

## TABLE OF CONTENTS

<b>1.0 Purpose</b> .....	<b>1</b>
<b>2.0 Scope</b> .....	<b>1</b>
<b>3.0 DEFINITIONS</b> .....	<b>1</b>
<b>4.0 SOURCES (ROOT CAUSES) OF EOS DAMAGE DURING THE ASSEMBLY PROCESS</b> ...2	
4.1 WHEN IS A POSSIBLE ROOT CAUSE A SIGNIFICANT RISK FOR EOS DAMAGE?.....	2
4.2 CATEGORIES OF EOS EXPOSURE.....	3
4.2.1 <i>Unpowered Devices</i> .....	3
4.2.2 <i>Powered Devices</i> .....	4
4.3 AC AND DC EOS SOURCES AND INADEQUATE GROUNDING.....	4
4.4 EMI-INDUCED ROOT CAUSES OF EIPD.....	5
4.5 BASICS OF EMI DIAGNOSTICS.....	5
4.6 EMI INSTRUMENTATION.....	8
4.6.1 <i>Time Domain Measurements</i> .....	8
4.6.2 <i>Frequency Domain Measurements</i> .....	9
4.6.3 <i>Broadband Measurements</i> .....	9
4.6.4 <i>Power Line EMI Adapters</i> .....	10
4.7 VOLTAGE OR CURRENT?.....	10
4.8 SOURCES OF EMI IN A MANUFACTURING ENVIRONMENT.....	11
4.8.1 <i>Commutation of Power</i> .....	11
4.8.2 <i>Dimmers/Gradual Heat Control</i> .....	12
4.8.3 <i>Switched Mode Power Supplies (SMPS)</i> .....	12
4.8.4 <i>Uninterruptable Power Supplies (UPS)</i> .....	13
4.8.5 <i>Servo and Variable Frequency Motors</i> .....	13
4.8.6 <i>CFL and LED Lighting</i> .....	14
4.8.7 <i>Power Line Surges</i> .....	15
4.9 PROPAGATION OF EMI.....	15
4.10 HOW EMI CAN CAUSE DAMAGE.....	15
4.10.1 <i>EMI on Power and Signal Lines</i> .....	15
4.10.2 <i>EMI on Ground</i> .....	16
4.11 MITIGATION OF EMI IN ELECTRONIC ASSEMBLY.....	18
4.11.1 <i>Reduction of AC Noise</i> .....	18
4.11.2 <i>Soldering</i> .....	19
4.11.3 <i>Servo Motors and Variable Frequency Drives</i> .....	20
4.11.4 <i>Ground</i> .....	21
4.11.5 <i>Power Line Spikes</i> .....	21
4.11.6 <i>DC Power</i> .....	22
4.12 CONCLUSION – EOS IN ASSEMBLY.....	22
<b>5.0 EOS Concerns during automated TESTING</b> .....	<b>22</b>
5.1 INTRODUCTION – SCOPE OF TESTING ENVIRONMENT.....	22
5.2 POWER AND SIGNAL INTEGRITY EVALUATION.....	22
5.3 TESTING FOR LATENT OR WOUNDED PRODUCTS.....	23

5.3.1	Order of Test Routines.....	24
5.3.2	Testing at PCBA Level.....	24
5.3.3	Testing at Strip Level.....	27
5.4	TEST CONDITIONS – BEST PRACTICE.....	27
5.4.1	Test Board Design Best Practice.....	29
5.5	SUMMARY.....	31
<b>6.0</b>	<b>REFERENCES.....</b>	<b>31</b>

**FIGURES**

Figure 1:	Voltage on Ground Caused by Return Current in Ground.....	5
Figure 2a:	Individual Transient on Power Line.....	6
Figure 2b:	Composite EMI Signal on Power Line.....	6
Figure 3:	Peak Versus Root Mean Square (RMS) Values.....	7
Figure 4:	Measuring Repetition Rate of Pulses.....	7
Figure 5a:	Portable Oscilloscope.....	8
Figure 5b:	Power Line EMI Adapter.....	8
Figure 5c:	Portable Spectrum Analyzer.....	9
Figure 5d:	Measuring Broadband EMI.....	9
Figure 5e:	High-Frequency Current Probe.....	10
Figure 6:	Miniature Current Probe.....	11
Figure 7:	Power Line Transient from Turning on Heat Gun.....	11
Figure 8:	Noise from a Light Dimmer.....	12
Figure 9:	Noise on AC Mains Generated by Several Switched Mode Power Supplies.....	12
Figure 10:	Waveform Shape of Typical Noise from Uninterruptable Power Supplies.....	13
Figure 11:	Effect of Servo Motor Pulse on Ground Noise.....	14
Figure 12:	LED Lighting as Source of EMI.....	14
Figure 13a:	High-Frequency Signal Between USB Ground and Equipment Ground.....	16
Figure 13b:	Resulting Voltage Between USB Data Line versus Ground.....	16
Figure 14:	High-Frequency Voltage Between Robotic Arm and a Tool Frame in an IC Handler.....	17
Figure 15:	Transient on Power Line from a Periodic Signal and Resulting Current from the Tip of a Soldering Iron.....	17
Figure 16a:	Connection of Equipment via Power Line EMI Filter.....	18
Figure 16b:	EMI Before and After the Filter.....	19
Figure 17a:	Connection of Soldering Iron via Specialized EMI Filter.....	19
Figure 17b:	Current from the Tip with Filter.....	20
Figure 18:	Servo Filter Reduces Ground Currents in the Tool.....	20
Figure 19:	Ground Filter Blocks Noise Propagation Throughout Facility Ground.....	21
Figure 20:	Using Small Ground Filter in Line with ESD Ground in Equipment.....	21
Figure 21:	Special EMI Filter Transient Surge Suppression Performance.....	22
Figure 22:	Recommended Retesting of Opens and Shorts after Functional Testing.....	23
Figure 23:	Example of Hot Swapping with Incorrect Order of Connection - IC on System Board with I/O 1 and I/O 2 Connecting Pins in First and Second Followed by VDD and GND.....	25
Figure 24:	Correct Order and Alignment of GND, VDD, and I/O to Prevent Mis-Biasing EOS Conditions.....	26
Figure 25:	First Mate Last Break Example.....	26
Figure 26:	Ground Bounce Solution.....	27
Figure 27:	Optical Micrograph Depicting Electrically-Induced Physical Damage in the Metal Connected to the VS Pin.....	28
Figure 28:	Simplified Schematic of Test Pins with Corresponding Bypass Capacitors Depicting Current Discharge Path from VOUTPUT to VS.....	28

Figure 29: TVS and Schottky Diode Protection Between Supply and Ground to Protect Against Positive and Negative Going Transients on Supply and Ground ..... 29

Figure 30: Random Fuse Block and Latch-up Like Failures in an Accelerometer IC..... 30

Figure 31: Root Cause and Fix for Supply Capacitor Switching Failure ..... 31