SMEI Flight Model

Electrical Interface Test Report

David Hoyland

University of Birmingham

Issue 1

28th March 2001

Table of Contents

SMEI Flight Model Electrical Interface Test Report 4

1 Introduction 4

2 Interface Characteristics 4

3 Power Dissipation 4

3.1 Test Configuration 4

3.2 SMEI Operating Power Requirements 4

3.3 Operational Mode Total Power Requirements 5

4 1Hz GPS Signal Compatibility 6

4.1 Test Configuration 6

4.2 1Hz GPS Signal Operational Characteristics 6

5 Bi-Level Command Signal Compatibility 6

5.1 Test Configuration 6

5.2 Bi-Level Operational Characteristics 6

6 Power Supply Ripple 7

6.1 Test Configuration 7

6.2 Supply Ripple Characteristics 8

7 Power Supply Transients 8

7.1 Test Configuration 8

7.2 Power Supply Transient Characteristics 8

7.2.1 Instrument Switch On Transient Characteristics 8
7.2.2 Camera Switch On transient Characteristics 9
8 Power Supply Inrush Current 9
8.1 Test Configuration 9
8.2 Inrush Current Characteristics 9
8.2.1 Instrument Switch On Inrush Characteristics 9
8.2.2 Camera Switch On Inrush Characteristics 10
9 Grounding and Isolation 10
9.1 Test Configuration 10
9.2 DC Isolation and Grounding Characteristics 10
9.2.1 Power Bus, Bi-Level and GPS 1Hz to Chassis Isolation 10
9.2.2 Bi-Level and GPS 1Hz to Power Bus Isolation 10
9.2.3 Side A to Side B Power Bus Isolation 10
9.2.4 Bi-Level to GPS 1Hz Returns Isolation 10
9.3 AC Isolation Characteristics 11
9.3.1 Power Bus to Chassis Capacitance 11
9.3.2 Power Bus to Bi-Level and 1Hz GPS Returns Capacitance 11
10 Conclusions 11
Appendices 12

SMEI Flight Model Electrical Interface Test Report

1 Introduction

This report summarizes the electrical interface characterization tests undertaken on the complete SMEI Flight instrument to demonstrate compliance with the ICD.

2 Interface Characteristics

Tests were performed on the instrument to characterize the following features of the interface:

i) Instrument Power Dissipation
ii) 1Hz GPS Signal Compatibility
iii) Bi-Level Signal Compatibility
iv) Power Supply Ripple
v) Power Supply Inrush Current
vi) Grounding and Isolation

3 Power Dissipation

3.1 Test Configuration

The system was configured in normal flight configuration with the three FM cameras. Power and communications were provided by the EGSE system. Power bus currents were measured using an ammeter in series with the positive supply rail.

3.2 SMEI Operating Power Requirements

Power dissipation tests were conducted according to the requirements of ICD Section B5.3.2. Results were taken at ambient temperature with nominal and extreme power rail voltages.

	28V Nom S/C Bus Voltage				22V Nom S/C Bus Voltage				34V Nom S/C Bus Voltage			
	Mean		Peak		Mean		Peak		Mean		Peak	
	Power	Current	Power	Current	Power	Current	Power	Current	Power	Current	Power	Current
DHU	2.9	0.102	3.6	0.130	2.6	0.116	3.3	0.152	3.2	0.095	4.0	0.117
Cameras (each)	5.7	0.203	6.2	0.222	5.6	0.253	6.1	0.278	5.9	0.174	6.4	0.189
De-Ice Heaters (each)	12.9	0.461	12.9	0.461	8.0	0.362	8.0	0.362	19.1	0.561	19.1	0.561
Shutter Motors (each)	3.2	0.113	3.2	0.113	2.0	0.091	2.0	0.091	4.5	0.131	4.5	0.131
Door Release (each)	16.6	0.594	16.6	0.594	10.3	0.467	10.3	0.467	24.5	0.722	24.5	0.722

Note: All power readings are in Watts, all Current readings are in Amps

Table 1 Operating Power Requirements

Table 1 demonstrates compliance with ICD Section B5.3.2.

3.3 Operational Mode Total Power Requirements

Total operational power requirements tests were conducted according to ICD Section B5.3.5. Results were taken at ambient temperature with positive extreme of power rail voltage.

PL Mode	Standby	Science Baseline	Science Hi Res	Engineering	LEO	Emergency Mode	Door Release
DHU	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Cameras (total)	-	19.2	19.2	19.2	6.4	19.2	-
De Ice Heaters	-	38.2	38.2	38.2	57.3	-	38.2
Shutter Motors	-	4.5	4.5	4.5	4.5	4.5	-
Door Release	-	-	-	-	-	-	24.5
TOTAL	**4.0**	**65.9**	**65.9**	**65.9**	**72.2**	**27.7**	**66.7**

Note: All power readings in Watts

Table 2 Maximum Operational Mode Power Requirements

Table 2 demonstrates compliance with ICD Section B5.3.1 (part) and Section B5.3.5.

4 1Hz GPS Signal Compatibility

4.1 Test Configuration

During this test, a programmable function generator provided the 1 Hz pulse. Current was measured using a 10R sense resistor in the positive signal line. The tests were conducted in accordance with the requirements of ICD Section B5.1.1.2.

4.2 1Hz GPS Signal Operational Characteristics

Operation over the voltage range 0v< V_{ol}< 0.5v and 4.5<V_{oh}< 5.5v was verified and the required signal current was measured at ambient temperature and nominal V_{oh}.

Channel	Current
1Hz_A	7.8
1Hz_B	7.8

Note : All current Measurements in mA

Table 3 1Hz GPS Signal Currents

Table 3 demonstrates compliance with ICD Section B5.1.1.2.

5 Bi-Level Command Signal Compatibility

5.1 Test Configuration

During this test, the circuit detailed in ICD Section 5.1.2.1 was used to generate the required bi-level signal voltage. A programmable function generator was used to provide the TTL command pulse input. Current was measured using a 10R sense resistor in the positive signal line. The tests were conducted in accordance with the requirements of ICD Section B5.1.2.

5.2 Bi-Level Operational Characteristics

Operation over the voltage range 22<V_{oh}< 34v was verified and the required signal current was measured at ambient temperature and nominal V_{oh}.

Channel	Current
Select_A	98
Select_B	98
Power_Off	94

Note : All current Measurements in mA

Table 4 Bi-Level Command Signal Currents

Table 4 demonstrates compliance with ICD Section B5.1.2.

