MIL-STD 202 and Electrical Component Testing

Anyone who has ever read a military standard knows they can be laborious texts but broken down into sections they contain precise direction and information. MIL-STD 202, "Test Method Standard, Electronic and Electrical Component Parts", consists of four sections including an Introduction, Environmental, Physical and Electrical tests. It is not an all-inclusive standard for electrical component testing. The specified values for components are detailed in individual specifications. MIL-STD 202 details the test apparatus, setup and summary of data needed for compliance. The Test or Manufacturing Engineer must first refer to the component's individual specification and then to MIL-STD 202.

MIL-STD 202 applies to manufacturers of electrical or electronic component parts used in military equipment. "Component Parts" includes capacitors, resistors, switches, relays, transformers, inductors and other components. The standard applies to these components that weigh ≤ 300lbs or have an RMS voltage ≤ 50,000V. It specifies laboratory conditions to match actual service (operating) conditions and requires manufacturers obtain reproducibility of test results. MIL-STD 202 is a collection standard. Its purpose is to gather together all like test methods that have been used in joint or single service electronic and electrical component part specifications. Sounds like a tall order yet consolidating the test methods keeps them uniform and conserves resources like equipment, man-hours and test facilities.

The current version of the standard is MIL-STD-202 G dated 8 February 2002 that superseded 202 F dated 1 April 1980. For the latest information on military standards visit the Defense Supply Center Columbus at http://www.dscc.dla.mil. Verify with DSCC that you have the latest revision and get questions concerning standards answered promptly.

The Four Sections

The Introduction encompasses 7 pages and includes the scope, applicable documents, definitions, general requirements, detailed requirements, notes and a very handy numerical index of the test methods. The Applicable Documents list DOD, Federal, CFR and non-government documents such as ANSI and ASTM standards. If you encounter any conflict between your part specification or drawing and MIL-STD 202, check the Introduction for the order of precedence of standards.

The second section, "Class 100 Environmental Tests" encompasses 52 pages and is inclusive of test methods 101 – 199. The environmental tests are meant to stress the component above the conditions it would ordinarily incur under normal operating conditions.

The third section, "Class 200 Physical-Characteristics Tests" encompasses 86 pages and is inclusive of test methods 201-299. The physical tests are meant to stress the mechanical aspects of the component above the conditions it would ordinarily incur under normal operating conditions.

The fourth section, "Class 300 Electrical-Characteristics Tests" encompasses 41 pages and is inclusive of test methods 301-399. The electrical tests are meant to stress the electrical aspects of the component above the conditions it would ordinarily incur under normal operating conditions.

The Class 100, 200 and 300 Test Methods of MIL-STD 202F are listed in Table 1.

Table 1: MIL-STD 202 Tests

Class 100	Environmental	Class 200	Physical	Class 300	Electrical
101E	Salt Atmosphere	201A	Vibration	301	Dielectric Withstanding Voltage
102A	Superseded by 107	202D	Superseded by 213	302	Insulation Resistance
103B	Humidity (Steady-State)	203C	Random Drop	303A	DC Resistance
104A	Immersion	204D	Vibration High Frequency	304	Resistance Temp Characteristic
105C	Barometric Pressure	205E	Superseded by 213	305A	Capacitance
106G	Moisture Resistance	206	Life (Rotational)	306	Quality Factor (Q)
107G	Thermal Shock	207B	High Impact Shock	307	Contact Resistance
108A	Life (Elevated Amb. Temp)	208H	Solderability	308	Current-Noise for Fixed Resistors
109C	Explosion	209	Radiographic Inspection	309	Voltage Coefficient of Resistance
110A	Sand and Dust	210F	Resistance to Soldering Heat	310	Contact-Chatter Monitoring
111A	Flammability	211A	Terminal Strength	311	Life (Low-Level Switching)
112E	Seal	212A	Acceleration	312	Intermediate Current Switching
		213B	Shock (Specified Pulse)		
		214A	Random Vibration		
		215K	Resistance to Solvents		
		216	Superseded by 210		
		217A	Particle Impact Noise Detection (PIND)		

The discussion within this application note focuses on the Electrical Tests of Class 300. QuadTech, a manufacturer of electrical test equipment for both active and passive components, has testing solutions that combine the equipment specified in Test Methods 301-307. Let's look first at the tests and then the apparatus required.

