Space Electronics' 1n-SQB-BTP Series of Weapon System Circuit Testers

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1n-SQB-BTP Series of Testers

Space Electronics designs and manufactures a wide range of ohmmeters and multimeters approved by the US Department of Defense for measuring the resistance and stray voltage in a weapon system's multiple electrical circuit paths.

Building on the success of our 101-5HJ Series of single-channel US Navy Igniter Circuit Testers, and with over 5,000 instruments placed in service in the past 40 years *without a single unintended detonation*, Space Electronics now offers the **1n-SQB-BTP Series** of multi-channel weapon system circuit testers—a family of multimeters with rugged control computer. These fully automated circuit testers are used to test rocket igniters, fuses, explosive bolts, squibs, blasting caps, bit test lines, and electro component lines (relays, actuators, diodes, semiconductor devices), dramatically reducing the risk of accidental detonations without compromising high accuracy.

Model 132-SQB-BTP weapon system circuit tester is a combination 19" rack and bench top unit

Applications

Space Electronics' 1n-SQB-BTP Series of testers are now a key element of OEM Quality Assurance and military Integrated Logistics Support programs for currently fielded US missile systems.

OEM Subassembly Level Testing

- Used to verify the electrical integrity of weapon subassembly components before they are integrated into the weapon system.

OEM System Level Testing

- For performing weapon-level electrical integrity testing before delivery to the customer.

Field Level Testing

- Used in the conduct of both field and depot-level electrical integrity tests before troop deployment or integration with a launch platform.

Design and Features

An igniter circuit tester is a special-purpose ohmmeter capable of making extremely accurate measurements of low resistance values while limiting test current to a value significantly lower than the minimum detonation current of the igniter being tested. With the addition of voltage and diode testing as well as a matrix switching system, the 1n-SQB-BTP tester line can now test several connection paths in a completed missile assembly with one automated sequence. Features of the 1n-SQB-BTP Series include:

Multi-meter Functionality

Six resistance ranges, two stray voltage ranges, and diode testing.

Fiber Optic Connectivity
Fiber optic connection between control computer and tester ensures safety isolation between computer power and the weapon system.

Lead Resistance Compensation
Kelvin four-wire test leads/cable arrangement automatically compensates for lead resistance.

Fast Readings
Reading stabilizes in less than 2 seconds. Large format LCD provides clear indication of measurement range and units, battery level, and calibration status.

Digitally Calibrated
Insensitive to thermomechanical drift of calibration trim potentiometers. No requirement to open the meter, which allows customers to calibrate the instrument at their facility.

Modular and Scalable
Our product designs support from 8 to 1,024 test points. Our unique matrix selector design permits measurement of any one test point relative to any other test point.

Tester Control
The 1n-SQB-BTP Series features a unique manual measurement mode (including test cables) that allows the user to verify test circuits without the need for a separate meter. For automated use, the tester can be controlled using either Space Electronics' or your own measurement control software.

Safety Features
Our 1n-SQB-BTP Series multi-channel weapon system circuit testers feature a unique approach to safety: redundant circuits and mechanisms, going beyond the single-point-failure methodology to guarantee that test current remains less than one one-thousandth of a device's firing current.

Our power system design ensures protection against power surges and inadvertent operator error, including attaching the tester to a source of voltage or current higher than allowed.

Our design incorporates multiple ground isolation barriers to ensure that there are no potential current paths to ground that could exceed the rated failsafe current.

To prevent damage to the circuit tester's current-limiting circuitry, we encapsulate and mount these failsafe devices directly at both the tester's input power and the weapon's test signal connection points. *This means that these barriers are after the matrix selector system, yielding an additional level of safety.*

