The Search for Accurate CDM waveforms
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The legacy of current value for verification is only one issue in a joint CDM standard. Another issue which has serious limitations is that of accurate CDM waveform measurements. This work is intended to identify errors present in both the JEDEC and ESDA current sensors. The original response of current sensors was limited to 1 GHz data because that was only reasonable bandwidth available. In the beginning of CDM testing 1 GHz scopes were the only reasonable instrumentation to define the CDM waveform parameters.

Although all current sensors for ESD testers were specified by their bandwidth or pulse response measured outside the tester, CDM current sensors were not. The response of CDM current sensors has been ignored since the beginning of CDM testing. CDM current sensors response was evaluated as part of the total system. The total system measurement included all variables in the charge and discharge circuit. Without the current sensor being measured individually as a separate element its bandwidth limitations were simply added to those of the rest of the CDM tester.

As faster scopes began to be used in CDM testing, different responses in high speed current sensor became confusing. An ESDA paper detailing measurements of individual CDM current sensors was published showing high speed response variations. That data identified limitations in their ability to provide repeatable bandwidth measurements beyond 1 GHz. The reported different responses which affect CDM repeatability were ignored both by standards groups and CDM tester manufacturers.

Current sensor bandwidth limitations have now become the critical issue in developing a joint ESDA-JEDEC CDM standard. Recent CDM discharge measurements of different packages made by Marty Johnson with an 8 GHz scope are presented in Figure 1.

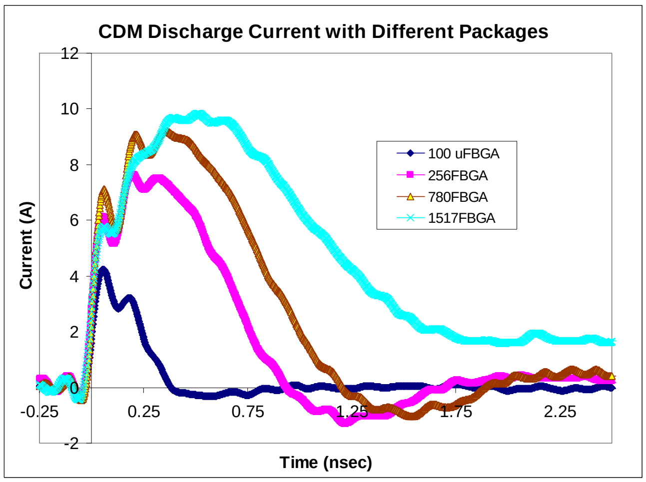

Figure 1. Marty Johnson's CDM measurements of different packages.

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The waveforms from different packages are distorted by the high speed ringing response of the JEDEC current sensor. The early ringing in each waveform is created by a special electrical circuit added to the current sensor to provide the legacy waveform when measured with a 1 GHz scope. The effect of the resonant circuit addition is shown in the current waveform distortion for a number of different packages. The ringing on the leading edge is caused by a resonant cavity in the current sensor used to make the 1 GHz discharge response meet testing waveform legacy.

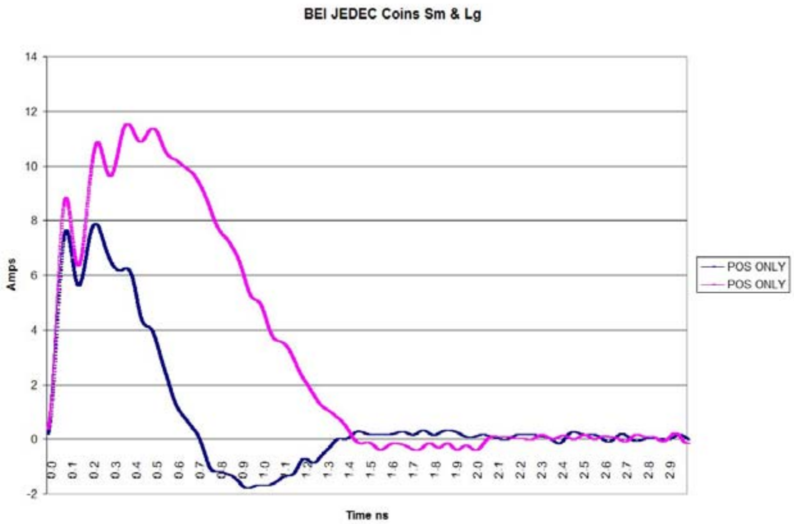

Figure 2. Marty Johnson’s measurements of CDM modules.

