WP 14012

Measurement capabilities for testing critical circuit configurations

Abstract: Measurement range, accuracy and repeatability are fundamental parameters to be considered in the choice of an in-circuit tester. Measurement capability do not reflect only the accuracy of the component values measurement: It results in the capability to detect failures or not. Therefore, not all testers are able to detect all the failures that can occur on an electronic circuit.

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SPEA

The importance of the measurement capabilities in the choice of the in-circuit tester

Measurement range, accuracy and repeatability are fundamental parameters to be considered in the choice of an in-circuit tester. Those that can appear as minimal differences in the datasheets of two different systems, can result in the capability – or not – to detect failures. Failures which can affect the overall board functionality, or critically compromise its lifetime.

In addition to the absolute values of measurement ranges that can be measured with a tester, it is essential to consider also the following, important parameters:

1. Measurement resolution
2. Measurement accuracy
3. Measurement repeatability
4. Measurement offset introduced by the system itself

For example, a tester whose capacity measurement range is 10pF-10mF, with an offset of 100pF, is able to guarantee a good real coverage only when the offset introduced by the system is negligible with respect to the measurement to be performed.

In this case, with a 100pF offset, the coverage is reliable only in the range from 10nF. It is clearly understandable that, if you need to measure a 50pF condenser, the offset introduced by the measurement would be 200% bigger than the value to be measured.

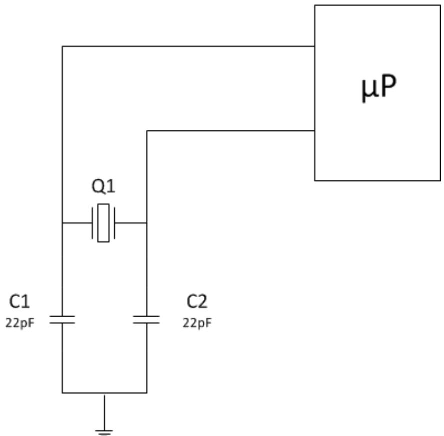
In this Application Note, we will describe some of the most common circuitry configurations that, if not properly tested, can imply a serious defectiveness of the board on the production line, or – even worse – directly on the field.

1) Oscillator capacitance

The electrical diagram here aside shows a typical case where it is fundamental to verify value and correct assembly of capacitors, even though their value is very low (22pF).

In case one of the two capacitors (C1 or C2) is not correctly assembled, or it is shorted, the quartz (Q1) cannot oscillate. This will not allow the board to work.

A tester introducing a high measurement offset (higher than 200pF) cannot guarantee an adequate test of this configuration, because its overall accuracy will be compromised.



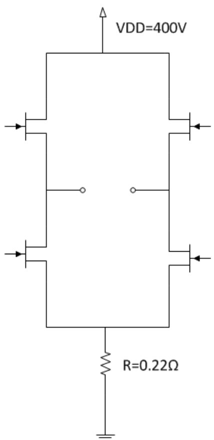
2) Low-Value Resistors

The electrical diagram here aside shows a typical case where it is fundamental to verify value and correct assembly of resistors, even though their value is very low (for example, 0.22Ω).

It is typical that low-value resistors are used as shunt for the current feedback on power circuitry. This feedback is typically acquired by the microprocessor for the correct regulation of the output current of the board.

In case one of the five parallel resistors is not correctly assembled, or it is shorted, the current feedback read by the microprocessor will not be correct.

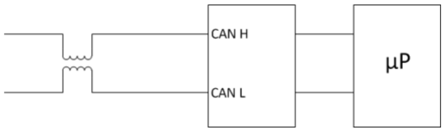
This will cause the non-correct working of the board in the high-current ranges (which are the most difficult to be tested also at the functional test), or the board breakdown at the power functional test, as soon as the board is switched on.



An in-circuit tester with high offset (e.g. ≥15mΩ) in the resistance range below 1Ω cannot be capable to properly test this circuitry. The failure detection will be postponed at the functional test (if performed), with all the risks related to the high-power test.

3) CAN Transceiver

The electrical diagram here aside shows a typical case where it is fundamental to verify value and correct assembly of inductors, even though their value is very low (e.g. 30 µH).



Low-value inductors are often used as filters on serial communication lines.

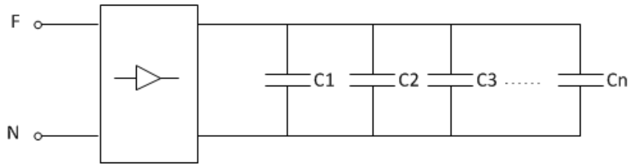
In case these inductors are not correctly assembled, or they are shorted, signal noise is not correctly filtered (in some cases, it can be even amplified, with a resonance effect) with the result to shorten the lifetime of the board on the field.

An in-circuit tester with a low measurement accuracy (e.g. 10% + 200µH) in the inductance range below 200µH will not be capable to properly test this circuitry.

This kind of failure is also hardly detectable at the functional test, so it will be detected only with the field returns.

4) Capacitors in parallel

The electrical diagram here aside shows a typical case where it is fundamental to verify value and correct assembly of high-value capacitors (e.g. 60mF).



High-value capacitors are often used as filter on the high-power line which powers the board output stages, avoiding voltage disruptions.

In case the high capacitance values resulting from this parallel configuration is not correctly identified, the downstream power stages (especially if they are switching) could work incorrectly. This could cause the immediate breakdown of the board, or a shorter lifetime.