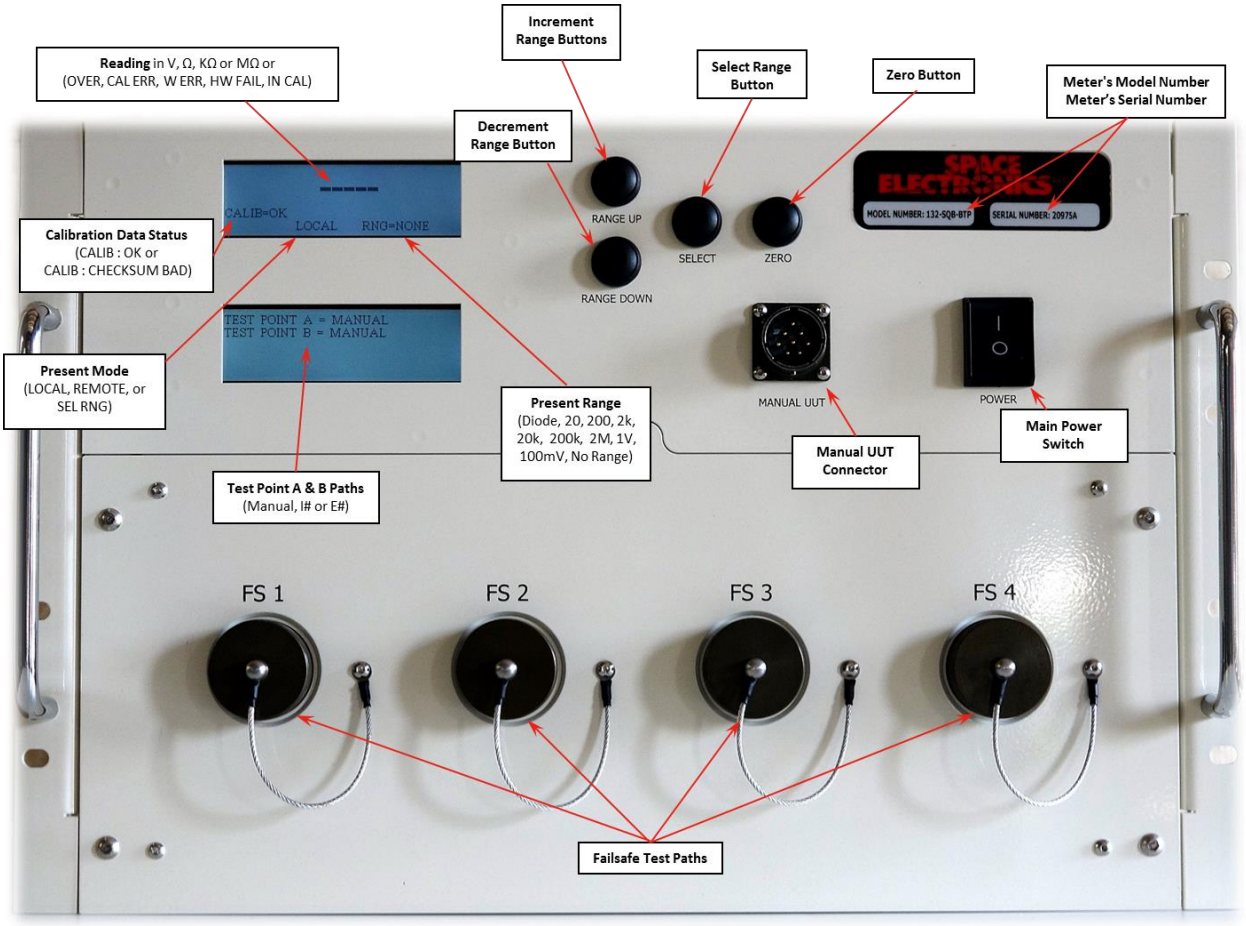
Available Configurations
Our multi-channel weapon system circuit testers are available in a wide range of configurations. The model number of the instrument follows the form **1n-SQB-BTP-V-c**.

1
The leading '1' indicates that the instrument is configured with measurement capability for resistance, diode, and voltage with matrix switching for automated multi-channel capability.

n
'n' is the number of test points in the matrix, i.e., 8, 16, 24, 32, 40 … 1,024.

BTP
'BTP' indicates that the instrument is a combination 19-inch rack and bench top unit. All BTP units can have the rack ears removed and feet installed for bench top use.

