



Calibration and Test for Space Instrument II

Environmental Tests

EMC Test

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大綱

- EMC
- 各類標準
- MIL-STD-461F
- Conducted EMC Test
- Radiated EMC Test

EMC

電磁相容性

- 電磁相容性（EMC）源於英文 Electromagnetic Compatibility。定義為設備或系統在其電磁環境中能夠正常工作，且不會對該環境中任何事物構成不能承受的電磁擾動。

目的

- 電磁相容性管理的目的：
 - 1.系統產生的電磁干擾不能太大。
 - 2.系統受到某個程度以下的電磁干擾仍然要正常運作。
- 電磁相容性包含下列兩類：電磁干擾（Emission）與電磁耐受（Immunity）。

$$EMC = EMI + EMS$$

- 電磁耐受 (Electromagnetic Susceptibility, EMS) : 系統本身抵制外界電磁雜訊，免於外界電磁雜訊干擾的能力。
- 電磁干擾 (Electromagnetic Interference, EMI) : 系統本身因動作時產生電磁雜訊，造成其他裝置的運作發生問題。
- 電磁干擾 (EMI) 加上電磁耐受 (EMS) 就是電磁相容性 (EMC) 。

電磁干擾 (EMI)

- 電磁干擾來源分為自然干擾源與人為干擾源。
- 電磁干擾有兩種傳播途徑，一種是透過傳導，另一種是透過空間輻射。
- 導體中變化的電流或電壓會產生電磁波輻射，電流或電壓變化頻率越高，則輻射效率越高。
- 一般電子、電氣設備的切換式電源、CPU、晶體振盪器、印刷電路板上的銅箔或纜線等都是干擾來源。
- 因脈衝電路的大量應用，凡是存在這種電壓或電流突然變化的地方，都要考慮電磁干擾問題。

構成電磁干擾的要素

- 電磁干擾源 (Source) : 指產生電磁干擾的任何系統或自然現象。
- 耦合途徑 (Path) : 指將電磁干擾能量傳輸到受干擾設備的通路或媒介。
- 受干擾設備 (Victim) : 指受到電磁干擾發生影響的設備。

電磁干擾的測試項目

- 輻射干擾 (Radiated Emission, RE)
- 傳導干擾 (Conducted Emission, CE)
- 諧波電流 (Harmonics)
- 電壓變動及閃爍 (Voltage Fluctuation and Flicker)

電磁耐受的測試項目

- 靜電 (Electrostatic Discharge, ESD)
- 輻射耐受 (Radiated Susceptibility, RS)
- 快速脈衝 (Electrical Fast Transient, EFT)
- 雷擊 (Surge)
- 傳導耐受 (Conducted Susceptibility, CS)
- 電源頻率磁場 (Power Frequency Magnetic Field, PFMF)
- 電壓瞬降及中斷耐受 (Voltage Dip and Short Interruption)

電磁相容試驗場地

- 兩個基本要求：
 1. 場地內不能有電磁波反射物，這會造成量測誤差。
 2. 場地內不能有其他電磁干擾，較好的環境是無反射遮罩室。

各類標準

各國標準

國家或組織	制定單位	標準編號
IEC (國際電工委員會)	CISPR (國際無線電干擾特別委員會)	CISPR
	TC77 (第77技術委員會)	IEC
European Community (歐洲共同體)	CENELEC (歐洲電工標準化委員會)	EN
美國	FCC (聯邦通信委員會)	FCC Part
日本	VCCI (干擾自願控制委員會)	VCCI
中國	質量技術監督局	GB, GJB
台灣	BSMI (標準檢驗局)	CNS

標準分類

標準	範例文件	敘述
基礎標準	IEC 61000-3-2	IEC基礎標準
通用標準	EN 61000-6-1	商業、住宅環境使用產品之EMS測試
	EN 61000-6-2	工業環境使用產品之EMS測試
	EN 61000-6-3	商業、住宅環境使用產品之EMI測試
	EN 61000-6-4	工業環境使用產品之EMI測試
產品類標準	EN 55014-1	電器類產品及系統之EMI測試
	EN 55014-2	電器類產品及系統之EMS測試
	EN 55022	資訊類產品之EMI測試
	EN 55024	資訊類產品之EMS測試
	EN 55025	車輛及零組件之EMI測試
專用產品標準	EN 50130-4	保全、報警系統之EMS測試
	EN 62040-2	不斷電系統之EMC測試

IEC 基礎標準

IEC Standard	Type	EMC Certificate Item
CISPR 22	EMI	Radiated Emission (30MHz~1GHz)
		Radiated Emission (1GHz~6GHz)
Conduction Emission		
Harmonic		
Voltage Fluctuation and Flicker		
IEC 61000-3-2		EMS
IEC 61000-3-3	Radiated Susceptibility	
IEC 61000-4-2	EFT	
IEC 61000-4-3	Surge	
IEC 61000-4-4	Conducted Susceptibility	
IEC 61000-4-5	Power Frequency Magnetic Field	
IEC 61000-4-6	Voltage Dip/Short Interruption	
IEC 61000-4-8		
IEC 61000-4-11		

EN 基礎標準

EN Standard	Type	EMC Certificate Item
EN 55022	EMI	Radiated Emission (30MHz~1GHz)
		Radiated Emission (1GHz~6GHz)
EN 55022		Conduction Emission
EN 61000-3-2		Harmonic
EN 61000-3-3		Voltage Fluctuation and Flicker
EN 61000-4-2	EMS	ESD
EN 61000-4-3		Radiated Susceptibility
EN 61000-4-4		EFT
EN 61000-4-5		Surge
EN 61000-4-6		Conducted Susceptibility
EN 61000-4-8		Power Frequency Magnetic Field
EN 61000-4-11		Voltage Dip/Short Interruption

產品類標準

CISPR	FCC	EN	說明
CISPR11	Part 18	EN 55011	工業、科學及醫療設備
CISPR13	Part 15	EN 55013	電視、收音機及附屬設備
CISPR14-1		EN 55014	家用電器及工具
CISPR15		EN 55015	電子式照明
CISPR22		EN 55022	資訊產品
CISPR25	Part 15	EN 55025	車輛及零組件

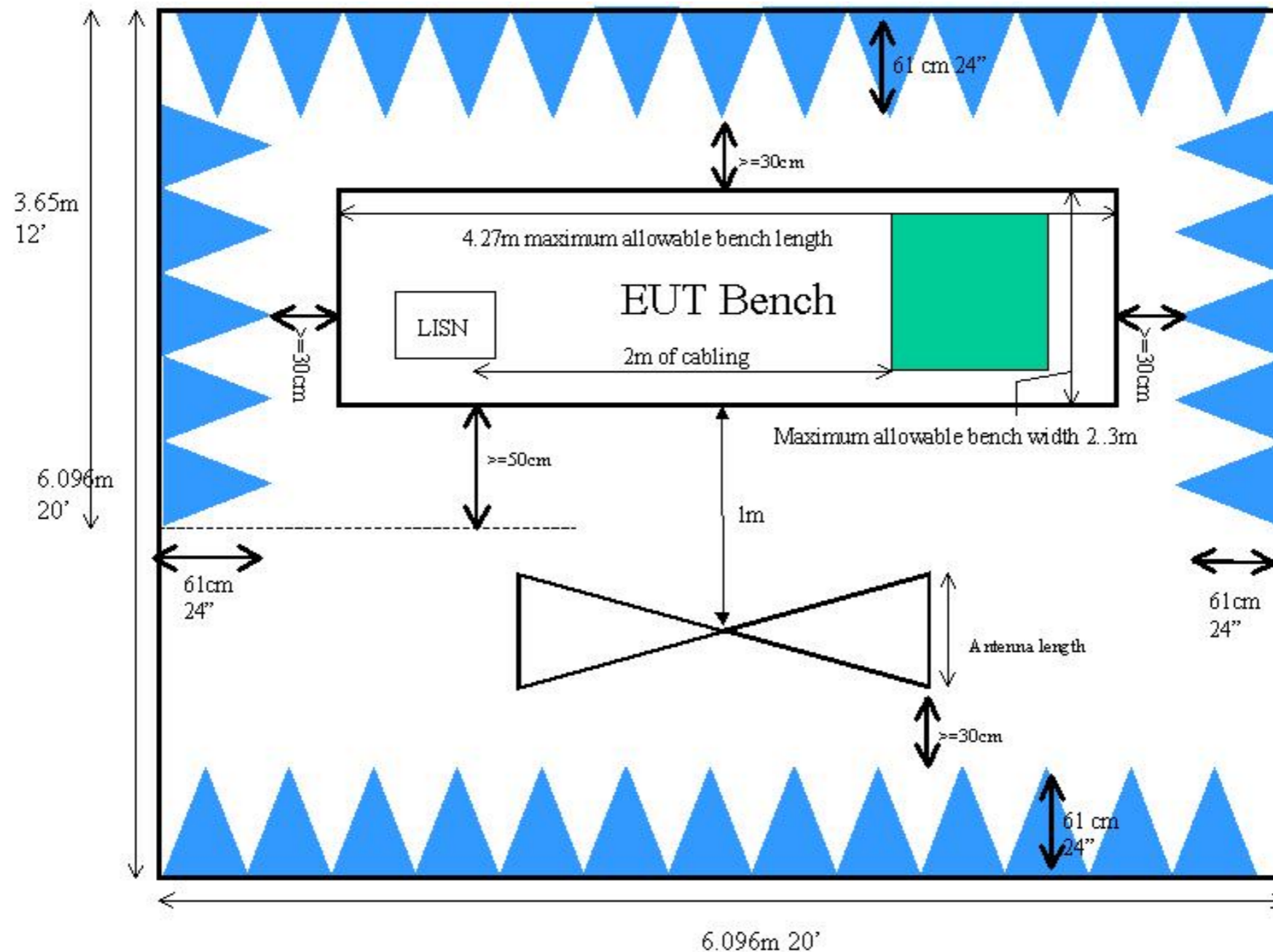
MIL-STD-461F

EMI	CE	CE-101	電源線，30Hz~10KHz
		CE-102	電源線，10KHz~10MHz
		CE-106	天線端，10KHz~40GHz
	RE	RE-101	30Hz~100KHz，磁場
		RE-102	10KHz~18GHz，電場
		RE-103	10KHz~40GHz，諧波
EMS	CS	CS-101	電源線，30Hz~150KHz
		CS-103	天線端，15KHz~10GHz，交互調變
		CS-104	天線端，30Hz~20GHz，消除不要訊號
		CS-105	天線端，60Hz~100KHz，交叉調變
		CS-109	60Hz~100KHz，結構電流
		CS-114	BCI，10KHz~200MHz
		CS-115	BCI，脈衝激發
		CS-116	電源線，10K~100M，阻尼式弦狀波暫態
	RS	RS-101	30Hz~100KHz，磁場
		RS-103	2MHz~18GHz電場
		RS-105	暫態電磁場

BCI : Bulk Cable Injection

Mil Std Chamber Side View

- Mil Std 461 Defines the size of the chamber in terms of the EUT being measured, EUT size determines the size of the chamber. The sketches below show the standard MIL-STD chamber offered by ETS-Lindgren.



EUT : Equipment under test

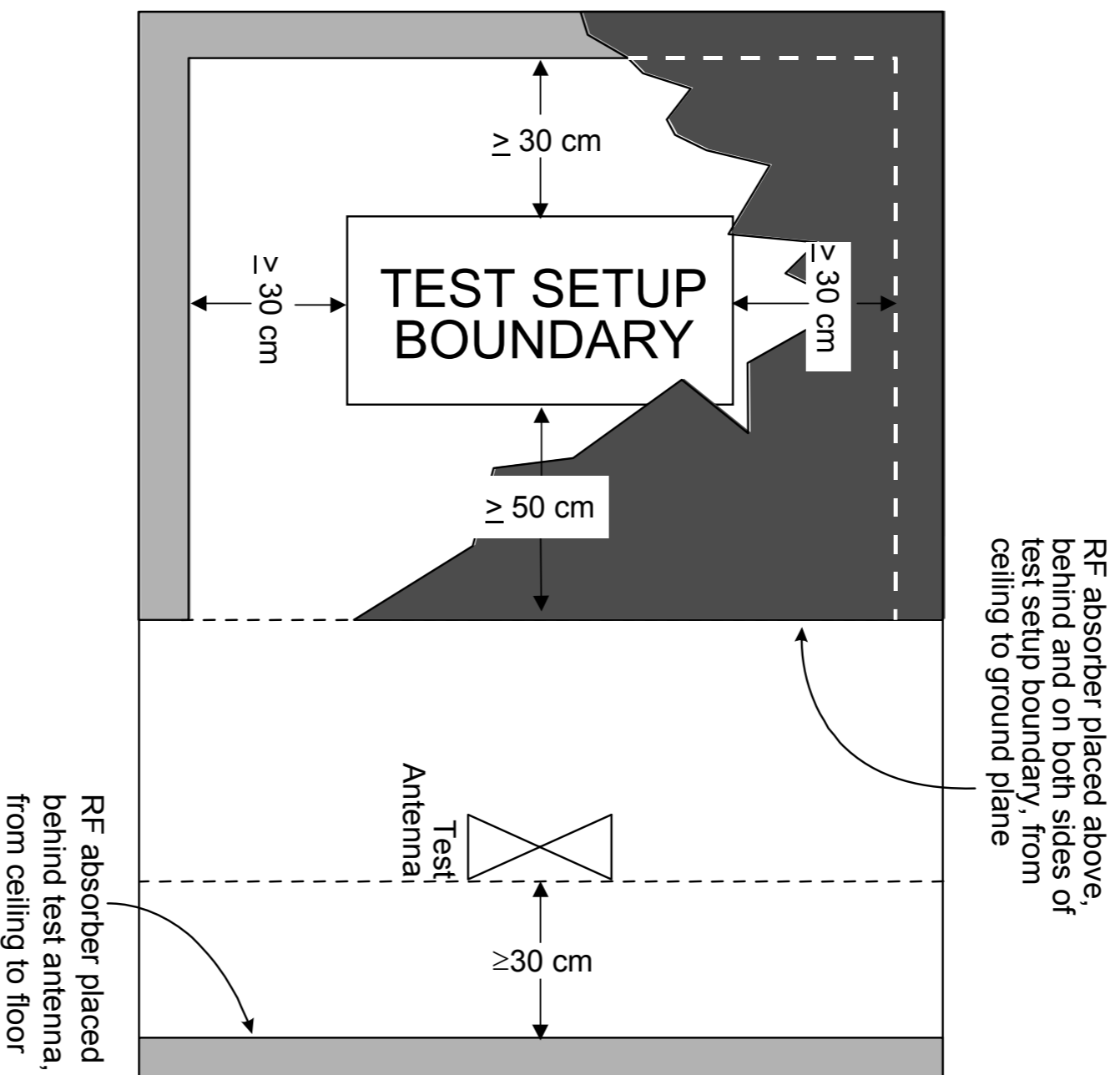


FIGURE 1. RF absorber loading diagram.

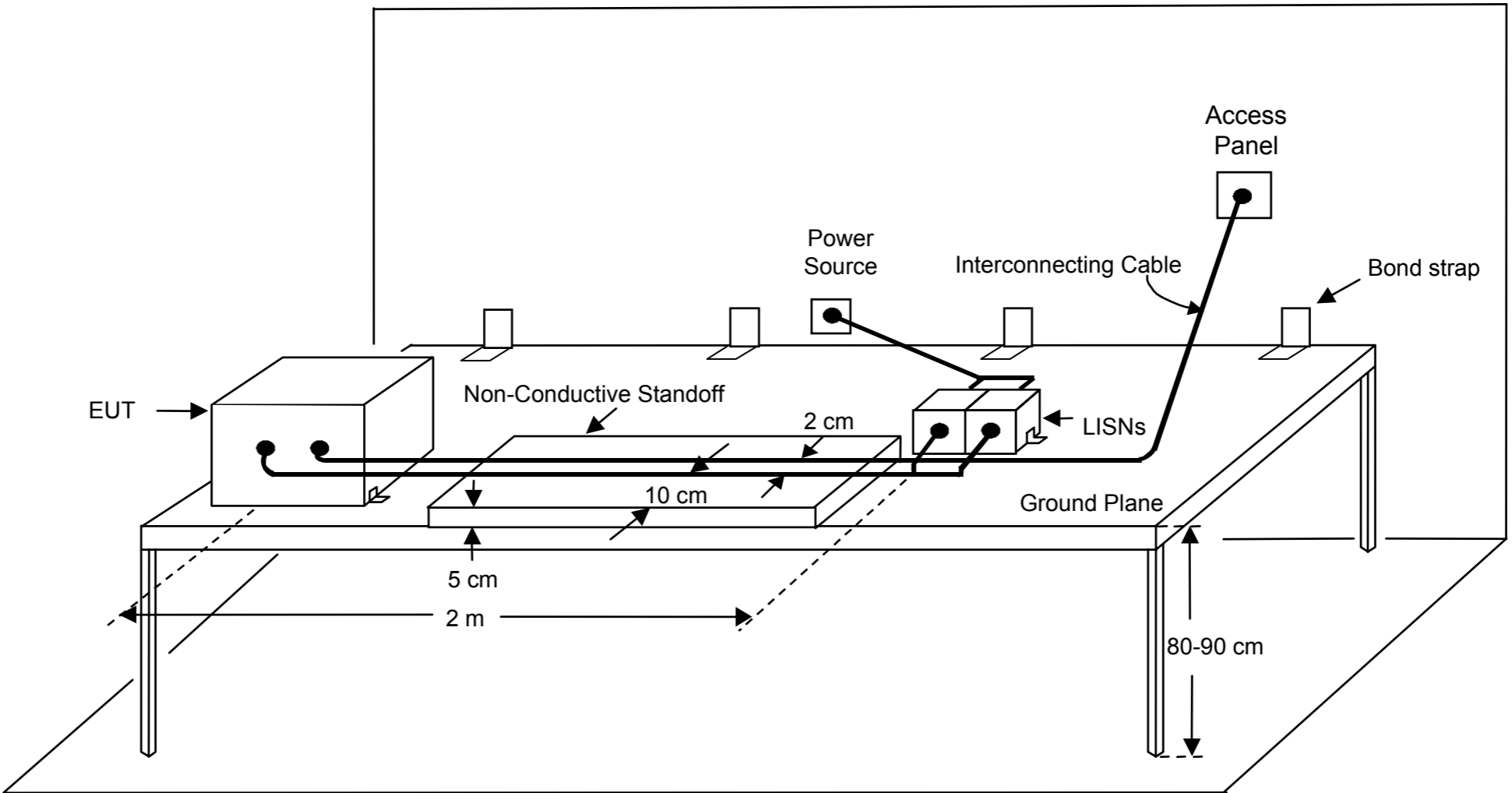


FIGURE 2. General test setup.

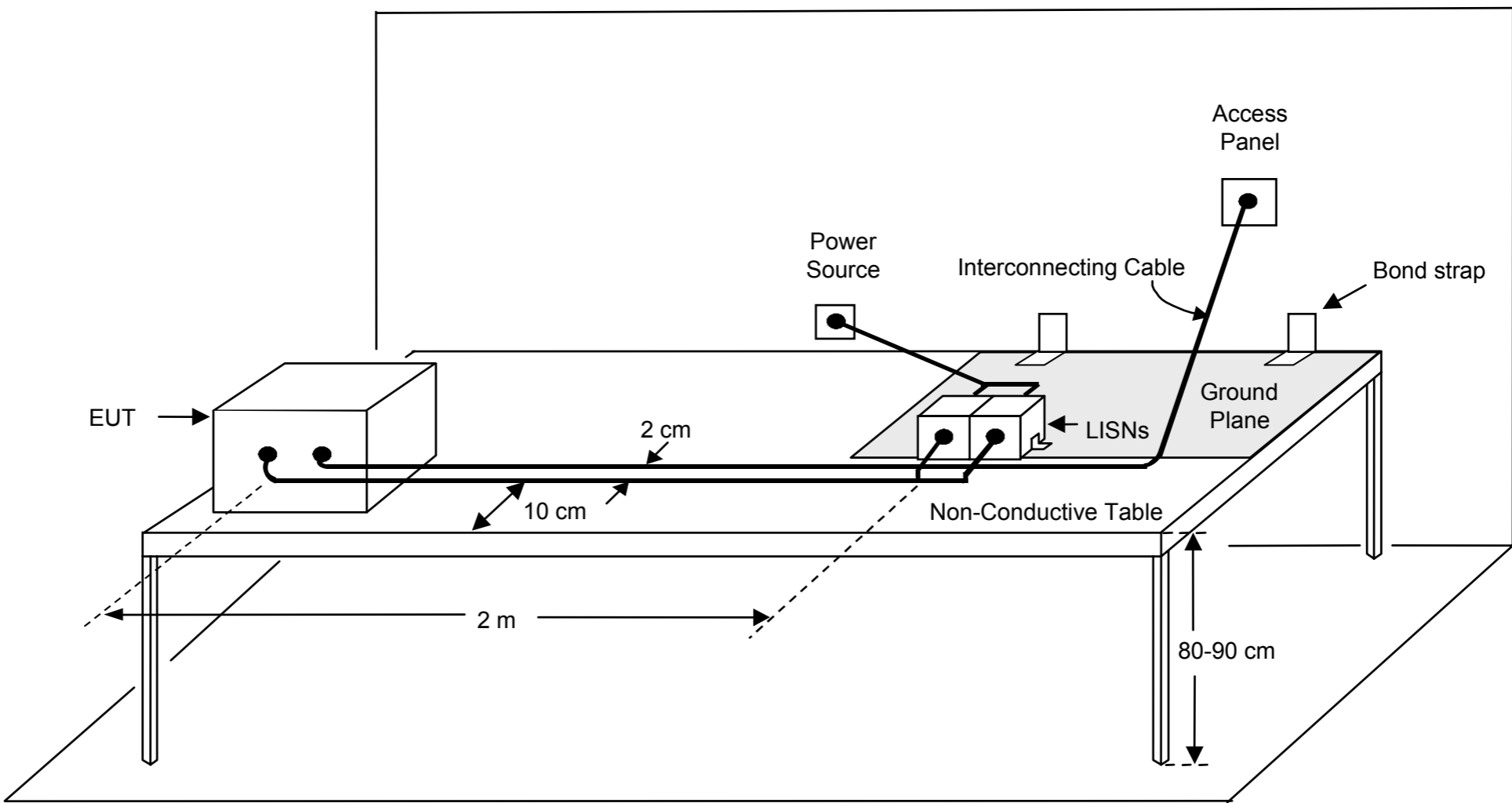


FIGURE 3. Test setup for non-conductive surface mounted EUT.

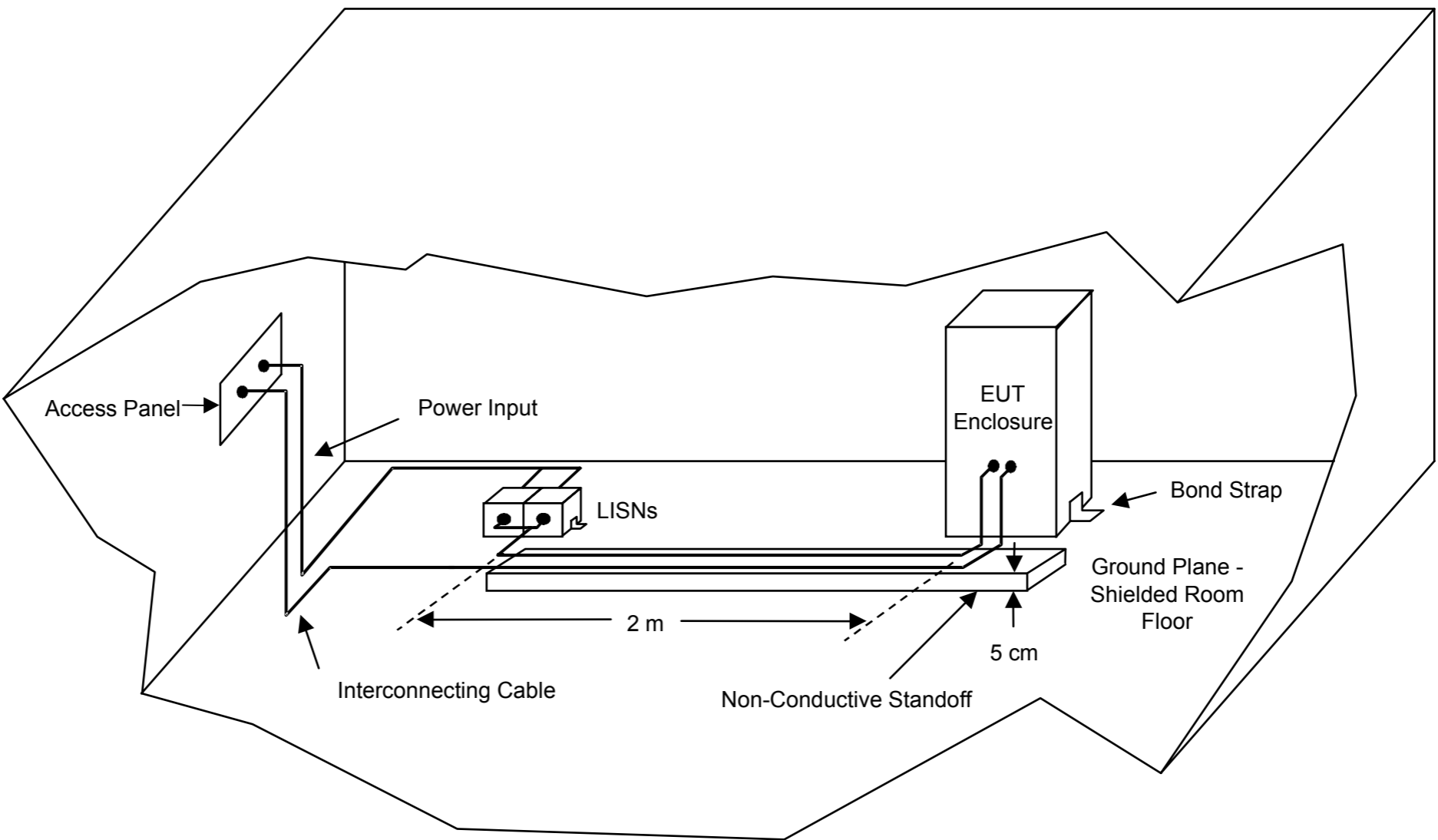


FIGURE 4. Test setup for free standing EUT in shielded enclosure.

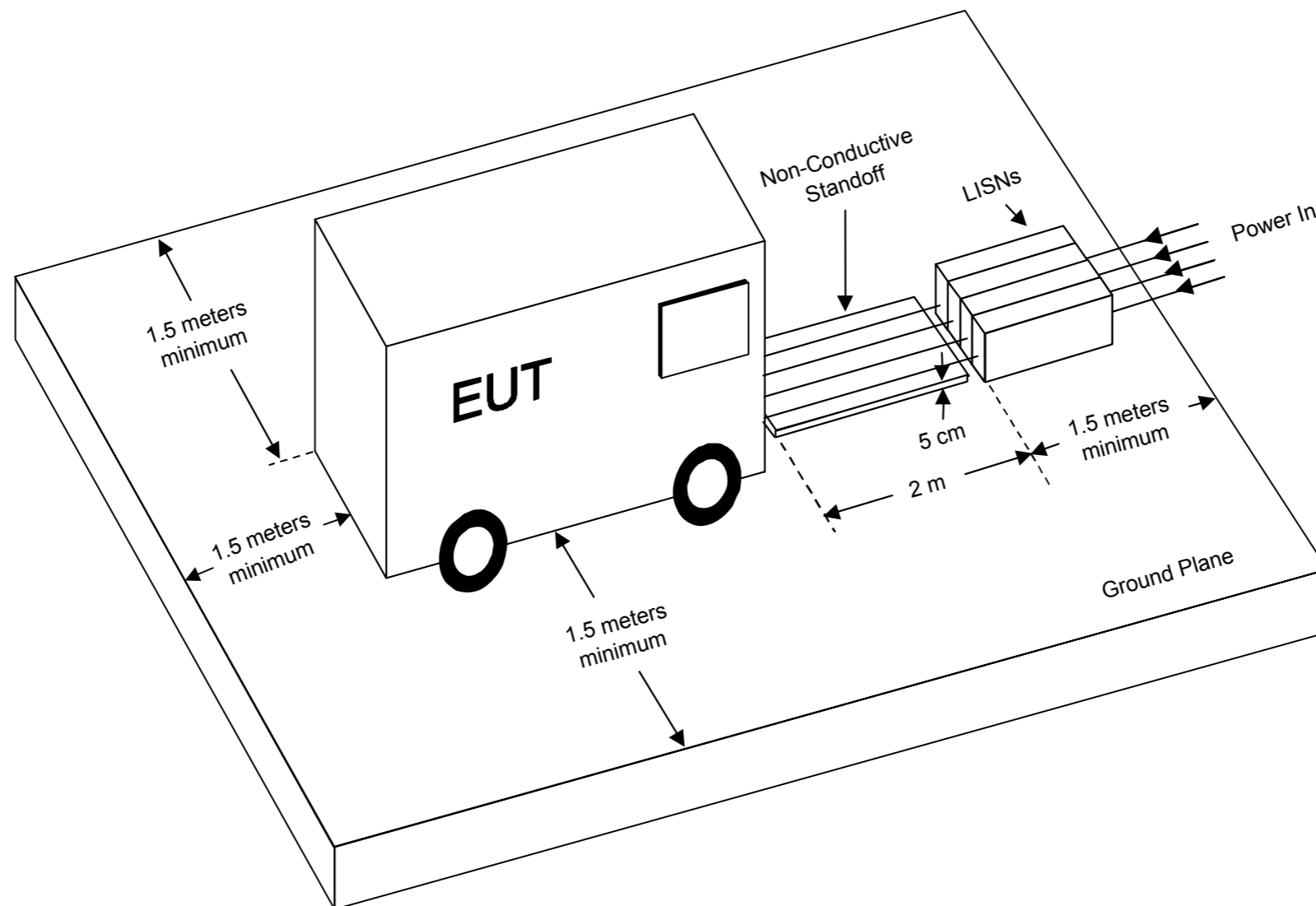


FIGURE 5. Test setup for free standing EUT.

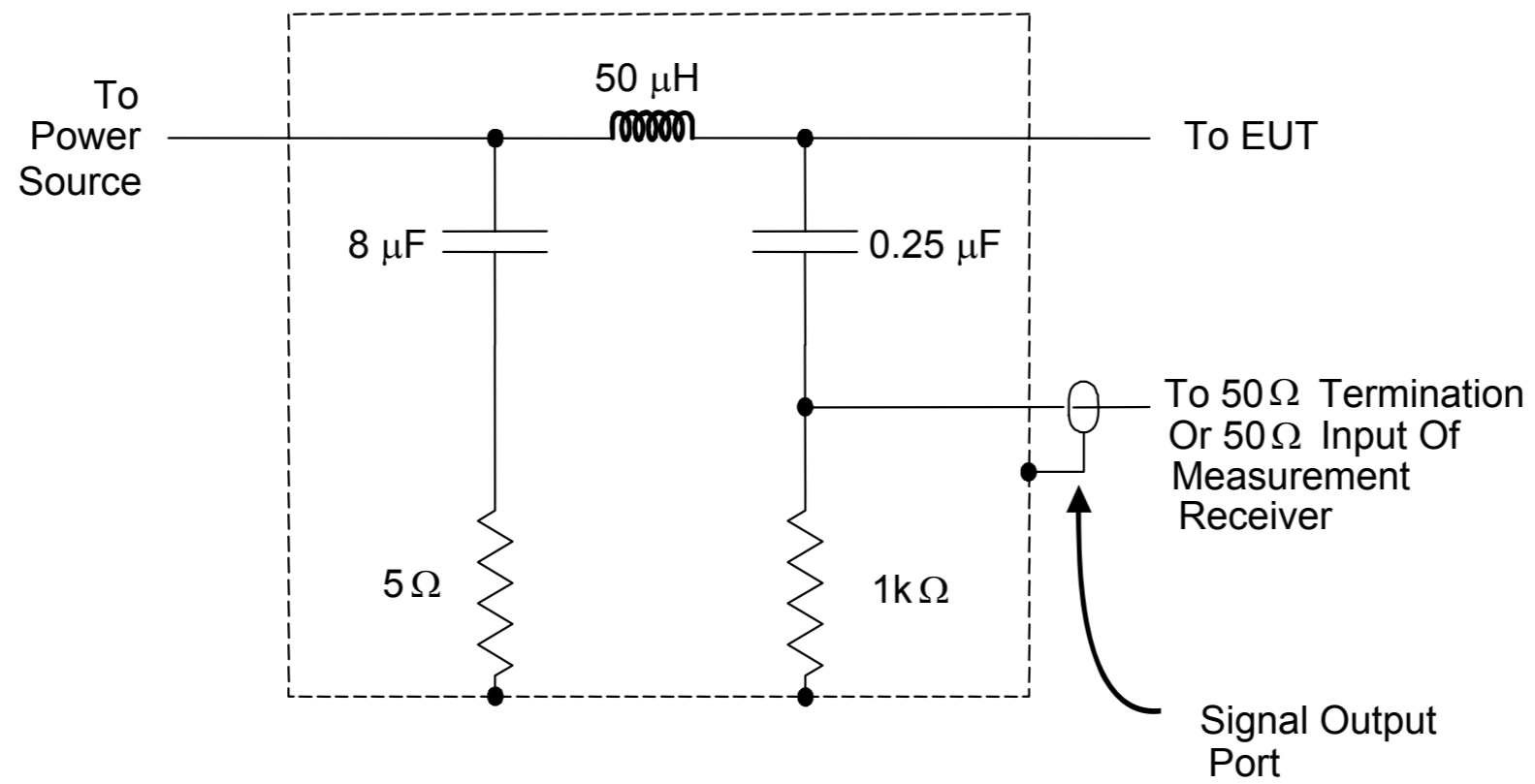


FIGURE 6. LISN schematic.