These same resonances are seen above Figure 2 which is Marty Johnson’s discharge current measurements from JEDEC coins. They were also taken with his 8 GHz scope. The risetime for the small module was 44 ps and for the large it was 189 ps. The ringing for both waveforms are distortions caused by the resonance used to achieve the originally necessary correct 1 GHz response. The 44 ps risetime for the small module is faster than it will be without the resonance because the first peak current is accentuated by the excessive high speed enhancement addition. The risetime of the large JEDEC coin is also distorted by the artificial resonance effect on the leading edge of the discharge waveform. Its risetime of 189 ps is also in error because the ringing does not allow the true 90% level to be identified.

These are the same errors shown in the device waveforms of Figure 1. The high speed errors were invisible when measured with 1 GHz scope bandwidth; and distort the current waveform when measured with a scope greater than 1 GHz bandwidth.

Unfortunately we do not have similar 8 GHz measurements for JEDEC current sensors. In place of that data I have made impulse measurements of three different current sensors available for measurement.

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The following impulse measurements were made of the three different current sensors with their 2 meter cables with bandwidths reduced as identified.
At 1 GHz bandwidth the three current sensors have very similar responses in both amplitude and shape. That all three units will produce very similar CDM discharge waveforms when measured with a 1 GHz scope is not surprising. The ESDA and JEDEC units were designed to provide similar current waveforms in the CDM tester at 1 GHz.

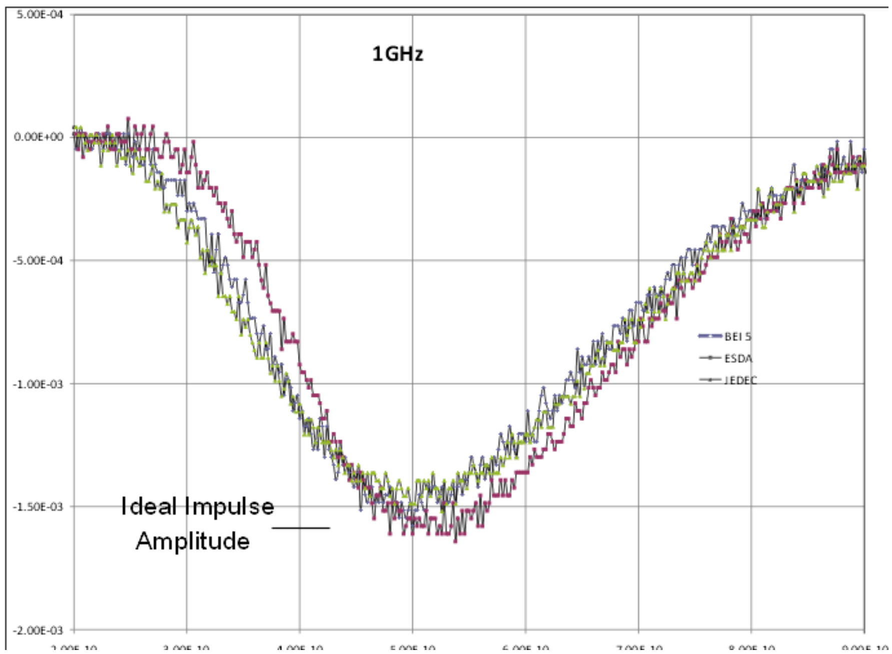

Figure 3. Impulse measurements of three current sensors at 1 GHz bandwidth

The BEI 5 current sensor also has very similar response at 1 GHz. Its high speed construction provides a much improved response above 12 GHz. In the time domain it has a measured step response risetime of about 30 ps with about 7% overshoot.

The 3 GHz impulse waveforms in figure 4 have noticeably different impulse responses. They identify the peak response to a fast CDM discharge when measured with a 3 GHz scope.