6 Power Supply Ripple

6.1 Test Configuration

In order to measure the ripple on the spacecraft bus, it was necessary to design a LISN to simulate the spacecraft bus impedance. The design is based on the topology used in the MIL-462D specification, with component values adjusted to suit this application. Calibration details for the LISN are detailed in appendix A. The upper measurement bandwidth limit was set by the oscilloscope to 20MHz. All measurements were taken at ambient temperature and nominal voltage. The tests were conducted in accordance with the requirements of ICD Section 5.3.7.

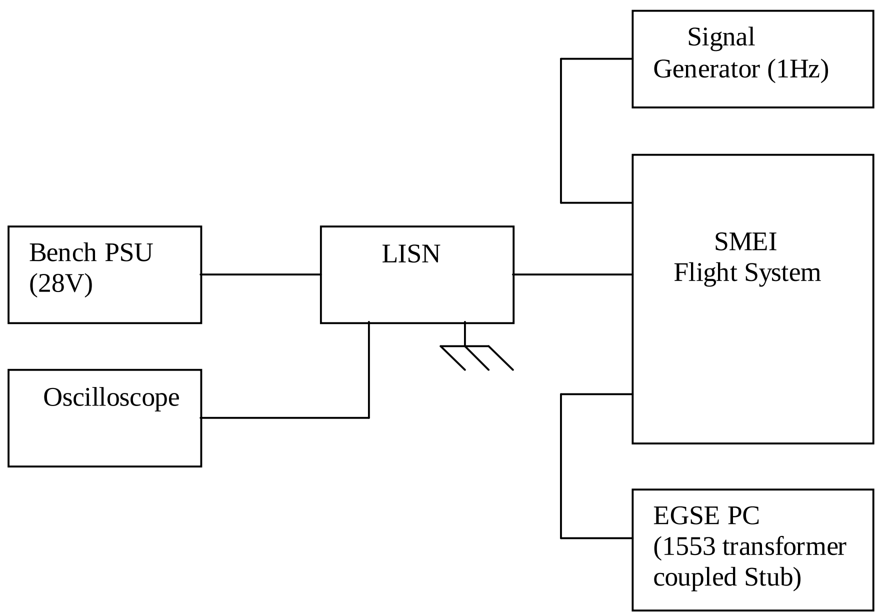

Figure 1 Ripple Measurement Test Setup

6.2 Supply Ripple Characteristics

The power bus ripple has 2 major components, a low frequency square wave component caused by 1553 bus activity, and high frequency noise component.

The high frequency component is considered to be within the bandwidth of interest, and is 56mV pk-pk.

The square wave component has a period of approximately 100mS for 128kbps 1553 operation and approximately 200mS for 64kbps 1553 activity, and is therefore considered to be outside the bandwidth of interest. Its amplitude is typically 80mV with a higher amplitude of 180mV once every 4 seconds. Oscillographs of typical waveforms for each ripple component may be found in Appendix B.

These results demonstrate compliance with ICD Sections 5.3.7 and B5.3.7.

7 Power Supply Transients

7.1 Test Configuration

The test configuration was identical to that used for the power bus ripple measurements. All measurements were taken at ambient temperature and nominal voltage. The tests were conducted in accordance with the requirements of ICD Section 5.3.8.2.

7.2 Power Supply Transient Characteristics

All instrument subsystems were exercised in order to determine worst case transients. No significant transients were found due to switching of static loads ie HOPs, Shutter Motor phases and heaters. The only significant source of bus transients was switching of dynamic loads ie DC-DC converters:

7.2.1 Instrument Switch On Transient Characteristics

The initial switch on of the instrument by relay command causes an initial transient of approximately 225uS duration as the relay contact closes and settles, followed 4mS later by a smaller secondary transient of approximately 500uS duration as the DC-DC converter starts. The primary transient is characterized typically by 2 peaks of maximum 6.3V and duration approximately 10uS, caused by relay contact bounce, with an underlying level of <2V. Oscillographs of typical waveforms may be found in Appendix C.

The initial peak of amplitude 6.3V marginally exceeds the ICD value of 6V. The times taken to decay to within 1V of steady state voltage are approximately 160uS and 350uS for the primary and secondary switch on transients, for the majority of these periods the amplitude is approximately 1.5V.

7.2.2 Camera Switch On transient Characteristics

Switch on of the 3 cameras is done simultaneously when the instrument goes from Configuration Mode to Observing Mode for the first time. The main transient caused by this event is typically 1.2mS in duration with a peak value of 2.44V. Oscillographs of typical waveforms may be found in Appendix C.

The time taken to decay to within 1V of steady state voltage is approximately 750uS, for the majority of this period the amplitude is approximately 1.5V.

8 Power Supply Inrush Current

8.1 Test Configuration

The test configuration was identical to that used for the power bus ripple measurements. Current sensing was achieved using a 0.1R sense resistor in the power return line. The unit was switched off for at least one minute prior to each test to ensure complete discharge of internal nodes. Inrush current was measured during instrument switch on and during camera switch on. All measurements were taken at ambient temperature and nominal voltage. The tests were conducted in accordance with the requirements of ICD Section 5.3.9.

8.2 Inrush Current Characteristics

8.2.1 Instrument Switch On Inrush Characteristics

The initial switch on of the instrument by relay command causes an initial inrush of approximately 225uS duration as the relay contact closes and settles, followed approximately 4mS later by a smaller secondary transient of approximately 500uS duration as the DC-DC converter starts. The primary inrush is characterized typically by 2 peaks of maximum 4.7A and duration approximately 10uS caused by relay contact bounce, with an underlying level of <3A. Oscillographs of typical waveforms may be found in Appendix D.

The inrush peaks of amplitude 4.7A and duration 10uS exceed the ICD value of 3.6A. However, these results are consistent with the results obtained during the SMEI to Hotbench Interface Checkout Test performed in July 2000.

8.2.2 Camera Switch On Inrush Characteristics

The main inrush caused by this event is typically 1.2mS in duration with current of 3A with an initial spike of duration 50uS and peak of 4.2A. Oscillographs of typical waveforms may be found in Appendix D.

The initial inrush peak of amplitude 4.2A exceeds the ICD value of 3.6A.

9 Grounding and Isolation

9.1 Test Configuration

The system was configured in normal flight configuration with 3 FM cameras. Isolation was measured with a DVM and capacitance was measured with an AVO LCR Meter. All measurements were taken at ambient temperature with the instrument un-powered. All isolation tests were carried out for each bi-level command state ie DHU_A_ON (camera power relays switched to side A), DHU_B_ON (camera power relays switched to side B), and ALL_OFF. The tests were conducted in accordance with the requirements of ICD Sections B5.4 and B5.5.

