BANAIR ELECTRONIC ENGINEERS
OUR BUSINESS IS HELPING YOUR BUSINESS

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What can go wrong?

1. You have built the wrong cable.
2. Some connections that should be made are not.
3. Some connections that should not be made are.
4. Some connections that should be made almost are.
5. Some connections that should not be made almost are.

There are many tests that can be applied to a cable. Deciding what are the most appropriate tests is not always obvious. This article provides an overview of the tests that can be applied. It explains how they work and the most appropriate application.

Level 1: Full visual and mechanical examination

This test requires no equipment other than a good pair of eyes, although a magnifier will help to spot the less obvious faults. key points to include are:

- Check that correct parts are being used (not just pattern but specified quality level)
- Cable length
- Wire colour
- wire gauge
- IDC cables are correctly registered
- Crimps are correctly positioned (ensure that insulation isn't trapped)
- contact fully into housing
- Pull test on Crimp
- Contacts are free of contamination e.g. Flux
- Loose or broken strands

It is important that the crimp force of tools is monitored as incorrect pressure can lead to loose crimps (force too low) or broken wire strands (force too high),

Level 2: Electrical check for continuity / shorts

This test is normally carried out at a low voltage and current, typically 5Volts at a few milliamps. The simplest tester is a battery and a buzzer. This is sometimes called ringing out a cable.

For each connected pin in the cable carry out the following

1. Ensure that it is connected to all the points shown on the drawing.
2. Check against all the other pins to ensure that there are no shorts.

This is repeated for every pin.

This test will find a high proportion of faults, but there are some disadvantages in performing it manually:

- You may miss a connection, possibly due to a lapse in attention, an interruption or misreading the drawing.
- If there is an intermittent fault the process of holding on the probes may make the connection.
- Shorts can be missed as the check is ignored for some (or all) of the pins on the assumption that a short is not possible in a particular configuration.
- The process is very slow.
- This process is very expensive.

There are automatic test systems that allow you to carry out the above test in a few seconds. The tests are exhaustive rather than exhausting.

- All connections are checked.
- The cable is checked against a golden sample or a previously stored master.
- The test can be repeated to check for intermittent faults.
- All possible shorts are checked for.
- The test takes little more than the time to connect up the cable.
- The equipment will typically recoup the cost in less than a year. See Appendix A

For small standalone test areas the Sharon tester provides a cost-effective solution. A more comprehensive tester is the Tracy. Both Testers use the same interface jigs and connectors so it is easy to mix the two, or to start with the Sharon and invest in the Tracy at a later date.

Level 3: Electrical check for resistance

Levels 1 and 2 will satisfy the majority of customers, but there are occasions when further testing is required. This is normally when failure of the cable is very costly or may cause a safety hazard. Measuring the resistance of the cable would be the preferred next step. The resistance of a cable may vary for a number of reasons.

- Wire outside spec.
- Poor soldered joint.
- Faulty crimp.
- Contamination on contact.
- Contact outside specification.

The simple way to measure the resistance of a cable is to use an ohmmeter. This may not be the best solution as the resistance of a cable is typically in the region of an ohm or less. This is similar to the uncertainty of the ohmmeter. This uncertainly is caused by variation in the lead resistance and the resistance of the probes. The better solution is to use a Kevin resistance meter or 4-wire tester. See Appendix B for a technical description of how 4 wire testing works.

You should bear in mind that the resistance of the cable will vary depending on its specification and manufacturer. The resistance will also vary with temperature. A tolerance should be allowed to account for this. Measuring at a constant temperature will make the job easier.

This measurement will add considerably to the confidence in the cable, however manual measurement does take a considerable amount of time. An automatic system such as the BA765 will carry out the test in a number of seconds. It is worth considering this system, as there are many advantages over manual measurement.

- All connections are checked.
- The cable is checked against a known spec.
- The test can be repeated to check for intermittent variation.
- The resistance can be stored in an Access database for SPC.
- All testing is documented automatically and printed evidence or bar-codes can be used.
- There is no chance of the wrong values being used as the part is tested against a part number defined specification.
- The equipment will typically recoup the cost in less than a year. See Appendix A.