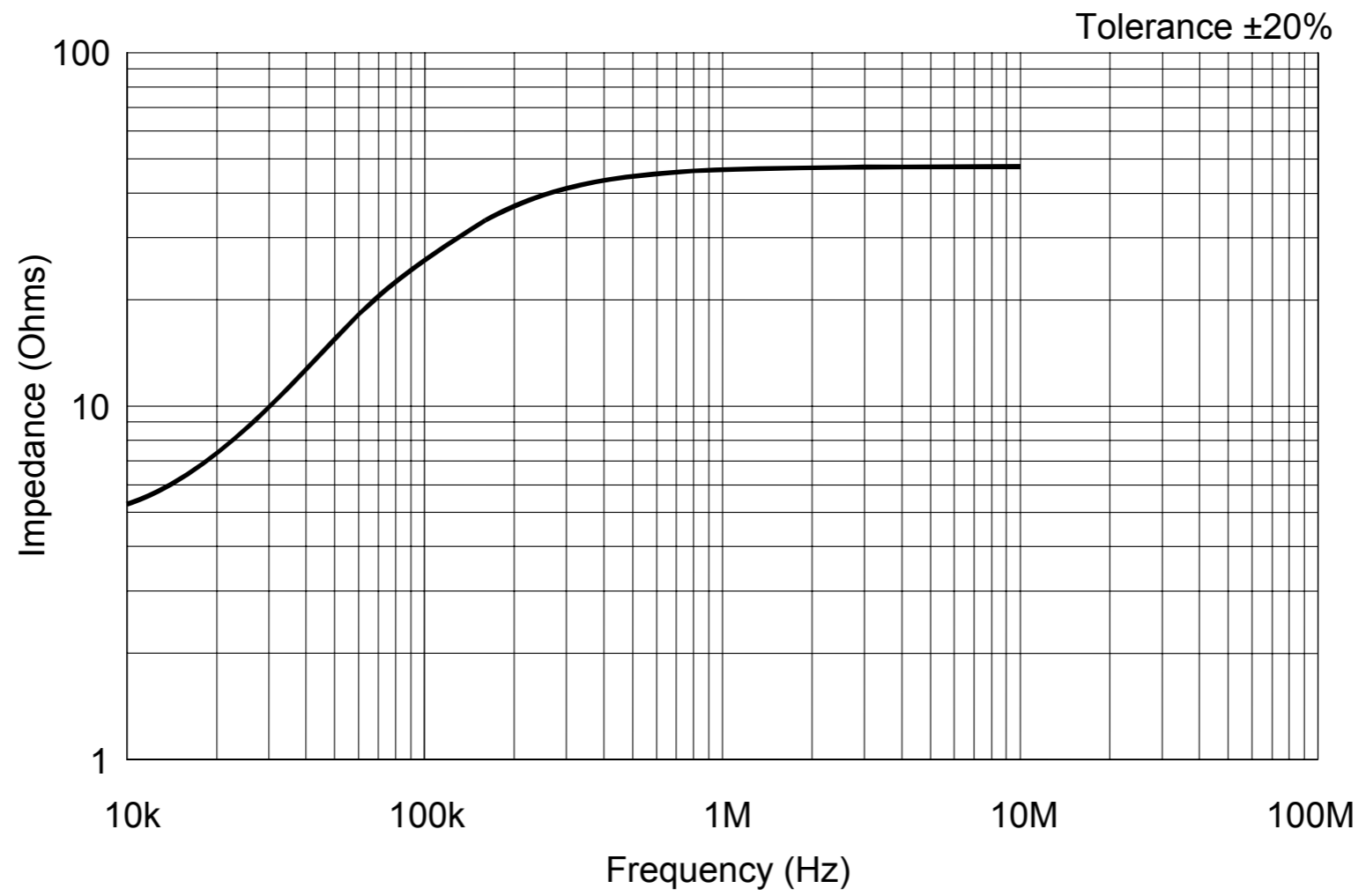


FIGURE 7. LISN impedance.

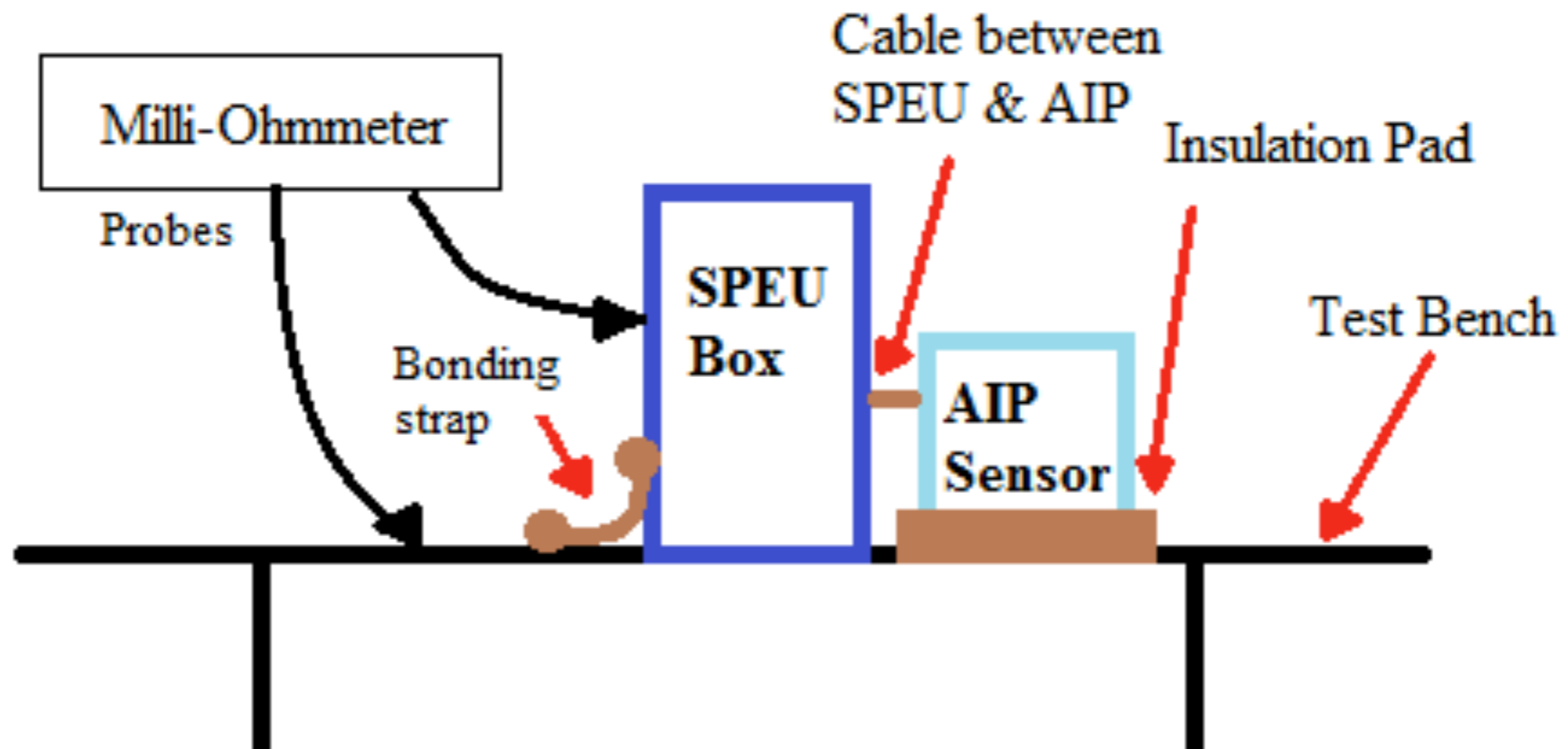
Conducted EMC Test

Conducted EMC Test

- Bonding Test
- Grounding Test
- Isolation Test
- CE on Transient Voltage and In-Rush Current-Time Domain
- CE on Primary Power Lines-Frequency Domain
- CE on Signal Lines-Time Domain
- CS on Primary Lines-Sine wave Injection
- CS on Primary Power Lines-Spike Injection

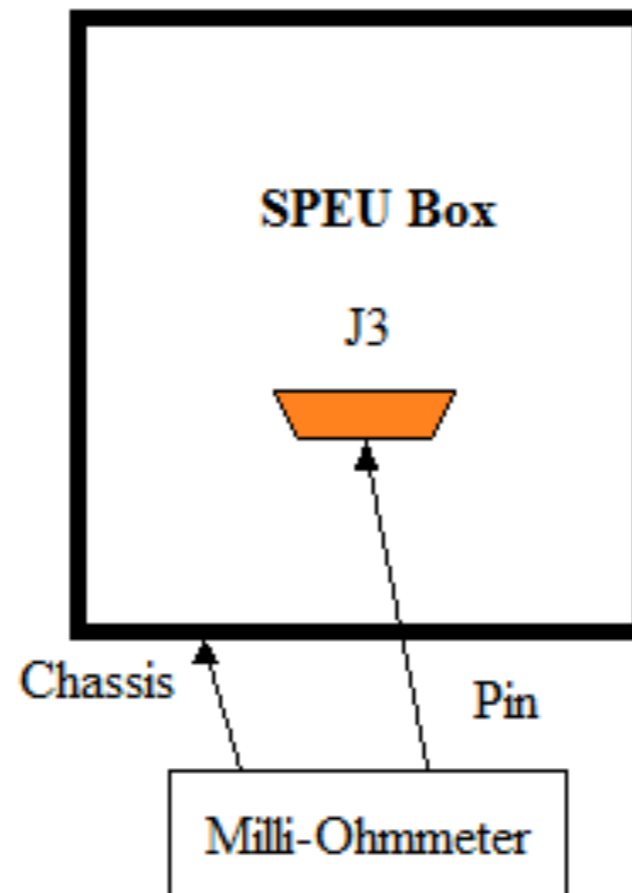
Bonding Test

Step	Action
1	如圖所示，將AIP放置在測試平台上，用Bonding strap將SPEU機構地與測試平台連接好。
2	用電錶量測SPEU機構底盤和測試平台的阻抗，應小於100m歐姆。



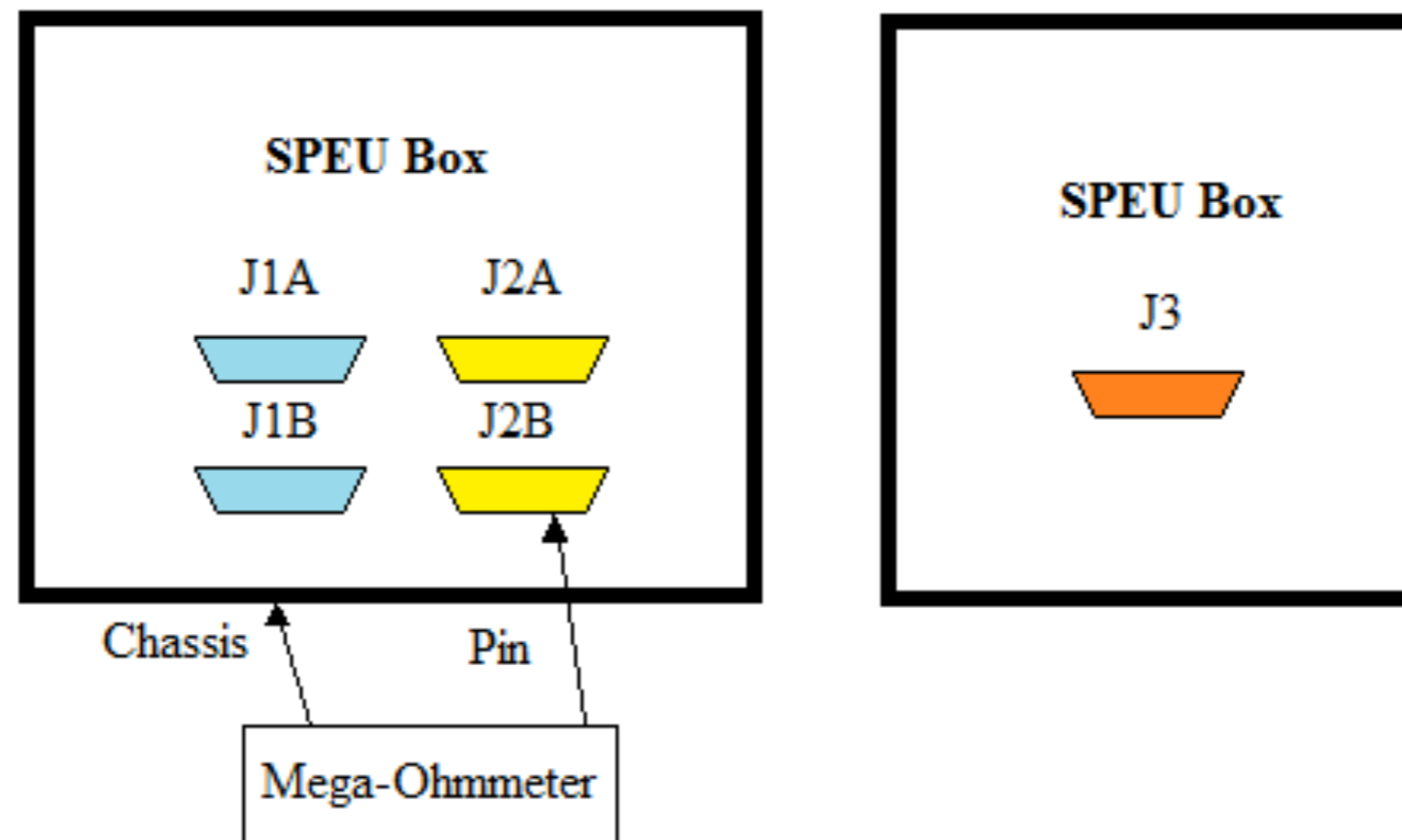
Grounding Test

Step	Action
1	如圖所示，將Saver與J3連接好。
2	用電錶量測SPEU機構底盤和Second地（J3接頭Pin 4與Pin 19）之阻抗，應小於等於100m歐姆。



Isolation Test

Step	Action
1	如圖所示，將Saver與J1A、J1B、J2A、J2B與J3連接好。
2	用電錶量測SPEU機構底盤和主電源+28V（J1A接頭Pin 2）之阻抗，應大於1M歐姆。

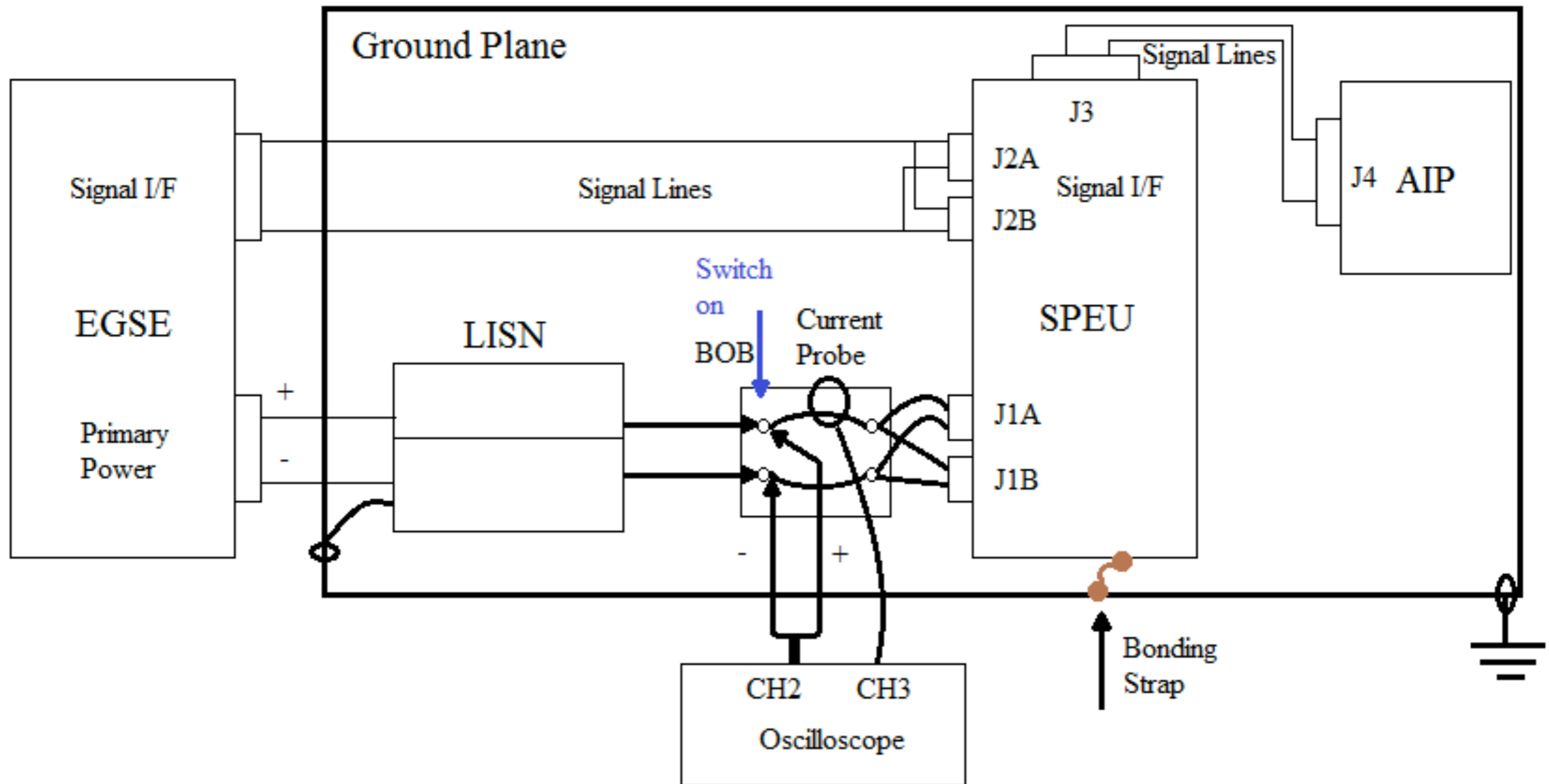


待測接頭	Type	Pin	阻抗
J1A	+28V	2	With SPEU Chassis : 大於1M歐姆
			With Secondary Power+ 15V : 大於1M歐姆
J1B	+28V	2	With SPEU Chassis : 大於1M歐姆
			With Secondary Power+ 15V : 大於1M歐姆
J1A	Power Ground	4	With SPEU Chassis : 大於1M歐姆
			With Secondary Power+ 15V : 大於1M歐姆
J1B	Power Ground	4	With SPEU Chassis : 大於1M歐姆
			With Secondary Power+ 15V : 大於1M歐姆

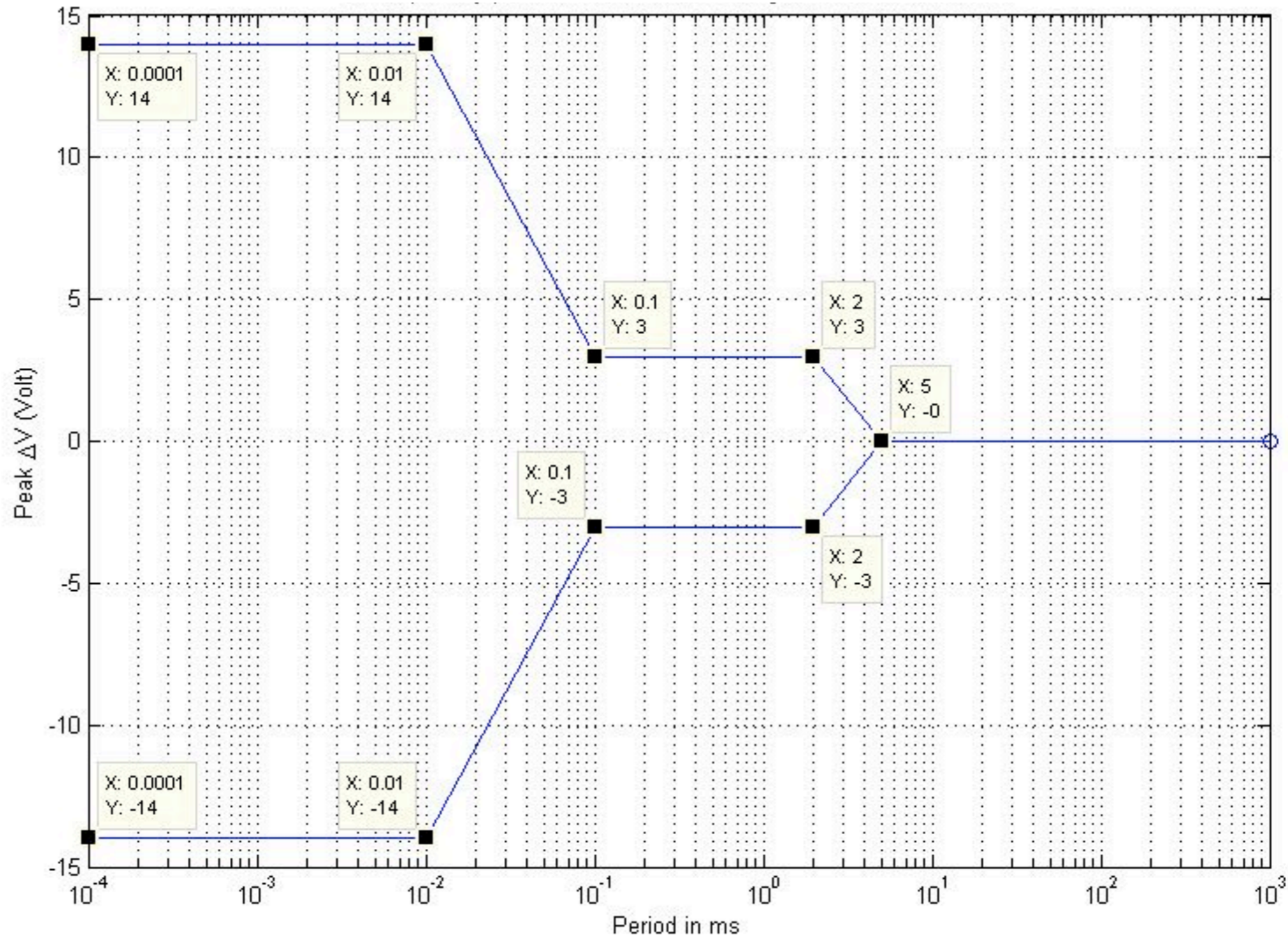
Secondary Power+ 15V : J3 Pin3

CE on Transient Voltage and In-Rush Current-Time Domain

設置



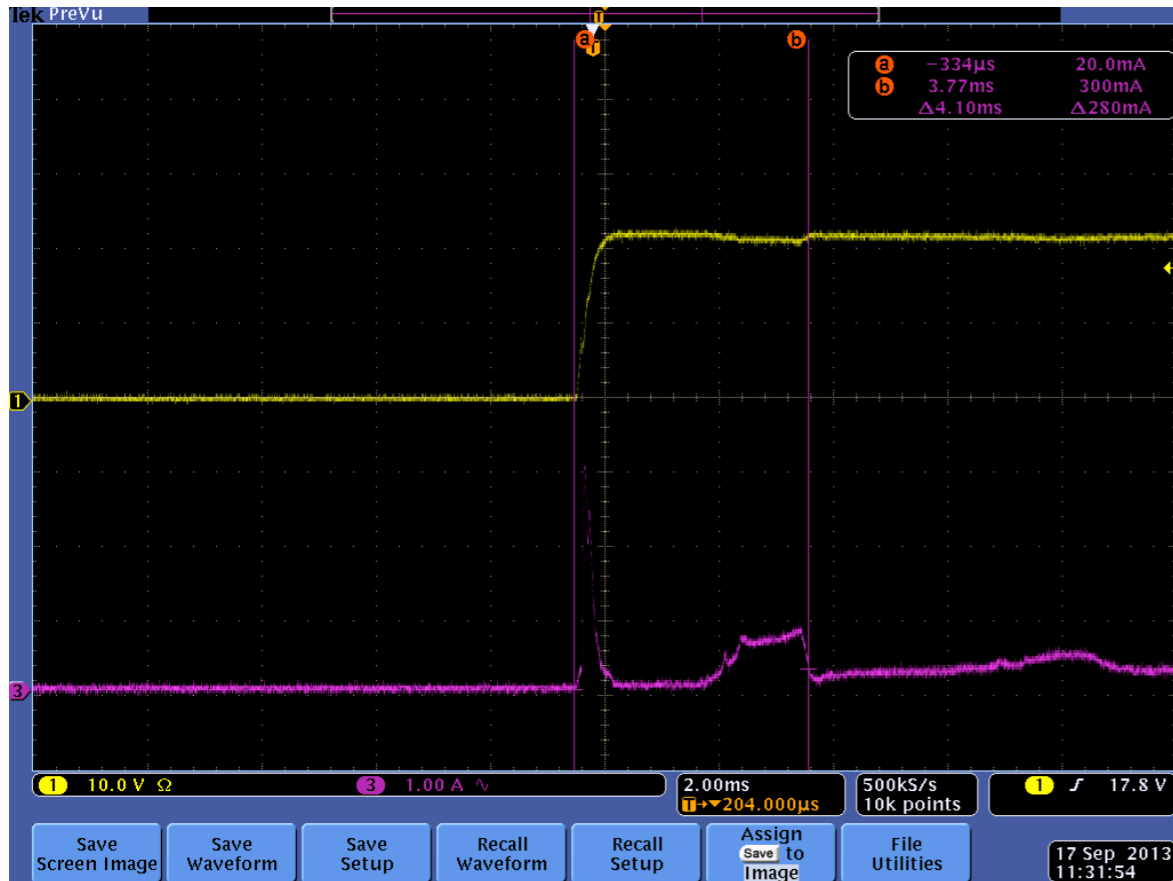
Transient Voltage



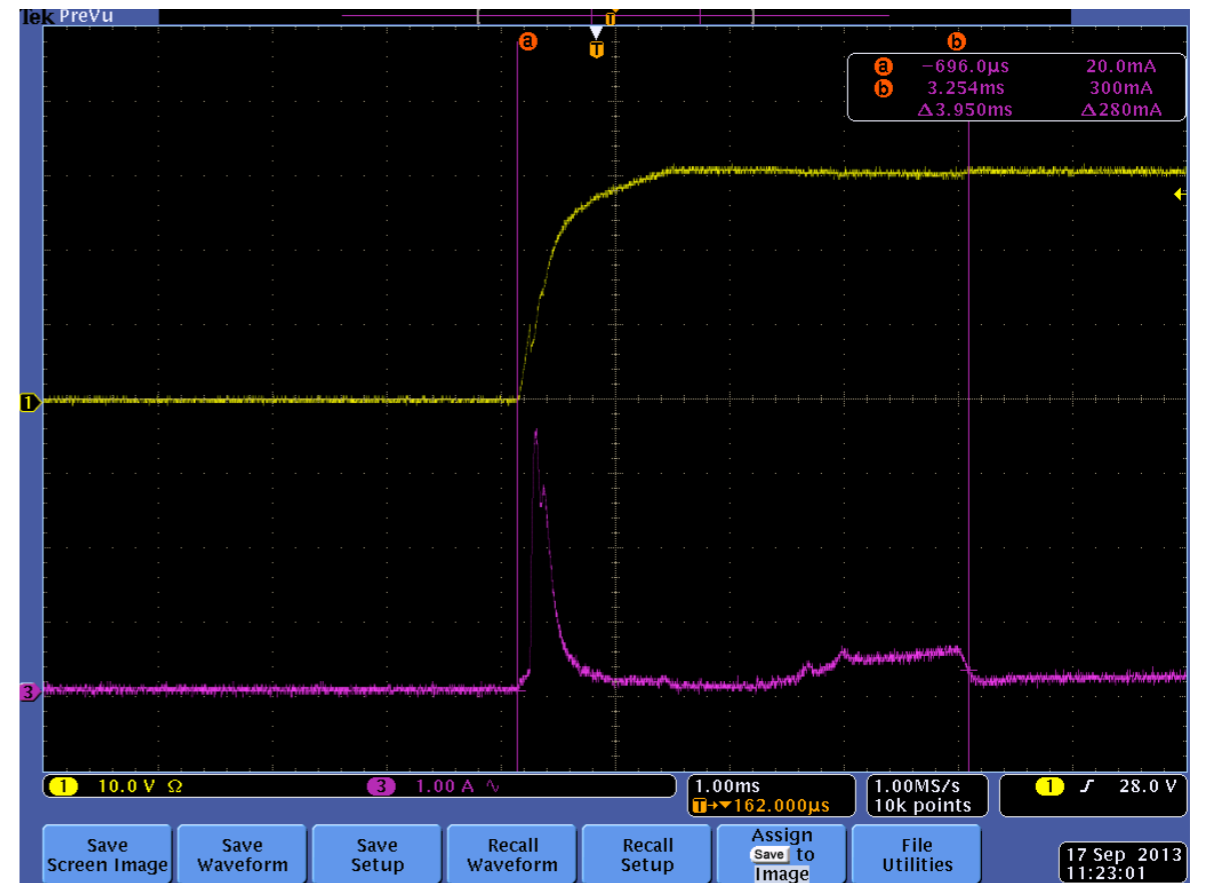
Step	Action
1	確認AIP測試的設置與接線。請參考FS5SPL-CT-PROC的3.4.3.1節。
2	確認EMC設備已上電。設置示波器的Trigger Coupling : DC Couple。Trigger Mode : Edge。Trigger Sweep : Trig'd。Horizontal : 200us/div。
3	將設備如圖所示擺設好，只連接J1A（J1B不連接）。並將正極電源線（紅線）插座開關打開，負極電源線（黑線）插座開關關閉。
4	確認AIP的電源為31V，接著上電。
5	將正極電源線BOB開關關閉，讓31VDC電源施加到AIP上。
6	在EGSE方面，確認CDMU模擬器顯示頁面。
7	在EGSE方面，確認功能測試程序。請參考FS5SPL-CT-PROC的3.4.3.2節。
8	在EGSE方面，監控指令與遙傳介面、科學資料是否異常。
9	確認上電後電流與電壓在5ms內回到穩定值。
10	將示波器上電流與電壓圖存下來。檔名為FS5_AIP_31V_A。
11	確認AIP功能不會因電源開關的運作而影響其功能。
12	將正極電源線BOB開關打開。

待測接頭	施加電壓	檔名
J1A	31VDC	FS5_AIP_31V_A
	34VDC , OVP : 36.1VDC	FS5_AIP_34V_A
	22VDC	FS5_AIP_22V_A
J1B	31VDC	FS5_AIP_31V_B
	34VDC , OVP : 36.1VDC	FS5_AIP_34V_B
	22VDC	FS5_AIP_22V_B

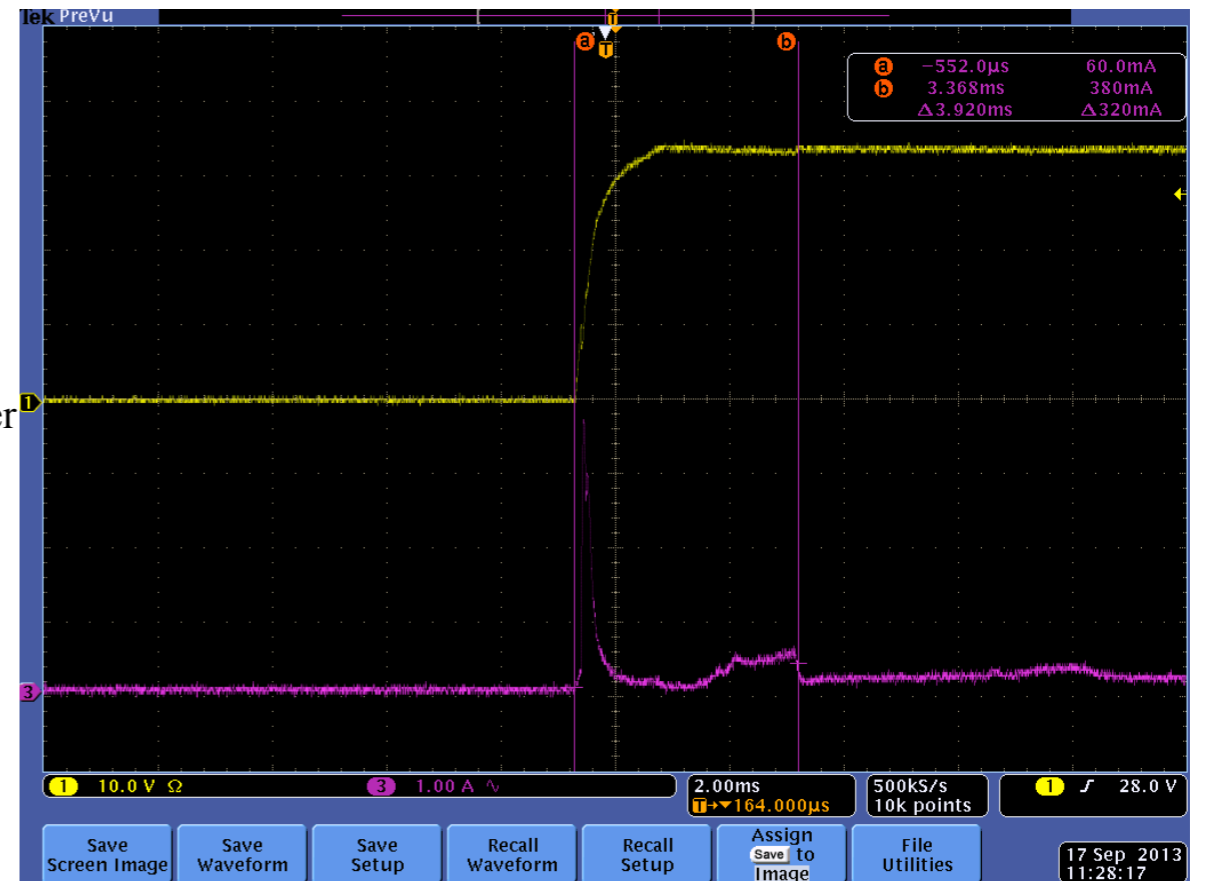
OVP : Overvoltage Protection



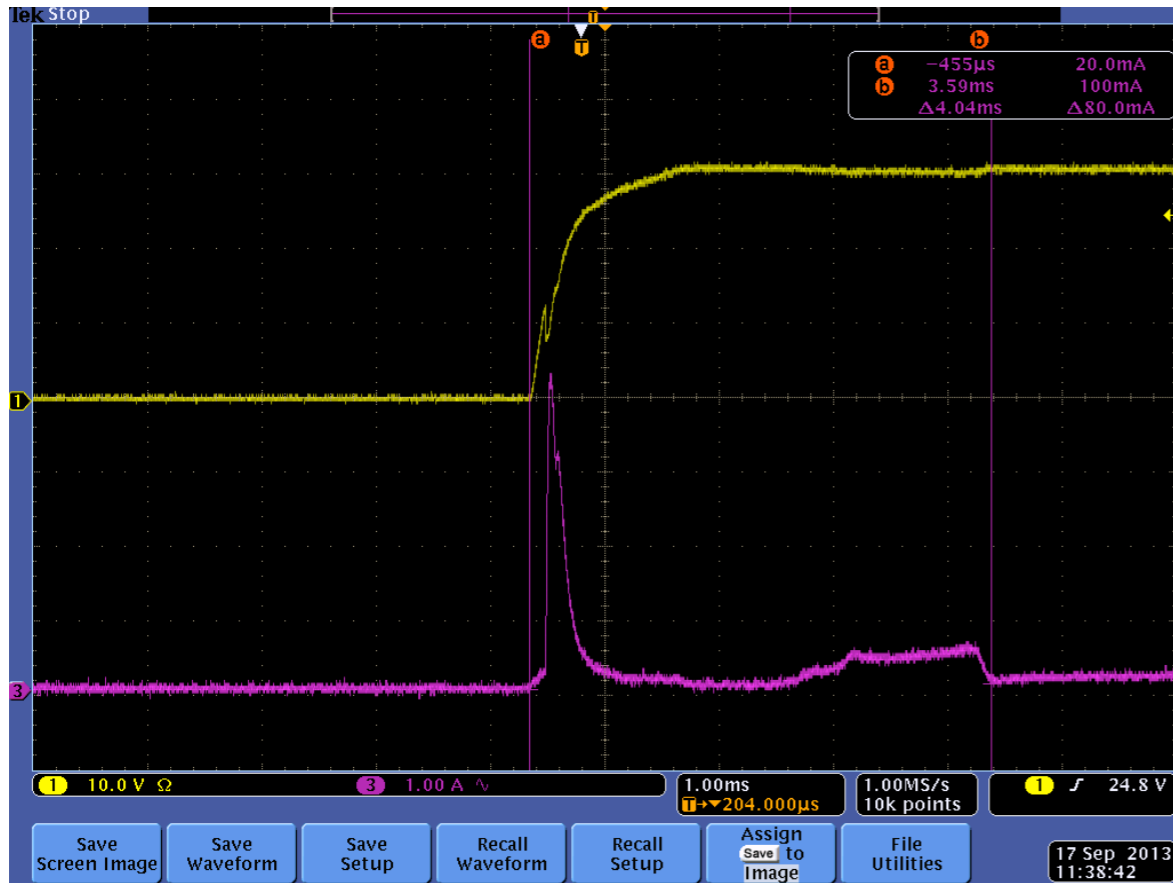
CE on transient voltage and in-rush current – time domain for primary controller turned on to +22 V.