9.2 DC Isolation and Grounding Characteristics

9.2.1 Power Bus, Bi-Level and GPS 1Hz to Chassis Isolation

In all cases the resistance was >20Mohm.

9.2.2 Bi-Level and GPS 1Hz to Power Bus Isolation

In all cases the resistance was >20Mohm.

9.2.3 Side A to Side B Power Bus Isolation

In all cases the resistance was >20Mohm.

9.2.4 Bi-Level to GPS 1Hz Returns Isolation

In all cases the resistance was >20Mohm.

The above results demonstrate compliance with ICD Sections 5.4, 5.5, B5.4 and B5.5.

9.3 AC Isolation Characteristics

9.3.1 Power Bus to Chassis Capacitance

In all cases the capacitance was less than 2uF.

9.3.2 Power Bus to Bi-Level and 1Hz GPS Returns Capacitance

In all cases the capacitance was less than 100nF.

The above results demonstrate compliance with ICD Sections 5.4 and B5.4.

10 Conclusions

All parameters measured were in accordance with ICD requirements except for the following:

When the instrument is switched on there is payload induced bus transient of amplitude 6.3V which marginally exceeds the ICD value (6V). *However, this transient is of very short duration (~10uS).*

When the instrument is switched on, and when the cameras are switched on for the first time, the payload induced bus transients take greater than 100uS to decay to within 1V of the steady-state voltage (typically 160, 350 and 750uS for the three transient events). *However, for the majority of these periods the amplitude is approximately 1.5V*.

When the instrument is switched on, and when the cameras are switched on for the first time, there are short-duration inrush current peaks of amplitude 4.7A and 4.2A, respectively. However, these results are consistent with the results obtained during the SMEI to Hotbench Interface Checkout Test performed in July 2000.

Appendices

Appendix A

Spacecraft Bus Impedance Simulator LISN

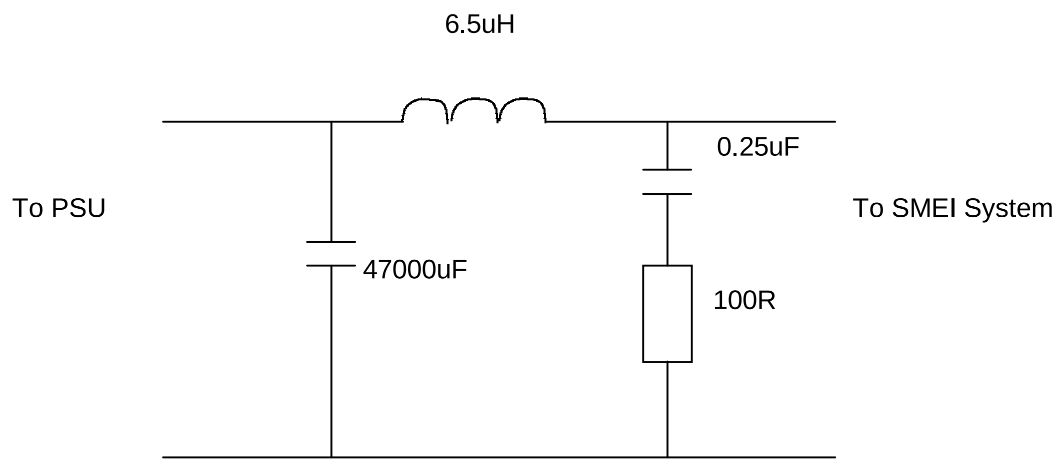

Figure A1 Simplified Schematic of the LISN

Frequency	LISN Impedances		
	Required	Simulated	Measured
10	0.5	0.6	-
1K	0.5	0.5	0.5
10K	0.5	0.64	0.6
50K	1	2.1	1.7
100K	4	4.1	3.3
500K	20	20	17.6
1M	30	37.9	35.5
10M	100	97.1	-

