

Testing An Electrolytic Capacitor Using Keysight i3070 In-Circuit System Polarity Test Solution

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Introduction

You will learn from this application note how to use the Keysight i3070 In-Circuit Polarity test solution for an Electrolytic Capacitor (ECAP). This device mounts on a printer circuit board assembly and are tested using the i3070 in-circuit system.

There are unique styles of non-solid aluminum electrolytic capacitors available in today's marketplace; see Figure 1. They range from Surface Mount Devices (SMDs), radial lead terminals, axial lead terminals, radial pin terminals, and large screw terminals for power applications.



Figure 1: Distinctive styles of non-solid aluminum electrolytic capacitors

The Methodology

Based on the ECAP construction, the values are estimates as shown in Figure 2. By implementing an unpowered test to verify the difference between the resistance from “+” pin to body, and from “-“ pin to body. However, it is difficult to maintain a stable and repeatable result — especially while using different device suppliers. The results may have differing values of resistance.

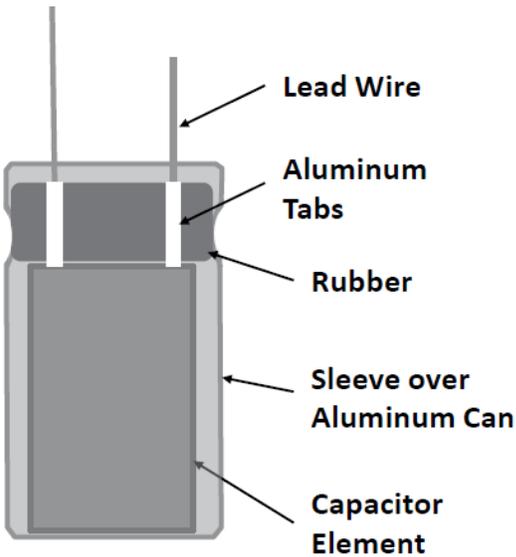


Figure 2a. ECAP construction (source from *Aluminum Electrolytic Capacitor Application Guide – Cornell Dubilier*)

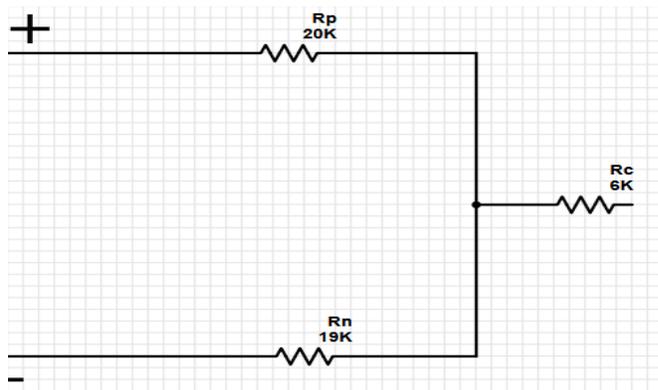


Figure 2b. ECAP estimated equivalent circuit

The *Aluminum Electrolytic Capacitor Application Guide – Cornell Dubilier* explains the elements of an ECAP — inductors, series resistance, and parallel resistance, and a Zener diode, see Figure 3. It takes into consideration the overvoltage and reverse overvoltage behavior of the ECAP.

The resistance measurement between the body and the terminal of the ECAP is computed efficiently by using the new model.

Figure 3 shows a detailed equivalent circuit for ECAP.

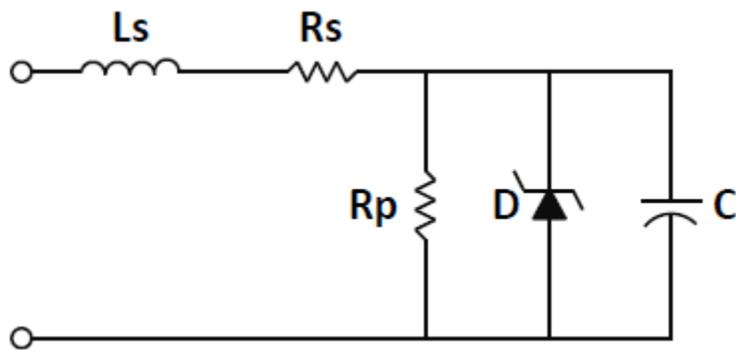


Figure 3: ECAP equivalent circuit ((source from *Aluminum Electrolytic Capacitor Application Guide – Cornell Dubilier*)

- Capacitance C is the equivalent capacitance
- Resistance Rs is the equivalent series resistance
- Ranges from 10m ohm to 1 ohm
- Inductance Ls is the equivalent series inductance
- Range 10nH to 200nH
- Resistance Rp is the equivalent parallel resistance and accounts for leakage current
- Every 100uF is 1M ohm
- The Zener diode D models overvoltage and reverse voltage behavior.