V (optional)
'V' indicates the type of power plug, as codified by the US Department of Commerce International Trade Administration. For example, plug type 'G' is mainly used for 220V 50/60 Hz power in the



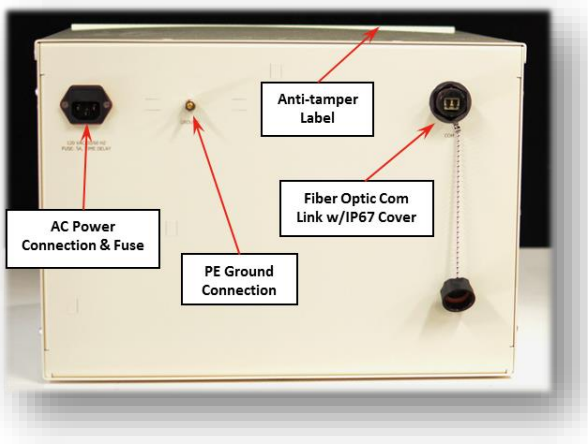
United Kingdom, Ireland, Malta, Malaysia, and Singapore. When omitted, the plug type is 'B', corresponding to US 100/110V 50/60 Hz power.

c (optional)

This field is reserved for alphanumeric identifiers pertaining to unique, customer-specific options.

How the 1n-SQB-BTP Series Circuit Tester Works

For manual operation, the supplied test leads are attached to the instrument. A measurement range is selected. The circuit resistance is then displayed on the digital readout—there is no need to balance a Wheatstone bridge as with older type igniter testers. An internal microprocessor stores calibration and zero offset values for all ranges. Four-wire test leads automatically compensate for test lead resistance so that there is no need for the subtraction of the test lead resistance. The 1n-SQB-BTP family of instruments supports from 8 through 1,024 failsafed test points, which can be selected through software in any configuration of test paths. The combination of any two test points creates a four-wire measurement path.

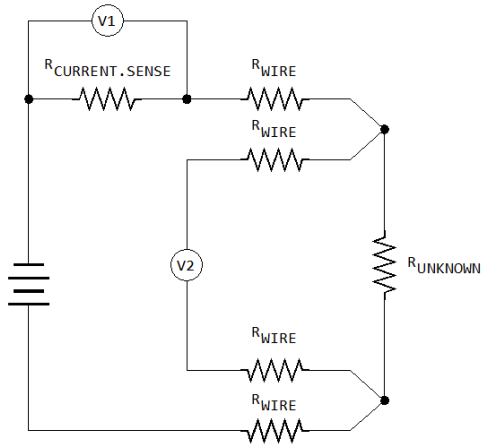


The concept of test points versus channels can be a bit confusing. Previous designs connect to test circuits through multiple sets of four-wire channels. If three paths to test connect to a single common pin, then each of the three four-wire sets has two wires connecting to that common pin, for a total of six wires to that single pin. If more paths share this common pin, the wire count gets unmanageable.

In a test point arrangement system, only a single set of two wires connects to each pin. The matrix system allows these two wires to connect either to positive excitation and positive sense or to negative excitation and negative sense. This brings down the cable conductor count while still maintaining the four-wire measurement system.

Theory of Operation

Test Circuit Concept



All test circuits use the same fundamental concept. The circuit is constructed of a known precision current sensing resistor in series with the unknown resistor. The processor measures the voltage $V1$ across the current sense resistor ($R_{CURRENT.SENSE}$) and the voltage $V2$ across the unknown resistor using a high accuracy differential amplifier. The Ohm's law calculation is then performed by the processor and the result is displayed on the LCD.

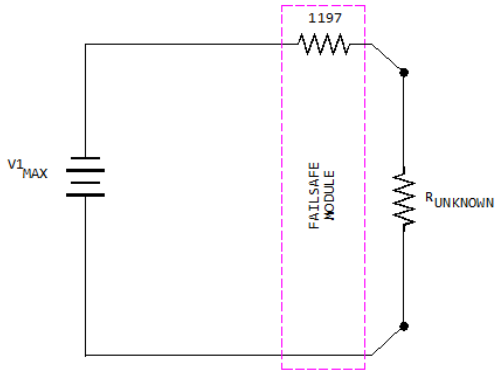
The Diode measurement circuit uses the unknown resistor amplifier circuit to directly measure the voltage across the diode using a failsafe-compatible current source.