Note: All Frequencies in Hz. All impedances in Ohm

Figure A2 LISN Performance Details

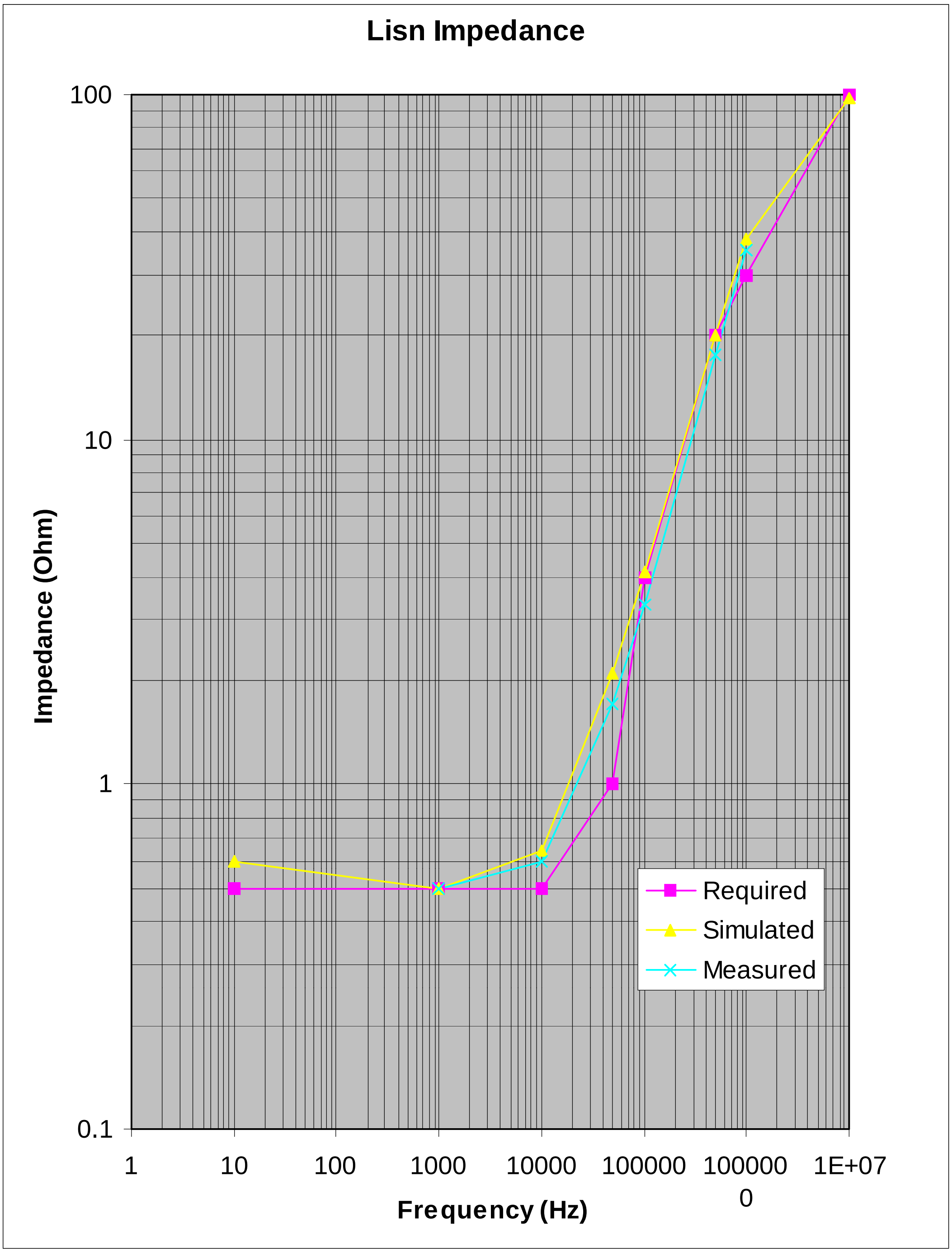

Figure A2 Magnitude Plot of LISN Impedance

Appendix B

Spacecraft Power Bus Ripple

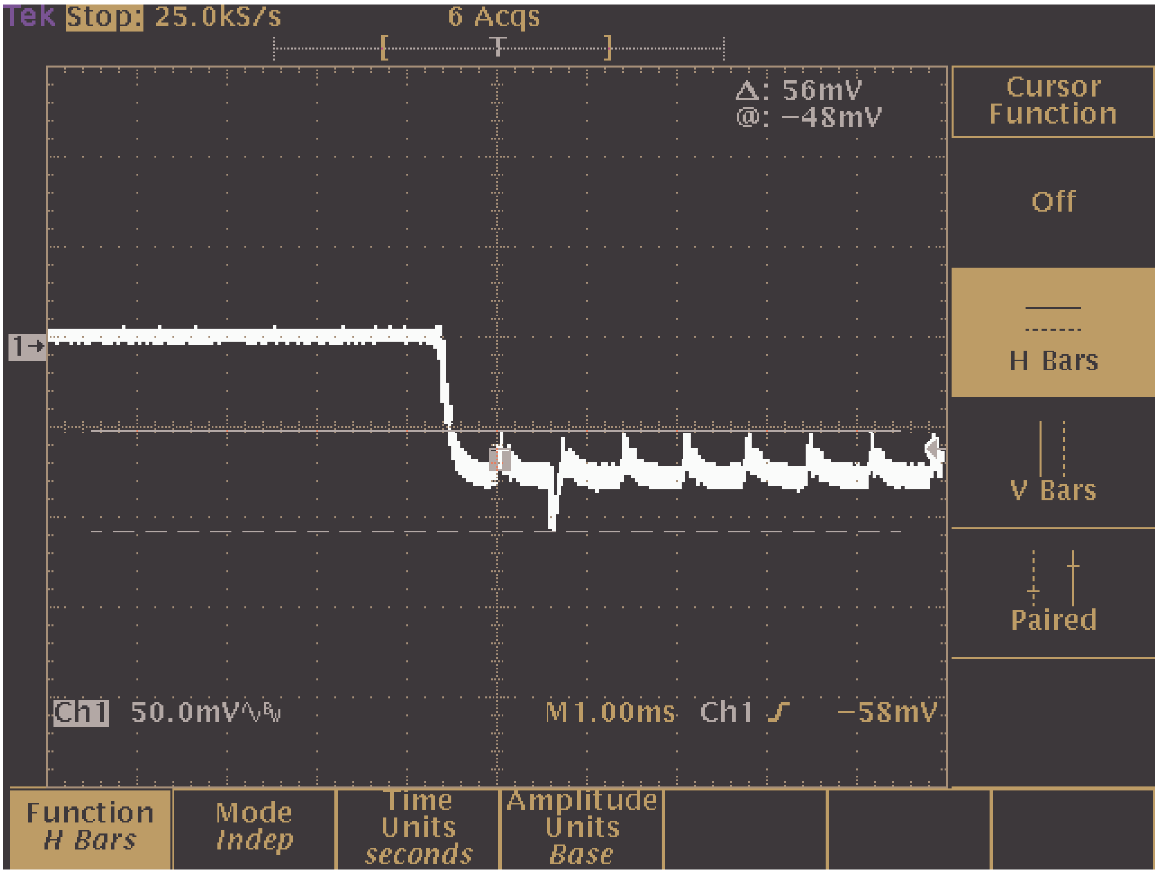

Figure B1
High frequency component pk to pk ripple of 56mV superimposed on the low frequency square wave caused by 1553 activity.

