuracy is expressed as ± (% of reading + digits) and applies at a temperature of 23˚C±5˚C and a humidity of 70% or less over six months.

The temperature coefficient is expressed as ± (% of reading + digit)/˚C over a temperature range from +5 to +35˚C and at a humidity of 70% or less.

### Charge Measurement Using R12601 and TR8652

| Extension range | 200 nC | 2 µC | 20 µC |
|---|---|---|---|
| TR8652 measurement accuracy | 1+50 | 0.5+5 | 0.5+2 |
| R12601 measurement accuracy | 3 % | | |
| Total accuracy | 4+50 | 3.5+5 | 3.5+2 |

The measurement accuracy is expressed as ± (% of reading + digits) and applies at a temperature of 23˚C±5˚C and a humidity of 70% or less over six months. However, the R12601 measurement accuracy is expressed as ± (% of reading).

**Input bias current:** 20 fA max. (at 23˚C±1˚C, 50% RH max.)
**Maximum allowable applied voltage:** 200 V peak
**Voltage Source Current Measurement (VSIM)**
**Measurement range:** 200 pA to 2 mA
**Resolution:** 10 fA to 100 nA
**Measurement accuracy:**
(DC current measurement accuracy) ± (0.2 + 100 × 20 mV/Vs) %
(Vs: Output voltage)
**Maximum allowable input capacitance:** 0.1 µF
(between Hi-Lo terminals or Hi-V SOURCE terminals)
**Voltage Source Resistance Measurement (VSRM)**
**Measurement range:** Same as for current
**Measurement range:** $5 \times 10^{1}$ to $2 \times 10^{14}$ Ω
**Measurement accuracy:** (Current range reading item + 0.2%)±
(Current range digit item +3 digits)
**Maximum allowable input capacitance:** 0.1 uF
(between Hi-Lo terminals or Hi-V SOURCE terminals)
**Display:** Data : 1 to 3-1/2 digits, Exponent : 2 digits

# Electrometers

## *General-Purpose Electrometer with Built-In Programmable Power Supply*

### TR8652 (Continued From Previous Page)

**DC Voltage Output (Vsource)**
**Output voltage range:** 0 to ±20.00 V
**Minimum step:** 10 mV
**Accuracy:** ±0.2% of setting ±20 mV
(at 23˚C±5˚C, 70% RH max., over 6 months)
**Temperature coefficient:** ±(0.02% of setting ±3 mV)/˚C
**Output resistance:** 0.3 Ω max.
(at output current of 2.5 mA or less)
**Maximum load current:** 2.5 mA
**Maximum shorted output current:** 25 mA
**Noise:** 10 m Vrms max. (DC to 500 Hz)
**Settling time:** 200 ms max.
(time to reach ±1% of the full scale)
**Output connector:** BNC

**Measured Data Processing Functions**
**Null:** Measured value at the time the NULL switch is pressed is subtracted from subsequent measured values.
$R = X - X_{NULL}$ [ R: Calculation result (displayed value); X: Measured value; $X_{NULL}$: Measurement data at the time the NULL switch was pressed ]
**Smoothing:** Number of smoothings setting range 1 to 100
**Delay:** Measurement trigger delay setting in the range 1 s to 2000 s
**Comparator:** R(Hi) [ X > Y X: Measured value
R(Go) Y β X β Z Y,Z: Preset value (setting value 0 to 1999 and ranges) ]
R(Ro) X < Z
**Computation:** R(Max) Maximum value of N measurements
R(Min) Minimum value of N measurements
R(Ave) Average value of N measurements
R(Tot) Integrated value of N measurements
(For current measurement only)
Number of measurements: N = 1 to 200

**Measurement Speed**
**Integration time and conversion time:**

| | SHORT | MED | LONG |
|---|---|---|---|
| Integration time | 20 ms (50 Hz)<br>16.7 ms (60 Hz) | 200 ms | 200 ms × 4 |
| A-D conversion time (max.) | 70 ms (50 Hz)<br>65 ms (60 Hz) | 250 ms | 1 s |
| Measurement speed | Approx. 13 times/s (50 Hz)<br>Approx. 15 times/s (60 Hz) | Approx. 4 times/s | Approx. 1 times/s |

**Other Functions**
**Zero cancel:** Manual or automatic zero-point compensation
**Auto-calibration:** In the DC current 200 pA to 200 nA ranges and resistance 200 MΩ to 200 GΩ ranges, a front panel key operation or remote control (GPIB) can be used to automatically calibrate out aging effects.
**Panel setting storage:** Panel measurement condition setting are held in battery backed up memory when the power is switched off. A key operation may also be used to initialize conditions.
**Alarm function:** A beeper alarm is sounded upon delay time-out, comparator HI and LO conditions, and computation complete condition.

**Data Output and Remote Control**
**GPIB interface** (not usable with battery-powered operation)
Applicable standard: IEEE 488-1978
Code system: ASCII
Functions: Displayed data output and control of all front panel key functions
**BCD parallel output** (not usable with battery-powered operation)
Measurement data output: TTL positive logic
External activation function: TTL positive pulse (positive edge), Pulse width: 100 µs min.
Output data: Measured data, polarity, decimal point, OVER indicator, units, HI/GO/LO, MAX/MIN/AVE/TOT, NULL
Output connector: 50-pin (Amphenol 57-40500 or equiv.)