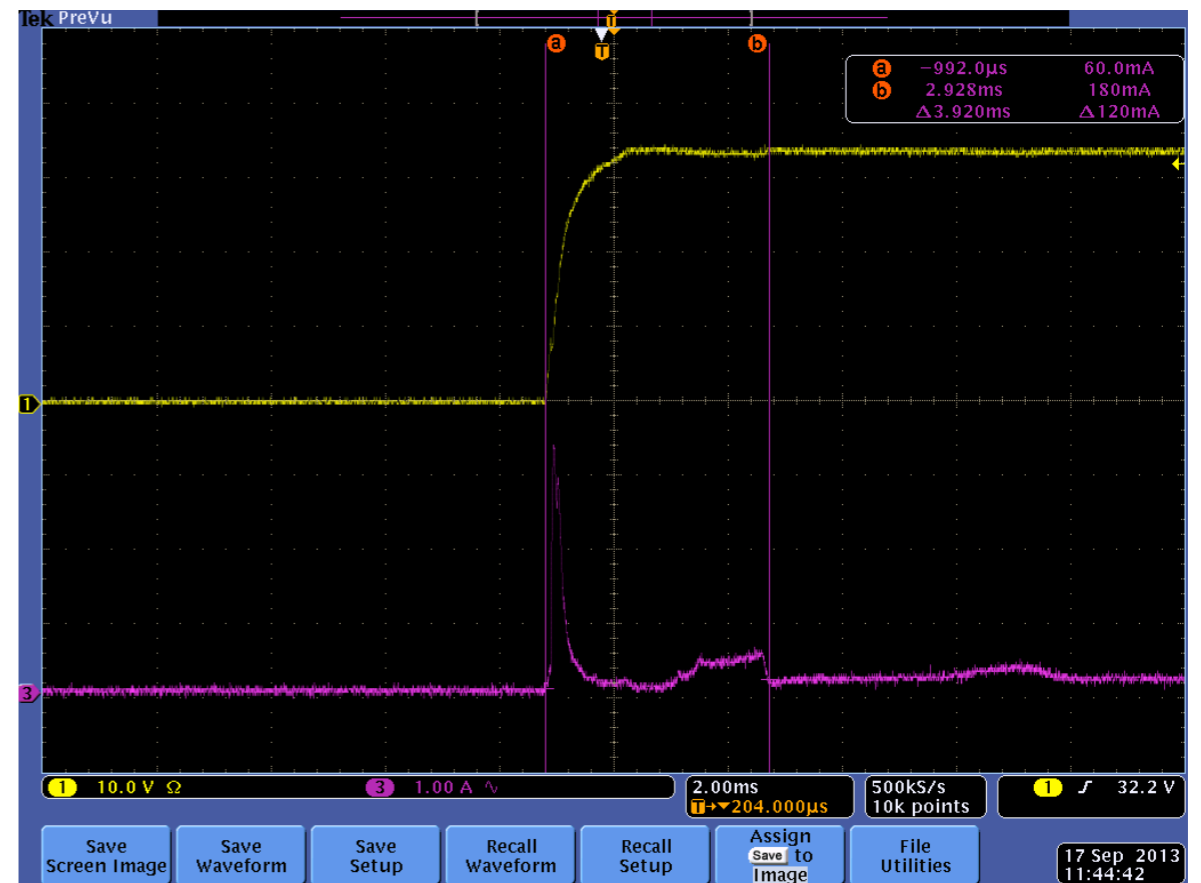
CE on transient voltage and in-rush current – time domain for primary controller turned on to +31 V.



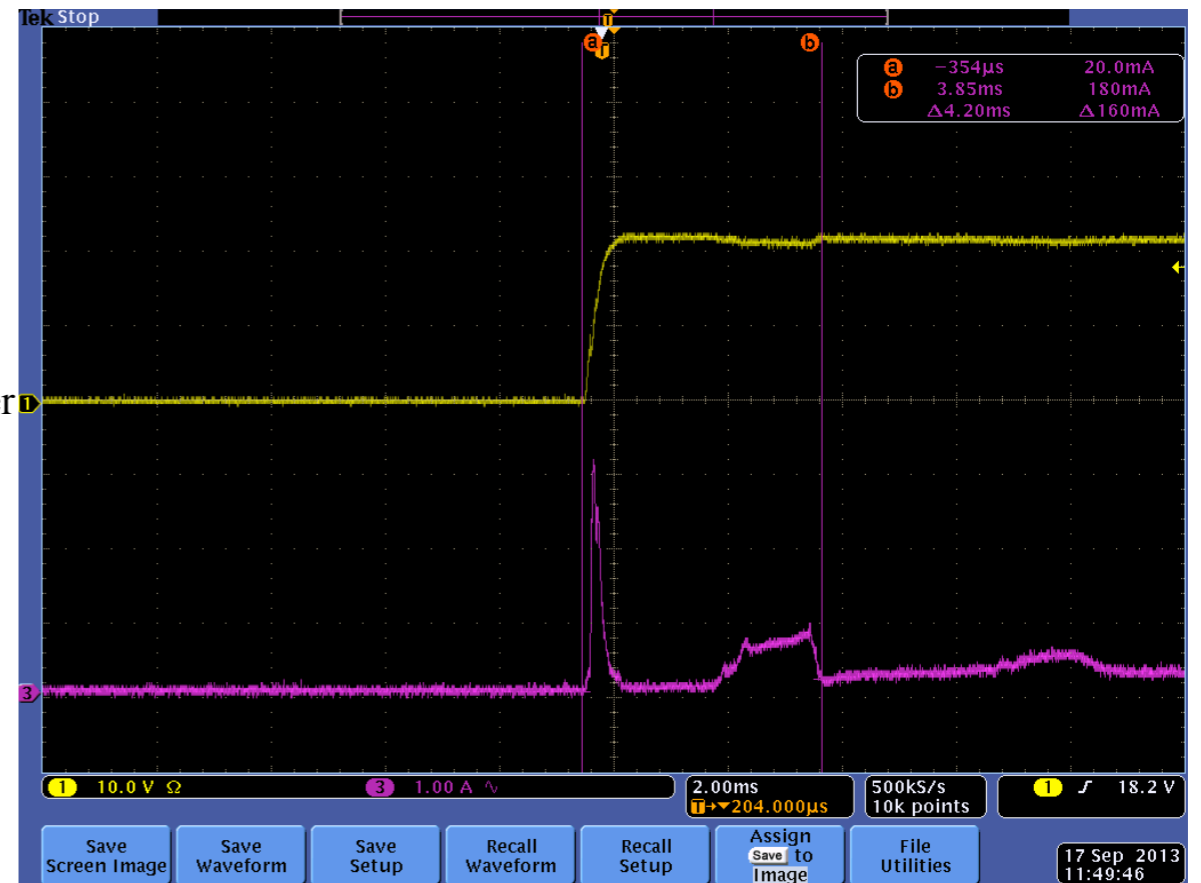
CE on transient voltage and in-rush current – time domain for primary controller turned on to +34 V.



CE on transient voltage and in-rush current – time domain for redundant controller turned on to +31 V.



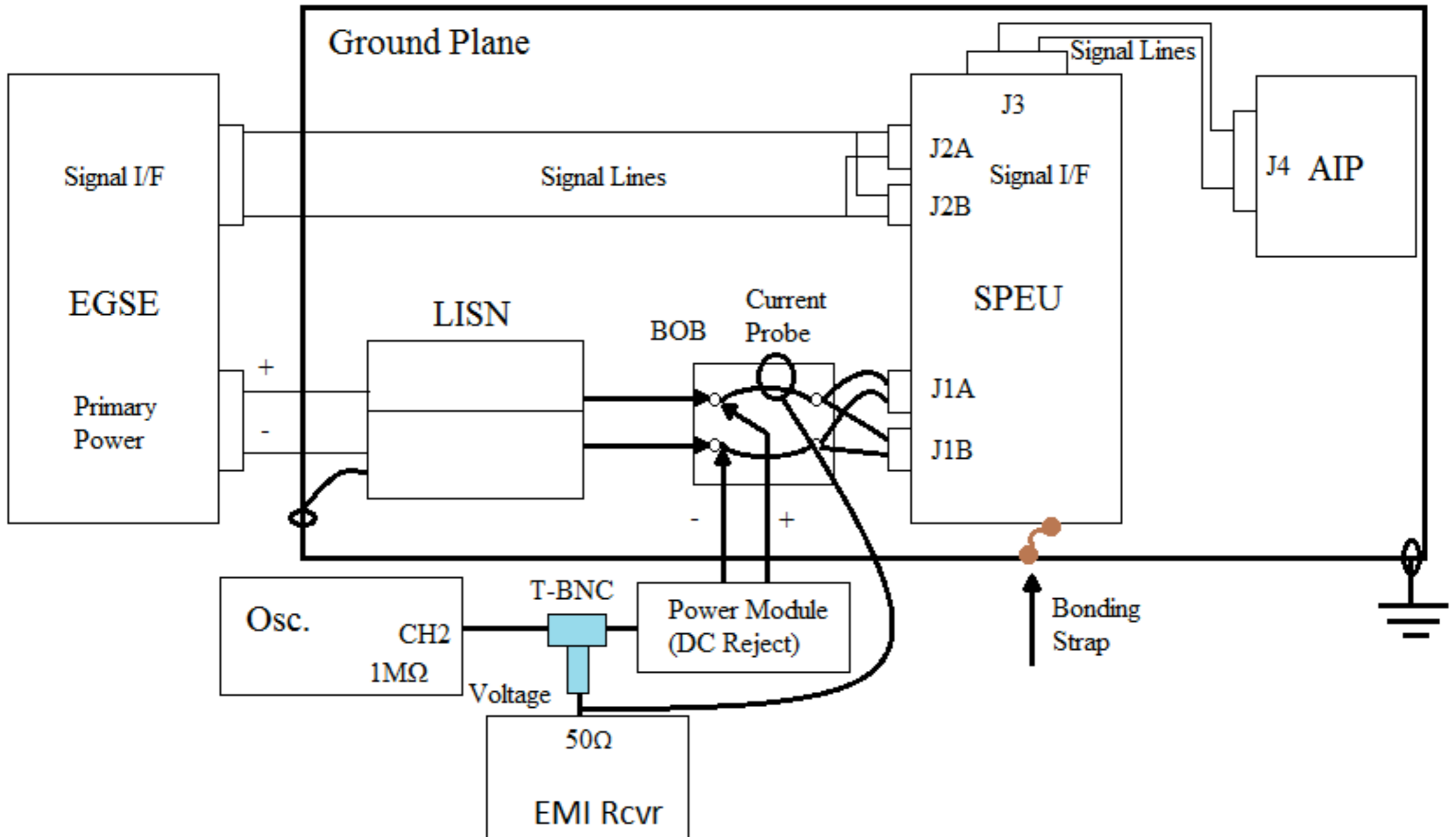
CE on transient voltage and in-rush current – time domain for redundant controller turned on to +34 V.



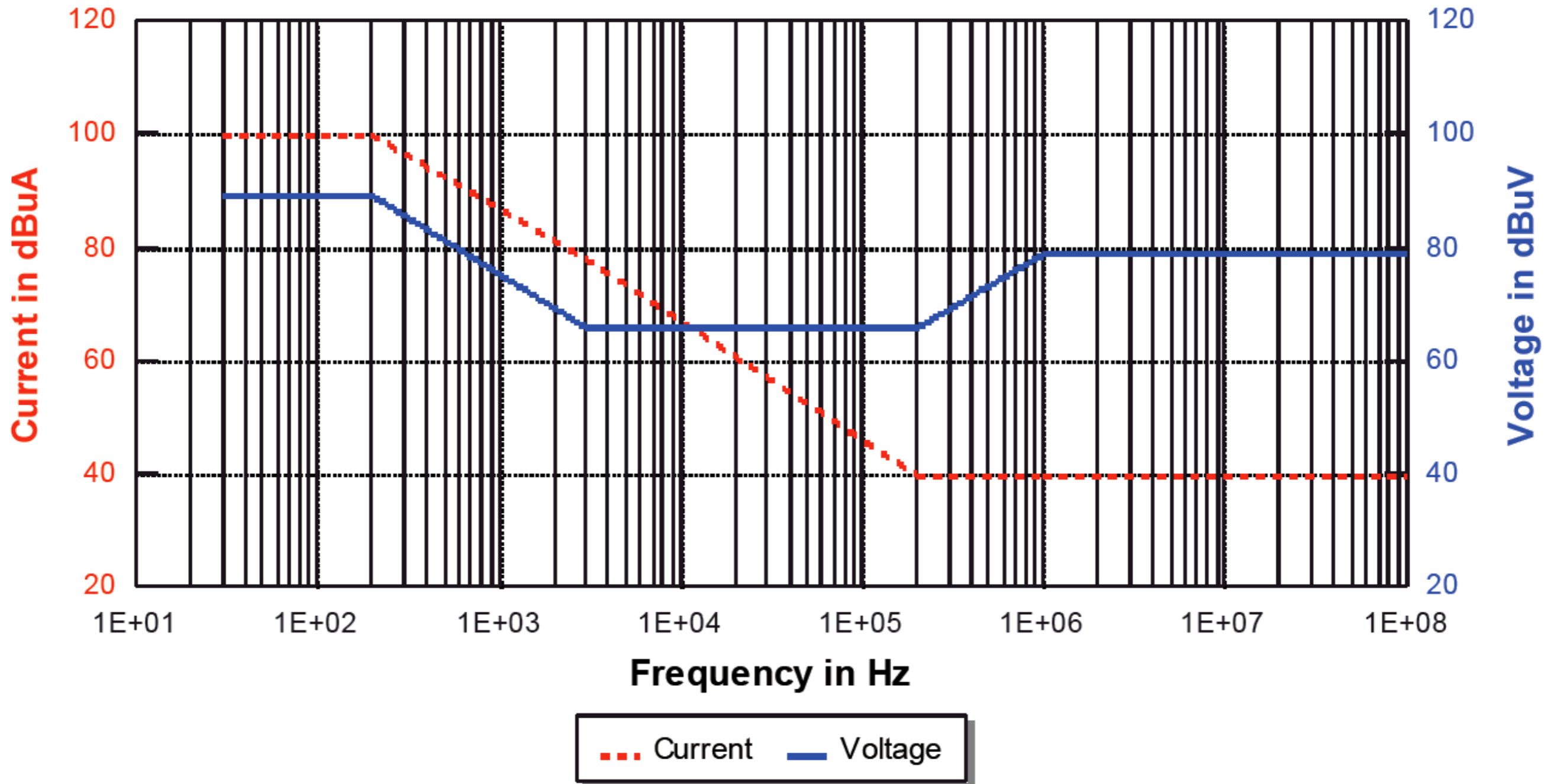
CE on transient voltage and in-rush current – time domain for redundant controller turned on to +22 V.

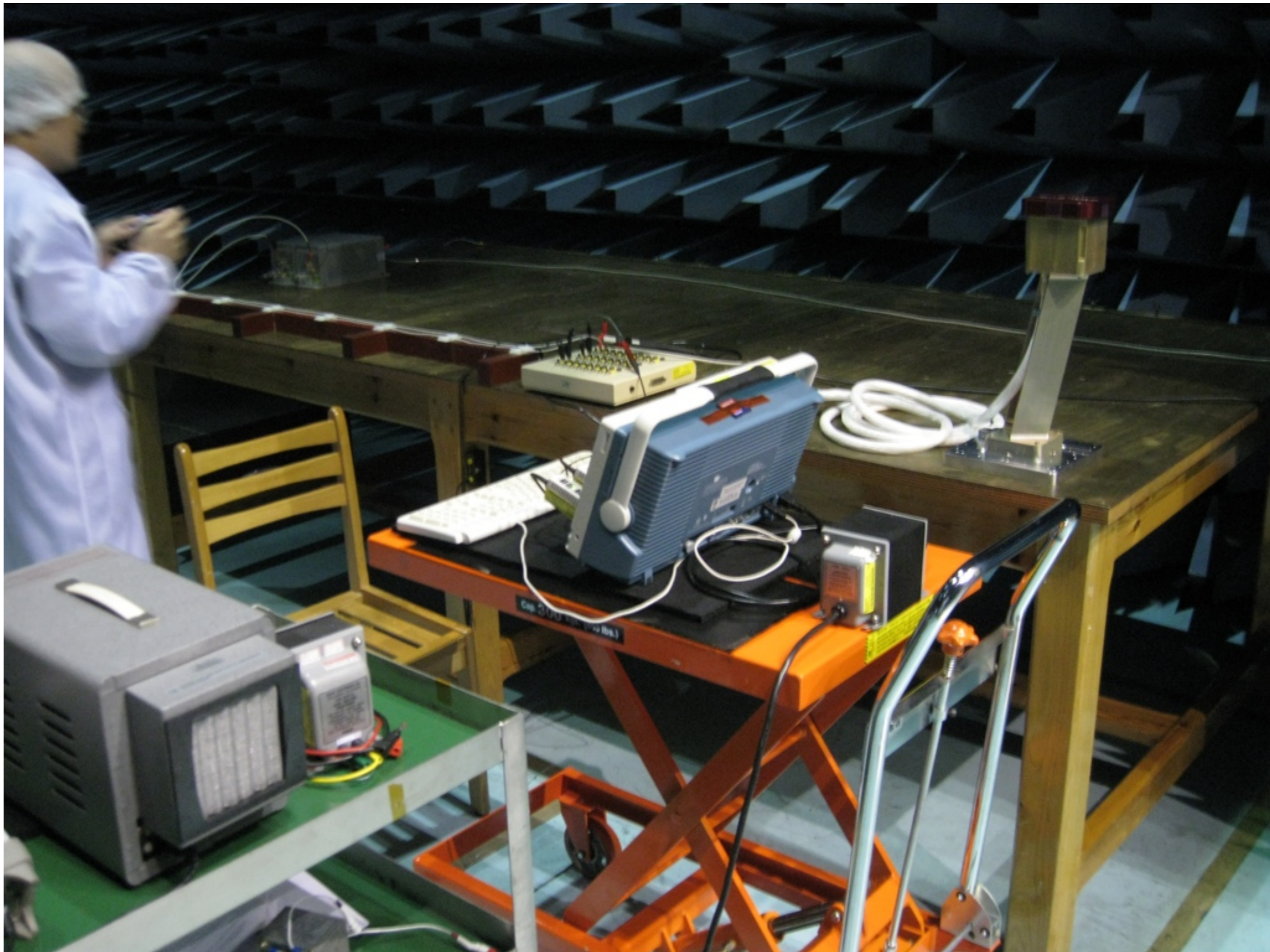
CE on Primary Power Lines-Frequency Domain

設置



Narrow-Band Current and Voltage Emission Limits

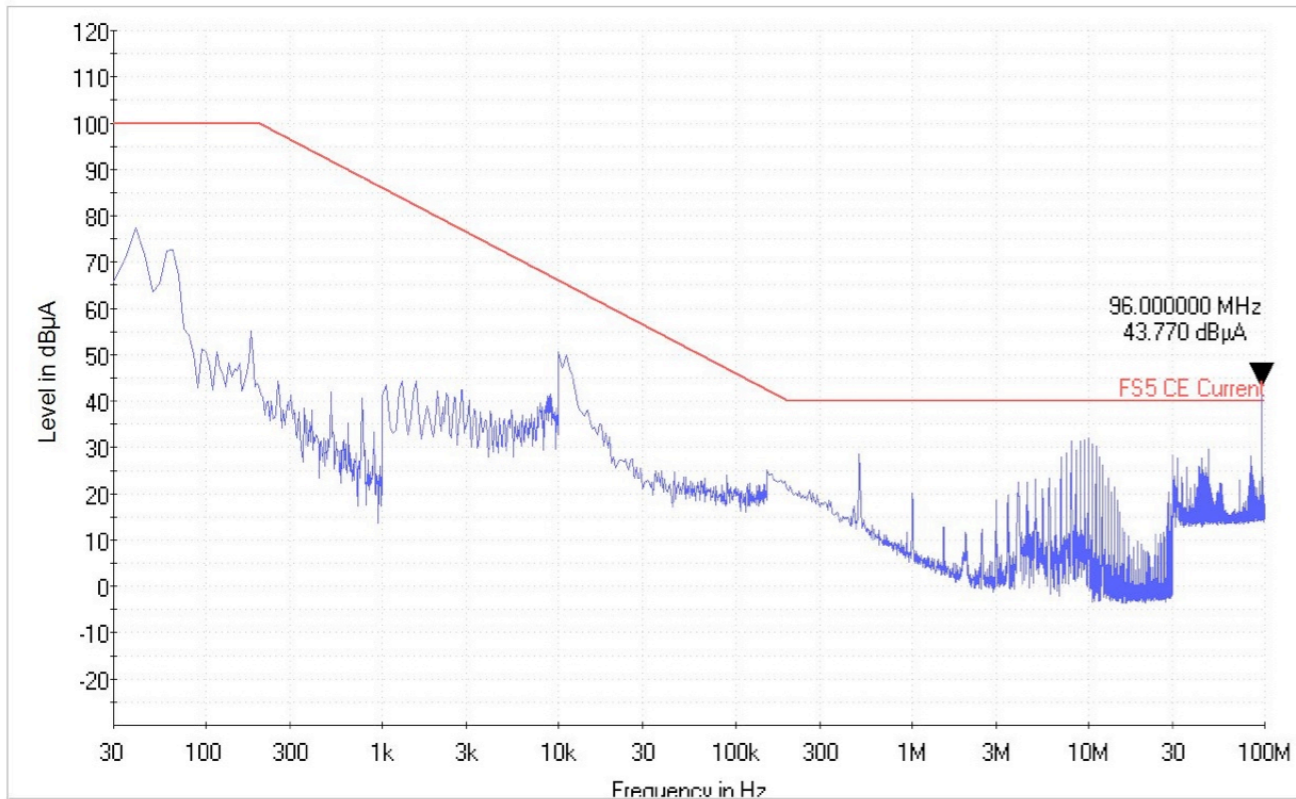




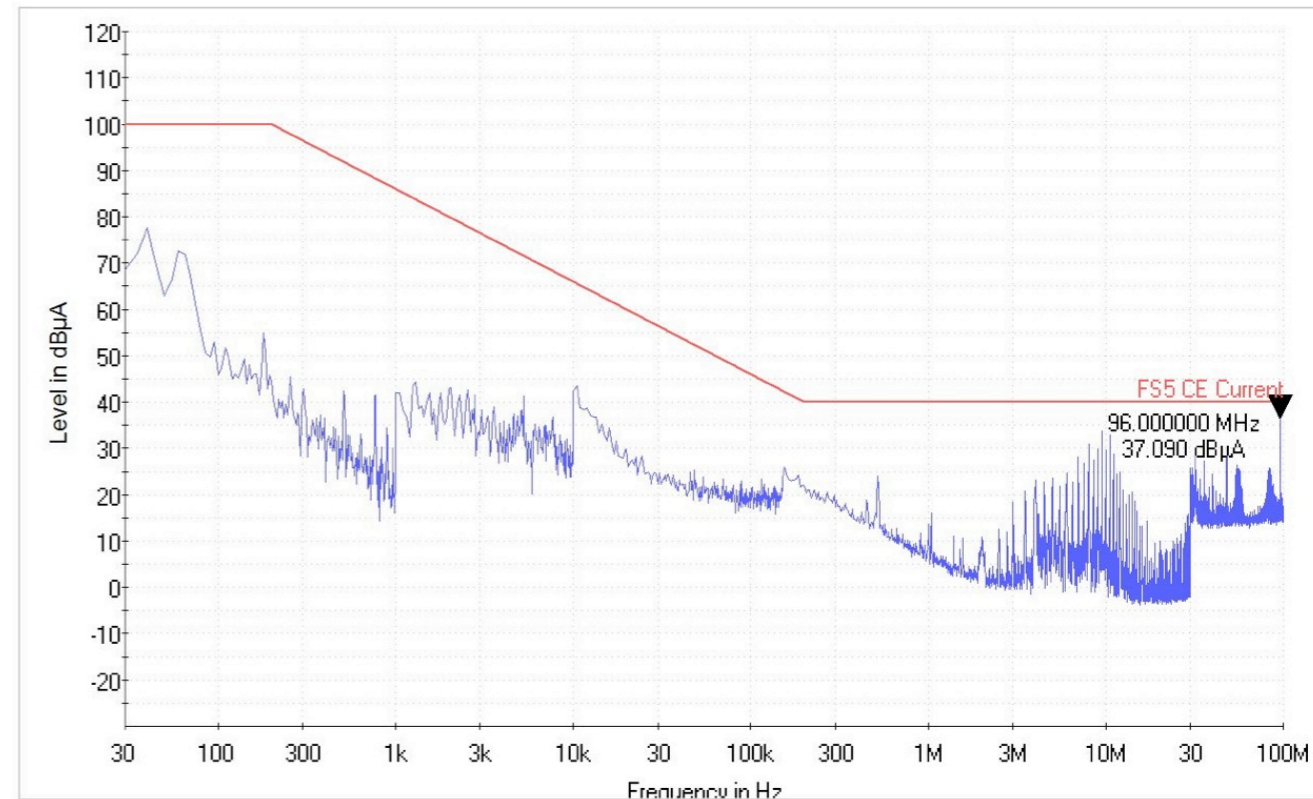
CE on primary power lines test setup.

Step	Action
1	將設備如圖所示擺設好，只連接J1A（J1B不連接）。並將正極電源線（紅線）插座開關與負極電源線（黑線）插座開關關閉。
2	確認AIP測試的設置與接線。請參考FS5SPL-CT-PROC的3.4.3.1節。
3	確認EMC設備已上電。
4	在EGSE方面，確認功能測試程序。請參考FS5SPL-CT-PROC的3.4.3.2節。
5	在EGSE方面，監控指令與遙傳介面、科學資料是否異常。
6	在EMC控制室執行EMC32軟體，執行程序FS5 CE Voltage電壓輻射量測。完成後存檔，檔名：FS5_AIP_CE_Pri_V_A。
7	解除EMI接收機的纜線，換上電流探針，設置如圖所示。
8	在EMC控制室執行EMC32軟體，執行程序FS5 CE Current電流輻射量測。完成後存檔，檔名：FS5_AIP_CE_Pri_I_A。
9	確認AIP功能不會因電流流經電壓產生器而影響其功能。
10	將正極電源線BOB開關打開。
11	將設備如圖所示擺設好，只連接J1B（J1A不連接）。並將正極電源線（紅線）插座開關與負極電源線（黑線）插座開關關閉。重複步驟2-10。

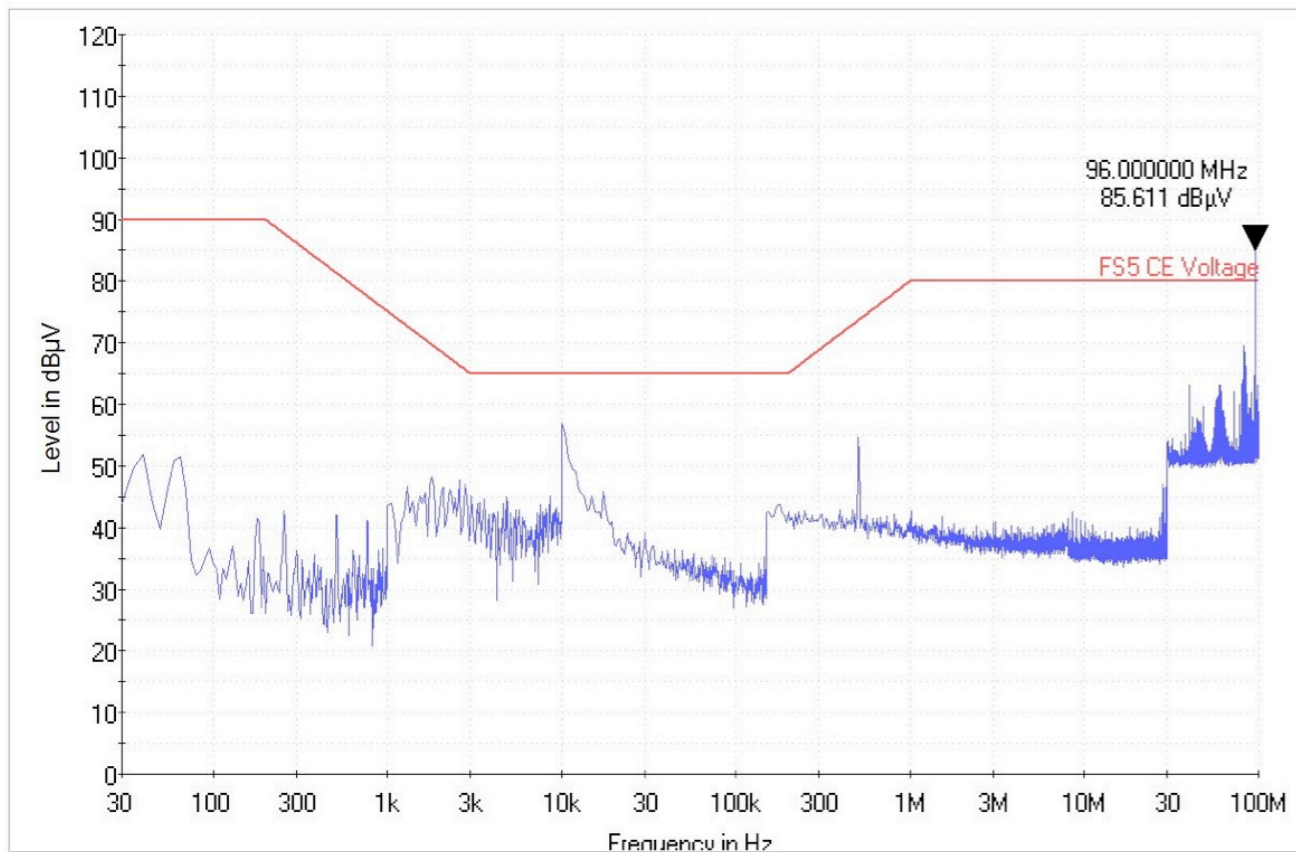
待測接頭	程序	檔名
J1A	FS5 CE Voltage	FS5_AIP_CE_Pri_V_A
	FS5 CE Current	FS5_AIP_CE_Pri_I_A
J1B	FS5 CE Voltage	FS5_AIP_CE_Pri_V_B
	FS5 CE Current	FS5_AIP_CE_Pri_I_B



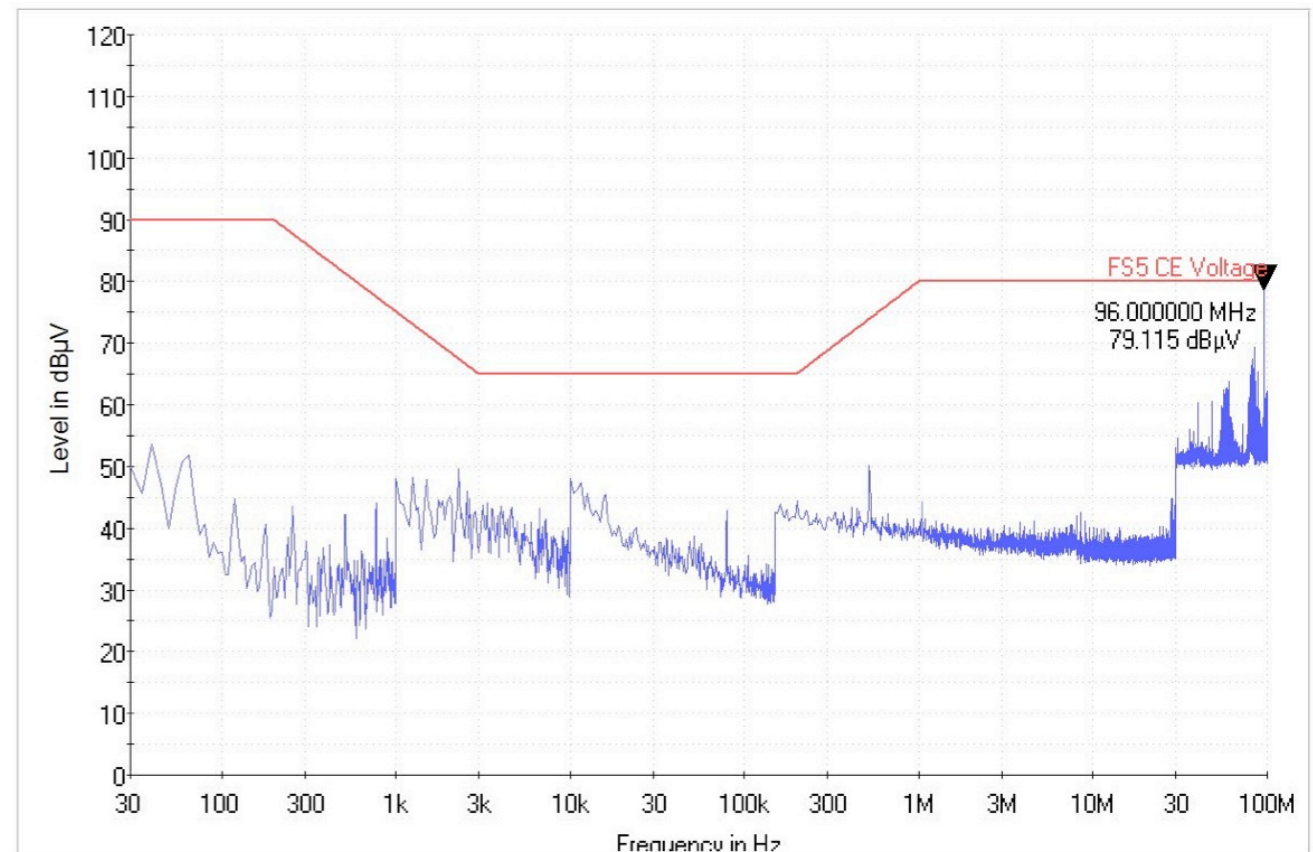
CE on primary power lines – frequency domain for primary controller on, current level.