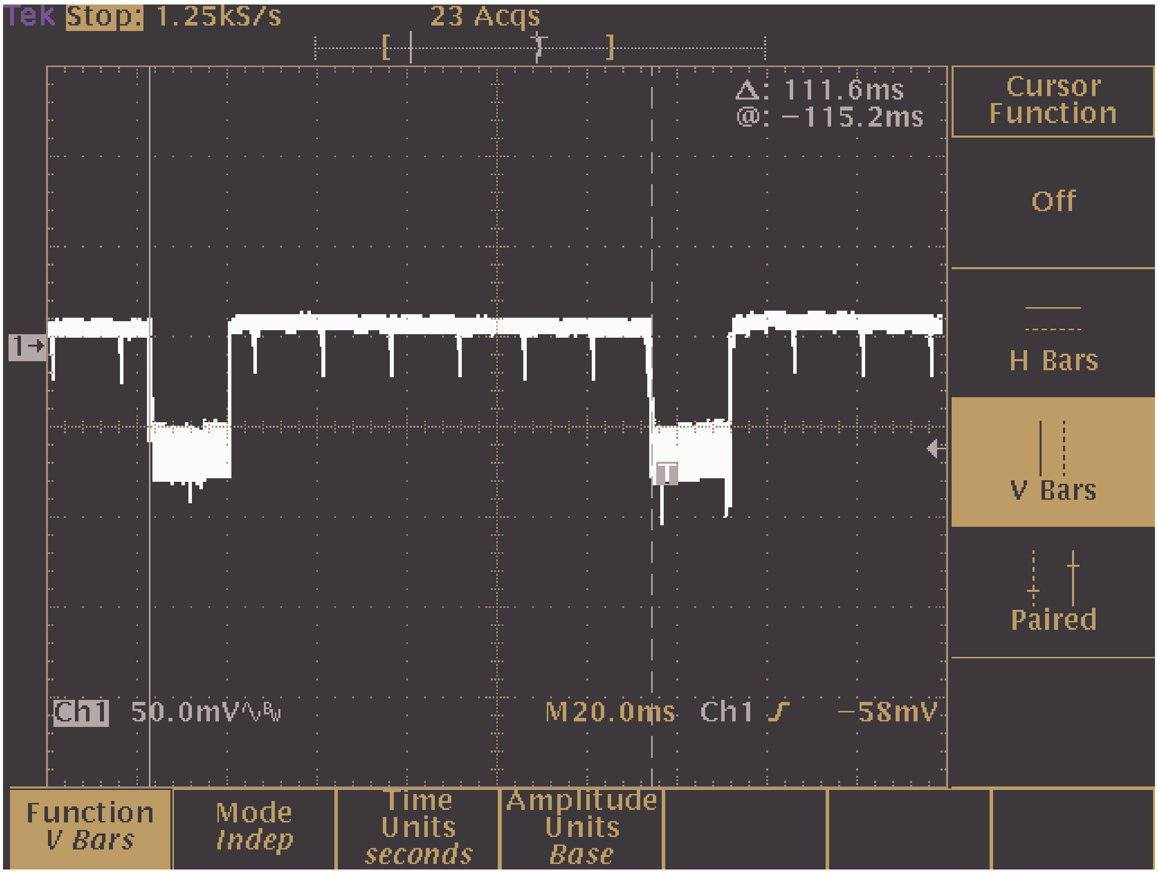

Figure B2
Timebase opened out to show the low frequency square wave component caused by 1553 activity.

Appendix C

Spacecraft Power Bus Transients

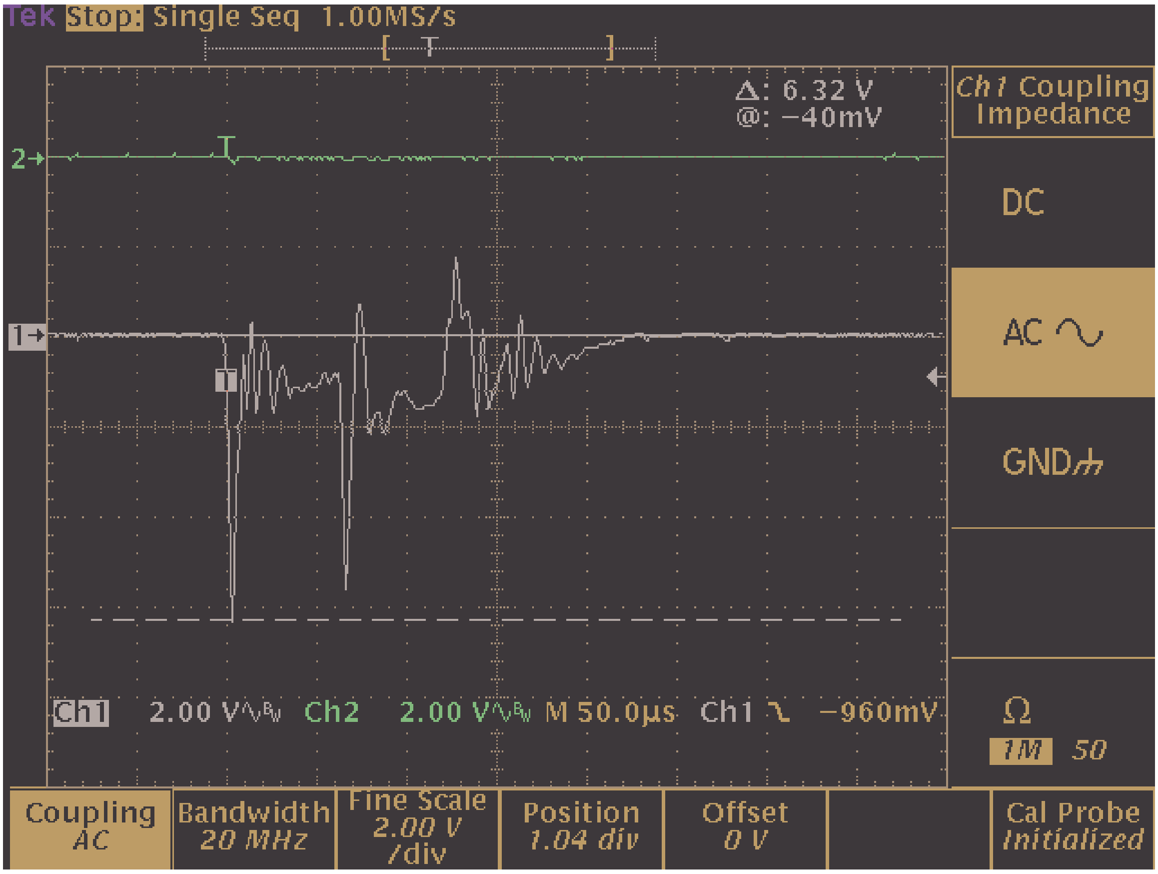

Figure C1
Primary instrument switch on transient.