If you apply 50V beyond the capacitor's surge voltage rating, you have a high leakage current and constant voltage operating mode. It is like the reverse conduction of a Zener diode. Both conditions are applied for a limited time.

The process is to apply the reverse voltage and have a measurable leakage current.

The resistance between the body and the terminals in the new model is shown in Figure 4.

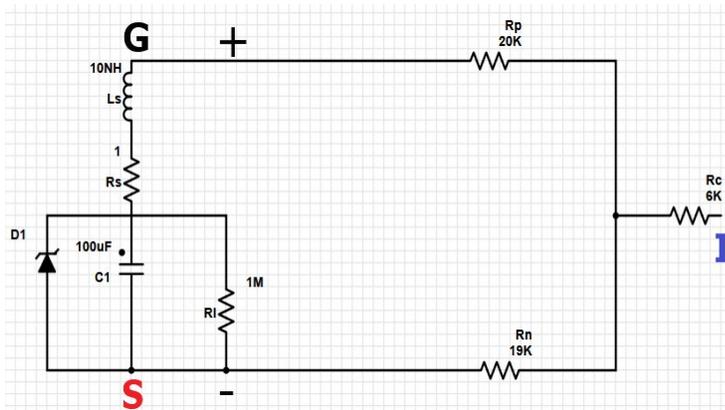


Figure 4. ECAP estimated equivalent circuit including the body to terminal resistances

As shown in Figure 5, the resources assigned to the i3070 to test this new circuit by connecting the busses. They are physically connected to the ECAP as follows:

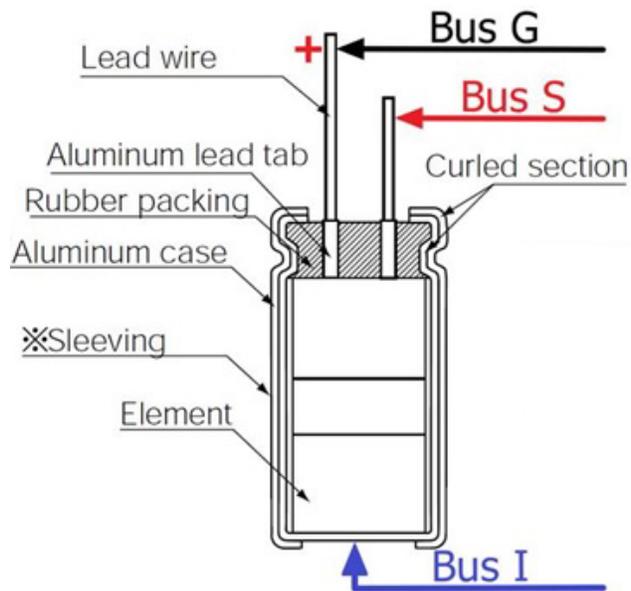


Figure 5. i3070 busses connected to the ECAP

This model with the G, S, and I busses connects the source to the negative terminal and grounds the positive via G bus. Figure 6 shows the measurement determination; the proper polarity is detected.

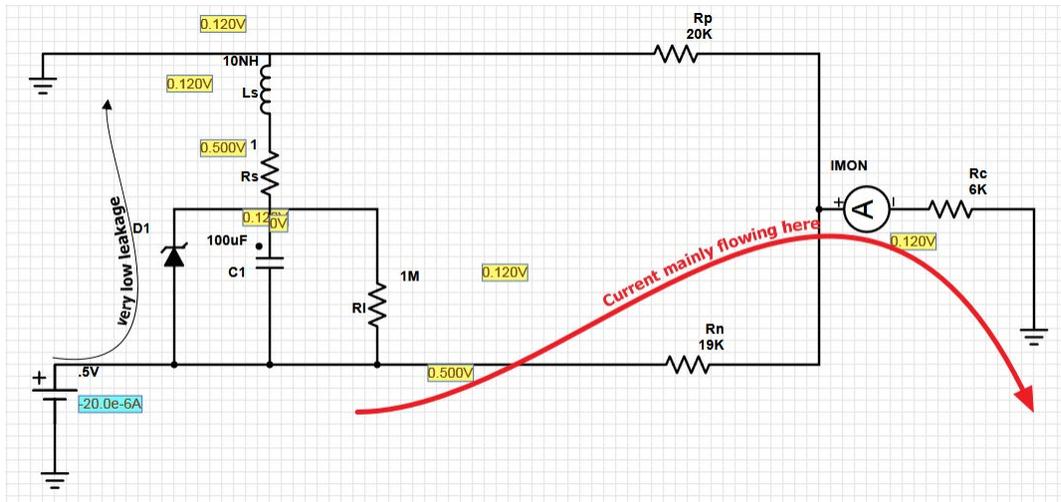


Figure 6. Correct polarity measurement as show by current flow in equivalent circuit

Under these conditions, if you try to measure the resistance between bus S and I, you will see a valid measurement.