CE on primary power lines – frequency domain for redundant controller on, current level.



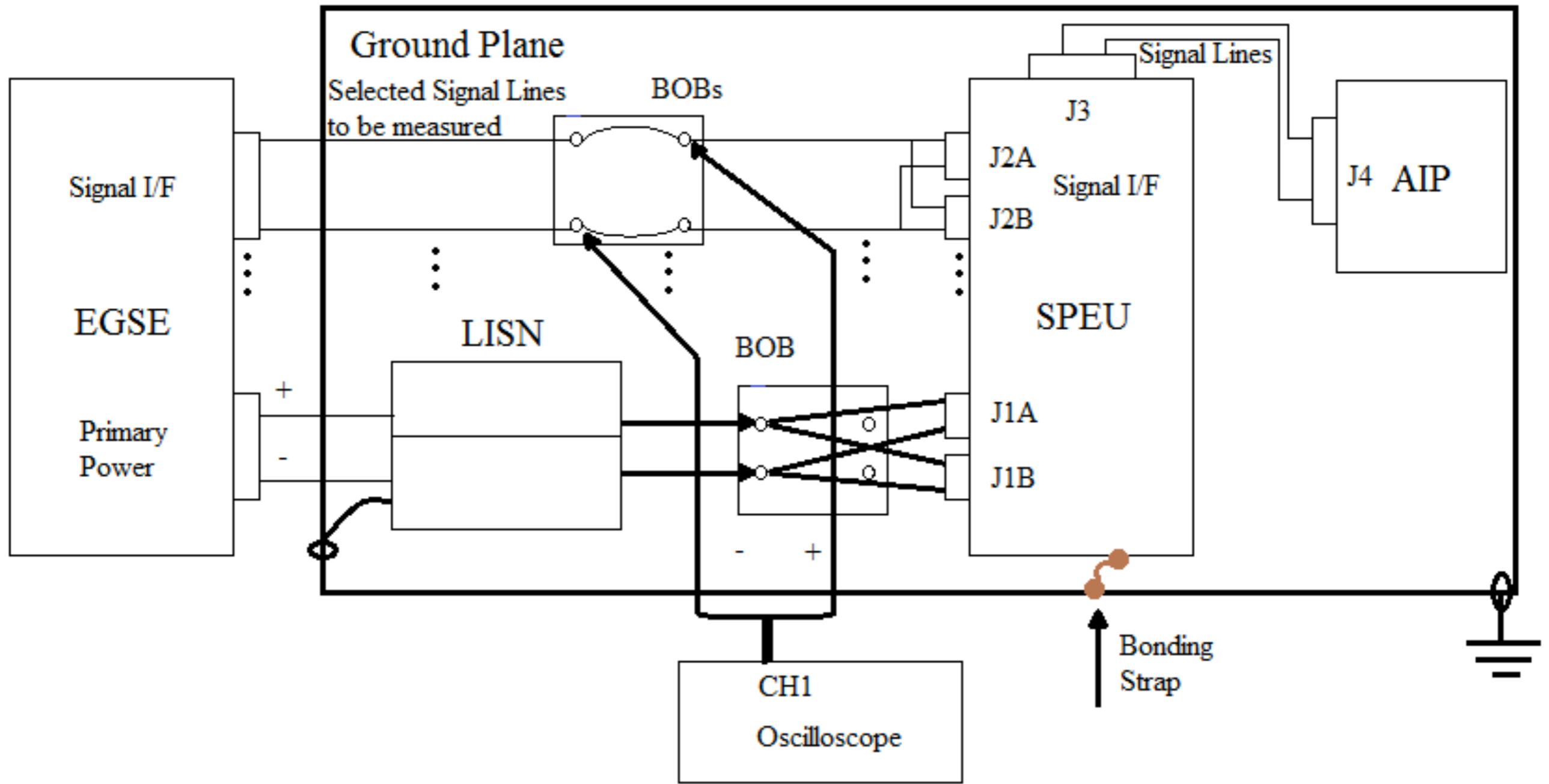
CE on primary power lines – frequency domain for primary controller on, voltage level.



CE on primary power lines – frequency domain for redundant controller on, voltage level.

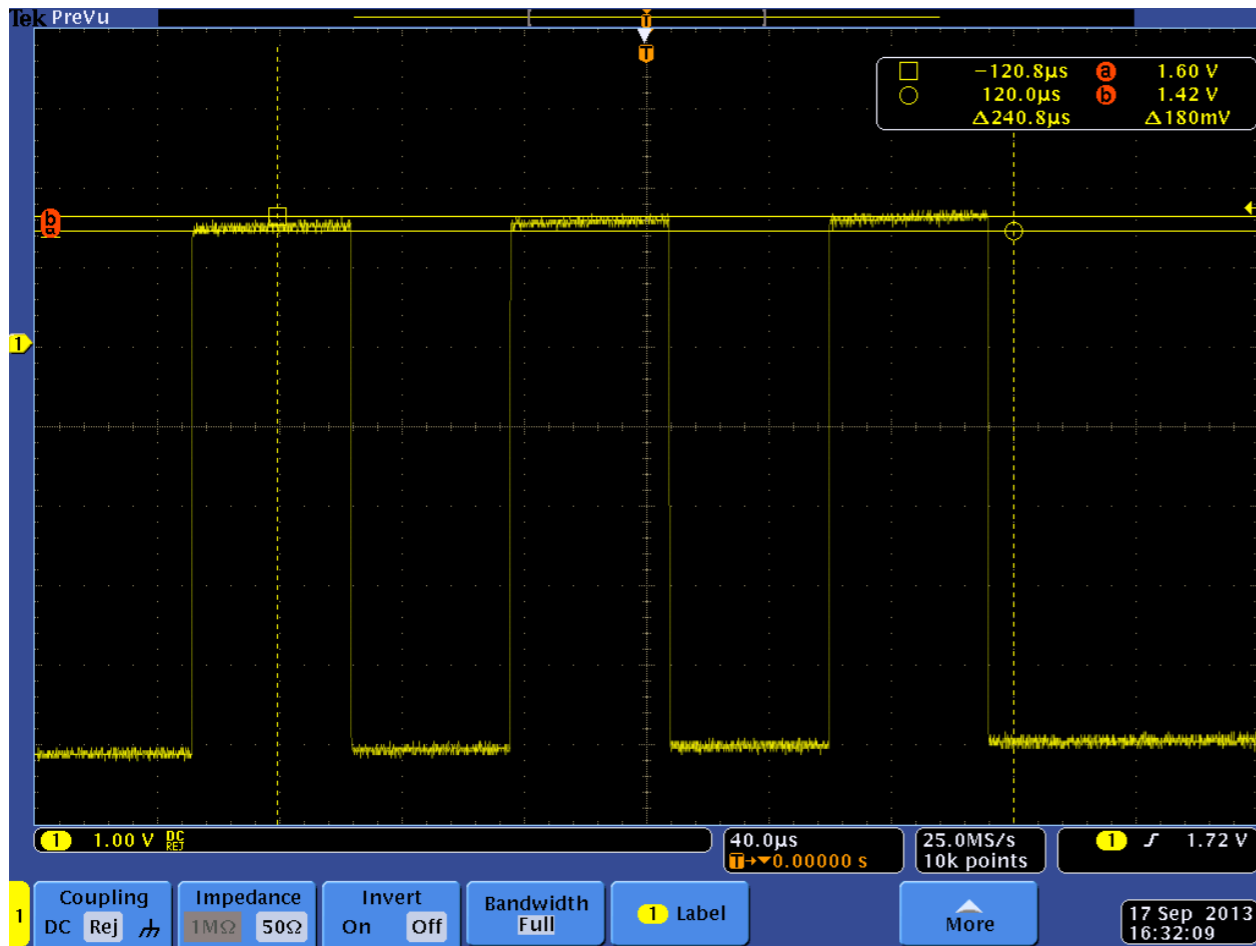
CE on Signal Lines- Time Domain

設置

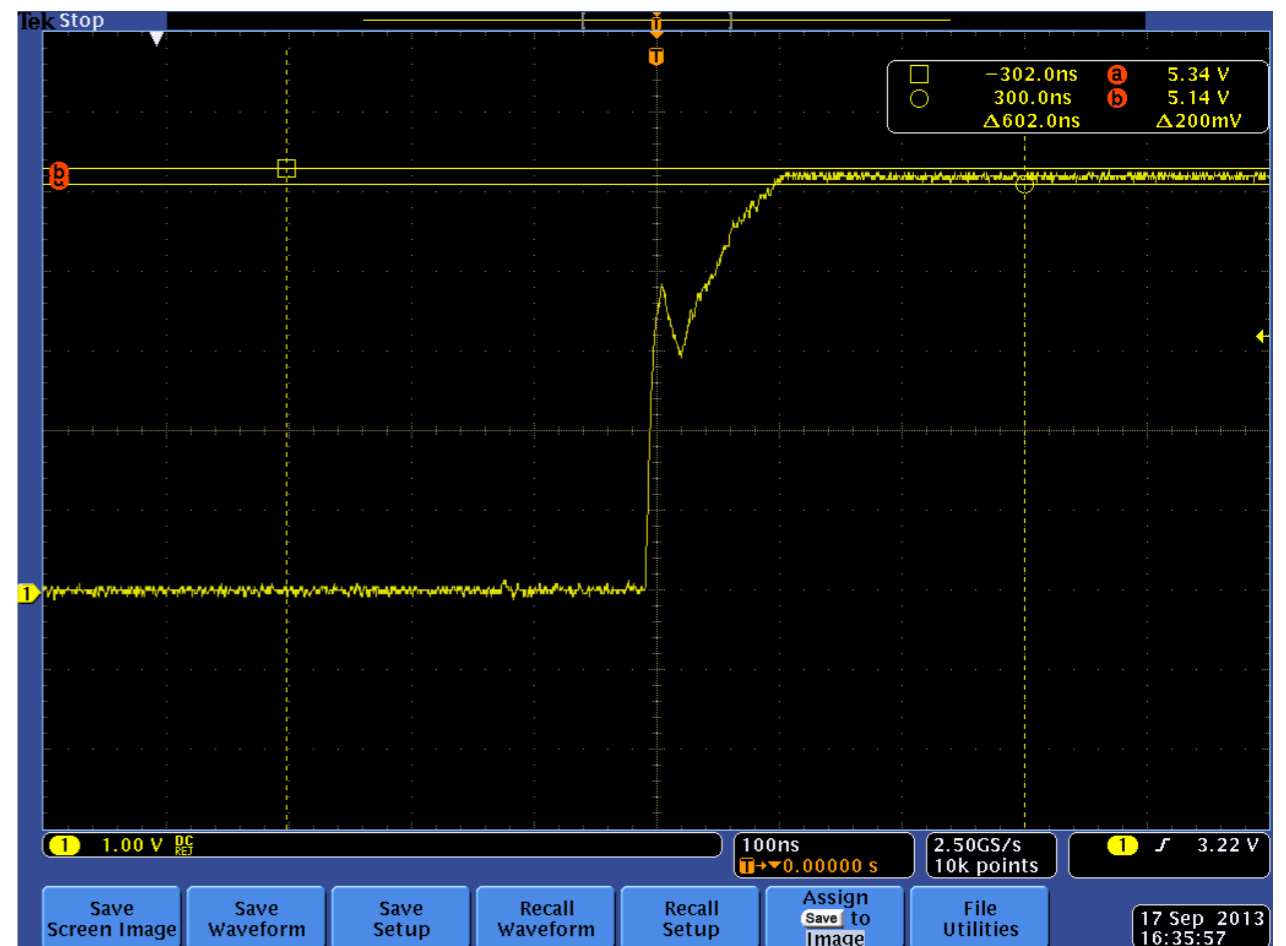


Step	Action
1	將設備如圖所示擺設好，只連接J1A（J1B不連接）。
2	將J2B與BOB開關連接好，當做訊號測試點。
3	確認AIP測試的設置與接線。請參考FS5SPL-CT-PROC的3.4.3.1節。並設置AIP主電源為+28VDC。
4	將訊號連接到示波器。
5	在EGSE方面，確認功能測試程序。請參考FS5SPL-CT-PROC的3.4.3.2節。
6	在EGSE方面，監控指令與遙傳介面、科學資料是否異常。
7	從BOB開關量測J2B訊號的電壓漣波，類比訊號不能超過10mVpp，數位訊號不能超過100mVpp。並將示波器上的圖存下來。
8	將正極電源線BOB開關打開。
9	解除J1A。將設備如圖所示擺設好，只連接J1B（J1A不連接）。重複步驟3-8。

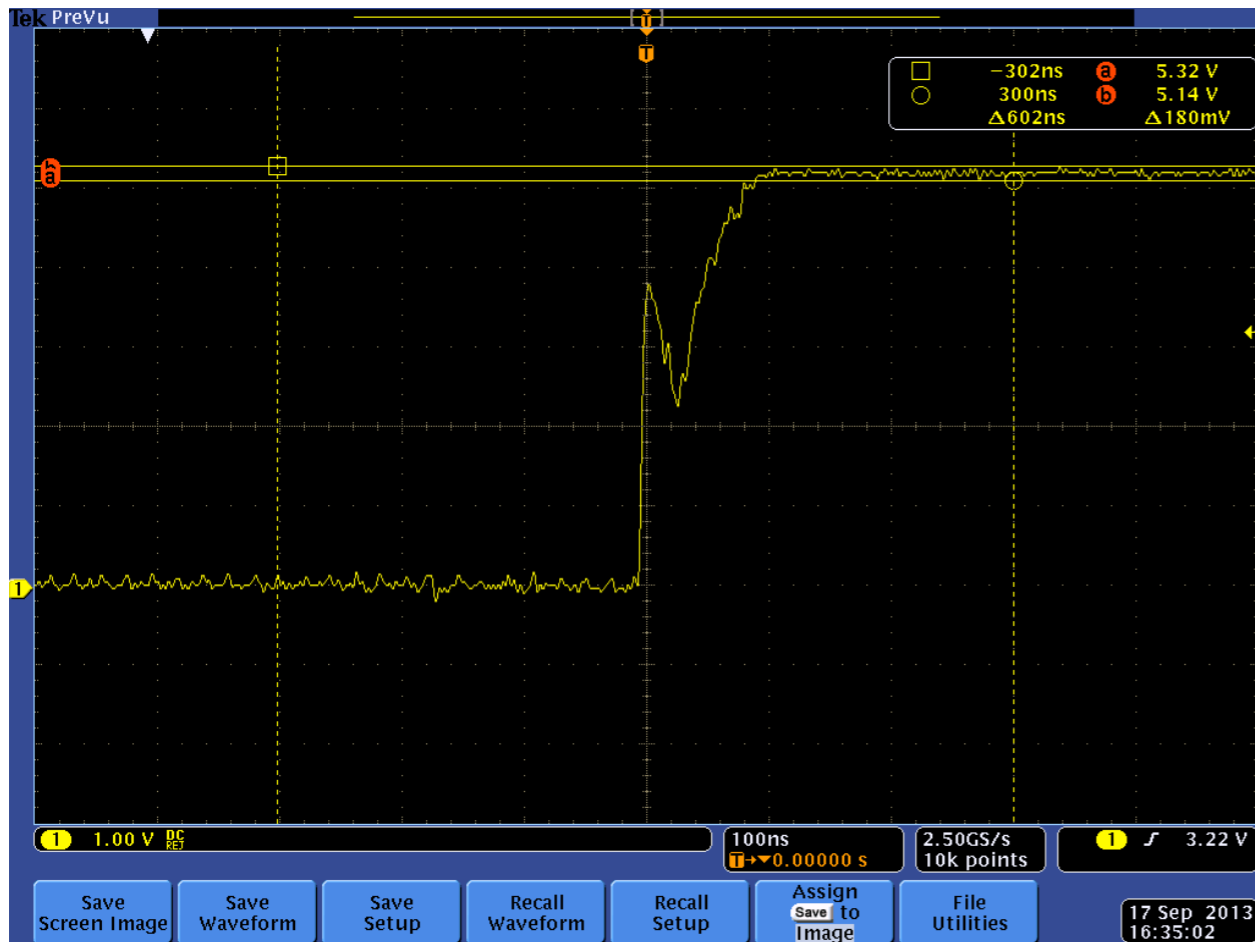
待測接頭	訊號	Through J2B Pin	Through J2A Pin	檔名
J2A	CDMU UART RX+	2	-	RX_1_A
	CDMU UART TX+	5		TX_1_A
	CDMU RTS+	11		RTS_1_A
	CDMU CTS+	12		CTS_1_A
	CDMU DATA+	14		DATA_1_A
	CDMU Clock+	16		Clock_1_A
	CDMU UART RX-	3		RX_1_A
	CDMU UART TX-	6		TX_1_A
	CDMU RTS-	19		RTS_1_A
	CDMU CTS-	12		CTS_1_A
	CDMU DATA-	14		DATA_1_A
	CDMU Clock-	16		Clock_1_A
J2B	CDMU UART RX+	-	2	RX_1_B
	CDMU UART TX+		5	TX_1_B
	CDMU RTS+		11	RTS_1_B
	CDMU CTS+		12	CTS_1_B
	CDMU DATA+		14	DATA_1_B
	CDMU Clock+		16	Clock_1_B
	CDMU UART RX-		3	RX_1_B
	CDMU UART TX-		6	TX_1_B
	CDMU RTS-		19	RTS_1_B
	CDMU CTS-		12	CTS_1_B
	CDMU DATA-		14	DATA_1_B
	CDMU Clock-		16	Clock_1_B



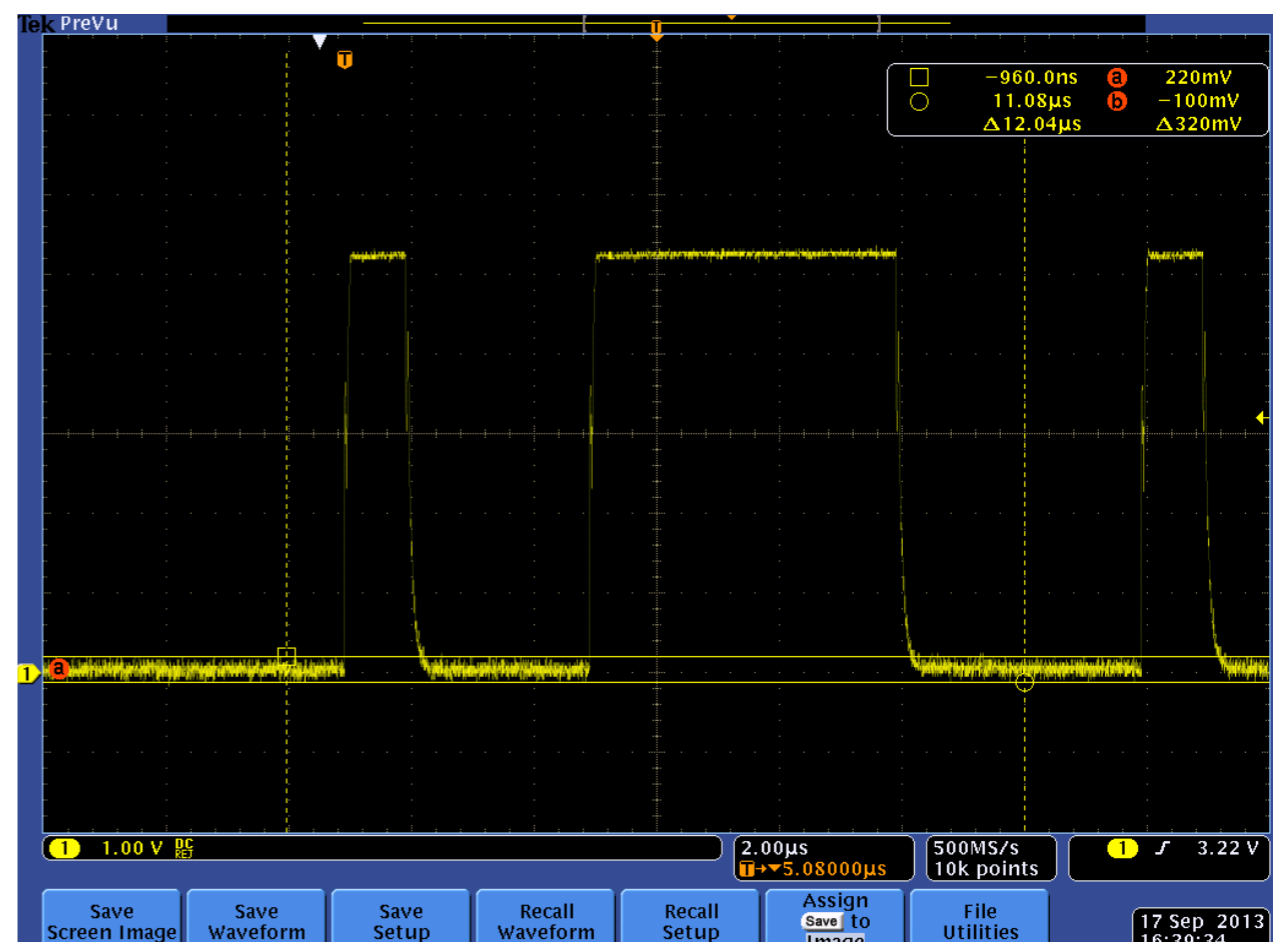
TX signal line ripple voltage measurement on primary controller.



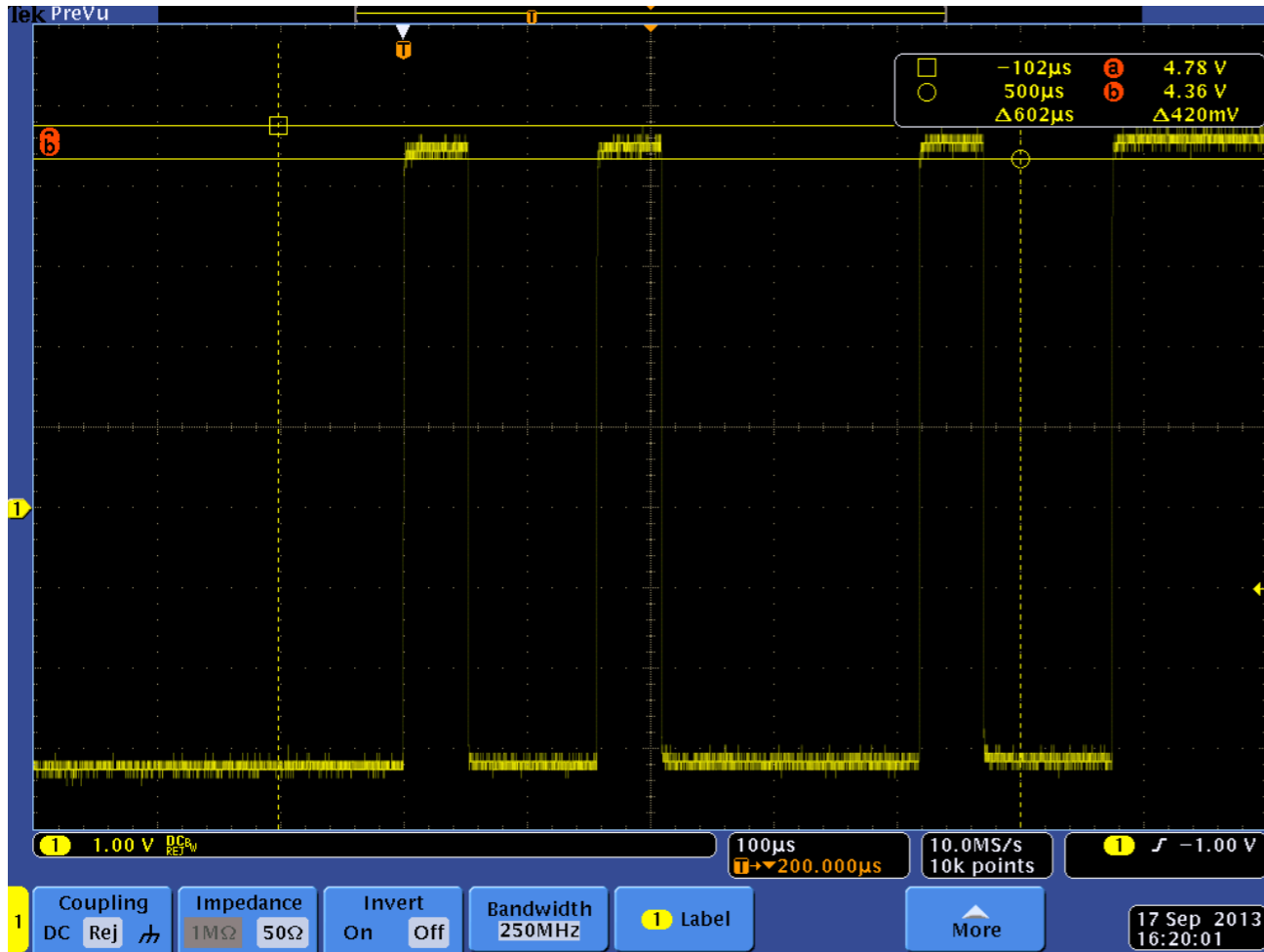
CTS signal line ripple voltage measurement on primary controller.



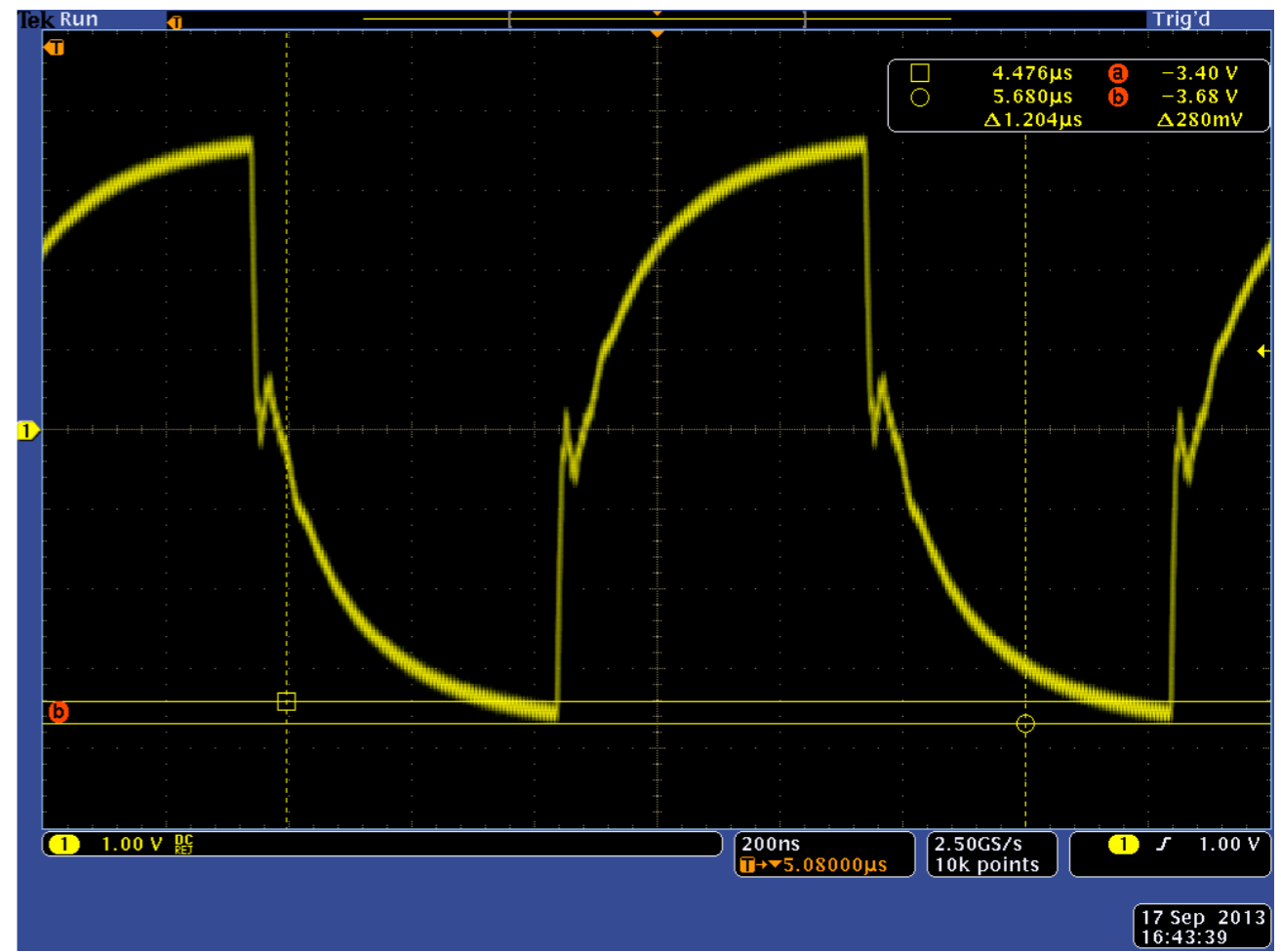
RTS signal line ripple voltage measurement on primary controller.



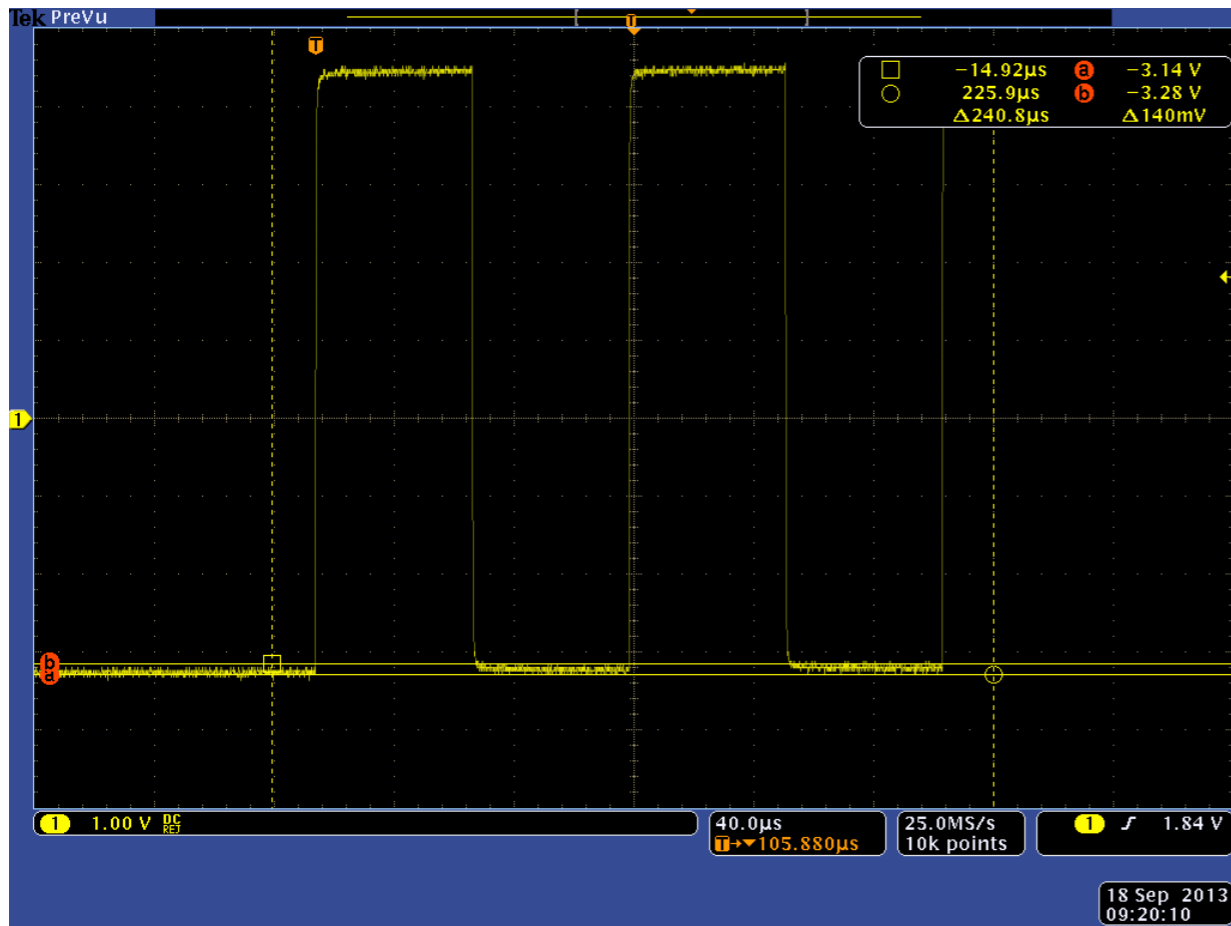
DATA signal line ripple voltage measurement on primary controller.