A four-wire or Kelvin method of measurement avoids lead resistance errors. Any voltage drop across the main current carrying wires will not be measured by the circuit and does not factor into the resistance calculation.

Failsafe Circuitry

The manual Unit Under Test (UUT) failsafe and several automated failsafes (FS 1, FS 2, …, FS n) are the last connections between the meter and the UUT circuits. They are housed in fully sealed potted assemblies that cannot be bypassed without purposeful disassembly.

The failsafes limit test current to the UUT using fusing resistors that are selected for measurement performance and failsafe protection.



Simplified measurement circuit for safety analysis

In the event of a worst-case failure of all active components, the measurement test circuit is reduced as shown in the circuit diagram above. The worst-case measurement circuit failure results in the maximum power supply voltage of 7 V at point $V1_{MAX}$ feeding a series circuit of 1,197 Ω and the $R_{UNKNOWN}$ load. Assuming the load to be less than 1 Ω, the failsafe current is 5.8 mA.

A Commitment to Safety

The primary method of initiating a weapon's detonation sequence is by passing an electrical current through a thin wire that is bonded to a small explosive. The heat generated by the flow of electric charge provides the threshold energy needed to initiate the explosive train. Electromechanical trigger circuitry controls the timing of the current pulse. Typically, the firing of a small explosive device triggers a much larger explosive. These firing circuits are of varying complexity, ranging from the simple low-component-count mechanisms found on "dumb" bombs to highly complex, very versatile circuitry seen in modern battlefield smart weapons.

The safety and reliability of these devices can be verified by electrically testing the detonators, wire cabling, and control circuitry at various points in the weapon's life cycle, including:

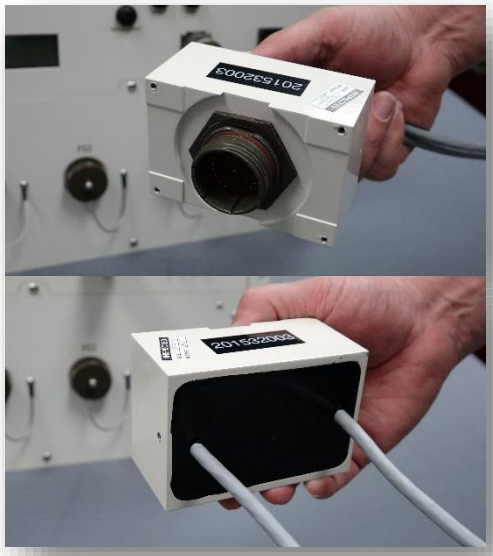
- QA tests during component manufacture
- QA tests during final assembly, e.g., explosive load, assemble, and pack
- Integrity testing during and after storage in warehouses or depots
- Point-of-use testing prior to deployment

Design for Safety

It is critical to recognize that this method of testing applies electrical current to the device in a manner similar to that which initiates detonation. The only way to safely accomplish the test is to severely limit the test current to a level several hundred to a thousand times lower than the detonation threshold. The current-limiting circuitry has to have high safety redundancy with known failure modes that always fail to a safe condition. Furthermore, in many cases the accuracy of the required measurement is quite high, often approaching one one-hundredth of an ohm.

Under normal circumstances, measuring resistance to this level of accuracy is difficult. The use of these low test currents only serves to exacerbate the problem in direct proportion, i.e., lowering the test current by a factor of one one-thousandth increases the difficulty of the measurement by a factor of 1,000.

The measurement system design engineer must then contend with lower internal signal-to-noise ratios, rendering unacceptable several normal but unsafe methods for controlling the injection of external noise.



Failsafe connectors are housed in fully sealed potted assemblies

Space Electronics brings the capability and experience to design failsafe and accurate testers. Every one of our weapon system circuit testers incorporates a sealed "failsafe" module (above), which limits test current to safe levels *even if every active element in the measurement circuit fails simultaneously*.