Example

c1 HAS PASSED
Subtest: Polarity
Measured: 5.8677k
Nominal: 6.0000k
High Limit:9.0000k
Low Limit: 3.0000k
Resistance in OHMS

As the primary purpose of this test is to measure resistance and not the exact value, the limits are numerous.

The current flowing into R_c is almost zero by inverting bus S and G to simulate opposite orientation of the ECAP. Therefore, no voltage drops were detected as shown in Figure 7.

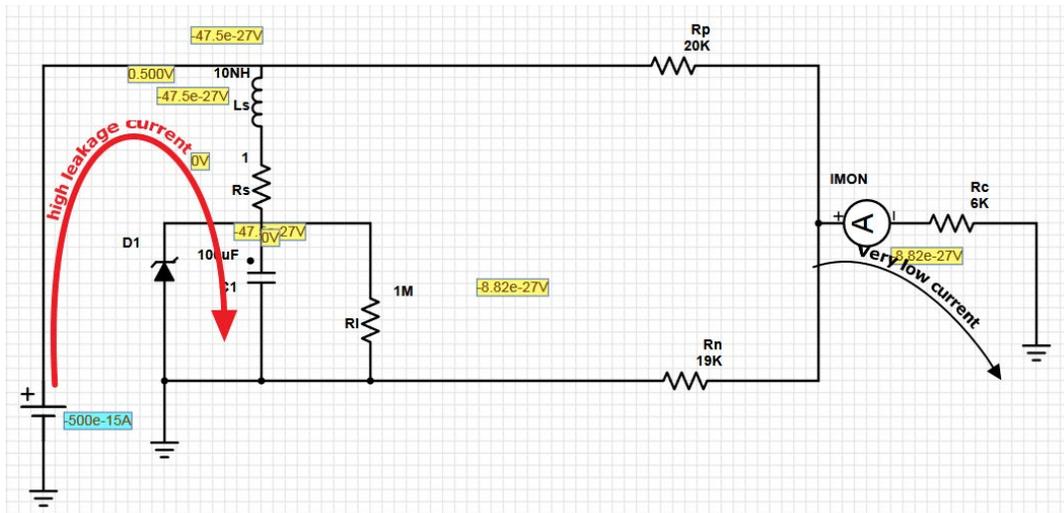


Figure 7. Incorrect polarity measurement as show by leakage current flow in equivalent circuit

The resistor test in this case, gives a weird measurement like:

```

c1 HAS FAILED
Subtest: Polarity
Measured:  -13.999k
Nominal:   6.0000k
High Limit: 9.0000k
Low Limit:  3.0000k
Resistance in OHMS
    
```

How to Enable the Test Point

You can add an extra test point on the top side of the ECAP from the board consultant graphical user interface, as shown in Figure 8. This enables you to:

- Allow the software to generate the resources for the detector
- Consider the type of probes along with the height and the degree of the capacitors mounted may cause contact problems
- Use a serrated head style probe to minimize the contact issue
- Create the test to include the polarity checking as shown in Figure 7