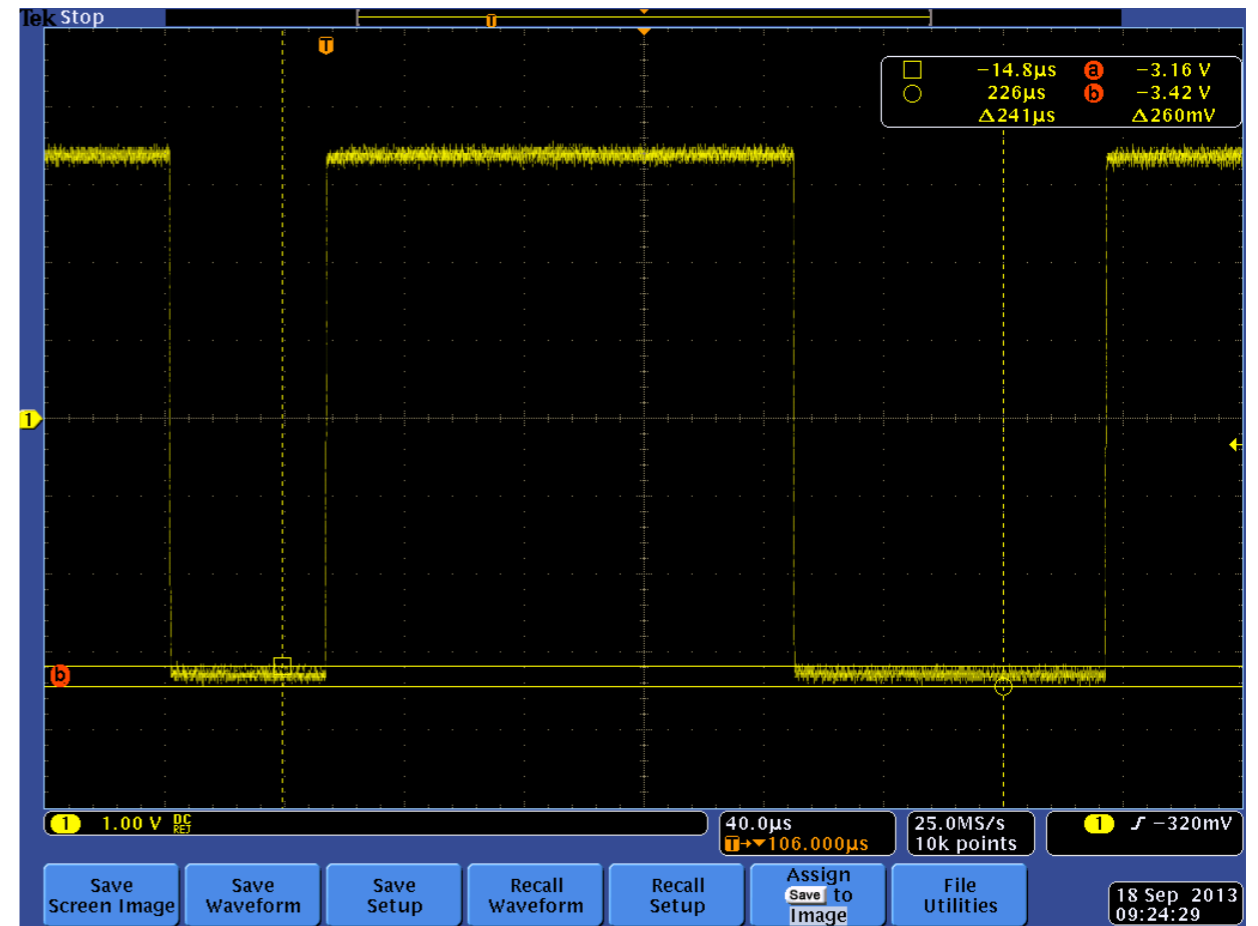
RX signal line ripple voltage measurement on primary controller.



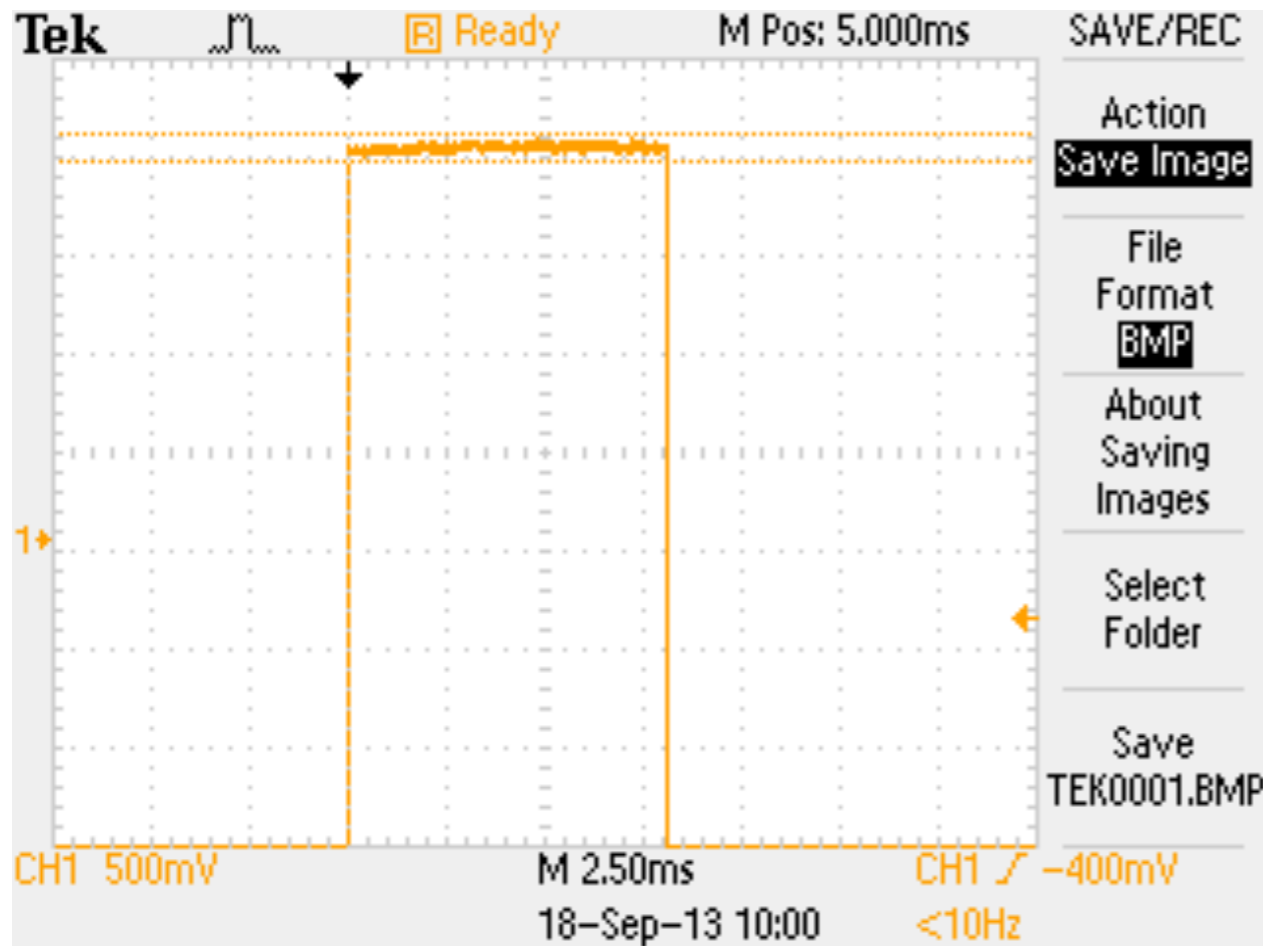
Clock signal line ripple voltage measurement on primary controller.



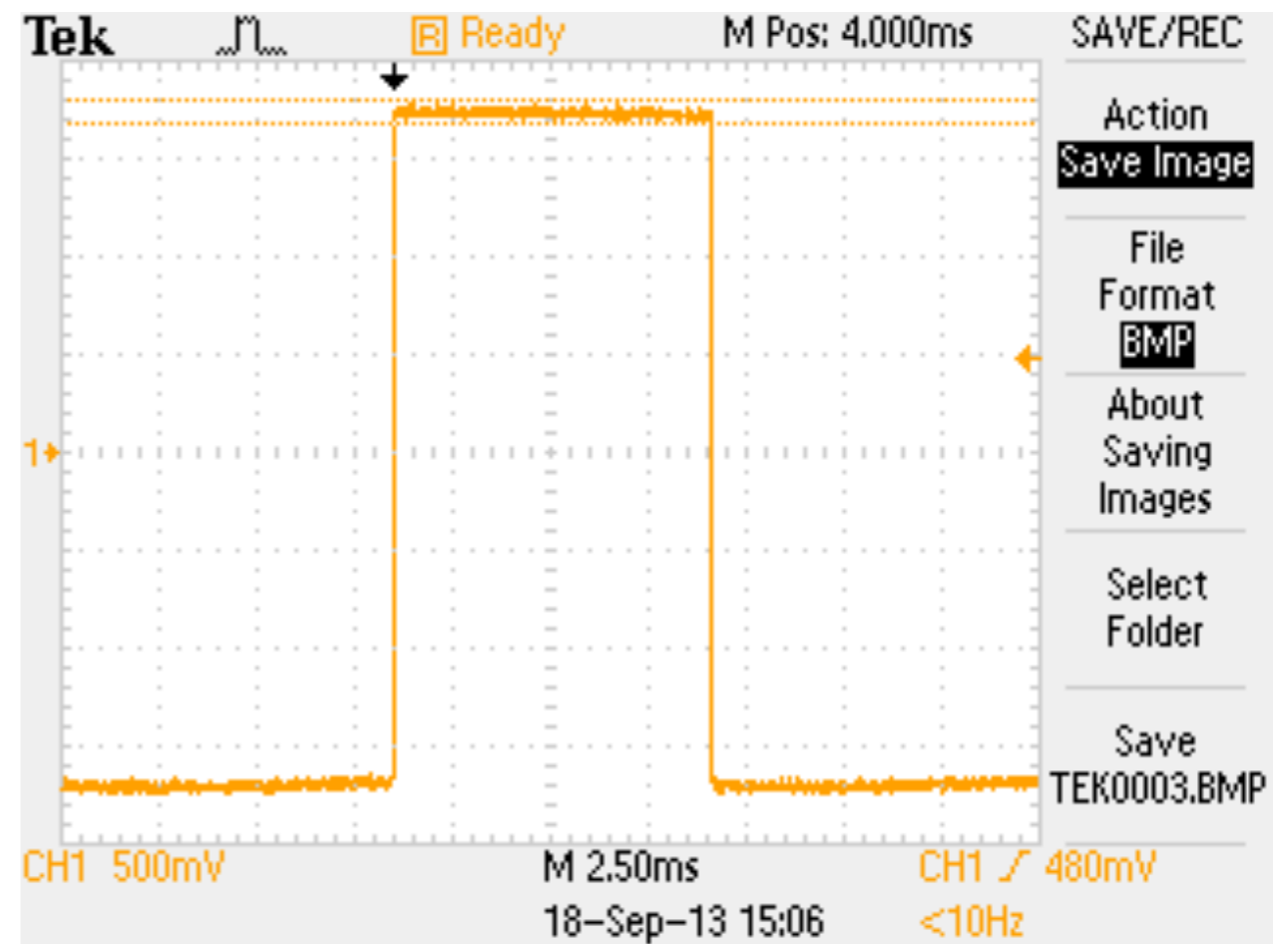
RX signal line ripple voltage measurement on redundant controller.



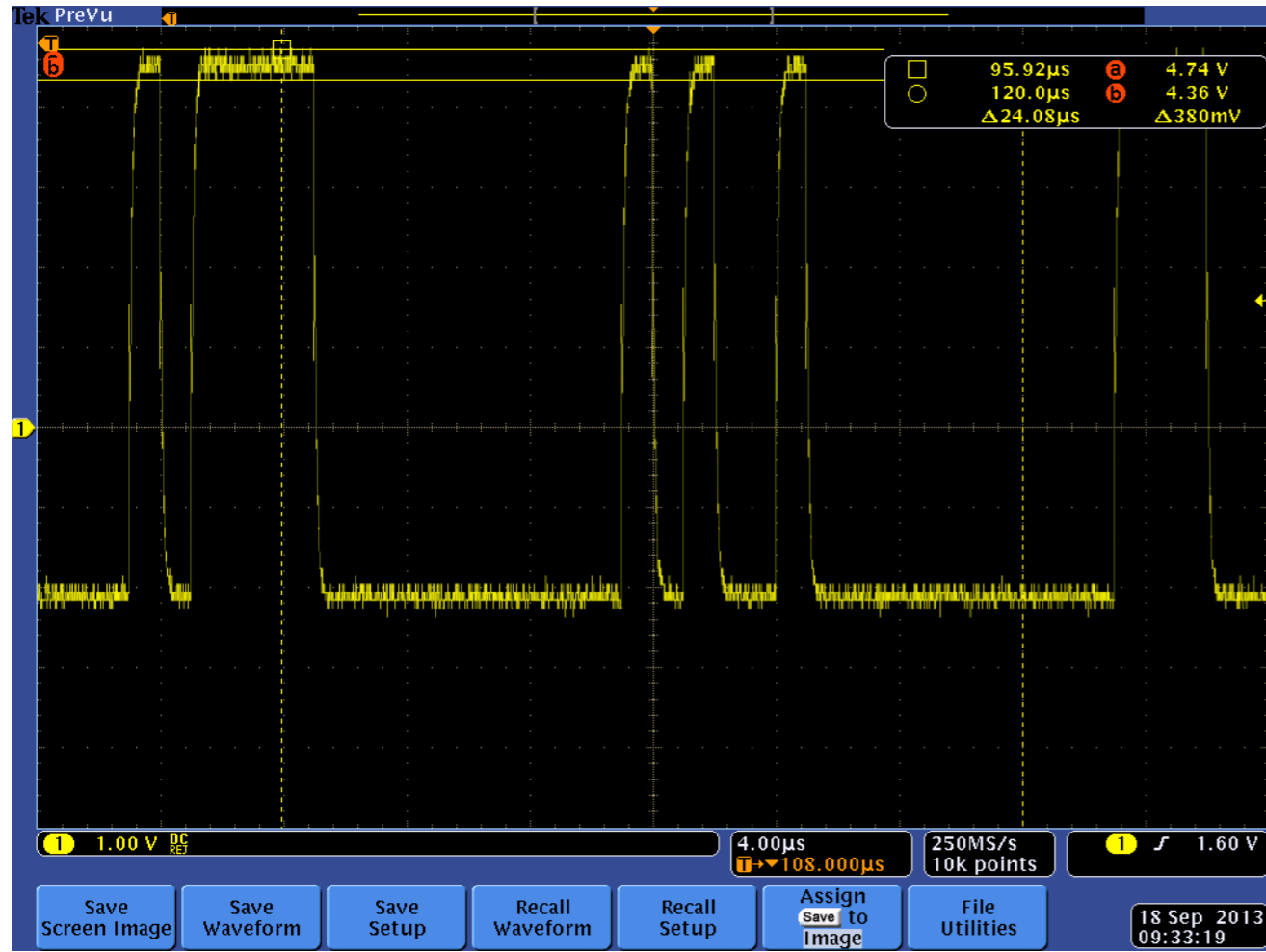
TX signal line ripple voltage measurement on redundant controller.



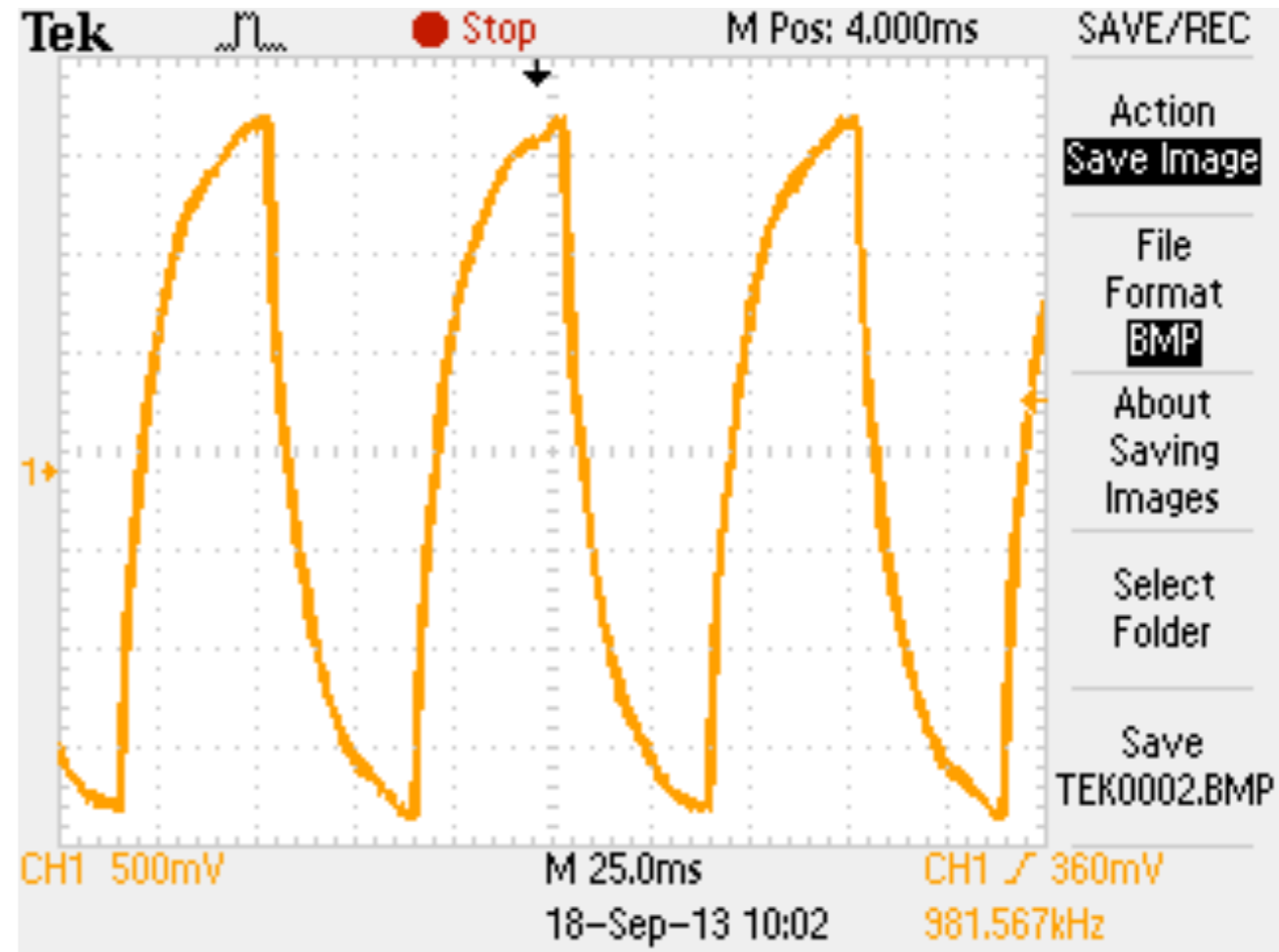
CTS signal line ripple voltage measurement on redundant controller.



RTS signal line ripple voltage measurement on redundant controller.



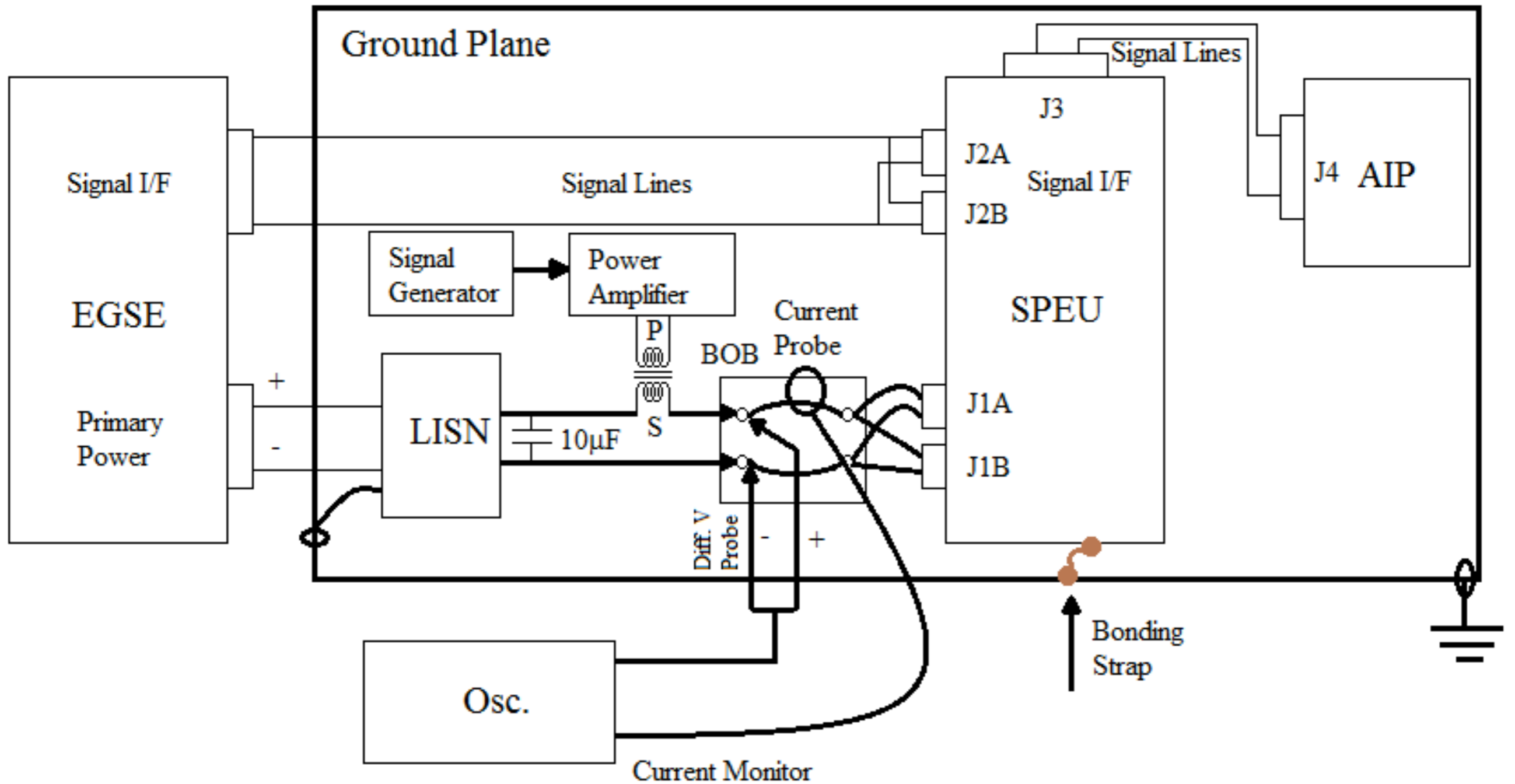
DATA signal line ripple voltage measurement on redundant controller.



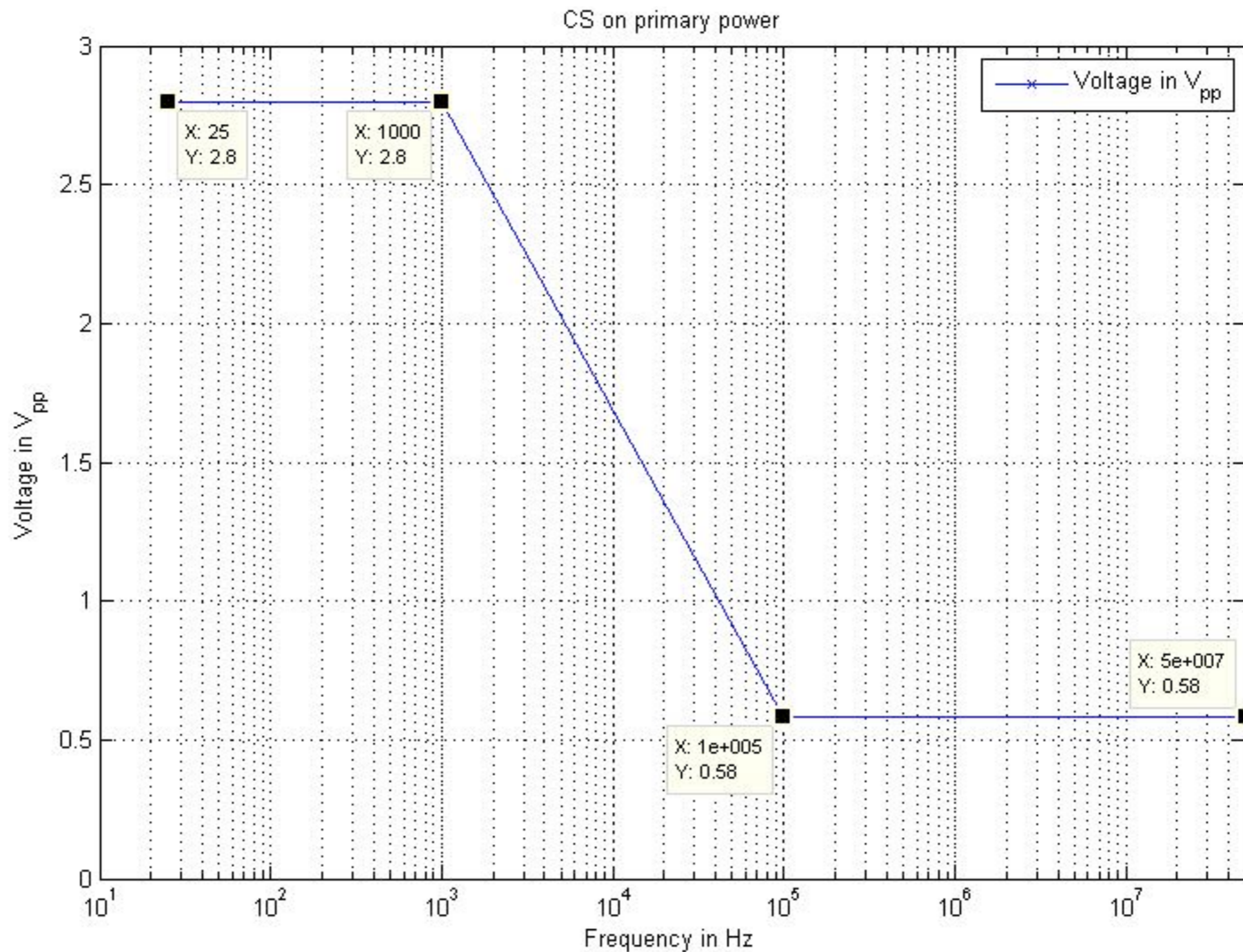
Clock signal line ripple voltage measurement on redundant controller.

CS on Primary Lines-Sine
wave Injection
(30Hz~10KHz)

設置



Conducted Sine wave Susceptibility

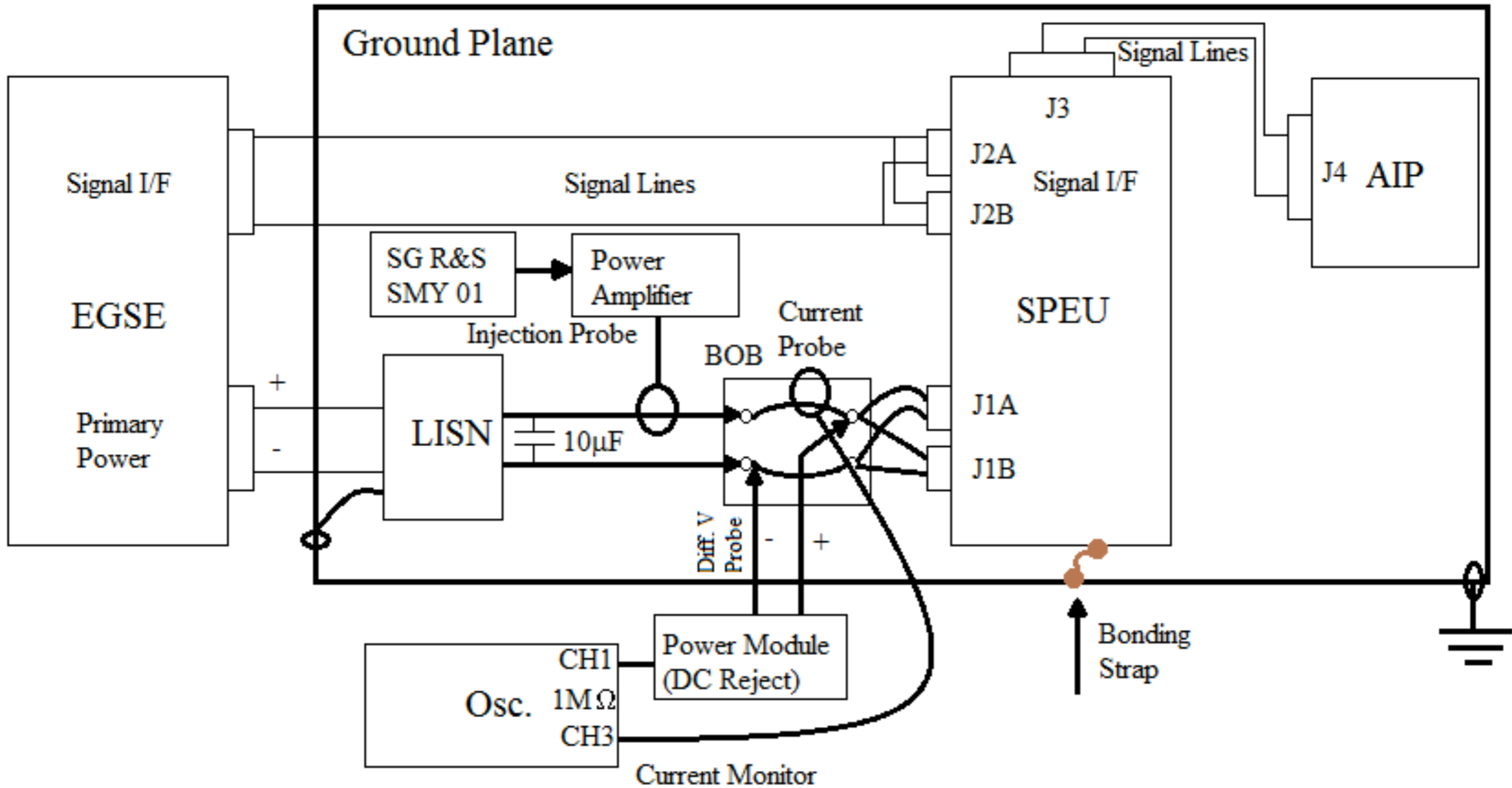


Step	Action
1	將設備如圖所示擺設好，只連接J1A（J1B不連接）。
2	確認AIP測試的設置與接線。請參考FS5SPL-CT-PROC的3.4.3.1節。並設置AIP主電源為+28VDC。
3	確認EMC設備已上電。
4	在EGSE方面，確認功能測試程序。請參考FS5SPL-CT-PROC的3.4.3.2節。
5	在EGSE方面，監控指令與遙傳介面、科學資料是否異常。
6	設置Sine波輸出頻率，並且緩慢調整輸出峰對峰電壓到下列的值，接著將示波器上的圖分別存下來。注意AC電流峰值不能超過DC電流的50%。每個頻率的Dwell時間為1秒。
7	確認AIP功能不會因注入而影響其功能。
8	將正極電源線BOB開關打開。
9	解除J1A。將設備如圖所示擺設好，只連接J1B（J1A不連接）。重複步驟3-8。

待測接頭	Frequency	Vpp	檔名
J1A	30	2.8	CS_30_A
	60	2.8	CS_60_A
	70	2.8	CS_70_A
	90	2.8	CS_90_A
	100	2.8	CS_100_A
	300	2.8	CS_300_A
	500	2.8	CS_500_A
	700	2.8	CS_700_A
	900	2.8	CS_900_A
	1k	2.8	CS_1K_A
	3k	2.26	CS_3K_A
	5k	2.01	CS_5K_A
	7k	1.85	CS_7K_A
	10k	1.67	CS_10K_A
J1B	30	2.8	CS_30_B
	60	2.8	CS_60_B
	70	2.8	CS_70_B
	90	2.8	CS_90_B
	100	2.8	CS_100_B
	300	2.8	CS_300_B
	500	2.8	CS_500_B
	700	2.8	CS_700_B
	900	2.8	CS_900_B
	1k	2.8	CS_1K_B
	3k	2.26	CS_3K_B
	5k	2.01	CS_5K_B
	7k	1.85	CS_7K_B
	10k	1.67	CS_10K_B

CS on Primary Lines-Sine
wave Injection
(10KHz~100MHz)