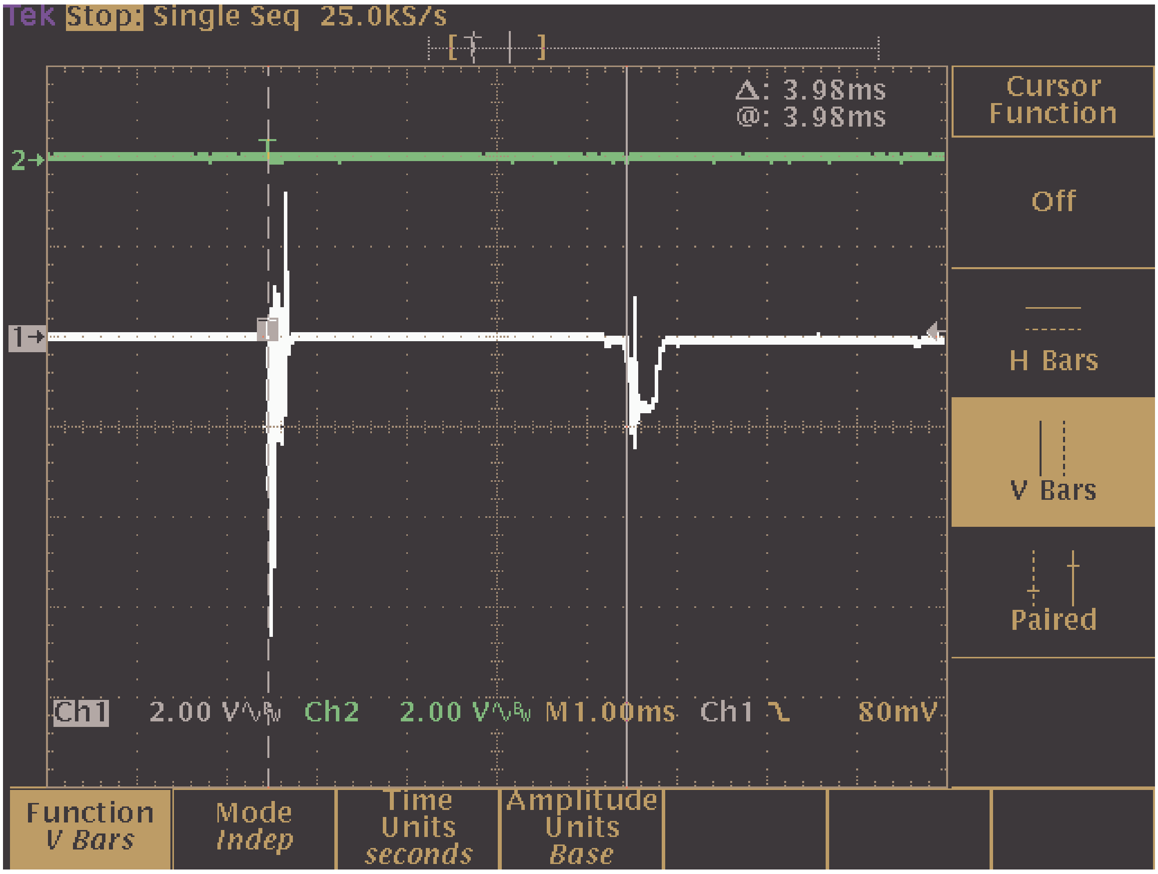

Figure C2
Primary and secondary instrument switch on transient.