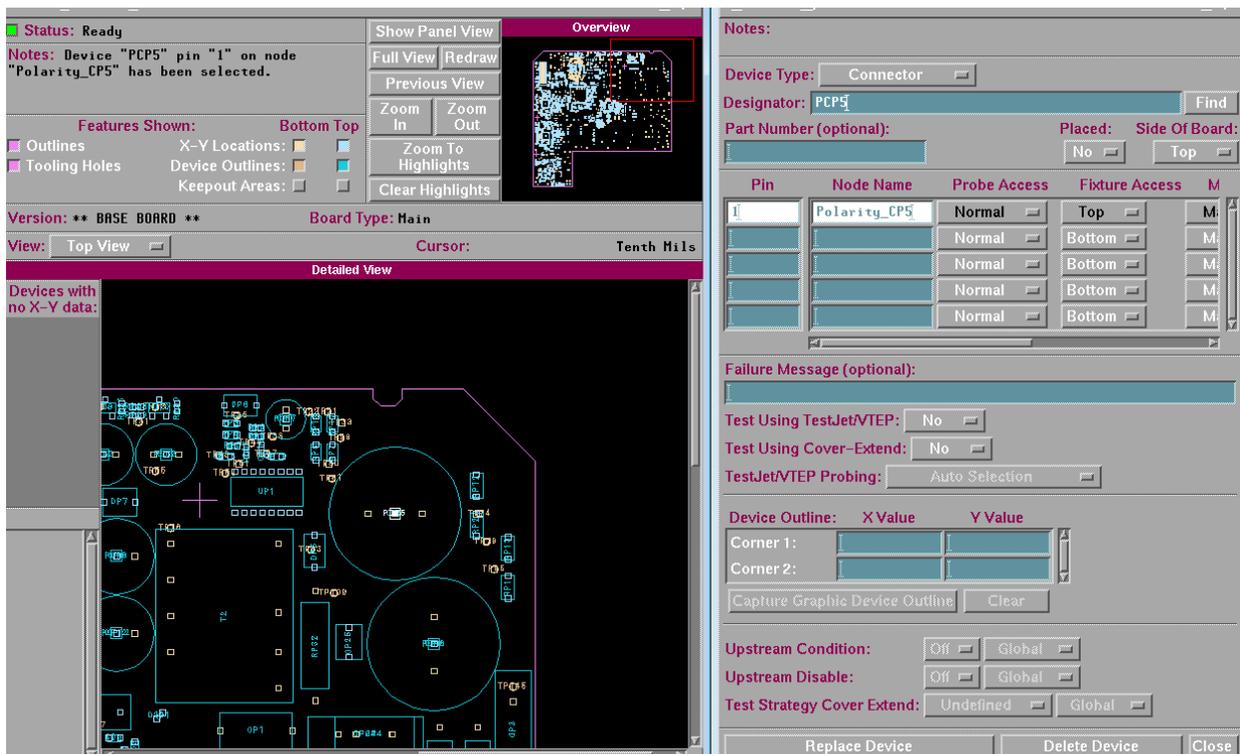


Figure 7. Adding test point through board consultant

Example: Test verification for polarity.

1. Node PolarityCP5 is manually added to the board consultant.
2. Test has two subtests.
3. Standard capacitor test measures the value of the capacitor. The IPG generates automatically.
4. Resistor test is manually added, and includes the node from the board consultant, and the bus G.

In this example, assume that the positive terminal of the ECAP connects to VCC and the negative terminal to GND.

```
! IPG: rev 09.10p Wed Mar 21 11:04:01 2018
! Common Lead Resistance 500m, Common Lead Inductance 1.00u
! Fixture: EXPRESS
disconnect all
connect s to "VCC"
connect i to "GND"
capacitor "Value", 1u, 20, 80, fr128, re1, am100m, ar50.0m, ed, nocomp
disconnect all
connect g to "VCC"
connect i to "PolarityCP5"
connect s to "GND"
resistor "Polarity", 16k, 50, 50, re3, am300m, icol
```

Examples of results with correct and incorrect polarity:

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-----
CP5 HAS PASSED
Subtest: Value

Measured: 0.95059u
Nominal: 1.0000u
High Limit: 1.2000u
Low Limit: 0.20000u
Capacitance in FARADS

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CP5 HAS PASSED
Subtest: Value

Measured: 0.95203u
Nominal: 1.0000u
High Limit: 1.2000u
Low Limit: 0.20000u
Capacitance in FARADS

-----
CP5 HAS PASSED
Subtest: Polarity

Measured: 17.292k
Nominal: 16.000k
High Limit: 24.000k
Low Limit: 8.0000k
Resistance in OHMS

-----
CP5 HAS FAILED
Subtest: Polarity

Measured: 327.98k
Nominal: 16.000k
High Limit: 24.000k
Low Limit: 8.0000k
Resistance in OHMS

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```

Conclusion

The test result shown that this new polarity test methodology successful detected the incorrect polarity of electrolytic capacitor on the printed circuit board. Hence, it improves the quality of the product as the coverage increased.

Related Information

Application Note:

Test Orientation of Polarized Capacitor in i3070 ICT Test Platform, 5992-3621EN

Data Sheet:

i3070 Series 5i Inline In-Circuit Test System, 5991-2686EN

Case Study:

Head-to-Head Comparison - Vectorless Test: NanoVTEP vs VTEP, 5992-3039EN

Application Note:

IEEE 1687 – Silicon Test to Board Test, 5992-3445EN

Other literature can be located on Keysight's i3070 In-Circuit Test website:

www.keysight.com/find/ict

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