A Proud History

Over the past 40 years, Space Electronics has designed and delivered more than 5,000 igniter circuit testers (ICTs) to every service branch of the US military; missile and smart weapon contractors

including Raytheon, Lockheed Martin, Textron, Boeing, General Dynamics, Northrop Grumman, BAE Systems, Hughes, Thiokol, Loral, ITT, and Israel Aerospace Industries; NASA; DoD and NASA-funded university research laboratories; Department of Energy national laboratories; launch system and spacecraft contractors including L-3 Communications, Aerojet Rocketdyne, Orbital ATK, SSL, and SpaceX; aircraft manufacturers including Bell Helicopter, Bombardier, and Airbus Group; numerous domestic and international airlines; and allied armed forces worldwide.

In 1983 Space Electronics earned US Navy Type Classification for the 101-5HJ-NAV portable battery-powered ICT

In 1981 we built the first ever computer-controlled multichannel tester, for the BGM-71 TOW anti-tank missile. In 1983 the US Navy type-classified our 101-5HJ-NAV portable single-channel igniter circuit tester. At the same time, we expanded our business to larger specialized multi-channel multi-meter test stands for use on weapon system production lines. Over time, we added dedicated pneumatically controlled fixturing with blast shields and other safety systems to protect operators from harm.

In all that time and for all the ICTs built and delivered, *there has never been a single unintended explosive detonation.*

Multi-Channel Multimeters

In 2012 Space Electronics delivered our first SQB instrument—the battery-powered 101-SQB-RAK—to Raytheon Missile Systems for the US Navy's Standard Missile-6 extended range anti-air warfare system. SQB represented a significant technological progression from our 101-5HJ-NAV with the incorporation of microprocessor control, large LCD information display, and digital zeroing and calibration technology.

Since that time, we have sold over 30 SQB instruments for use with SM-6, the Navy's Evolved SeaSparrow Missile (ESSM), and other Raytheon missile programs.

In 2013, we combined our earlier multi-channel ICT experience with the technology advances incorporated in the 101-SQB to consolidate what was a full-height 19-inch rack into a 7U rackmount configuration, providing a commercial, off-the-shelf solution. This led to the sale of the first instruments in the 1n-SQB-BTP series, the rackmount 132-SQB-BTP, to Lockheed Martin Space Systems for the US Army's Terminal High Altitude Area Defense (THAAD) anti-ballistic missile system.

The result is that today we offer a family of instruments that supports everything from as few as 8 circuit paths to as many as 1,024.

Customizing and Using Your 1n-SQB-BTP Series Tester

A Total Solution Approach

Our weapon circuit tester is a commercial, off-the-shelf system available in several test point configurations. We can provide custom optional accessories to bring your testing system into production more quickly. Ordering your

1n-SQB-BTP weapon system circuit tester with these options can create a complete turnkey solution for your weapon testing needs.

Custom Cables

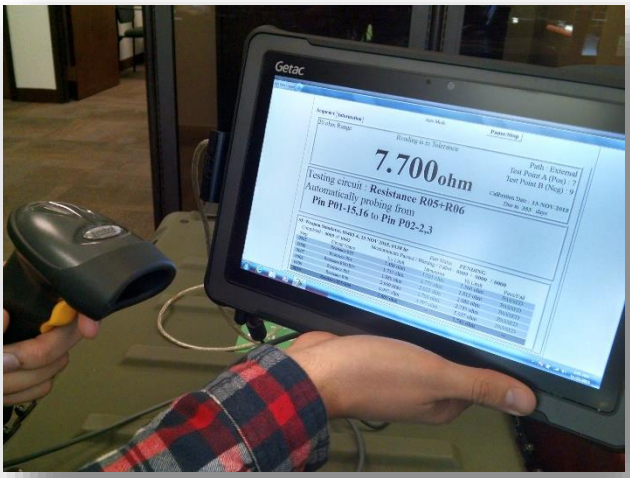
Every weapon system has its own connectors that our weapon system circuit tester must interface with. Once the circuit paths in these connectors are identified, we can create optimized custom cables engineered for safety while at the same time retaining performance.

Custom Weapon Verification Device

Our engineers will analyze your circuits under test and create an inert device to use in conjunction with our custom test cables. This will simulate the measurement of your weapon, insuring that the complete system is functioning correctly prior to use. Depending on the complexity of the weapon, this can be as small as a cable connector plug (doubling as a connector protector cap) or as big as a 19-inch rack chassis.