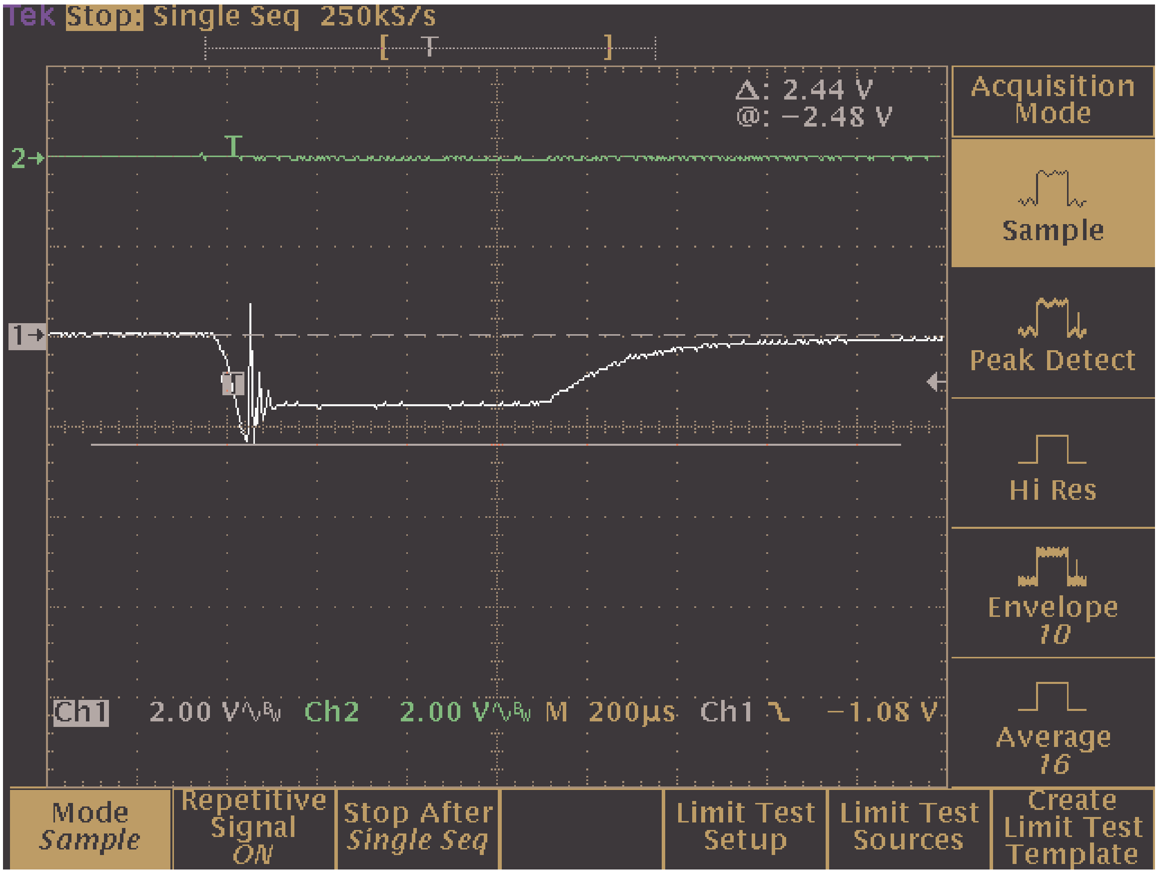

Figure C3
Transient caused by simultaneous switch on of three cameras

Appendix D

Spacecraft Power Bus Inrush Current

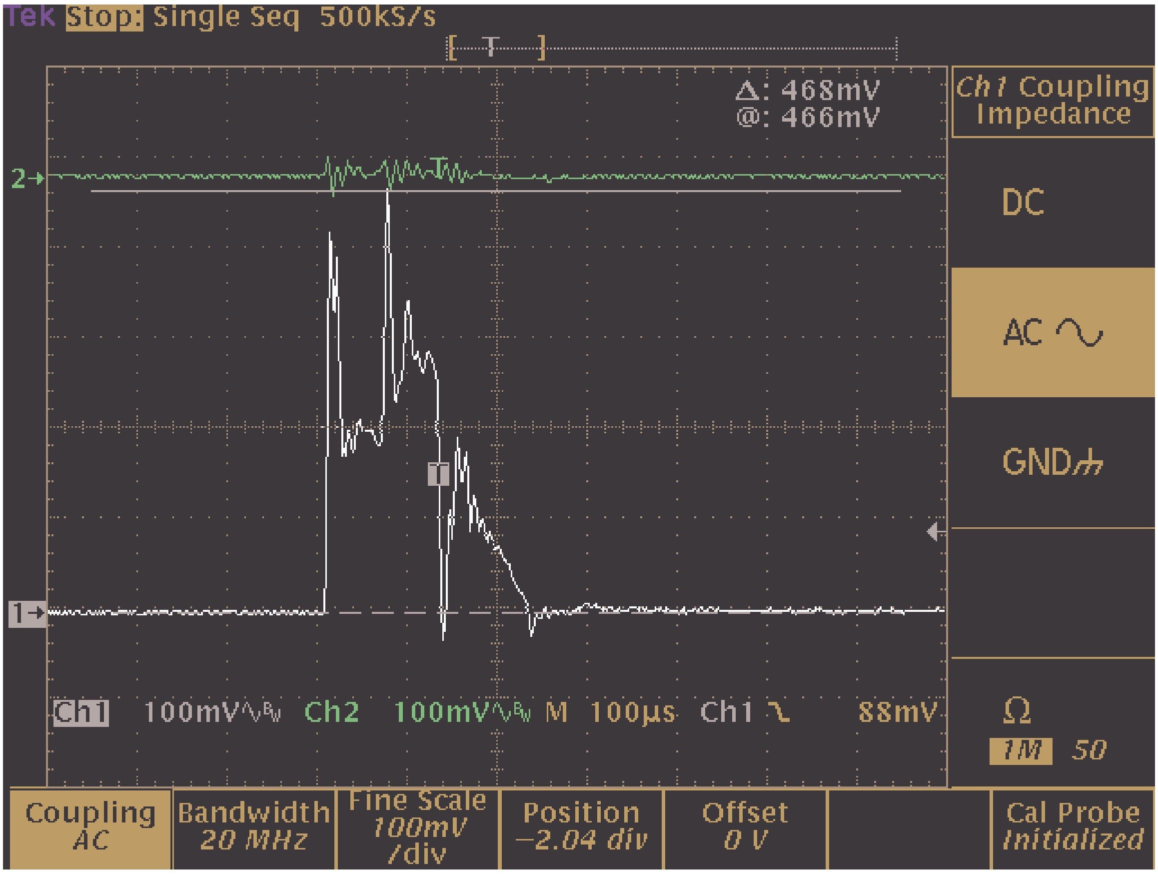

Figure D1
Instrument switch on primary inrush (100mV = 1A)

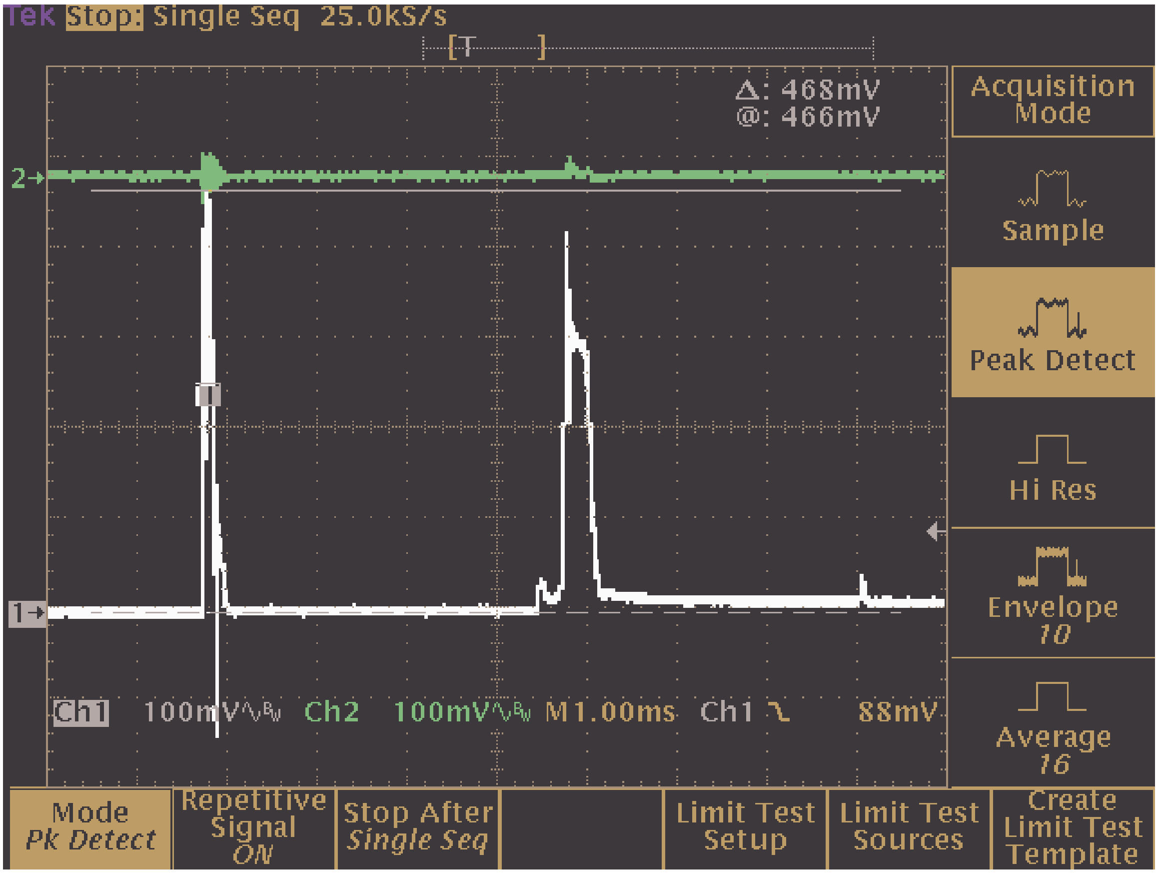

Figure D2
Instrument switch on primary and secondary inrush (100mV = 1A)