| Function | | | Pin No. | | Function |
|---|---|---|---|---|---|
| Mantissa data output | | SIGNAL GND | 1 | 26 | 1 |
| | $10^0$ digit (LSD) | 1 | 2 | 27 | 2 |
| | | 2 | 3 | 28 | 4 |
| | | 4 | 4 | 29 | 8 |
| | | 8 | 5 | 30 | 1 |
| | $10^1$ digit | 1 | 6 | 31 | 2 |
| | | 2 | 7 | 32 | 4 |
| | | 4 | 8 | 33 | 8 |
| | | 8 | 9 | 34 | 1 |
| | $10^2$ digit | 1 | 10 | 35 | 2 |
| | | 2 | 11 | 36 | Hi level |
| | | 4 | 12 | 37 | Hi level |
| | | 8 | 13 | 38 | 4 |
| | $10^3$ digit | 1 | 14 | 39 | 8 |
| | | 2 | 15 | 40 | 1 |
| | | 4 | 16 | 41 | 2 |
| | | 8 | 17 | 42 | 4 |
| | $10^4$ digit | 1 | 18 | 43 | 8 |
| | | 2 | 19 | 44 | 1 |
| | | 4 | 20 | 45 | 2 |
| | | 8 | 21 | 46 | 4 |
| | Mantissa sign | 1 | 22 | 47 | Print command output signal |
| | | 2 | 23 | 48 | External activation input signal |
| | | 4 | 24 | 49 | NC |
| | | 8 | 25 | 50 | SIGNAL GND |

$10^0$ digit exponent data
Exponent sign
$10^1$ digit
Function
$10^2$ digit
Unit
$10^3$ digit
Decimal point
$10^4$ digit

**Analog (D-A) output:** D-A converted output of either 2 or 3 adjacent digits of the displayed data
Output voltage: ±1 V and ±10 mV full-scale
Converted output: 3-digit display: 000 to ±999 (0 V to ±0.999 V) +50% settable offset
Offset output: (-500 to 0 V, 000 to 0.5 V, +499 to 0.999 V)
Digit selection: 19999, 19999, 19999, 19999
Conversion accuracy: 1V output: ±1% of full-scale
10mV output: ±2% of full-scale
Output resistance: 1 V output: 1 Ω max.
10 mV output: Approx. 100 Ω
Maximum load current: 100 µA
Output connector: Binding posts
**Preamplifier output:** An impedance converted DC voltage is output (current-to-voltage, resistance-to-voltage and charge-to-voltage converted output)
Output voltage: ±200 mV, ±2 V, ±20 V at fullscale (depending upon measurement function and range)

## General-Purpose Electrometer with Built-In Programmable Power Supply

# TR8652

Output impedance: Approx. 1 kΩ
Maximum output voltage: ±32 V or less
Output connector: Binding posts

**Complete output:** Indicates completion of a measurement
Signal level: TTL negative pulse (pulse width approx. 1 ms)
Output connector: BNC

**Trigger input:** External activation signal
Single level: TTL negative pulse (negative edge)
Input connector: BNC

**General Specification**

**Measurement method:** Integration method
**Input method:** Floating and guarded
**Display:** Liquid crystal display (LCD)
**Input connector:** Triaxial (double coaxial connector)
**Range switching:** Automatic and manual
**Sampling modes:** Run, hold/manual, external
**Maximum applied voltages between terminals:**

| SHIELD DRIVE | ON | OFF |
|---|---|---|
| Between Hi-Lo | 70 V or 200 Vpeak, depending on the range | 70 V or 200 Vpeak, depending on the range |
| Between Lo-GUARD | 200 Vpeak * | 200 Vpeak * |
| Between GUARD-Chassis | 500 Vpeak * | 500 Vpeak * |

* For DC voltage and resistance measurements only. For other functions, Lo is connected to GUARD.

**Warm-up time:** Approx. 30 min (to reach the specified accuracy)
**Power supply:**
AC power supply: Specified at time of ordering.

| Option No. | Standard | 31 | 32 | 42 | 43 | 44 |
|---|---|---|---|---|---|---|
| Line voltage (V) | 100 | 115 | 120 | 220 | 230 | 240 |
| Power fluctuation (%) | ±10 | ±10 | ±10 | ±10 | +8, -10 | +4, -10 |

**DC power supply:** An internal NiCd battery provides continuous operation for 6 hours or longer (on a 15 hours or longer charge). Charging time of 15 hours or longer is required (with AC line cable connected and power switch set to OFF).

**Power consumption:** 15 VA max.
**Operating environment:** Temperature: +5˚C to +35˚C,
Humidity: 70% RH or less
**Dimensions:** 240(W) × 88(H) × 410(D) mm
**Mass:** Approx. 5 kg max. (including battery)

**Standard Accessories**

| Item | Model | Product code | Remarks |
|---|---|---|---|
| Power cable | **A01402** | | |
| Input cable | **A01010** | | Triax-to-miniature alligator clips (1) |
| Output cable | **MI-03** | | BNC-to-miniature alligator clips (1) |

**Accessories (Optional)**

**R12706A** Test fixture
**TR42** Sample box for extra-high resistance measurement
**TR47W** Charge measurement adapter
**TR8031** Faraday cage
**TR16206** Carrying case
**A01009-50,100,150,200**
Input cable (TRIAX-TRIAX connector)
**A01010** Input cable (TRIAX-alligator clip), 100 cm
**A01011-50,100,150,200**
Input cable (TRIAX-BNC connector), general-purpose
**A02019** Panel mount set
**A02624-J** Rack mount set (JIS standard)
**A02624** Rack mount set (EIA standard)

**R12701A Test Fixture**

**R12702A/B Resistance Measurement Sample Box**

**R12601 Coulomb Range Extender**

**R12602 Voltage Divider Probe** **R12603 Test Lead**