Level 4: Electrical test for insulation (Insulation resistance)

Damage to the insulation or contamination may not be detected by testing at levels 1 to 3. If the insulation system fails it can be very costly. An IR Test measures the electrical insulation resistance of the system. This is sometimes also called a Mega test. Failure of this test may be due to one or more of the following.

- Damaged insulation.
- Contamination by flux or finger residues.
- Excessive humidity.

This measurement is carried out at a high voltage in order to measure the resistance accurately, however the voltage is not intended to stress the cable. The test would typically be carried out at a voltage in the range 500 to 1000 V although if sensitive components such as capacitors have been fitted for EMC purposes then the test may have to be carried out at a much lower voltage. The tests are usually carried out at DC so that only the resistive current is measured. An AC test would include the capacitance of the cable in the measurement.

The test voltage should be allowed to settle for a short while so that any current due to the cable capacitance being charged can be nulled out. An adjustable dwell time ensures the system has stabilised. Attempting to ignore this will produce unreliable readings.

This measurement will add considerably to the confidence in the cable, however manual measurement does take a considerable amount of time. An automatic system such as the BA765 will carry out the test faster and will enable the operator to deal with other tasks during the testing period.

It is worth considering this system, as there are many advantages over manual measurement.

- All connections are checked.
- The cable is checked against a known spec.
- All testing is documented automatically and printed evidence or bar-codes can be used.
- There is no chance of the wrong values being used as the part is tested against a part number defined specification.
- The equipment will typically recoup the cost in less than a year. See Appendix A.
- Automatic testing allows the operator to be protected from high voltages using interlocks. This is an important area of operator safety.

Level 5: Electrical test for insulation (Dielectric Strength Test)

This test is carried out at a high voltage but it differs from the Insulation Resistance test in the following ways.

1) The purpose of this test is to stress the insulation so that the insulation breaks down, it is typically carried out at twice the operating voltage plus 1000 volts.

2) The current measured in the "Insulation Resistance Test" is the average current after the system has stabilised. In a "Dielectric Strength Test" the peak current is measured so that if flashover occurs then this will be recorded as a failure.

3) The test is typically carried out at AC, however if permitted by the specifying authorities the test can be carried out at DC using 1.4 times the voltage.

4) This test can detect points that are nearly touching such as wire ends, if flashover occurs this would be logged as a fault. It should be remembered that at the typical test voltage of 1500V DC flashover will only occur if the points have a separation of less than 0.2mm

Appendix A
How much time and money could you save every year?

Hourly Cost	Hours Saved Per Week 5	10	15	20	25
	£ / $ / €				
4	1,040	2,080	3,120	4,160	5,200
5	1,300	2,600	3,900	5,200	6,500
6	1,560	3,120	4,680	6,240	7,800
7	1,820	3,640	5,460	7,280	9,100
8	2,080	4,160	6,240	8,320	10,400
9	2,340	4,680	7,020	9,360	11,700
10	2,600	5,200	7,800	10,400	13,000
11	2,860	5,720	8,580	11,440	14,300
12	3,120	6,240	9,360	12,480	15,600
13	3,380	6,760	10,140	13,520	16,900
14	3,640	7,280	10,920	14,560	18,200
15	3,900	7,800	11,700	15,600	19,500
16	4,160	8,320	12,480	16,640	20,800
17	4,420	8,840	13,260	17,680	22,100
18	4,680	9,360	14,040	18,720	23,400
19	4,940	9,880	14,820	19,760	24,700
20	5,200	10,400	15,600	20,800	26,000
21	5,460	10,920	16,380	21,840	27,300
22	5,720	11,440	17,160	22,880	28,600
23	5,980	11,960	17,940	23,920	29,900
24	6,240	12,480	18,720	24,960	31,200
25	6,500	13,000	19,500	26,000	32,500
26	6,760	13,520	20,280	27,040	33,800
27	7,020	14,040	21,060	28,080	35,100
28	7,280	14,560	21,840	29,120	36,400
29	7,540	15,080	22,620	30,160	37,700
30	7,800	15,600	23,400	31,200	39,000

Reducing testing time by using Automatic Test Equipment (ATE) can save huge amounts of money. The hourly cost to a company is typically at least twice the hourly rate.