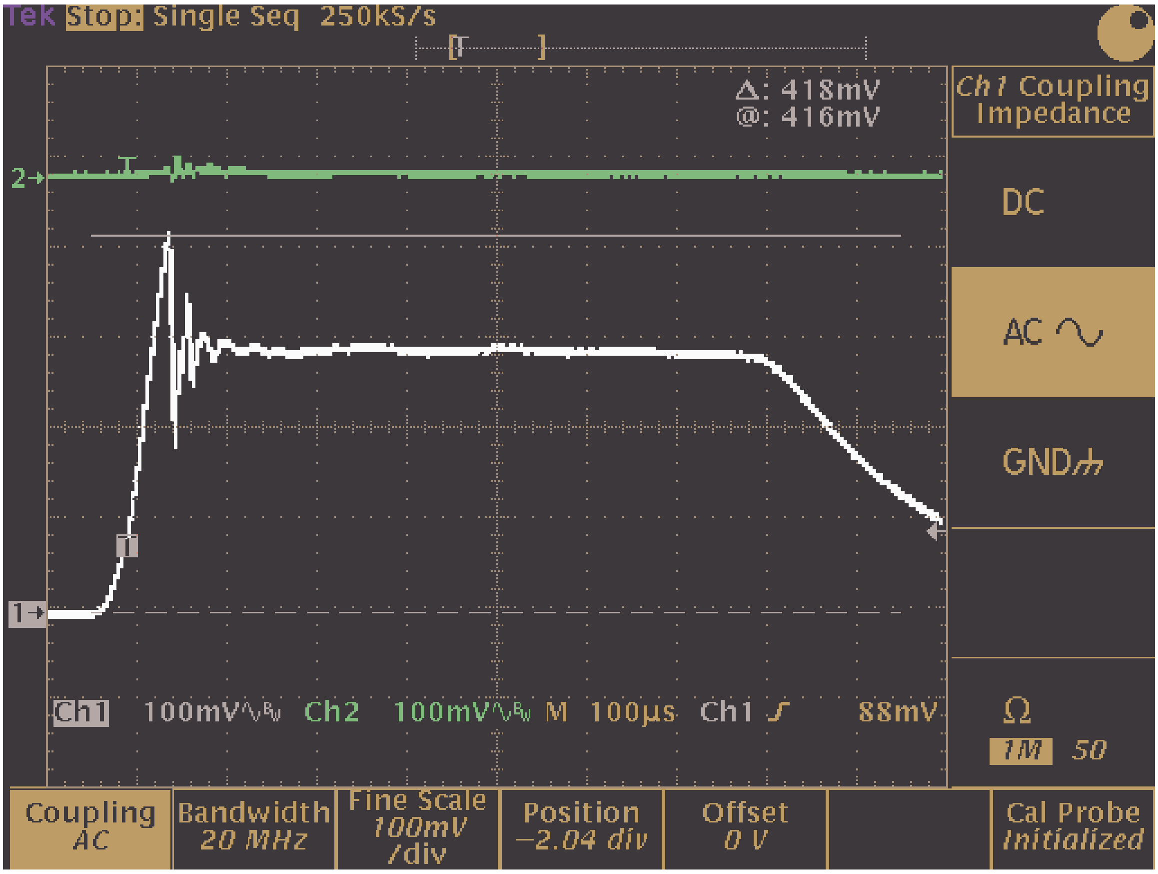

Figure D3
Inrush current caused by simultaneous startup of 3 cameras (100mV = 1A)

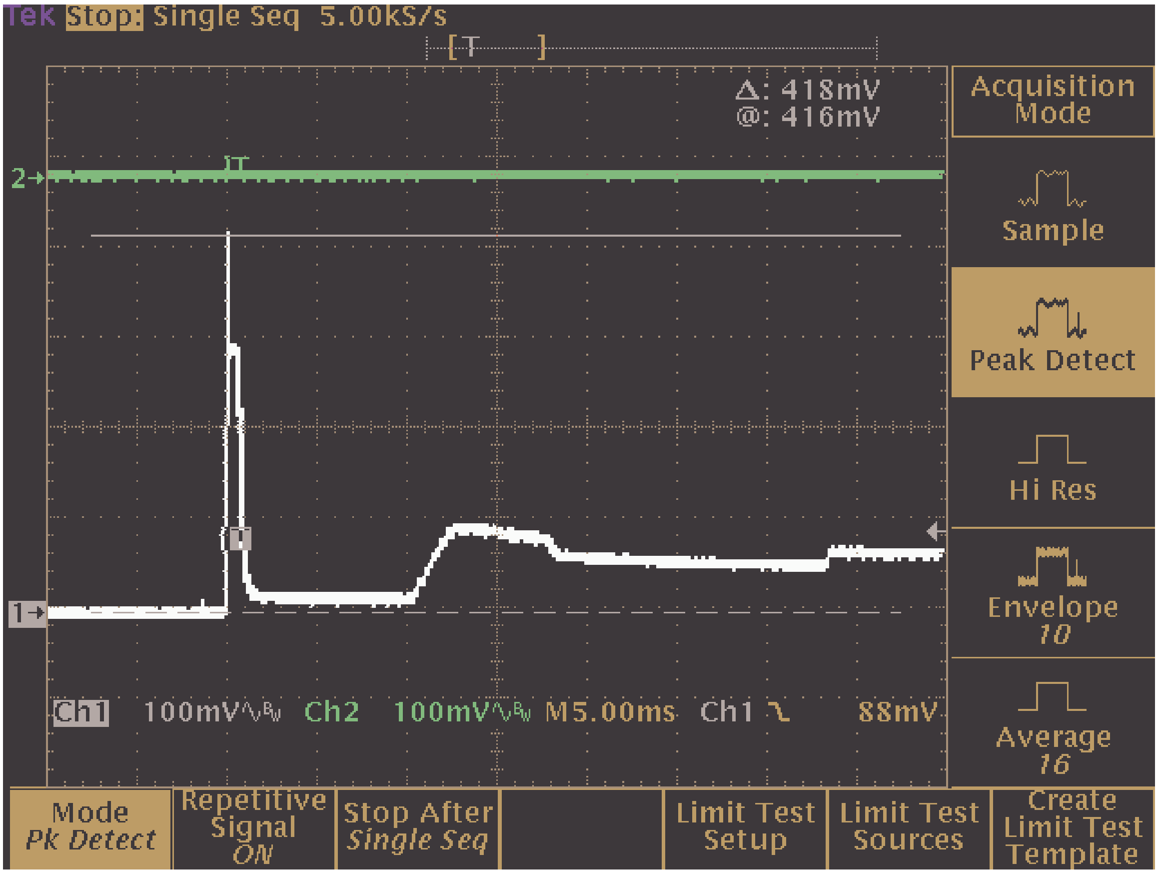

Figure D4
Inrush current caused by simultaneous startup of 3 cameras, also showing startup of camera dc-dc converters approximately 10mS later (100mV = 1A)