設置

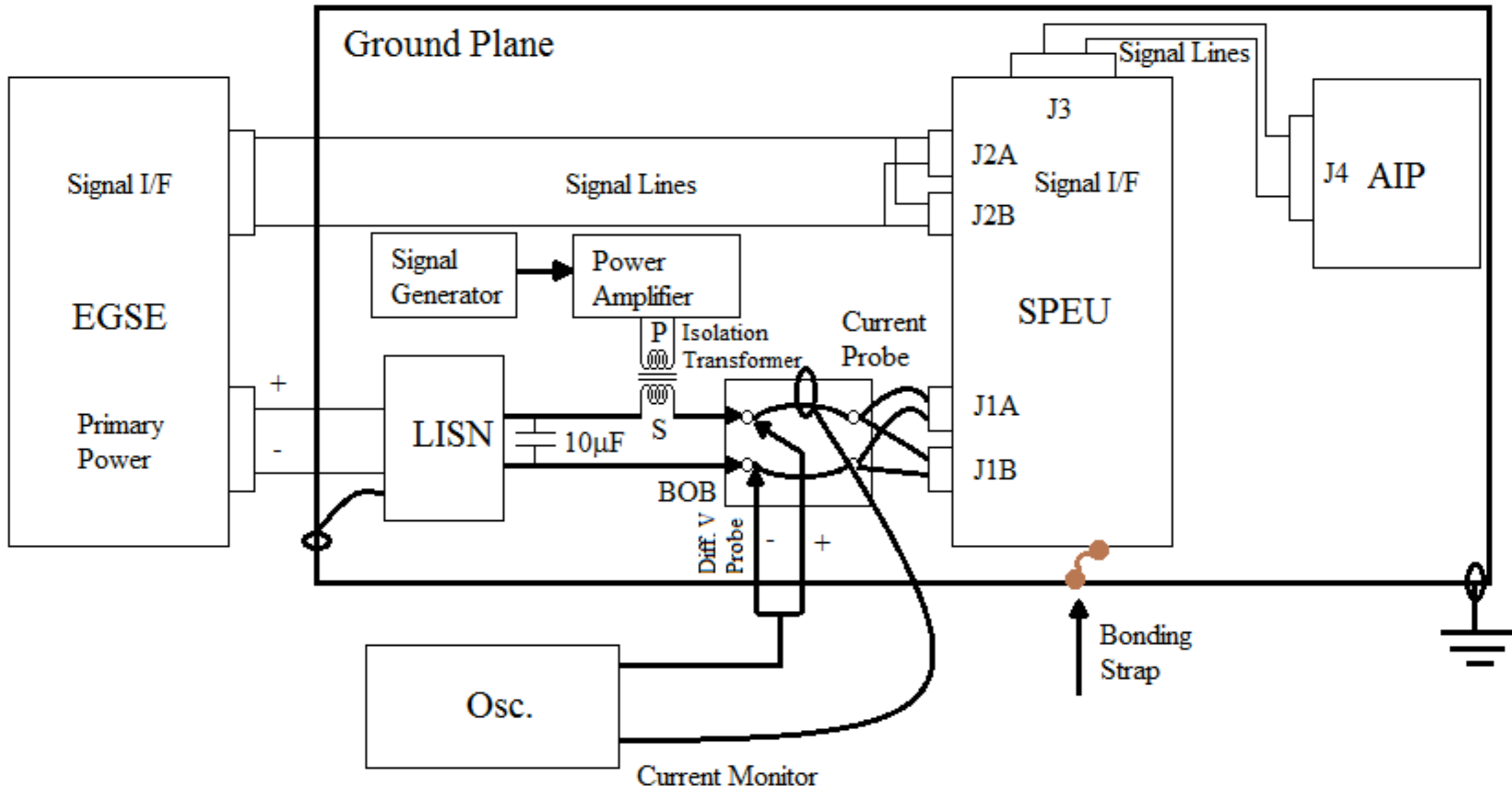


Step	Action
1	將設備如圖所示擺設好，只連接J1A（J1B不連接）。
2	確認AIP測試的設置與接線。請參考FS5SPL-CT-PROC的3.4.3.1節。並設置AIP主電源為+28VDC。
3	確認EMC設備已上電。
4	在EGSE方面，確認功能測試程序。請參考FS5SPL-CT-PROC的3.4.3.2節。
5	在EGSE方面，監控指令與遙傳介面、科學資料是否異常。
6	設置R&S SG Sine波輸出頻率，並且緩慢調整輸出峰對峰電壓到下列的值，接著將示波器上的圖分別存下來。注意AC電流峰值不能超過DC電流的50%。每個頻率的Dwell時間為1秒。
7	確認AIP功能不會因注入而影響其功能。
8	將正極電源線BOB開關打開。
9	解除J1A。將設備如圖所示擺設好，只連接J1B（J1A不連接）。重複步驟3-8。

待測接頭	Frequency	Vpp	檔名
J1A	30k	1.14	CS_30K_A
	50k	0.89	CS_50K_A
	70k	0.73	CS_70K_A
	90k	0.60	CS_90K_A
	100k	0.55	CS_100K_A
	300k	0.55	CS_300K_A
	600k	0.55	CS_600K_A
	1M	0.55	CS_1M_A
	3M	0.55	CS_3M_A
	6M	0.55	CS_6M_A
	10M	0.55	CS_10M_A
	30M	0.55	CS_30M_A
	50M	0.55	CS_50M_A
	70M	0.55	CS_70M_A
	100M	0.55	CS_100M_A
J1B	30k	1.14	CS_30K_B
	50k	0.89	CS_50K_B
	70k	0.73	CS_70K_B
	90k	0.60	CS_90K_B
	100k	0.55	CS_100K_B
	300k	0.55	CS_300K_B
	600k	0.55	CS_600K_B
	1M	0.55	CS_1M_B
	3M	0.55	CS_3M_B
	6M	0.55	CS_6M_B
	10M	0.55	CS_10M_B
	30M	0.55	CS_30M_B
	50M	0.55	CS_50M_B
	70M	0.55	CS_70M_B
	100M	0.55	CS_100M_B

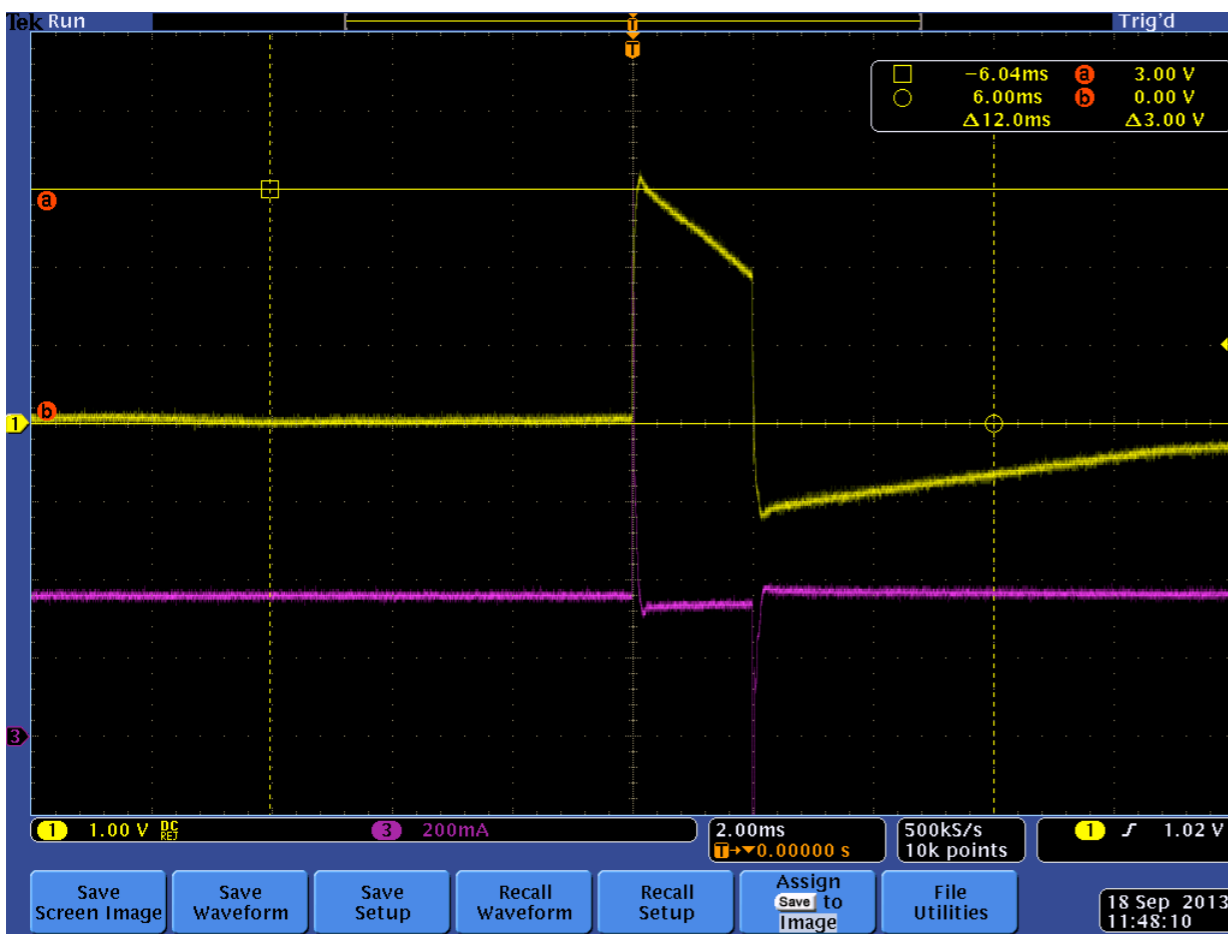
CS on Primary Power Lines-Spike Injection

設置

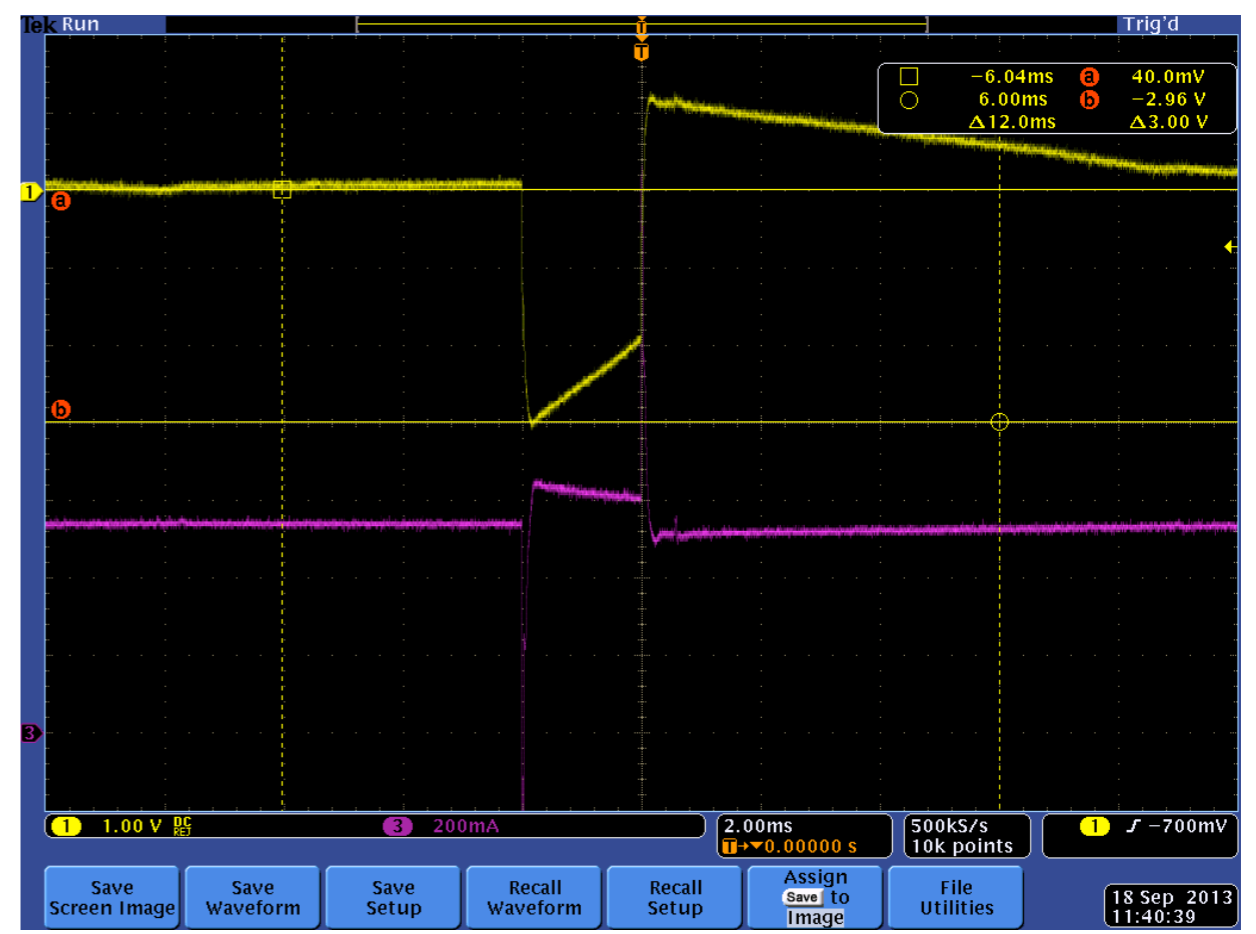


Step	Action
1	將設備如圖所示擺設好，只連接J1A（J1B不連接）。
2	確認AIP測試的設置與接線。請參考FS5SPL-CT-PROC的3.4.3.1節。
3	確認EMC設備已上電。
4	在EGSE方面，確認功能測試程序。請參考FS5SPL-CT-PROC的3.4.3.2節。
5	在EGSE方面，監控指令與遙傳介面、科學資料是否異常。
6	設置AIP的主電源為34VDC。
7	用訊號產生器產生3V/2ms的突波疊加到主線上。每次脈衝設置完後測試時間1分鐘，脈衝頻率為10Hz。將檔案儲存：CS_SPK_+3_A。
8	確認AIP功能正常。
9	將訊號產生器關掉，調整電源放大器至最小值。
10	將變壓器極性顛倒至紅色電源線。
11	設置AIP的主電源為22VDC。
12	用訊號產生器產生-3V/2ms的突波疊加到主線上。每次脈衝設置完後測試時間1分鐘，脈衝頻率為10Hz。將檔案儲存：CS_SPK_-3_A。
13	將正極電源線BOB開關打開。
14	解除J1A。將設備如圖所示擺設好，只連接J1B（J1A不連接）。重複步驟3-8。

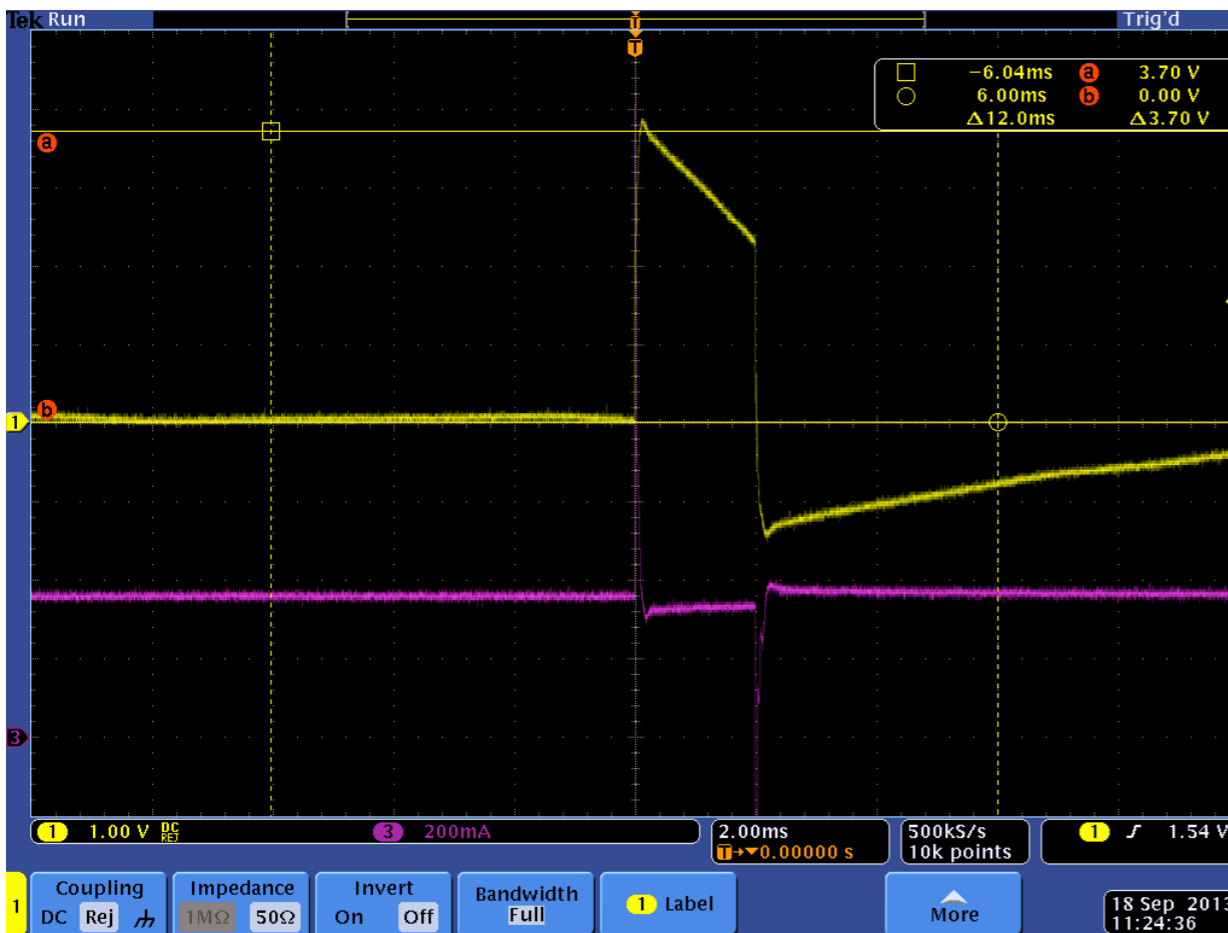
待測接頭	電源設置	突波	檔名
J1A	34V	3V/2ms	CS_SPK_+3_A
	22V	-3V/2ms	CS_SPK_-3_A
J1B	34V	3V/2ms	CS_SPK_+3_B
	22V	-3V/2ms	CS_SPK_-3_B



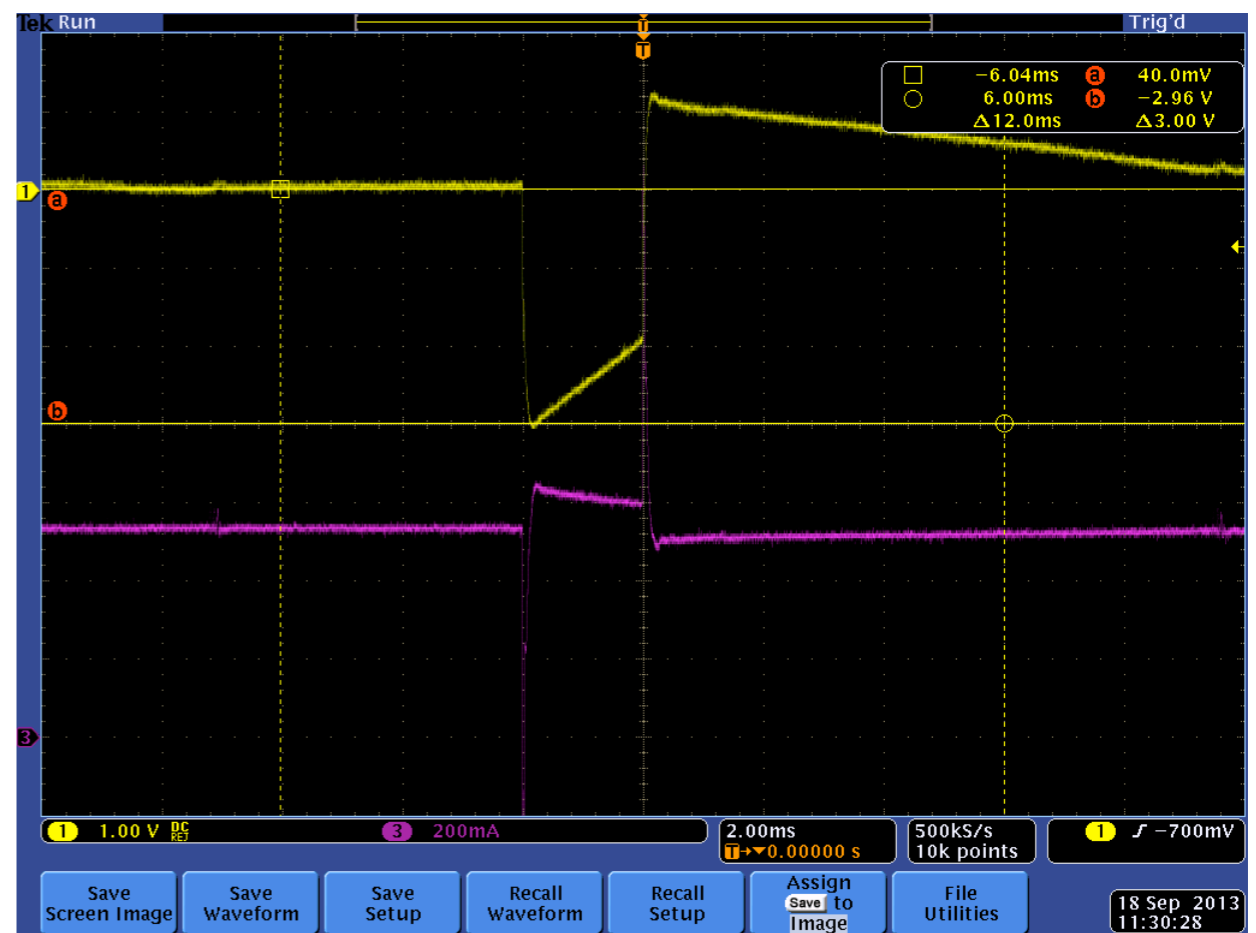
Spike injection on the Primary Power Line of the primary controller for +34VDC with +3V/2ms.



Spike injection on the Primary Power Line of the primary controller for +22VDC with -3V/2ms.



Spike injection on the Primary Power Line of the redundant controller for +34V with +3V/2ms.



Spike injection on the Primary Power Line of the redundant controller for +22VDC with -3V/2ms.

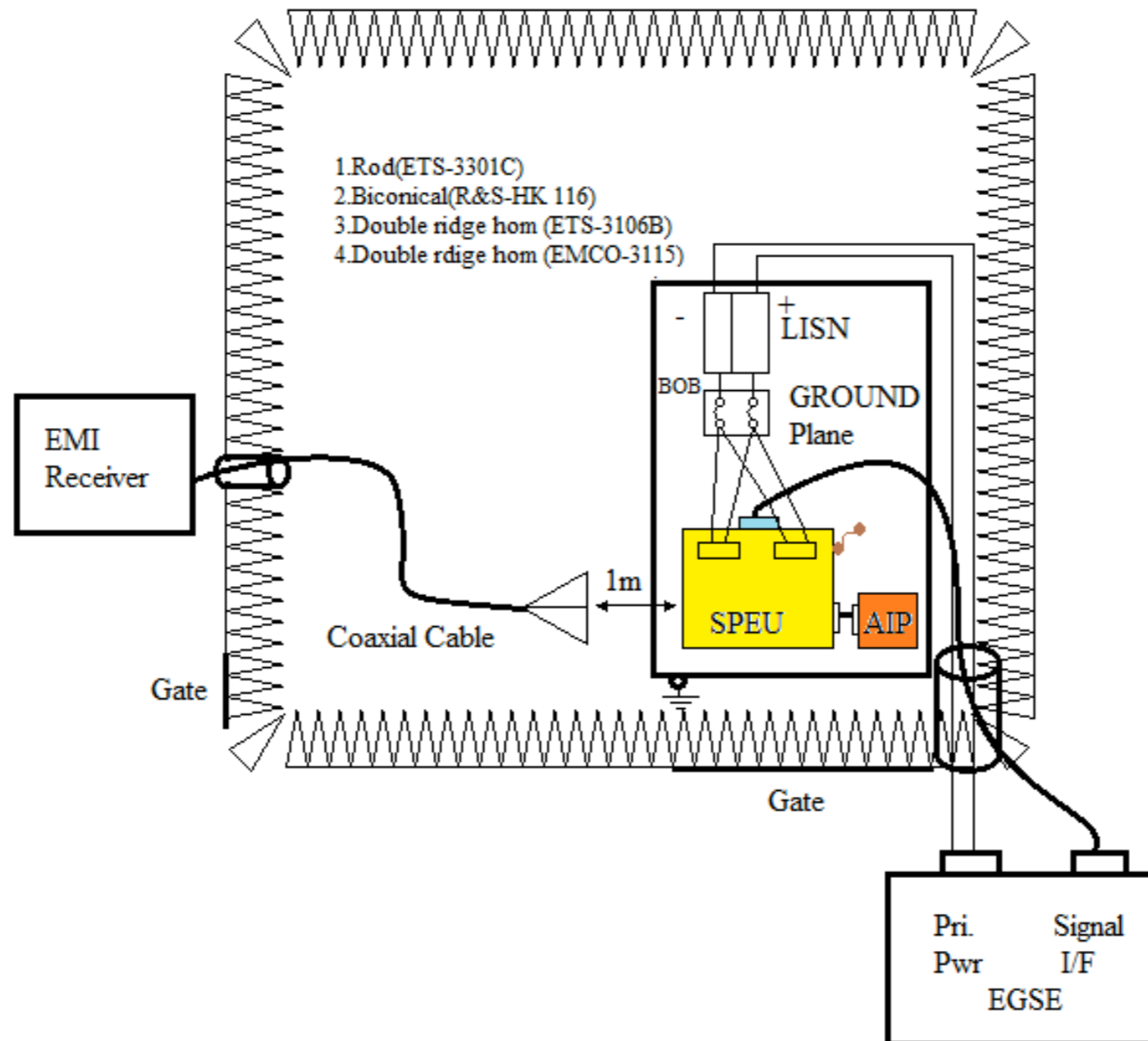
Radiated EMC Test

Radiated EMC Test

- Background Noise Measurement
- Radiated Emission Test
- Radiated Susceptibility Test

Background Noise Measurement

設置



Background Noise Measurement

Step	Action
1	確認AIP測試的設置與接線。請參考FS5SPL-CT-PROC的3.4.3.1節。
2	確認EMC設備已上電。
3	將設備如圖所示擺設好，將Rod antenna (3310C) 設置成垂直方位，準備進行14KHz~30MHz的量測。
4	設置EMC32的檔案為FS5_RE_14K-30M。
5	確認量測頻率範圍為14KHz~30MHz。
6	完成量測，將檔案存檔，檔名：BG_AIP_14K-30M。

Antenna	EMC File	檔名
Rod antenna (3310C)	FS5_RE_14K-30M	BG_AIP_14K-30M
Biconical (HK116)	FS5_RE_30M-200M	V : BG_AIP_30M-200M_V
		H : BG_AIP_30M-200M_H
Double ridge horn (3106B)	FS5_RE_200M-1G	V : BG_AIP_200M-1G_V
		H : BG_AIP_200M-1G_H
Double ridge horn (3115)	FS5_RE_1G-10G	V : BG_AIP_1G-10G_V
		H : BG_AIP_1G-10G_H
	FS5_RE_1565M-1585M	V : BG_AIP_1565M-1585M_V
		H : BG_AIP_1565M-1585M_H
	FS5_RE_2039M-2041M	V : BG_AIP_2039M-2041M_V
		H : BG_AIP_2039M-2041M_H
	FS5_RE_2025M-2110M	V : BG_AIP_2025M-2110M_V
		H : BG_AIP_2025M-2110M_H

Radiated Emission Test

RE Limits

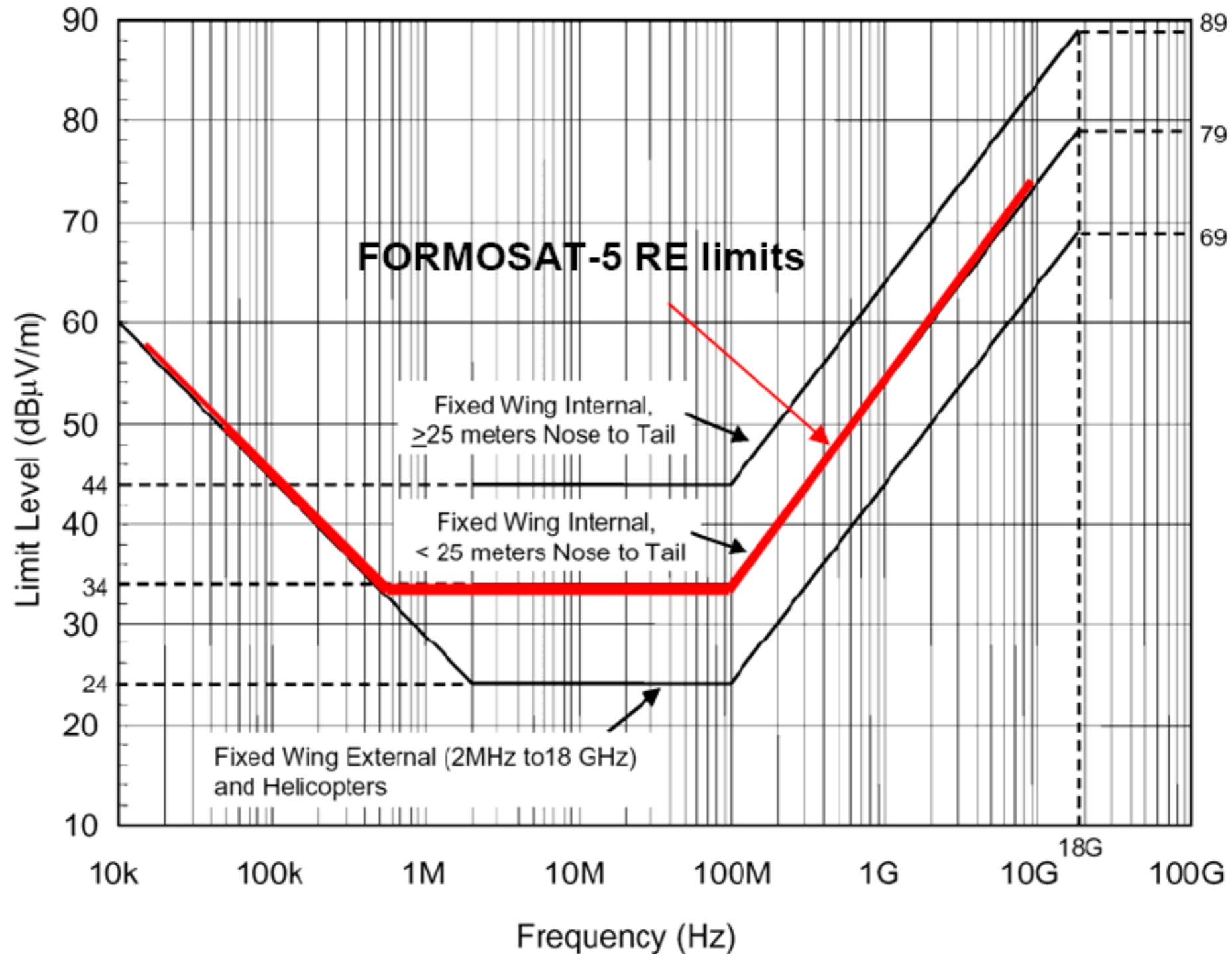


Fig. 5-2 RE Limits

Step	Action
1	將設備如圖所示擺設好，只連接J1A（J1B不連接）。將Rod antenna（3310C）設置成垂直方位，準備進行14KHz~30MHz的量測。
2	確認AIP測試的設置與接線。請參考FS5SPL-CT-PROC的3.4.3.1節。
3	確認EMC設備已上電。
4	在EGSE方面，確認功能測試程序。請參考FS5SPL-CT-PROC的3.4.3.2節。
5	在EGSE方面，監控指令與遙傳介面、科學資料是否異常。
6	設置EMC32的檔案為FS5_RE_14K-30M。
7	確認量測頻率範圍為14KHz~30MHz。
8	完成量測，將檔案存檔，檔名：RE_AIP_14K-30M_A。
-	-
45	最後要打開正極電源（紅線）BOB開關。

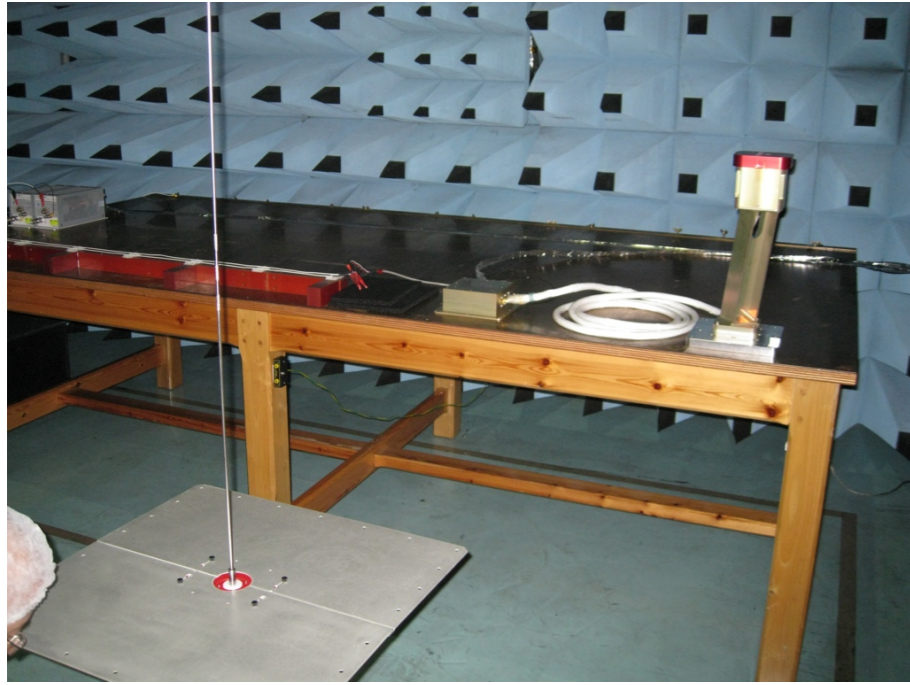
Primary (J1A)

Antenna	EMC Test File	檔名
Rod antenna (3310C)	FS5_RE_14K-30M	RE_AIP_14K-30M_A
Biconical (HK116)	FS5_RE_30M-200M	V : RE_AIP_30M-200M_V_A
		H : RE_AIP_30M-200M_H_A
Double ridge horn (3106B)	FS5_RE_200M-1G	V : RE_AIP_200M-1G_V_A
		H : RE_AIP_200M-1G_H_A
Double ridge horn (3115)	FS5_RE_1G-10G	V : RE_AIP_1G-10G_V_A
		H : RE_AIP_1G-10G_H_A
	FS5_RE_1565M-1585M	V : RE_AIP_1565M-1585M_V_A
		H : RE_AIP_1565M-1585M_H_A
	FS5_RE_2039M-2041M	V : RE_AIP_2039M-2041M_V_A
		H : RE_AIP_2039M-2041M_H_A
	FS5_RE_2025M-2110M	V : RE_AIP_2025M-2110M_V_A
		H : RE_AIP_2025M-2110M_H_A