This table covers the rate for the operator doing the testing. Setting up for a test could easily take 4 hours of valuable engineer or technician time.

There are other benefits too.

- Your parts will be tested the same way every time. Eliminate errors.
- Identify faults for fast rework
- The results can be stored for you and your customer.
- The employee is safe. What are the health and safety issues in your current testing methods. RSI? Shock Hazards?

Examples of Time Saving

Testing cables
Sharon Cable tester
Investment £850
Example cable: - 25 way D type Male to female.
Test-time including load and unload: - 8 Seconds
Time to check with a buzzer:- 120 seconds
Time Saved per unit 112 Seconds

Testing high integrity cable including 1000 AC test
BA765 with AC option
Investment £5400
Example cable: - 80 wires. Measure resistance in Ohms using 4 wire tester, check DC insulation at 500V D.C. and hi pot test at 1000V AC (3 seconds per test)
Test-time:- 350 seconds. The operator can perform other tasks during this time and will be protected from shock risk during this time
Time to check using stand alone instruments. 3440 seconds.
Time saved per unit 3090 seconds

Appendix B
Measuring small Resistances

Choosing Two wire or Four wire (Kelvin) testing

A 2-wire tester such as AVO or digital multimeter has one problem.
When you measure a resistance with a 2-wire tester you also measure the resistance of the test leads. This will be in the range 0.01 to 1 Ohms and is typically 100 milliohms for a digital multimeter. If you want to measure resistances of less than 10 ohms you should consider using a 4-wire tester.

Resistance is usually measured by passing a current through the test piece and then measuring the voltage drop across it. The current source and the voltmeter use the same leads (fig 1).

Vm Vm

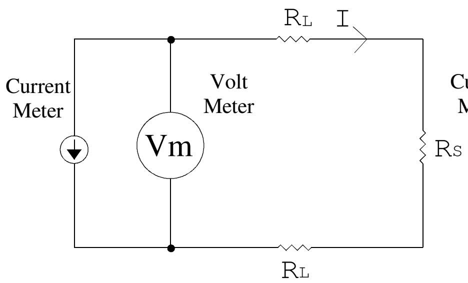

Fig 1

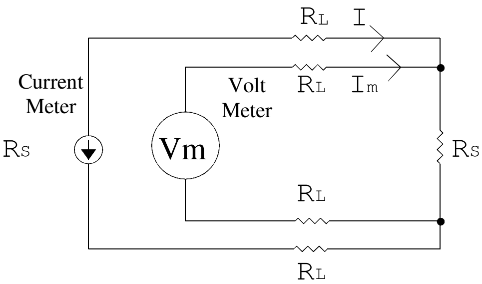

Fig 2

This is why a 2-wire tester is inaccurate for measuring low resistance's (fig 1).
R_S : -Resistance of sample (e.g. Cable or Harness) R_L : -Resistance of lead
V_M : - Measured voltage

$V_M = (R_S + R_L + R_L)\ I$

The meter will read $R_S + R_L + R_L$ instead of reading R_S

The alternative is to use 4 wires (fig 2). i.e. One pair of wires for the current source and another pair of wires for the voltage measurement.

The current due to the voltage reading I_m will be so small that it is negligible, so $V_M = R_S I$. The meter will now read R_S.

<u>Interface considerations</u>

It is important that current and voltage wires are connected as close to the sample as possible. If you are testing very small resistances (> 50 m Ohms), this may mean using specially designed connectors with separate points making contact with each pin of the sample being tested. This approach can also help when the resistance of connectors becomes significant due to wear.

A four-wire test system can be appropriate when testing very large harnesses as the length of wire from the tester to the harness can become significant.

Thermal EMF

When the junction of 2 dissimilar metals is heated (e.g. by the testing current) a voltage can be generated leading to an error in the resistance being measured. It is possible to remove this effect by reversing the polarity of measurement. This phenomenon is unlikely to be encountered during testing of most cables. If you take a reading and the value changes when you swop the leads, then this could be the cause.