Calibration Kit

The calibration kit includes a precision resistance decade box, cables, software, and everything necessary to calibrate your 1n-SQB-BTP weapon system circuit tester at your facility. [Note: this facility must have a room capable of meeting the environmental requirements for calibration.]



Optional 1D bar code scanner and rugged tablet computer

Custom Rack

The custom 19-inch rack encloses all equipment needed for testing as well as other features that might be desired (e.g., drawers, lock boxes, document holders, etc.).

Bar Code Scanner

Use of a bar code scanner can help to minimize data entry errors by scanning operator identification, UUT part number, UUT serial number, and other bar-coded information. Both 1D and 2D scanners are available.

Computer Options

Communication with the 1n-SQB-BTP series of weapon system circuit testers is via a fiber optic serial connection. Either a USB-to-fiber optic or Ethernet-to-fiber optic interface can be used to interface between the computer and the tester. These interfaces allow for the use of a wide variety of computers. Available options, all running the Microsoft Windows OS, include:

- Rugged laptop computer
- Rugged tablet computer
- 19-inch rack-mount computer

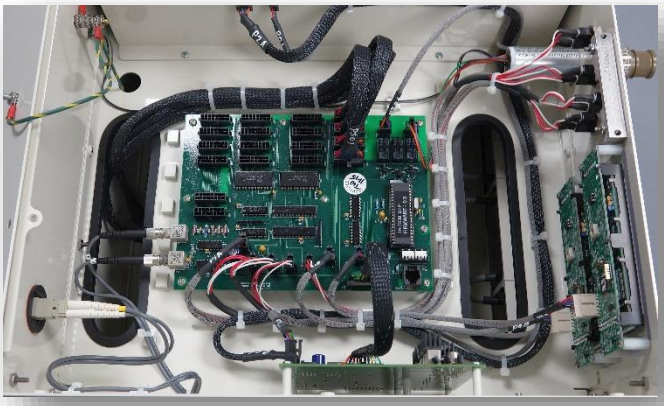
Software

The tester's computer comes preloaded with Space Electronics' engineer-configurable sequence control measurement software. Using this software, your on-site engineer can develop a sequence script that controls the measurements performed by the tester. This allows you to measure any number of combinations of circuits, comprised of test points to test points. The software performs a number of crucial health and status checks. For example, for portable versions of the 1n-SQB-BTP Series, the

software monitors battery health and prevents use when power is too low. The software uses the calibration data stored in the meter to determine if the instrument is within the calibration window. Also, through a combination of fault messages from the meter and the software, the system stops erroneous measurements that are the result of wiring defects in the connection cables from being taken. *This is the only instrument of its type with this feature.*

Test Sequence and Data Collection

The sequence script can be configured to work in either manual or automated mode. You can define test points, type of measurement, and pass/fail criteria. You can also establish whether the test is a quality test that must be passed or an engineering test for performance data collection.



Our 1n-SQB-BTP Series architecture is designed for scalability

Operators conduct a test by selecting the script and following the instructions provided. The final result of the test is the pass/fail status of weapon. At the end of the test the software generates a complete test result file in CSV (Comma Separated Values) format that can be entered into the customer's records storage database. It can also be imported into a spreadsheet application, e.g., Microsoft Excel, for any post-test analysis or processing required.

Test data recorded by the software include measurement mode (resistance, voltage, or diode), measurement range (from 20 ohm to 2 Mohm for resistance and 1mV to 1 V for voltage), and measurement test points (defined as Point A [positive side of the test] and Point B [negative side of the test]).

Ease of Use—Speed to Production

The 1n-SQB-BTP Series test software in conjunction minimal training will allow your engineers to create a measurement sequence to test your circuit paths and bring your measurement system online faster than developing the capability on your own. We can also create these sequences for you.

Safety, Flexibility, Value

Space Electronics has over 40 years of experience designing and manufacturing electrical test instruments with a primary focus on safety. From the power source to the final connection, we examine how the design of every system element affects safety. We ALWAYS opt for the SAFEST solution, regardless of its impact on cost or schedule.