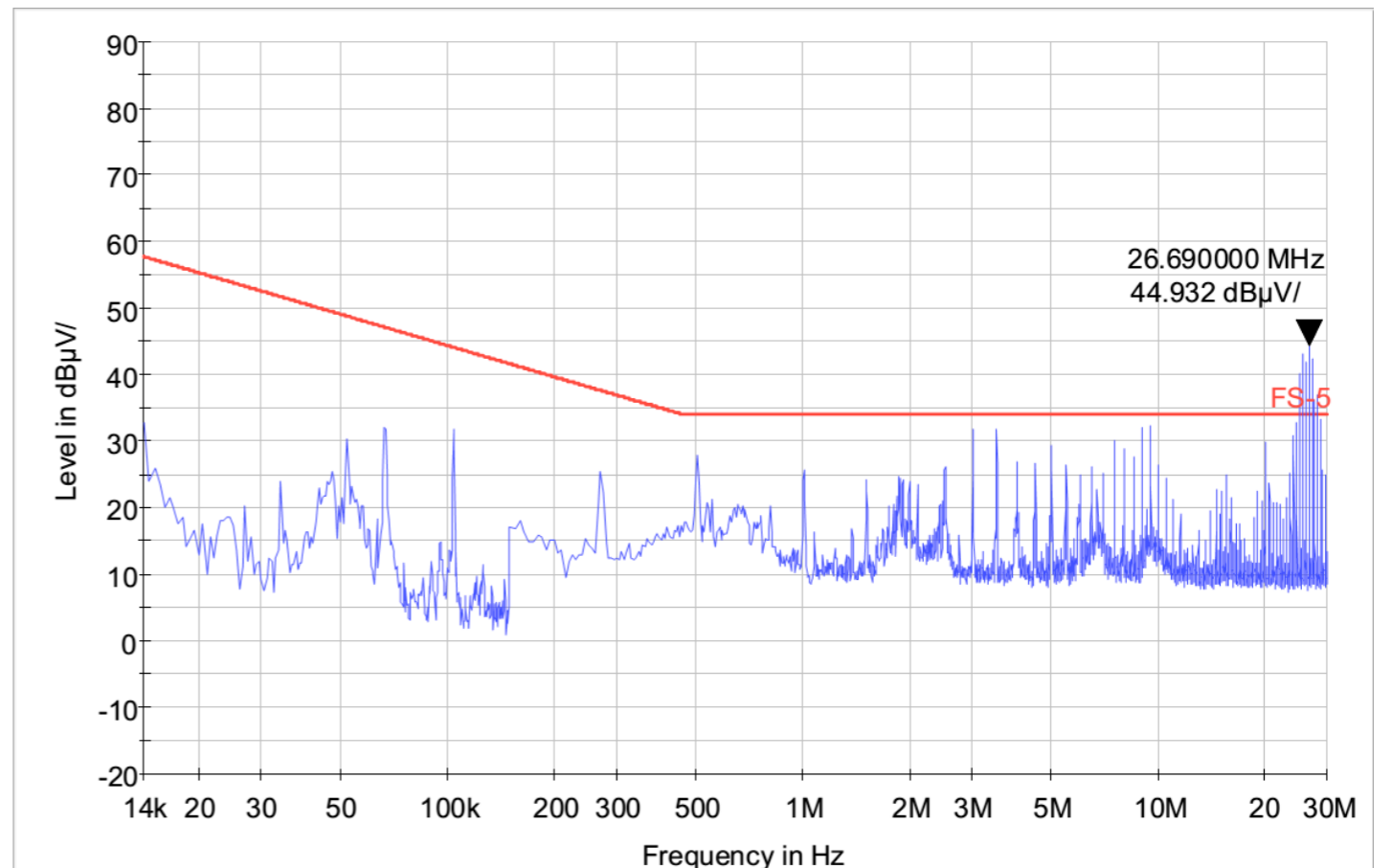
Step	Action
1	將設備如圖所示擺設好，只連接J1B（J1A不連接）。將Rod antenna (3310C) 設置成垂直方位，準備進行14KHz~30MHz的量測。
2	確認AIP測試的設置與接線。請參考FS5SPL-CT-PROC的3.4.3.1節。
3	確認EMC設備已上電。
4	在EGSE方面，確認功能測試程序。請參考FS5SPL-CT-PROC的3.4.3.2節。
5	在EGSE方面，監控指令與遙傳介面、科學資料是否異常。
6	設置EMC32的檔案為FS5_RE_14K-30M。
7	確認量測頻率範圍為14KHz~30MHz。
8	完成量測，將檔案存檔，檔名：RE_AIP_14K-30M_B。
-	-
45	最後要打開正極電源（紅線）BOB開關。

Redundancy (J1B)

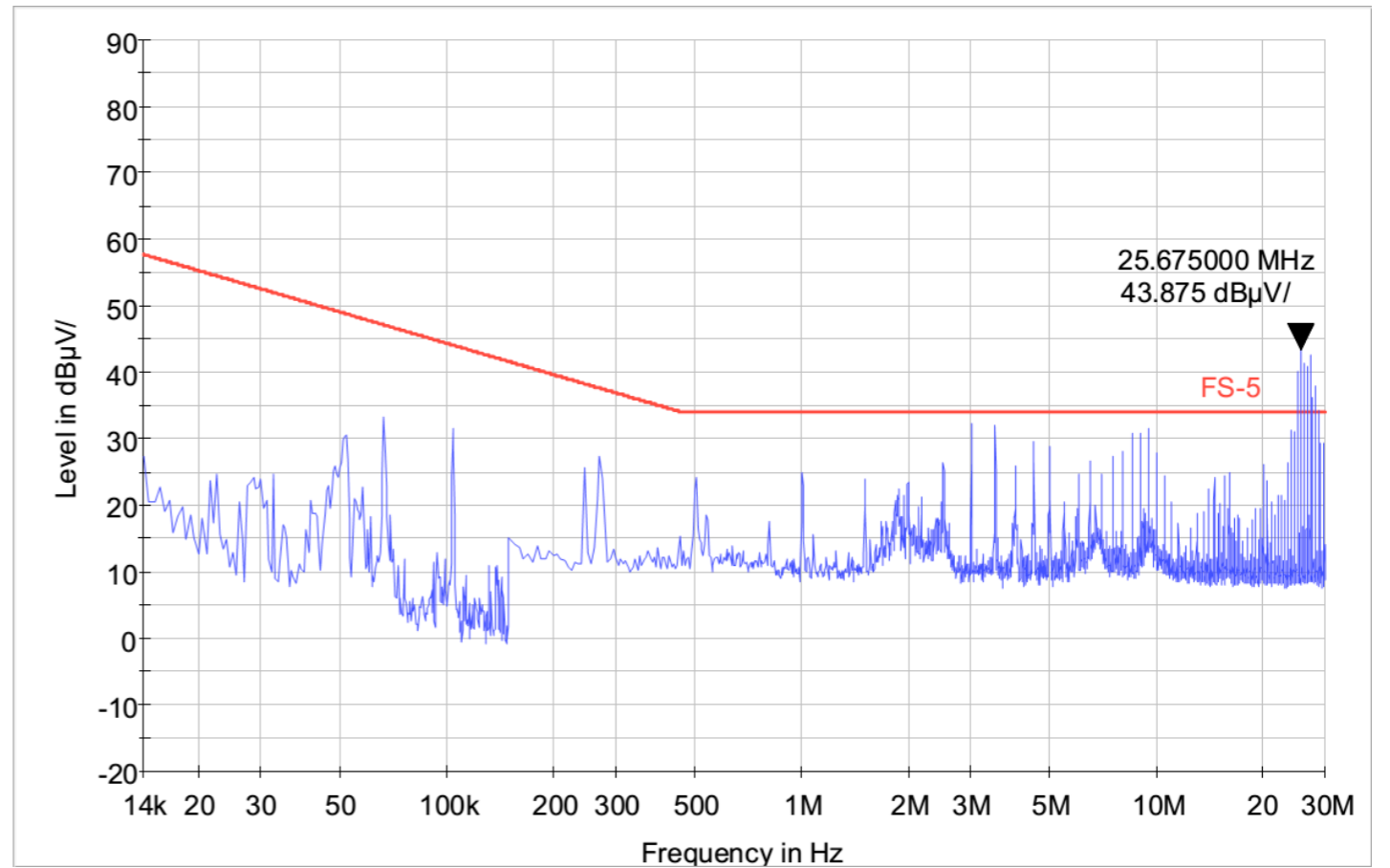
Antenna	EMC Test File	檔名
Rod antenna (3310C)	FS5_RE_14K-30M	RE_AIP_14K-30M_B
Biconical (HK116)	FS5_RE_30M-200M	V : RE_AIP_30M-200M_V_B
		H : RE_AIP_30M-200M_H_B
Double ridge horn (3106B)	FS5_RE_200M-1G	V : RE_AIP_200M-1G_V_B
		H : RE_AIP_200M-1G_H_B
Double ridge horn (3115)	FS5_RE_1G-10G	V : RE_AIP_1G-10G_V_B
		H : RE_AIP_1G-10G_H_B
	FS5_RE_1565M-1585M	V : RE_AIP_1565M-1585M_V_B
		H : RE_AIP_1565M-1585M_H_B
	FS5_RE_2039M-2041M	V : RE_AIP_2039M-2041M_V_B
		H : RE_AIP_2039M-2041M_H_B
	FS5_RE_2025M-2110M	V : RE_AIP_2025M-2110M_V_B
		H : RE_AIP_2025M-2110M_H_B



RE for 14KHz to 30 MHz.



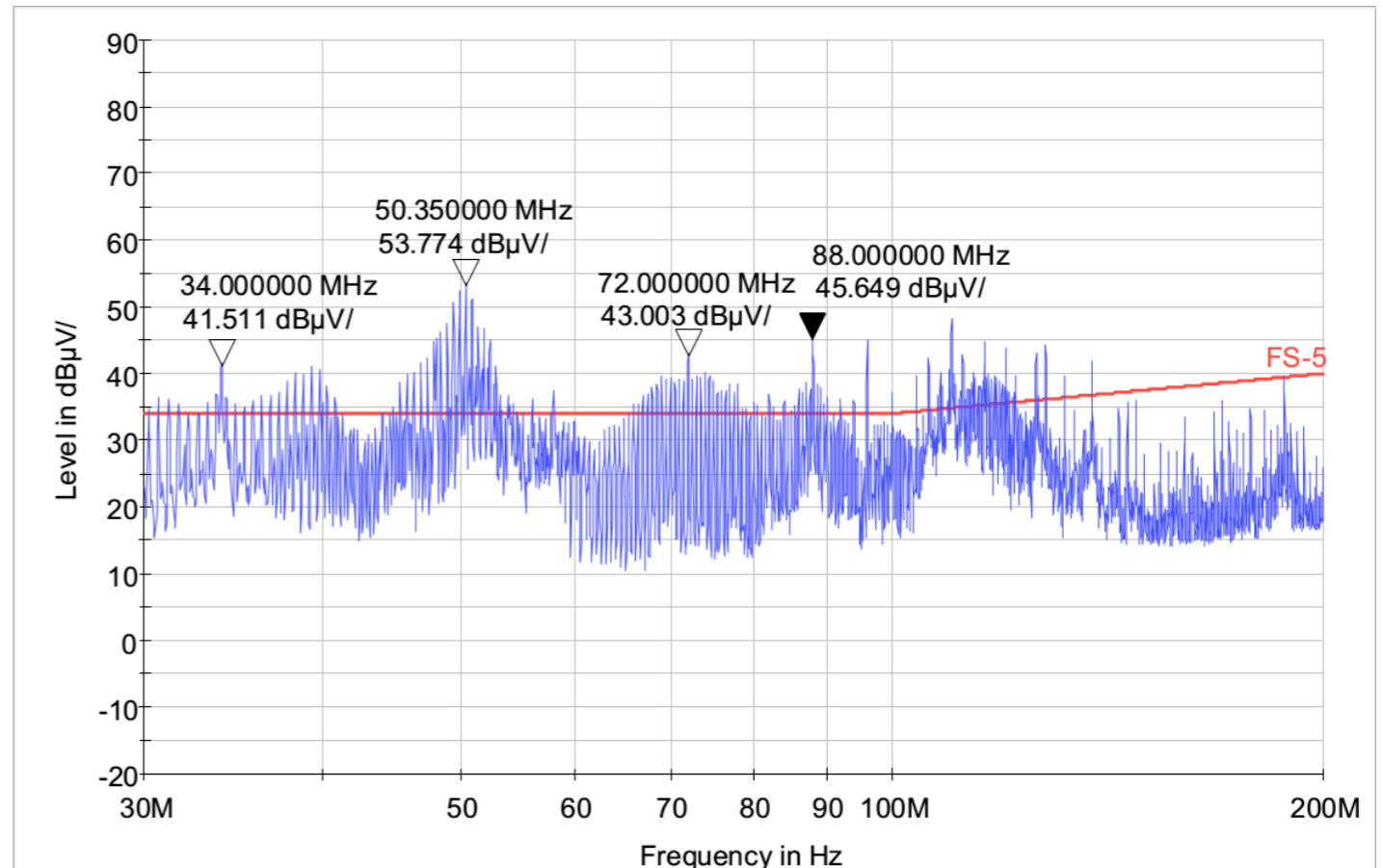
RE with primary controller on for 14KHz to 30 MHz.



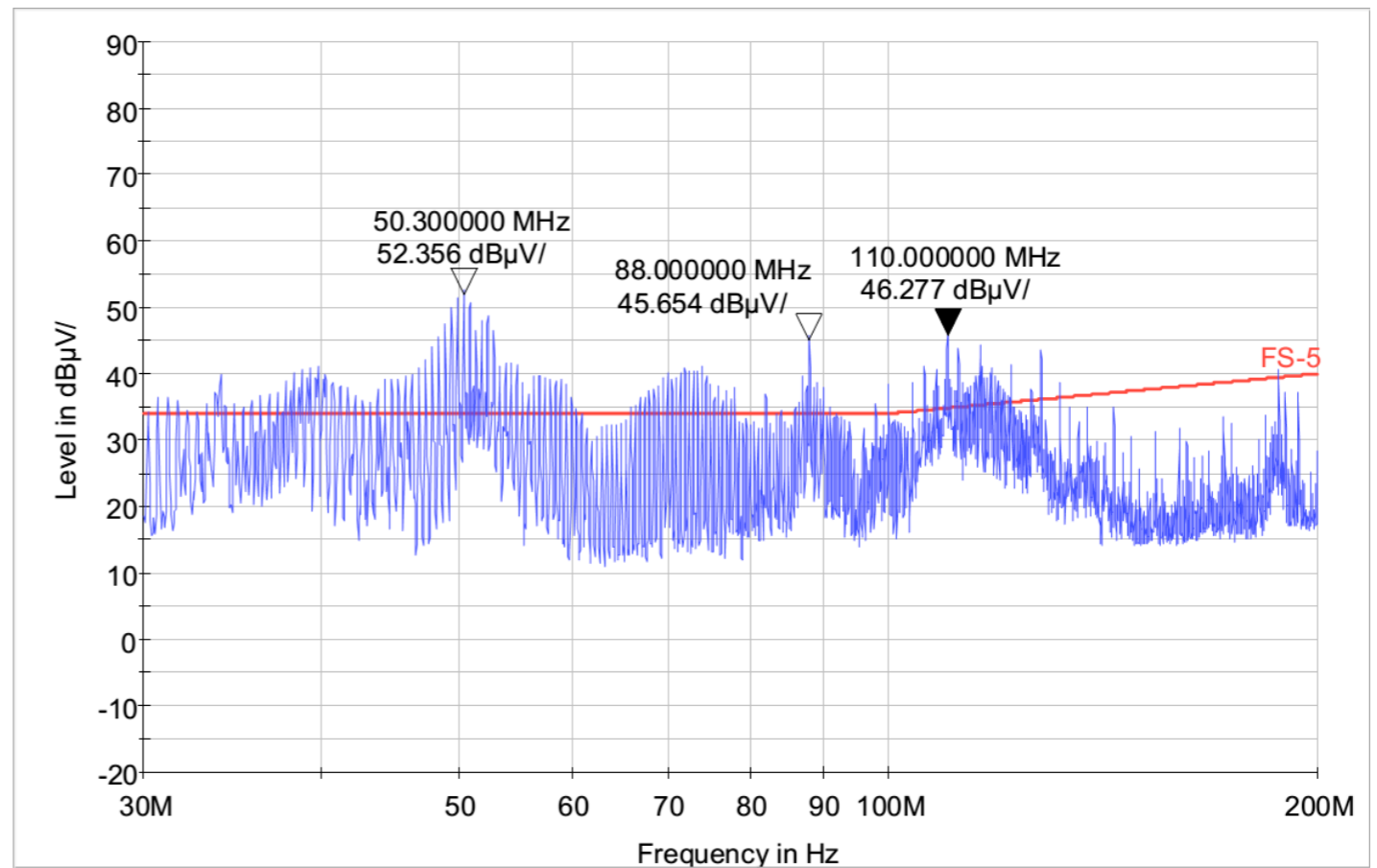
RE with redundant controller on for 14KHz to 30 MHz.



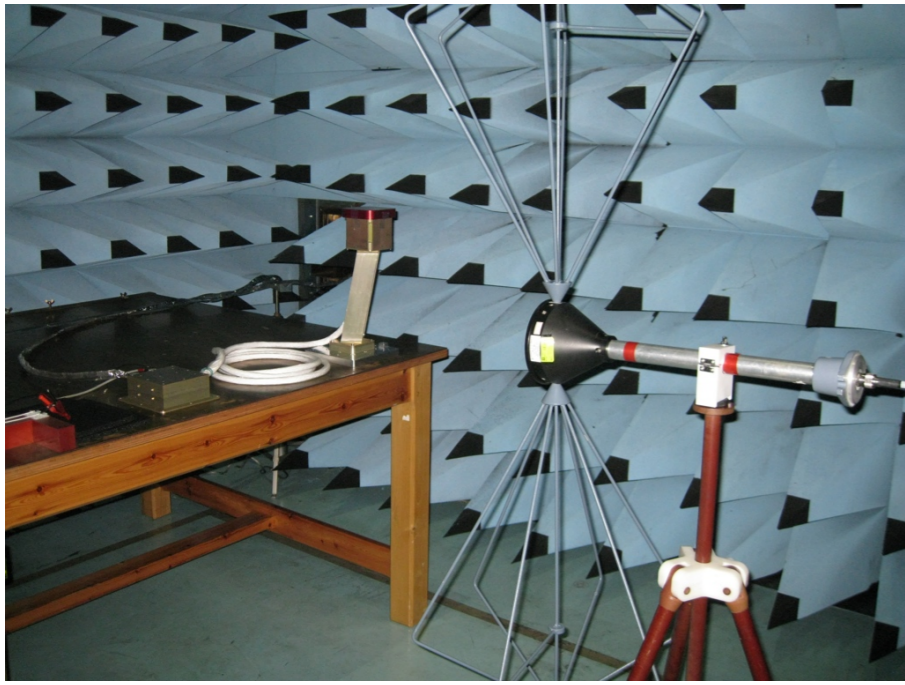
RE for 30 MHz to 200 MHz in horizontal position.



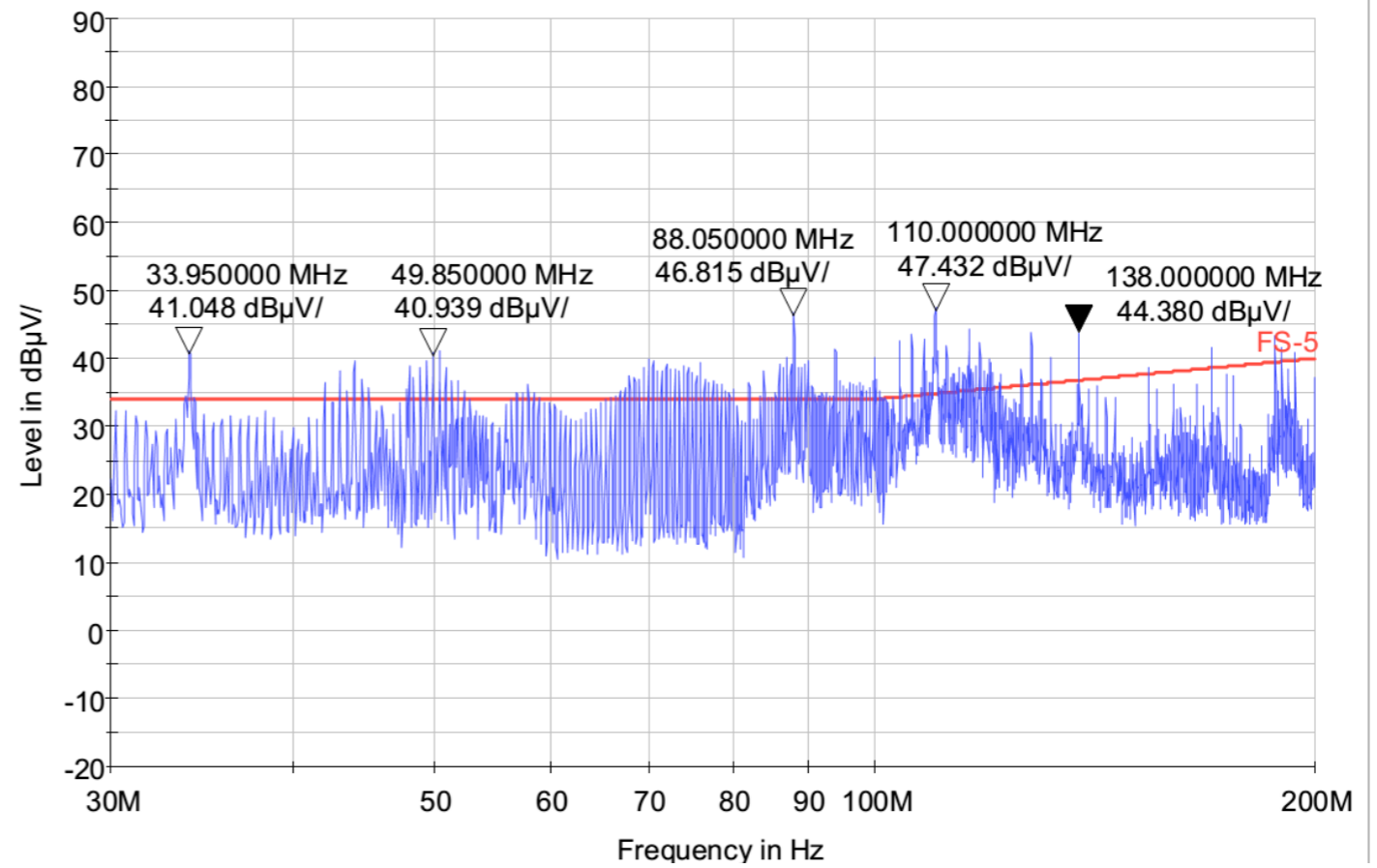
RE with primary controller on for 30 MHz to 200 MHz in horizontal position



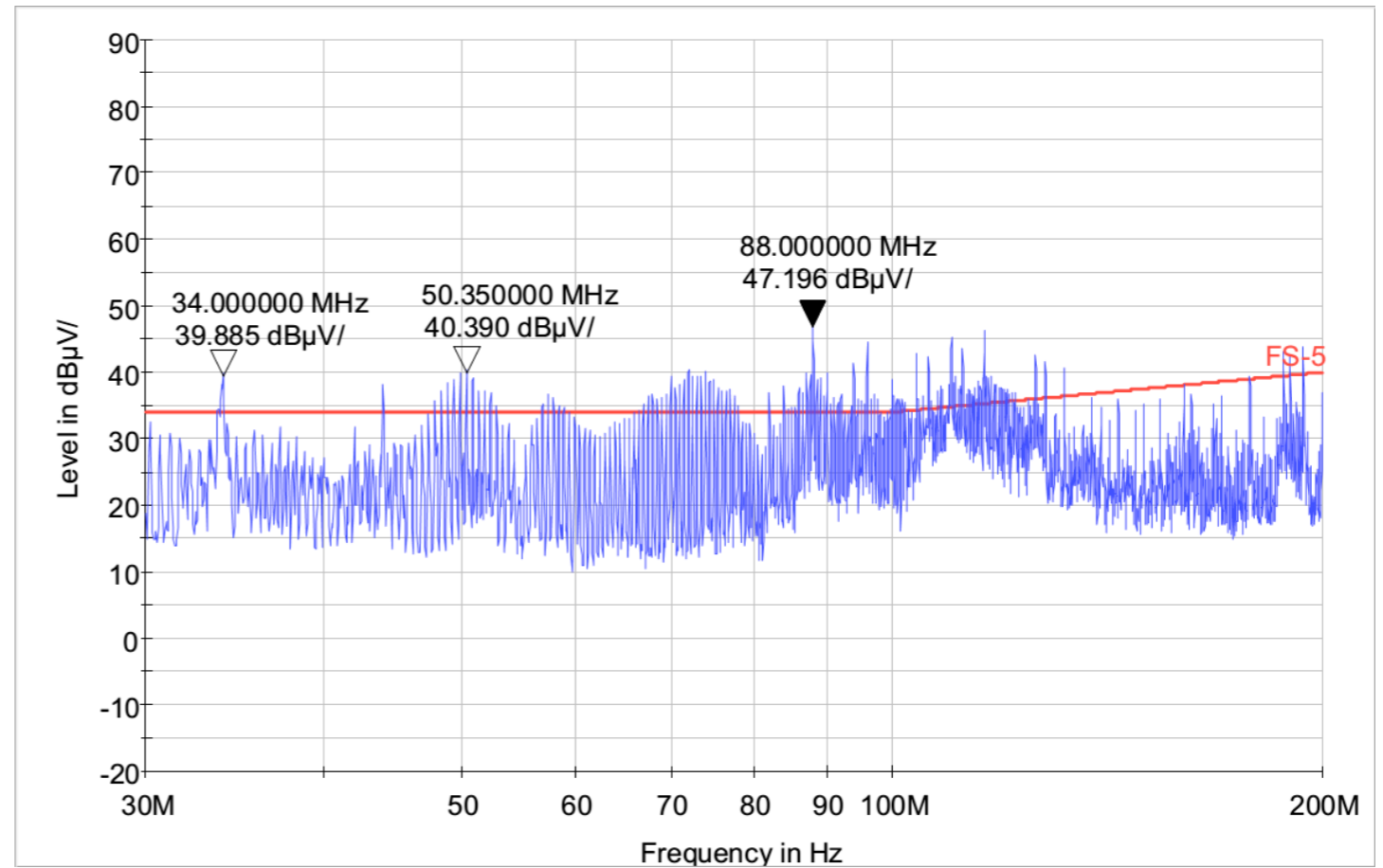
RE with redundant controller on for 30 MHz to 200 MHz in horizontal position



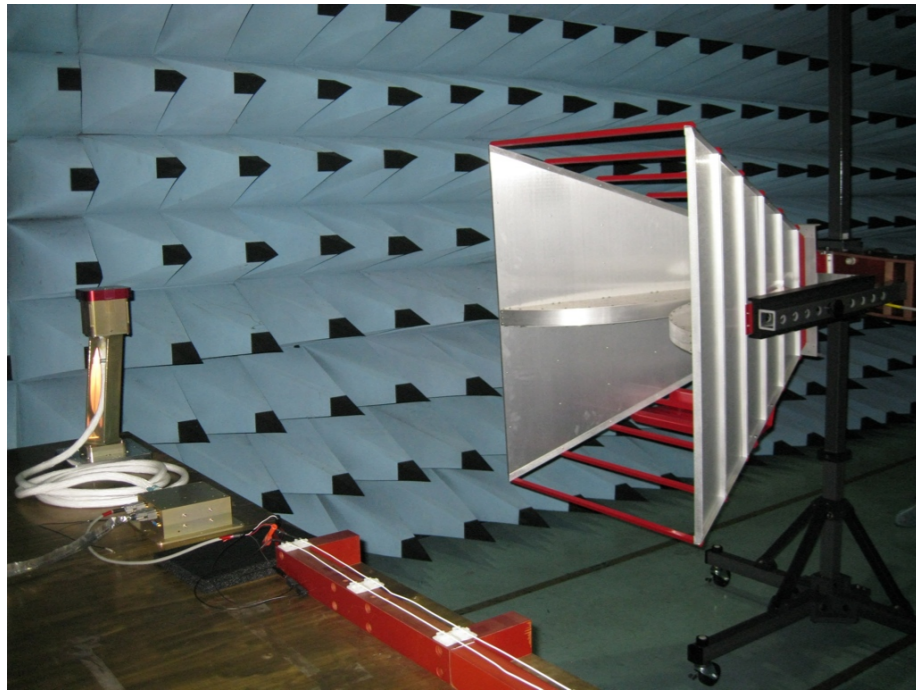
RE for 30 MHz to 200 MHz in vertical position.



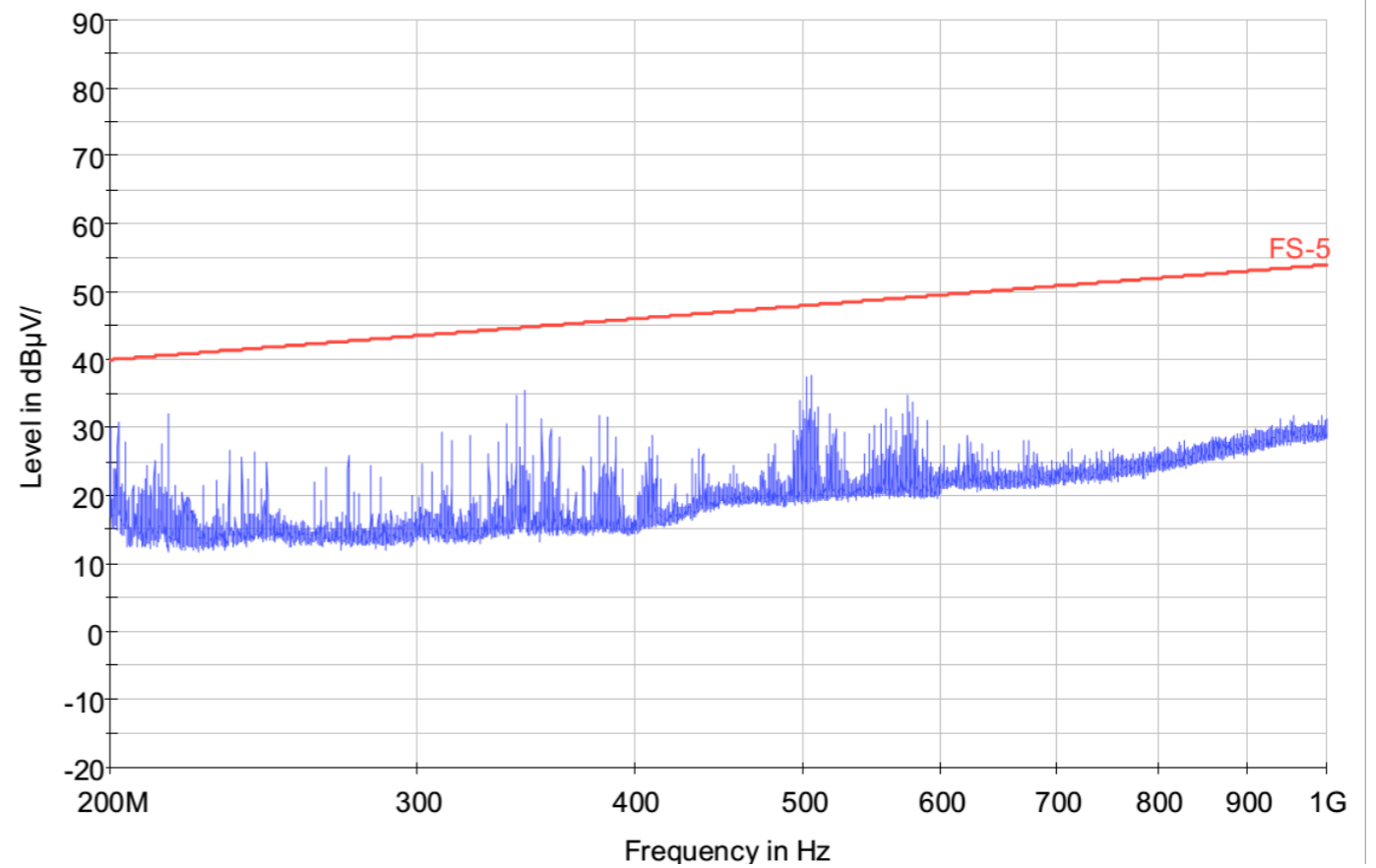
RE with primary controller on for 30 MHz to 200 MHz in vertical position.



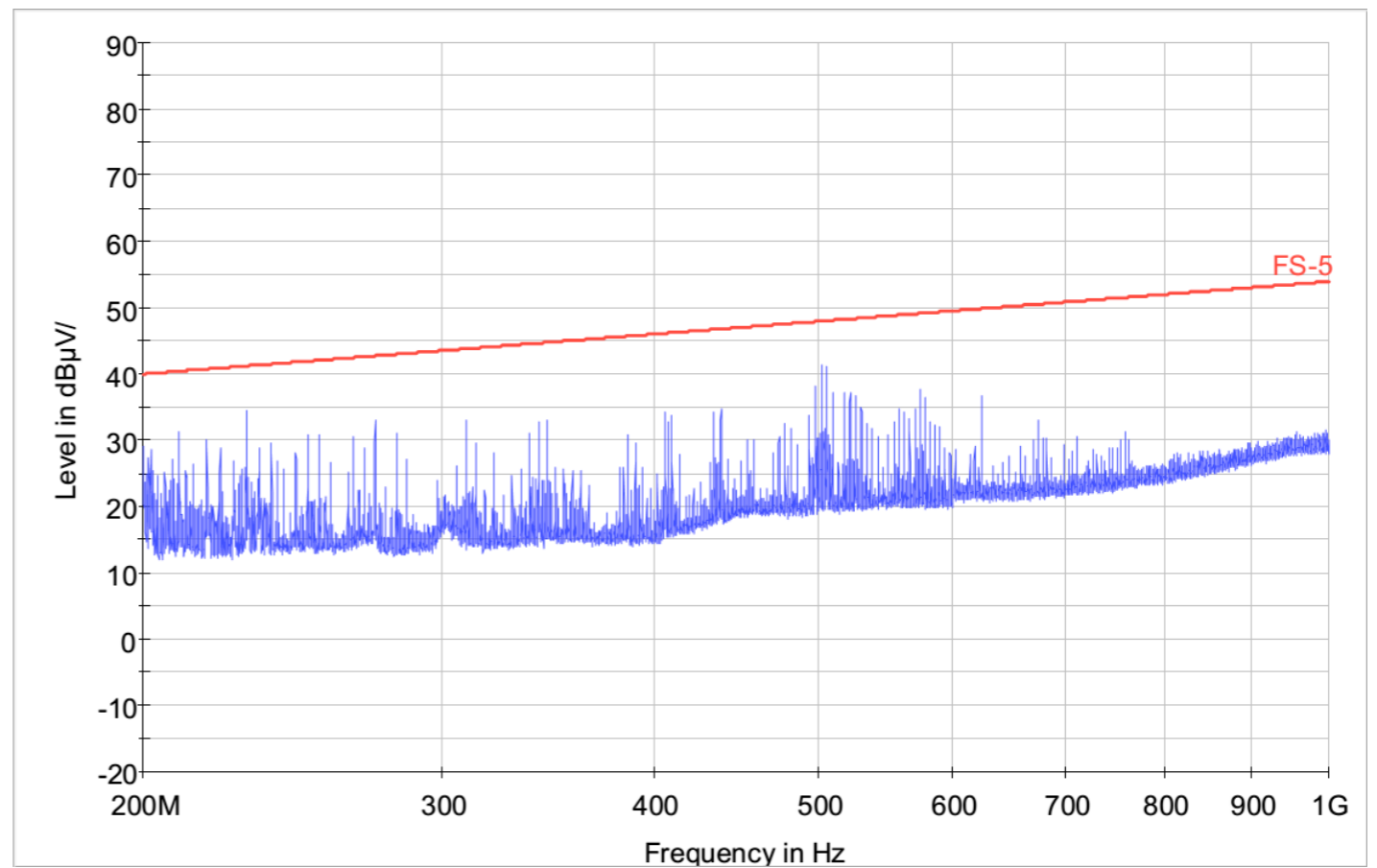
RE with redundant controller on for 30 MHz to 200 MHz in vertical position.