Class 300: Electrical-Characteristics Tests

Method 301: Dielectric Withstanding Voltage

Dielectric Withstanding Voltage also known as hipot, over-potential, voltage breakdown or dielectric strength is a measure of the strength of the component's insulation. A high (AC or DC) voltage is applied between the components operating circuits and chassis ground to determine if/when a breakdown will occur in the insulation of the component. The current is measured between the component insulation and ground. The purpose of the dielectric withstand voltage test is to prove that the component can operate safely at its rated voltage and with stand over-voltage that may occur in switching or surges.

The apparatus required by MIL-STD 202 for Method 301 includes: a high voltage source (60Hz), a voltmeter (5% accuracy), a leakage current measuring device (5% accuracy) and a fault indicator. It requires the voltage be ramped up at a rate of 500Vrms DC/sec and a test time of 60 seconds.

Method 302: Insulation Resistance

Insulation Resistance (IR) determines how affective the dielectric (insulation) of a component is in resisting the flow of electrical current. In an IR test, high DC voltage is applied to the component. DC voltage is used to produce a leakage of current through or on the surface of the component's insulation. The resistance is measured between the component insulation and ground. A low IR can mean a large leakage current and that can disturb the operation of circuits intended for isolation. Over time, large leakage current can degrade the components insulation through heating or DC electrolysis.

The apparatus required by MIL-STD 202 for Method 302 is a megohm bridge. It requires the DC voltage applied to the component under test be one of these conditions: A: 100V ±10%, B: 500V ±10% or C: 1000V ±10%.

Method 303A: DC Resistance

The DC Resistance (DCR) test is used to measure the direct current (DC) resistance of resistors, electromagnetic windings of components and conductors. DC voltage is used because the amount of opposition (resistance) a conductor (wire) has is directly proportional to the frequency of the current variation. At low frequencies, the DC resistance of the wire is equivalent to the copper loss of the wire. Temperature and measuring voltage affect the measurement of DCR.

The apparatus required by MIL-STD 202 for Method 303A is a resistance bridge. It requires that the test voltage be applied for ≤5 seconds and that the DCR measurement be made at 25°C ±5°C.

Method 304: Resistance-Temperature Characteristic

The Resistance-Temperature Characteristic test more commonly known as the temperature coefficient of resistance, determines the percentage of change of the components DC resistance between the test temperature and the reference temperature. Depending on the material of the component under test, its resistivity can change with temperature. The resistivity of a metal conductor increases linearly with temperature. Semiconductor materials like Germanium exhibit an exponential decrease in resistivity as temperature increases. Superconductor materials are defined as having zero resistance at a given temperature known as critical temperature (Tc). Having an accurate milliohm meter with the capability to calculate the temperature coefficient would be beneficial for this test.

The temperatures required by MIL-STD 202 for Method 304 are divided into two series. The first series runs room temp to cold: 25°C, 0°C, -15°C and -55°C. The second series runs room temp to hot: 25°C, 50°C, 75°C, 100°C, 125°C, 200°C, 275°C and 300°C. It requires that the resistance measurements be made in accordance with test method 303A.

Method 305A: Capacitance

The Capacitance (C) test measures the capacitance of the component, i.e. the ability of the component to store charge. Capacitance is the ratio of the charge on either plate of a capacitor to the potential difference (voltage) across the plates. The required test frequencies are 60Hz, 100Hz, 120Hz, 1kHz, 100kHz and 1MHz.

The apparatus required by MIL-STD 202 for Method 305A is a capacitance bridge capable of the specified frequencies. AC or DC voltage may be applied to the component under test but the magnitude of the AC rms signal or polarizing (DC) voltage must be specified. The capacitance measurements must be made at 25°C ±5°C.

Method 306: Quality Factor (Q)

The Quality Factor (Q) test measures the quality of a reactive component (inductor or capacitor) or circuit. Q is equal to the series reactance (Xs) divided by the resistance (Rs). Q is also know as the Storage Factor because it is a measure of the ability of the component to store energy compared with the energy it wastes. Q is equal to the inverse of the dissipation factor. Q = 1/Df

The apparatus required by MIL-STD 202 for Method 306 is a 'suitable instrument' with ±10% accuracy capable of the frequencies specified in the individual (component) specification.