An in-circuit tester that cannot test in the capacitance range above 40 mF cannot be capable to properly test this circuitry configuration, postponing these verifications to the power final test, with all the risks connected (at the switch on, or during the high-current test, the board could break down, or even catch fire or make the output stages explode).

This kind of failure is also hardly detectable at the functional test, so it will be detected only with the field returns.

5) Fuses

The fuse is the first protection element of the boards. It is therefore fundamental to verify that fuses have the correct value.

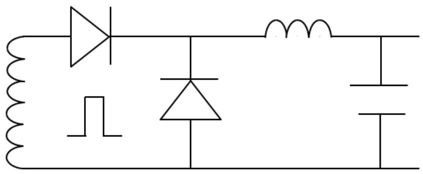
In case the fuse value is higher than expected, the board protection will not operate correctly, but at a higher current value.

An in-circuit tester with a current capability lower than 800 mA cannot detect this kind of fail.
Moreover to appreciate the fuse difference a tester with a current capability from 800mA up to 3Amp is recommended.

This kind of failure is also hardly detectable at the functional test, so it will be detected only with the field returns.

6) Diodes in parallel

The electrical diagram here aside shows a typical case where the rectifier bridges could result in parallel through the transformer inductance.

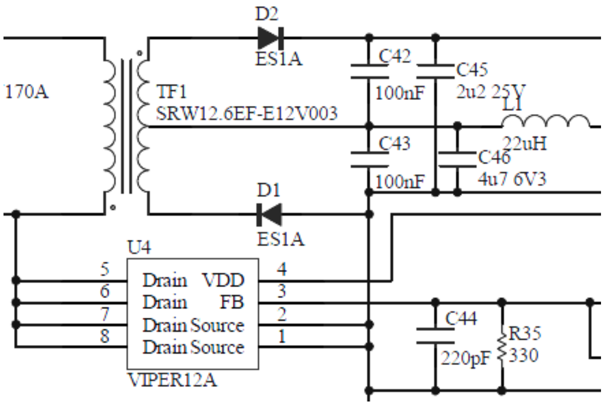


To detect this case, a tester with precise current resolution (at least with a range of 10 µA and 14 bits of resolution) is required, in order to measure low-current diodes when they still have a resistive behavior.

Otherwise, diodes can be tested with an high-speed analog timing (typically, below 0.1ms). In this case, the inductance behaves as an open circuit, and the two diodes are no longer in parallel in the circuitry.

7) Transformers

The verification of the correct assembly and values of a transformer coils are fundamental, especially in case of switching stages: the tester must be capable to measure a wide inductance range (100 µH). But, in this case, also the verification of the turns ratio and the phase of the secondaries is of the utmost importance.



These verifications require the application of analog stimulus with a timing that is similar to the typical working frequencies of a switching transformer.

The in-circuit tester used to test these components must be capable to apply analog stimulus with timing below 100 µsec.

Equipment accuracy: a comparison summary

The chart here below shows, as a reference case, measurement ranges and equipment accuracy values of two different equipment, for some exemplifying cases. It is evident that the same measurement ranges result in different real measurement capabilities, due to different offset values. This results in the capability, or not, to identify failures in the specified measurement ranges. Failures which, as we explained above, can affect the overall board functionality, or critically compromise its lifetime.

Table 1 – Declared measurement ranges of SPEA 3030 and TRI xxx

	Measurement ranges		Notes
	SPEA 3030	TRI xxx	
Resistance	1mΩ ÷ 1GΩ	1mΩ ÷ 1GΩ	Declared measurement ranges are the same
Capacitance	0.5pF ÷ 1F	0.5pF ÷ 1F	
Inductance	1μH ÷ 1H	1μH ÷ 1H	

Table 2 - Equipment accuracy of SPEA 3030 and TRI xxx: Exemplifying cases

		Equipment accuracy		Notes
	Measurement range	SPEA 3030	TRI xxx	
Resistance	10mΩ ÷ 100mΩ	10%	3%+15mΩ	15mΩ is 150% than 10mΩ. Resistors in this range will not be tested with TRI
Capacitance	10pF ÷ 100pF	2%	10%+200pF	200pF is 2000% than 10pF Capacitors in this range will not be tested with TRI
	40mF ÷ 100mF	10%	Not measurable	Capacitors in this range will not be tested with TRI
Inductance	20μH ÷ 47μH	7%	10%+200μH	200μH is 200% than 20μH Inductors in this range will not be tested with TRI

WARNING

- A tester with capacitance measurement with an high offset cannot guarantee an adequate test of oscillators capacitance, or capacitors in parallel
- A tester introducing a high measurement offset (higher than 200pF) cannot guarantee an adequate test of oscillators capacitance
- An in-circuit tester with high offset (e.g. ≥15mΩ) in the resistance range below 1Ω cannot be capable to properly test low-value resistors
- An in-circuit tester with a low measurement accuracy (e.g. 10% + 200μH) in the inductance range below 200μH will not be capable to properly test low value inductors
- An in-circuit tester that cannot test in the capacitance range above 40 mF cannot be capable to properly test high value capacitors

HINTS AND TIPS

- An in-circuit tester with precise current resolution (at least with a range of 10 μA and 14 bits of resolution) is required to measure low-current diodes when they still have a resistive behavior
- An in-circuit tester with low offset and high accuracy in capacitance measurement is required to test oscillators capacitance, or capacitors in parallel