Our extensive work over the years with the Naval Ordnance Safety and Security Activity (NOSSA) makes us well-suited to developing and supporting safety-related presentations to any regulatory authority.

At Space Electronics, we design and code all of our microprocessor-based control systems. As a Small Business with an unusually stable workforce, we use our skills and facilities to constantly improve the performance of our systems and the capabilities of our company.

1n-SQB-BTP Series Specifications

Measurement Ranges & Accuracy*

Range	Full Scale (FS)	Overage Capacity†	Resolution	Accuracy %FS	Units	Nominal Measurement Current
20 Ω	20 Ω	5%	0.001 Ω	0.05 %	Ω	2.2 mA
200 Ω	200 Ω	5%	0.01 Ω	0.025 %	Ω	2 mA
2 kΩ	2 kΩ	5%	0.1 Ω	0.025 %	kΩ	0.5 mA
20 kΩ	20 kΩ	10%	1 Ω	0.05 %	kΩ	0.044 mA
200 kΩ	200 kΩ	5%	10 Ω	0.5 %	KΩ	0.005 mA
2 MΩ	2 MΩ	5%	100 Ω	1.0 %	MΩ	0.001 mA
DIODE	2.0 VDC	10%	0.001 VDC	0.5 %‡	Volts	2.6 mA
2 VDC	2.0 VDC	10%	0.001 VDC	0.5 %	Volts	None
100 mVDC	100 mVDC	10%	0.001 mVDC	0.5 %	mVolts	None

Notes:
* All accuracies have 3 sigma confidence factors.
† Up to full scale plus over-range capacity.
‡ Diode accuracy is specified as the accuracy of measuring the voltage drop across the diode. This voltage drop is a function of the current through the diode, its forward bias voltage and the internal resistance. Once the diode's forward voltage is exceeded, it starts conducting; once past the knee, the more current, the more voltage drop that is generated from the diode's internal resistance. There is no nationally established test current for diode test function; different brand meters will measure different voltages. However, for any given meter's supply current, the voltage measured across the diode is what is certified for accuracy.

Electrical Specifications

Failsafe Current ..... 10 mA
Number of Test Points ..... 8 to 128 (Expandable to 1,024)
Maximum Meter Current Draw ..... 0.5A @ 120 VAC
(Optional 0.25A @ 220 VAC)
Input Power ..... 120 VAC (Optional 220 VAC) 50/60 Hz

Physical

Weight
8 to 64 Test Points ..... 42 to 50 lb
72 to 128 Test Points ..... 52 to 100 lb

Dimension
8 to 64 Test Points ..... Overall 12.25"H × 19"W × 18.5"D
7U 19" Rack, Requires 17.5" Minimum Rack Depth, 1.5" Forward Clearance
72 to 128 Test Points ..... Overall 19.6"H × 19"W × 18.5"D
10U 19" Rack, Requires 17.5" Minimum Rack Depth, 1.5" Forward Clearance

Operating Range

Temperature ..... 18 °C to 30 °C (or ±6 °C of calibration)
(In Storage) ..... -10 °C to 60 °C
Humidity Maximum ..... 70% non-condensing
(In Storage) ..... 90% non-condensing

Available Models

Part Number Coding: 1n-SQB-BTP-V-c

1n-SQB-BTP-V-c	1	Tester with measurement capability for Resistance, Diode, and Voltage with matrix switching for automated multi-channel capability
1**n**-SQB-BTP-V-c	n	Number of test points in matrix Example 8, 16, 24, 32, 40 … 1,024
1n-SQB-**BTP**-V-c	BTP	Combination 19" rack and bench top unit
1n-SQB-BTP-**V**-c	E, F, G, I, L *[Optional]*	US Department of Commerce International Trade Administration (ITA) Plug Type *[100/110V 50/60 Hz Plug Type 'B' if omitted]*
1n-SQB-BTP-V-**c**	*[Optional]*	Alphanumeric string indicating customer-specific option(s)

Note: All units can have the rack ears removed and feet installed for bench top use.

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