Method 307: Contact Resistance

The Contact Resistance (CR) test measures the resistance 'between the electrical contacting surfaces of connecting components such as plugs, jacks, connectors and sockets or between the electrical contacts of current controlling components like switches, relays and circuit breakers. The purpose of the test is to minimize and stabilize the CR so that the voltage drop across contacts does not affect the accuracy of the circuit. Passing high current through high resistance contacts can cause the contacts to overheat and the component to lose energy.

Contact resistance is affected by the surface material resistivity, contact pressure, contact condition (hardness, cleanliness), current, open circuit voltage, temperature and thermal conductivity of leads. A 4-terminal Kelvin connection is used to measure contact resistance with one pair of leads driving the current and the other sensing the voltage.

The apparatus required by MIL-STD 202 for Method 307 is a Kelvin bridge or suitable instrument with ±5% accuracy. It requires that the magnitude of the DC current, maximum open circuit voltage (if necessary), the number of activations prior to measurement, the number of test activations and the number of measurements per activation be specified.

Method 308: Current-Noise Test for Fixed Resistors

The Current-Noise test measures the 'noise quality' of fixed resistors within electronic circuits that have critical low-noise requirements. The purpose of the test is to minimize the interference of unwanted noise signals generated by fixed resistors that could impede the intended output signal and result in loss of information. The "Noise Quality Index" (in dB) is a measure of the ratio of the root-mean-square (rms) value of current-noise voltage (µV) to the applied DC voltage (V). The pass band is geometrically centered at 1000Hz.

The apparatus required by MIL-STD 202 for Method 308 is a Quan-Tech 315 Resistor Noise Test Set or equal built to NBS standards. DC or AC measurements can be made and considerations are detailed for both methods. The requirements of 308 are many and beyond the scope of this application note.

Method 309: Voltage Coefficient of Resistance Determination Procedure

The Voltage Coefficient of Resistance test is used for varying resistors (varistors) and determines the change in the components resistance with changes in the voltage across the component (resistor). This test applies to resistors ≥1000Ω (1kΩ).

The apparatus required by MIL-STD 202 for Method 309 is a 'resistance measuring device that can apply 0.1 X and 1.0 X the rated continuous working voltage to the resistor under test'. It requires that the all measurements and test be made at 25°C ±5°C.

Method 310: Contact-Chatter Monitoring

The Contact-Chattering Monitoring test is used for electrical components that have moveable electrical contacts like switches and relays. The test determines if there is "opening of closed contacts" and "closing of open contacts", the result of either could inhibit the correct function of the circuit.

The apparatus required by MIL-STD 202 for Method 310 is one of two test circuits that each requires calibration. Test circuit A includes low-level or dry circuit ratings of ≤10mA and ≤2V and for closings <10µs. Test circuit B is for closings >10µs. Test time ranges from 10µs to 20ms depending upon the individual components specification. The requirements of 310 are many and beyond the scope of this application note.

Method 311: Life, Low-Level Switching

The Life test is used to determine the stability of the electrical contacts of electrical components like switches and relays during low-level operation. Low-level switching means the resistance of the component is not affected by the voltage or energy stored during normal switching operation. Very specific requirements are laid out for the contact resistance of the component (contacts) under test. The test determines if there is any change in the resistance of the contacts, the result of which could inhibit the correct function of the circuit.

The apparatus required by MIL-STD 202 for Method 311 is a 'monitoring device that can continually cycle the contacts with a power source for the open circuit voltage that does not exceed 30mV DC or peak AC at 10mA'. This voltage can be generated by passing a stable current through a low-ohm (shunt) resistor. The requirements of 311 are many and beyond the scope of this application note.

Method 312: Intermediate Current Switching

The Intermediate Current Switching test is used to determine the stability of the electrical contacts of electrical components like switches and relays during normal (minimum current) operation. Intermediate switching means that there is not enough voltage or stored energy to cause the contacts to arc during closure. This will preclude the normal use of arcing to wear off oxide build-up on the contacts that decreases their contact resistance. The test determines if there is any change in the resistance of the contacts, the result of which could inhibit the correct function of the circuit. Intermediate Switching will catch the relays and switches that pass low-level and full-rated load test.