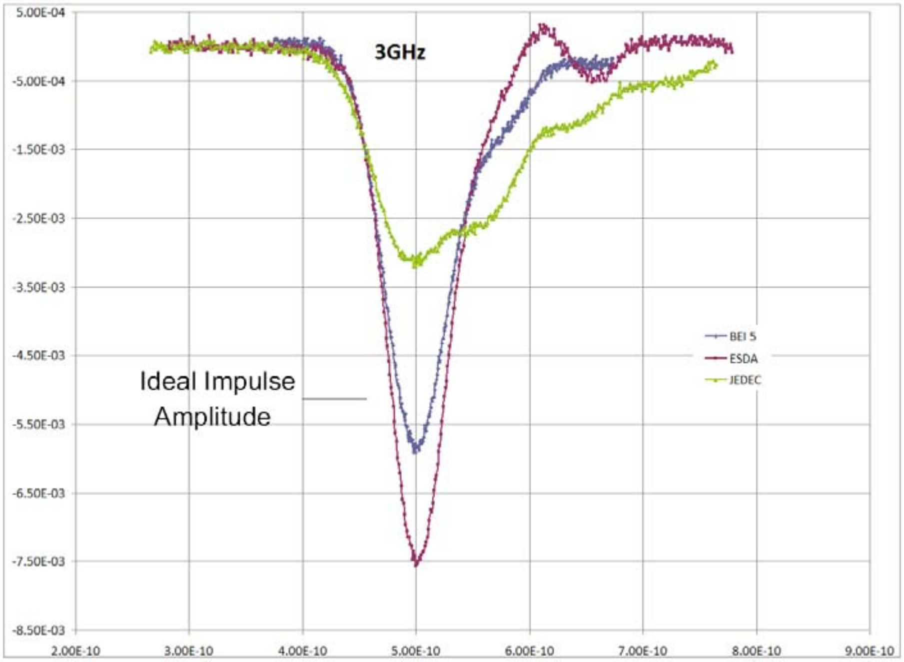

Figure 4. Impulse measurements of three current sensors at 3 GHz bandwidth

Figure 5 below shows the impulse response of the same three CDM current sensors. The increased difference between them at 6 GHz is clearly seen.

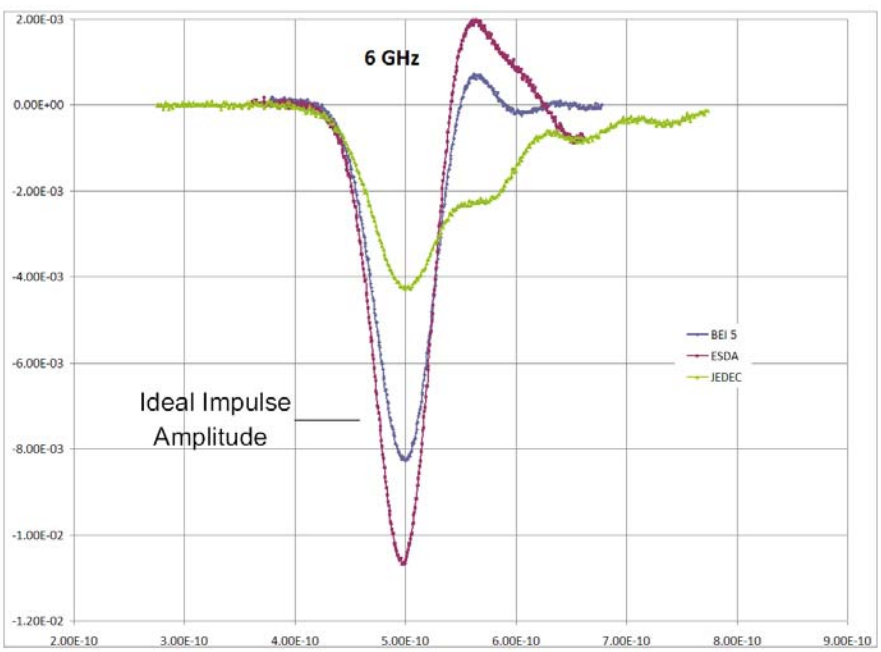

Figure 5. Impulse measurements of three current sensors at 6 GHz bandwidth

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The JEDEC current sensor which was designed to meet that standard is too slow to register the correct peak impulse current when measured with a 6 GHz scope. However the current sensor designed to meet the ESDA standard is too fast to register the correct current when measured with the same 6 GHz system.

The major amount of overshoot of the ESDA current sensor shows as an inverted waveform after the impulse. The minor amount of overshoot in the BEI 5 current sensor also appears as an inverted waveform after the impulse.

The peak values of the ideal impulse amplitude are identified by attenuating the cables alone impulse by that of a one ohm current sensor in a coaxial 50 ohm system. The attenuation of a one ohm current sensor fed with a 50 ohm impulse has a theoretical voltage attenuation of 25.5/1.

These first impulse measurements were made with a sampling scope with a high noise level. The bandwidth reduction method was only approximately Gaussian. The Ideal peak impulse amplitude is shown for each current sensor measured. All three current sensors have very similar responses at 1 GHz at the maximum frequency response they were designed to provide. Although the impulse waveforms have some obvious errors they show the major differences between the ESDA and the JEDEC current sensors at 3 GHz and 6 GHz. We are continuing the work to improve the impulse measurement system with higher amplitude and better Gaussian impulse test waveforms. More data will be available on the BarthElectronics.com website as it becomes available. It will be located in our CDM measurement section.

Conclusion

While this data has some accuracy limitations it clearly shows the differences between the ESDA and the JEDEC current sensors we had available for measurement. The joint ESDA-JEDEC standard will probably include higher bandwidth scope discharge parameter data.

If the joint ESDA-JEDEC standard is to have accurate high speed measurements with greater than 1 GHz bandwidth scopes, more repeatable and accurate current sensors will be needed. The much improved response at bandwidth calibrated with specific tolerance measured parameters will provide two significant improvements in the CDM standard.

1. It will reduce CDM variations between testers.
2. It will also provide greatly improved current measurement accuracy if faster scopes are used.

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