The apparatus required by MIL-STD 202 for Method 312 is a 'monitoring device that can continually cycle the contacts'. The resistive load voltage applied to the contacts shall be 3V to 10VDC at 100mA ±10mA. This voltage can be generated regulated power supply with controllable low voltage. The requirements of 312 are many and beyond the scope of this application note.

Apparatus

At first glance, it would appear that many pieces of test equipment are required to perform all twelve Electrical test methods. That is not necessarily so. Dielectric Withstand, Insulation Resistance and Leakage Current can be performed using a typical hipot tester. Capacitance, Quality Factor and DCR can be performed using an LCR meter or digital impedance bridge (digibridge) and Contact Resistance measurements are well suited to a milliohm meter. Yet there is some equipment on the market that combines many of these tests.

The Horizon HV & LV Wiring Analyzers and Fusion Multi-Point Cable Analyzer are two instruments that combine AC & DC Hipot Capability, Low Voltage Testing, Insulation Resistance, 4-wire Resistance Measurements, Capacitance Measurements and more. These instruments are not simply for wire and cable testing, they are integral units for multi-point and/or multi-device testing. Table 2 illustrates the Horizon and Fusion instrument specifications as they relate to MIL-STD 202 apparatus needs.

Table 2: Horizon, Fusion Compatibility with MIL-STD 202 Apparatus

Mil-STD 202		QuadTech Instrument	
Class 300 Method	Apparatus Required	Horizon HV 1500	Fusion
301	HV Source: Ramp Capability: AC Leakage Current Measuring Device: DC Leakage Current Measuring Device: Fault Indicator:	50~1067Vac, 50~1500Vdc 10mV/Second ~ 10kV/Second I Total, 5uA ~ 5mA Idc, 1uA ~ 5mA Yes	50~3500Vac, 50~3000Vdc 0~100 Seconds from 0V to Max I Total & I Real, 1uA ~25mA Idc, 1nA~3mA Yes
302	Megohm Bridge DC Voltage: 100V, 500V or 1000V:	50 ~ 1500Vdc 100kOhm ~ 1.5GOhm	50~3000Vdc 1MOhm ~ 100GOhm
303A	Resistance Bridge Low Voltage:	0 ~ 50MOhm: 2 or 4 Wire	0 ~ 400kOhm: 4 Wire 0 ~ 50MOhm: 2 Wire
304	Resistance Bridge Resistance and Temperature Characteristic Low Voltage:	N/A (QT LR2000 Milliohmmeter)	N/A (QT LR2000 Milliohmmeter)
305A	Capacitance Bridge DC Voltage: AC Freq: 60Hz, 100Hz, 120Hz, 1kHz, 100kHz and 1MHz:	DC: 50pF ~ 10,000mF AC (QuadTech LCR Meters)	DC: 100pF ~ 999.9uF AC (QuadTech LCR Meters)
306	Measure Q with "Suitable Instrument" with ±10% accuracy	N/A (QuadTech LCR Meters)	N/A (QuadTech LCR Meters)
307	4-Terminal Resistance Measurement Kelvin Bridge or 'suitable instrument' with ±5% accuracy	N/A (QuadTech LCR Meters)	N/A (QuadTech LCR Meters)

Depending upon the component under test, one or two instruments may fulfill your MIL-STD 202 Class 300 equipment needs. Start with a review of the requirements of your individual part (performance) specification then review MIL-STD 202. In addition to the Fusion and Horizon, QuadTech manufactures a complete instrumentation line including electrical safety analyzers that provide AC/DC hipot capability, insulation resistance and leakage current measurements; LCR Meters, Inductance Analyzers, Digital Impedance Bridges, Megohmmeters and Milliohmmeters. QuadTech designs and produces automation software to attain the full potential of its instrumentation and provides test system consultation.

For complete product specifications on the Fusion Wire & Cable Analyzer or any of QuadTech's products, visit us at http://www.quadtech.com/products. Call us at 1-800-253-1230 or email your questions to info@quadtech.com. The information presented in this application note is subject to change and is intended for general information only.

NOTE: This application note is not a substitute for MIL-STD 202 Class 300 Tests. Read MIL-STD 202 in its entirety and direct questions to the Defense Supply Center Columbus at http://www.dscc.dla.mil.