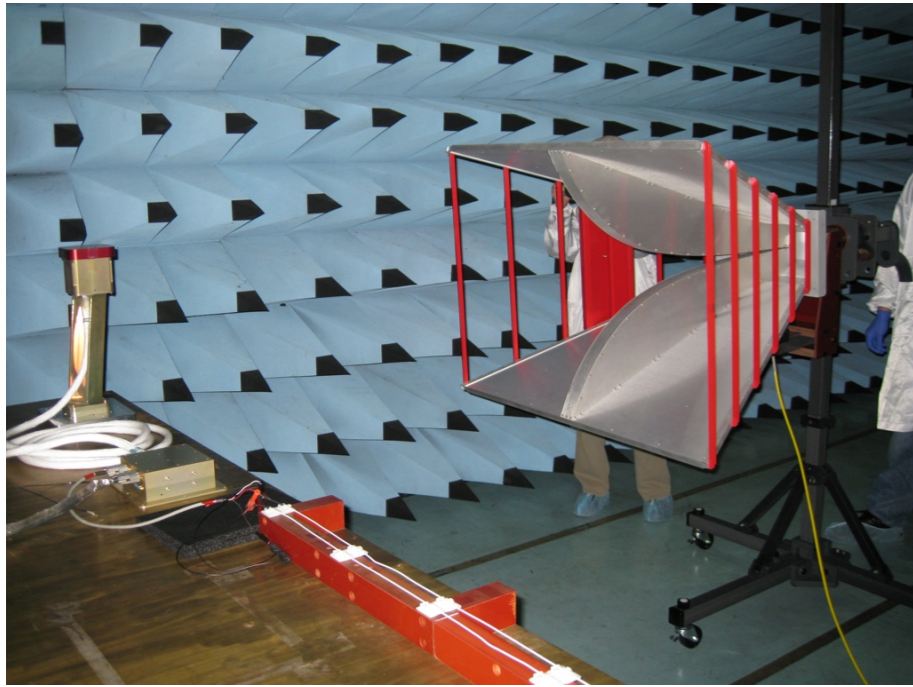
RE for 200 MHz to 1 GHz in horizontal position.



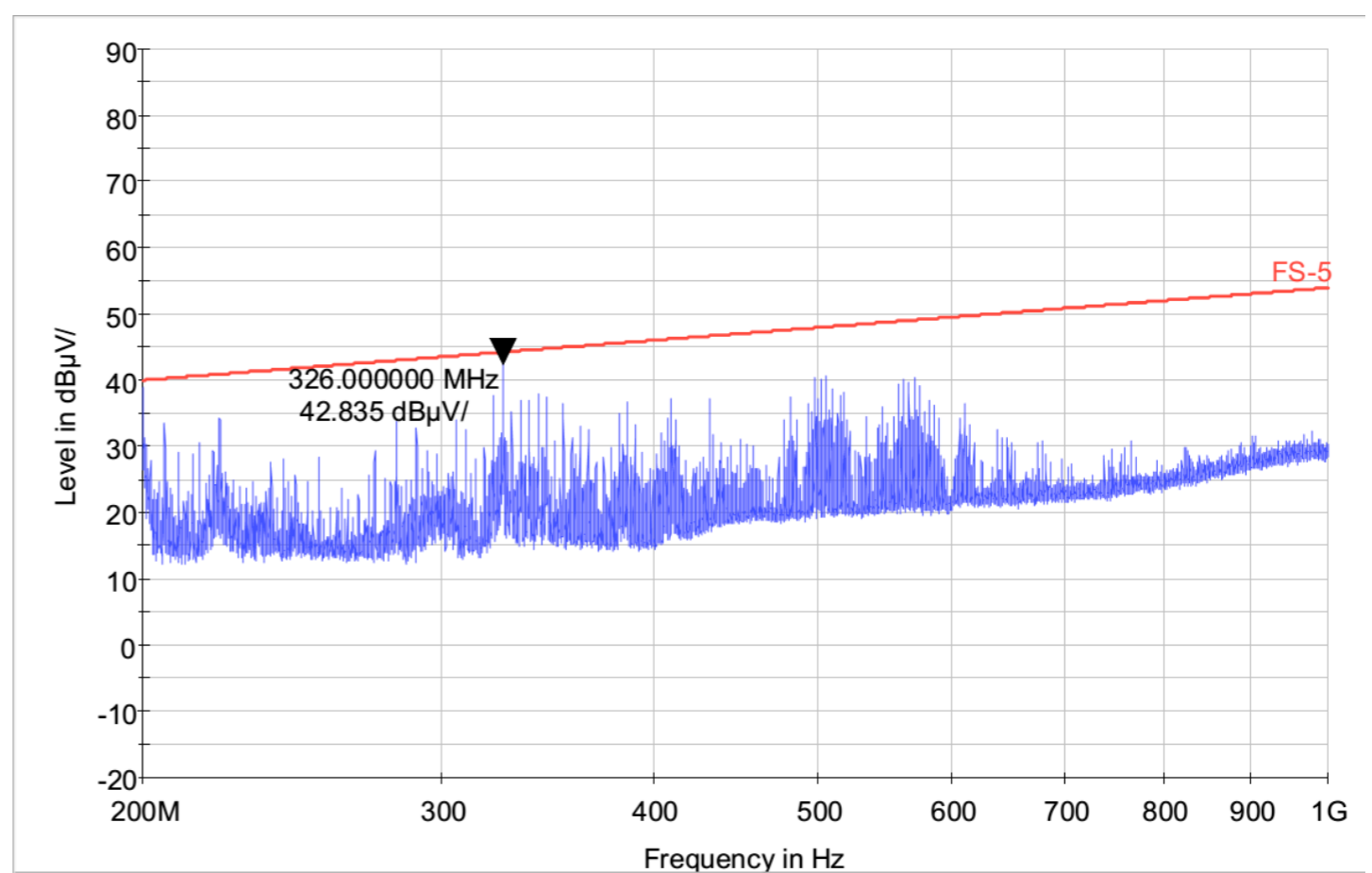
RE with primary controller on for 200 MHz to 1 GHz in horizontal position.



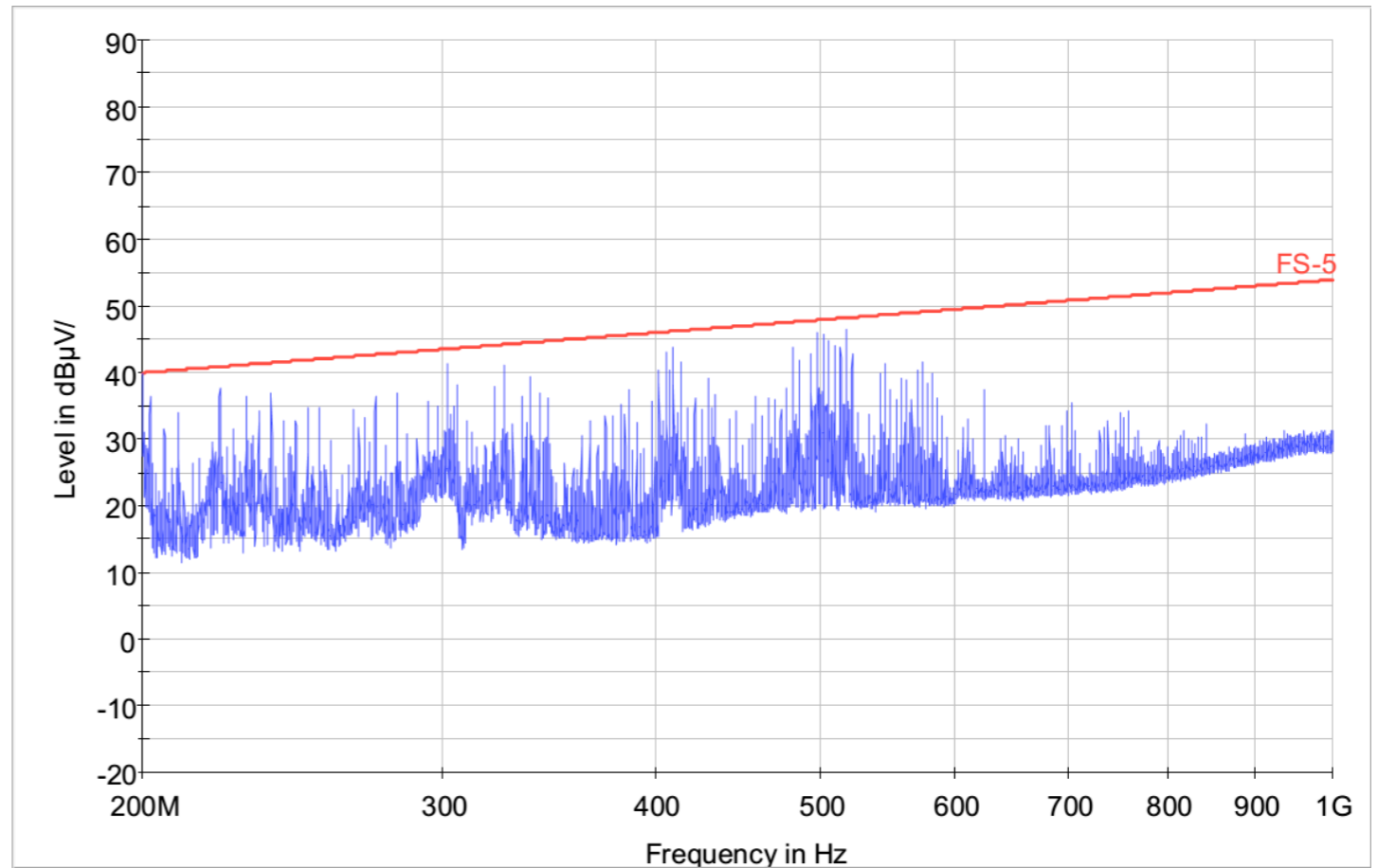
RE with redundant controller on for 200 MHz to 1 GHz in horizontal position.



RE for 200 MHz to 1 GHz in vertical position.



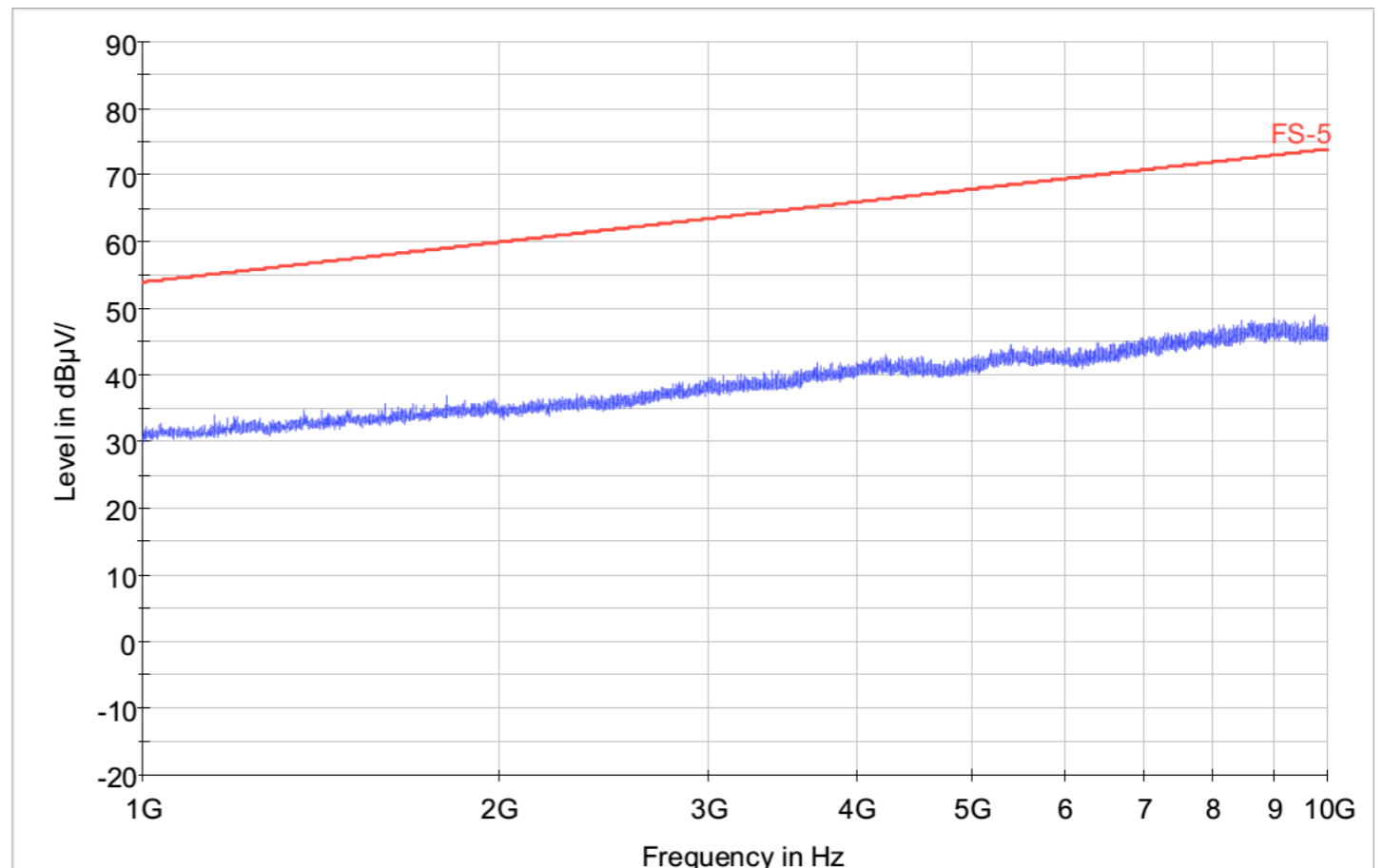
RE with primary controller on for 200 MHz to 1 GHz in vertical position.



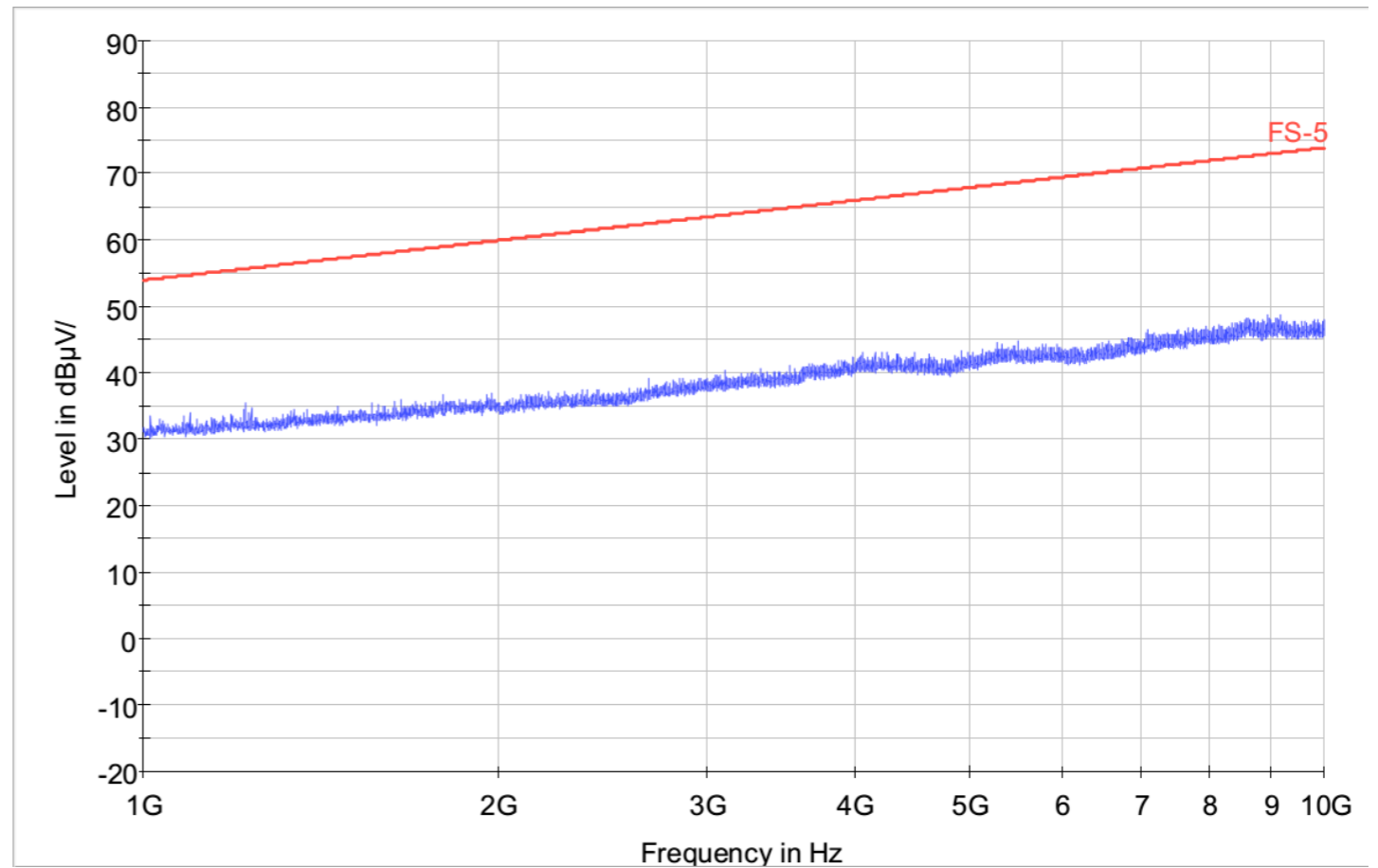
RE with redundant controller on for 200 MHz to 1 GHz in vertical position.



RE for 1 GHz to 10 GHz in horizontal position.



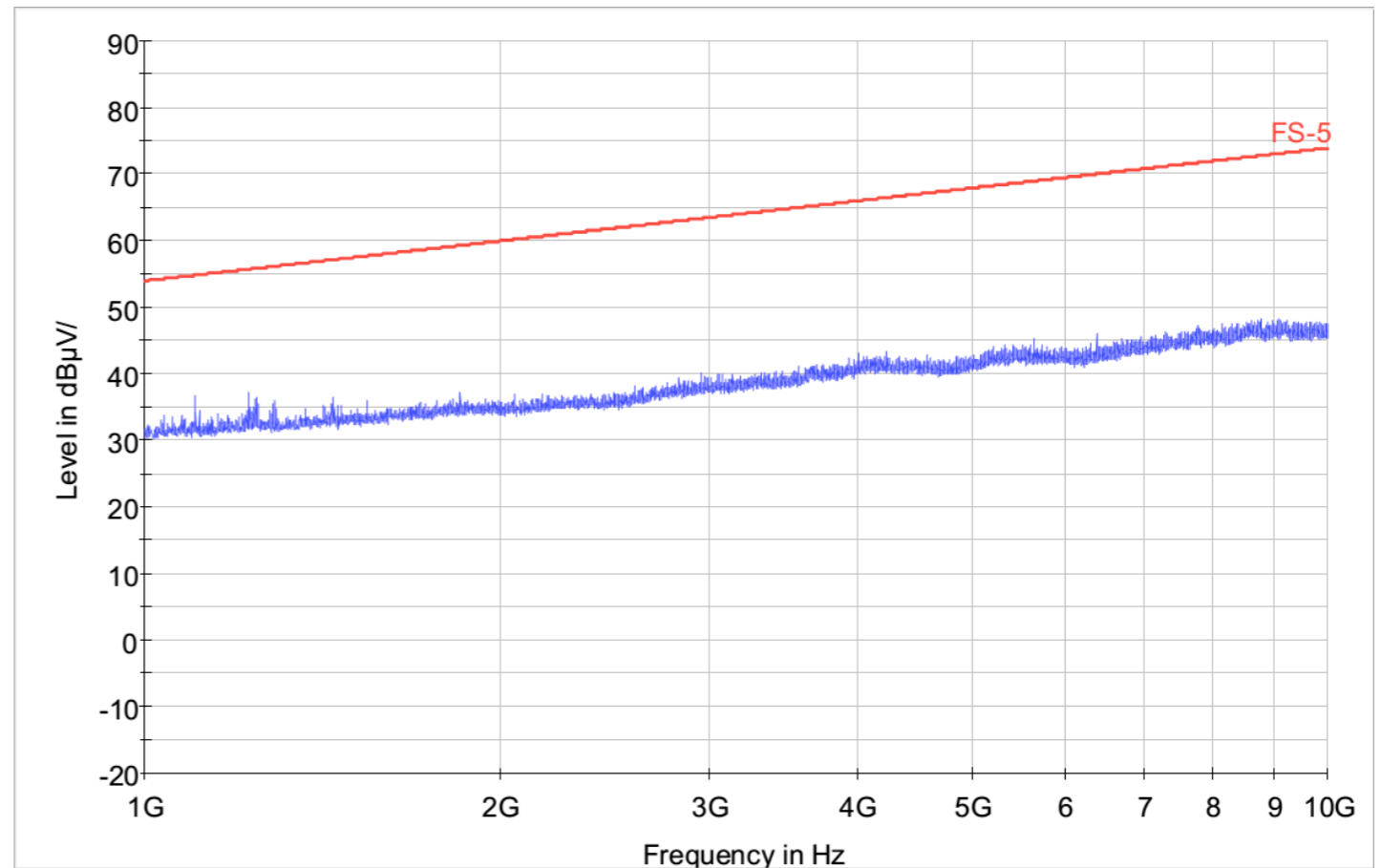
RE with primary controller on for 1 GHz to 10 GHz in horizontal position.



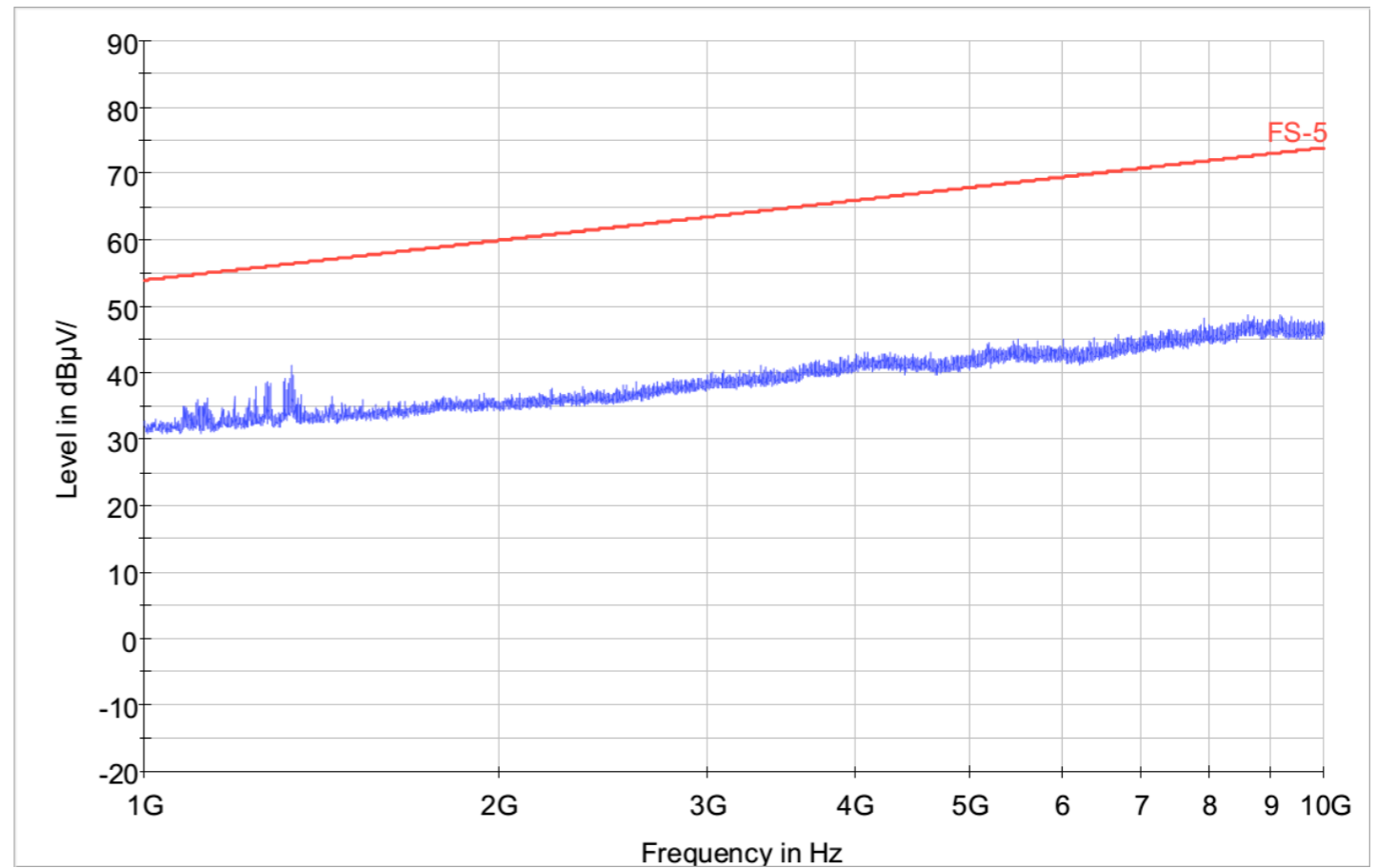
RE with redundant controller on for 1 GHz to 10 GHz in horizontal position.



RE for 1 GHz to 10 GHz in vertical position.



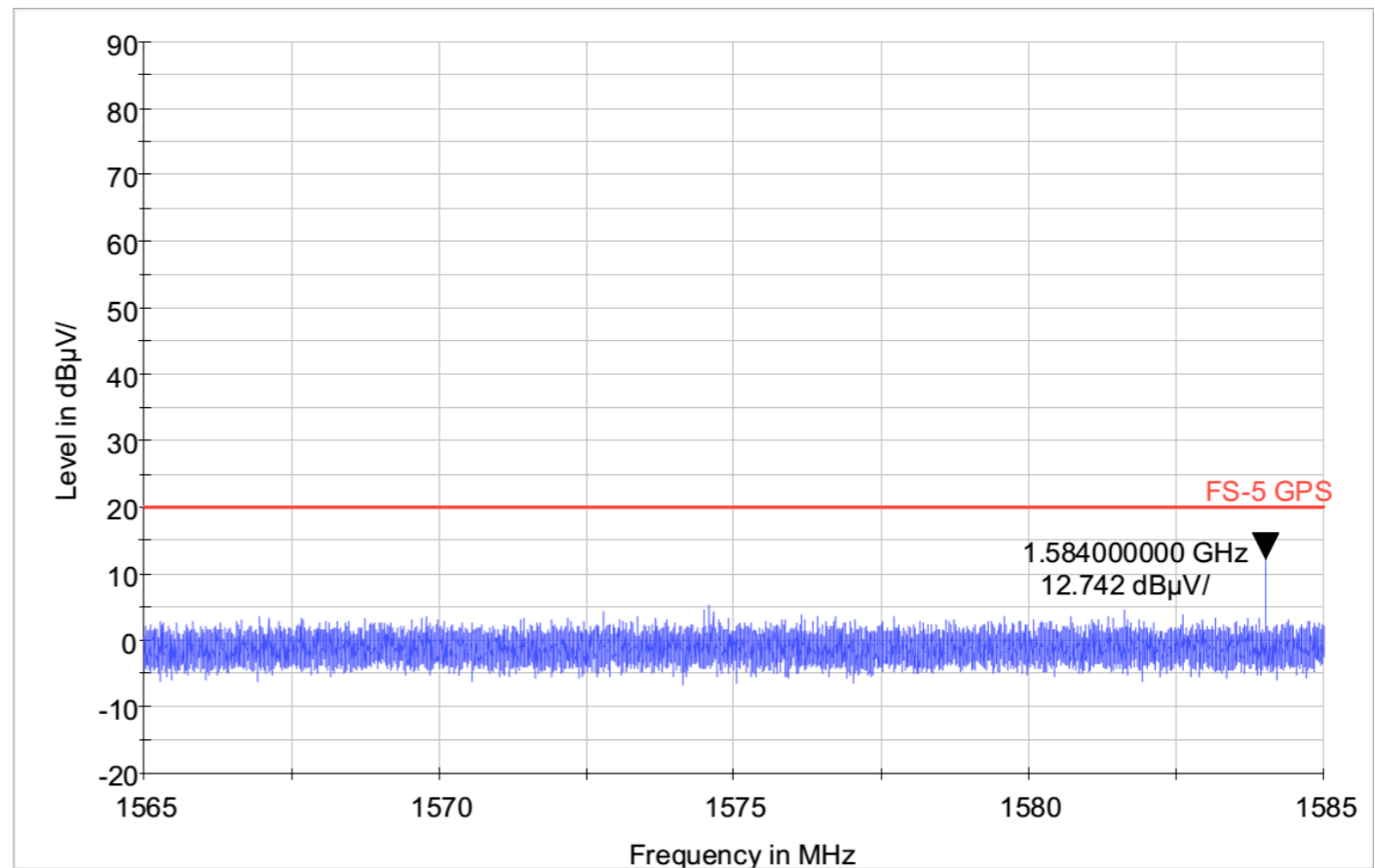
RE with primary controller on for 1 GHz to 10 GHz in vertical position.



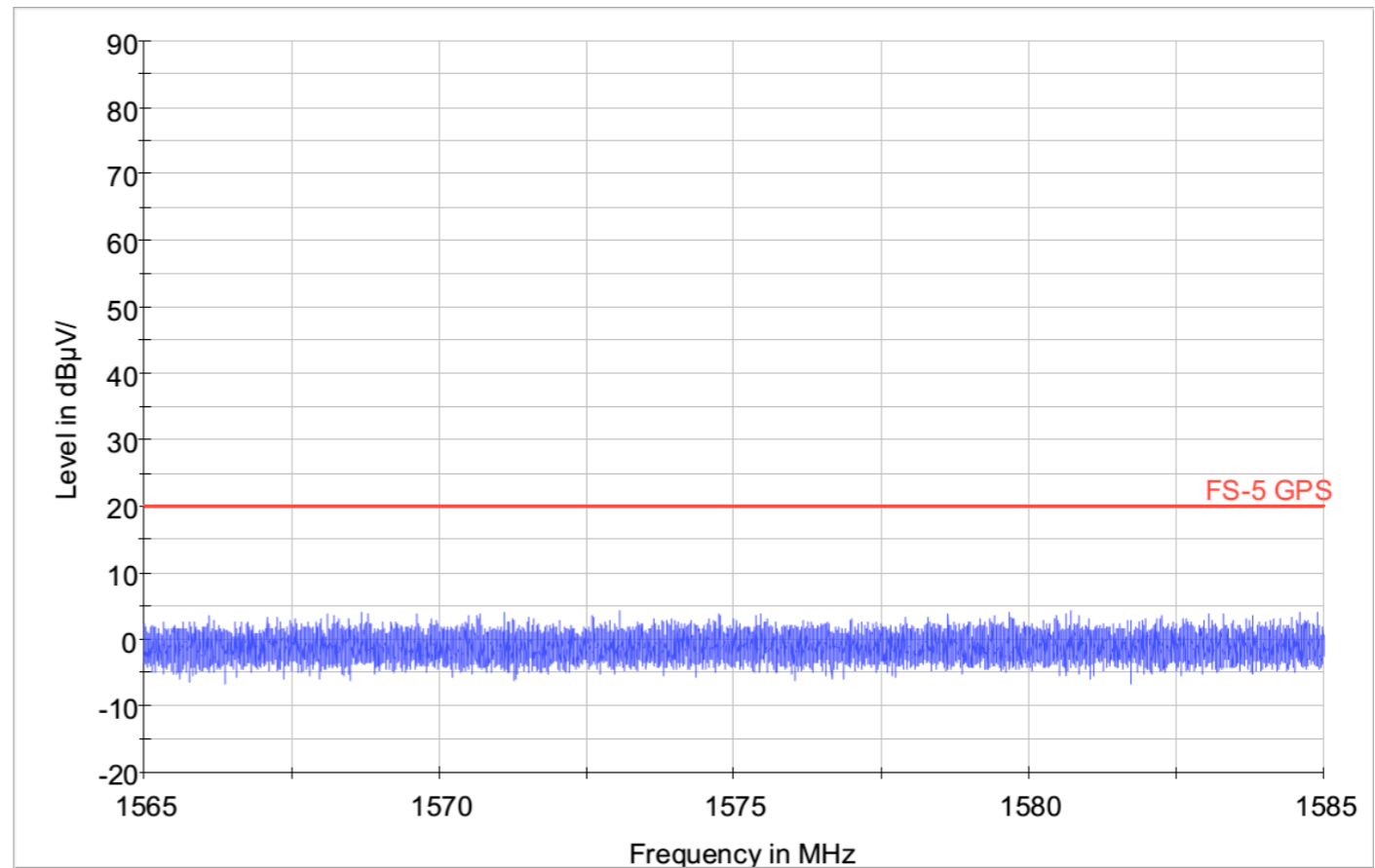
RE with redundant controller on for 1 GHz to 10 GHz in vertical position.



RE for 1,565 MHz to 1,585 MHz in horizontal position.



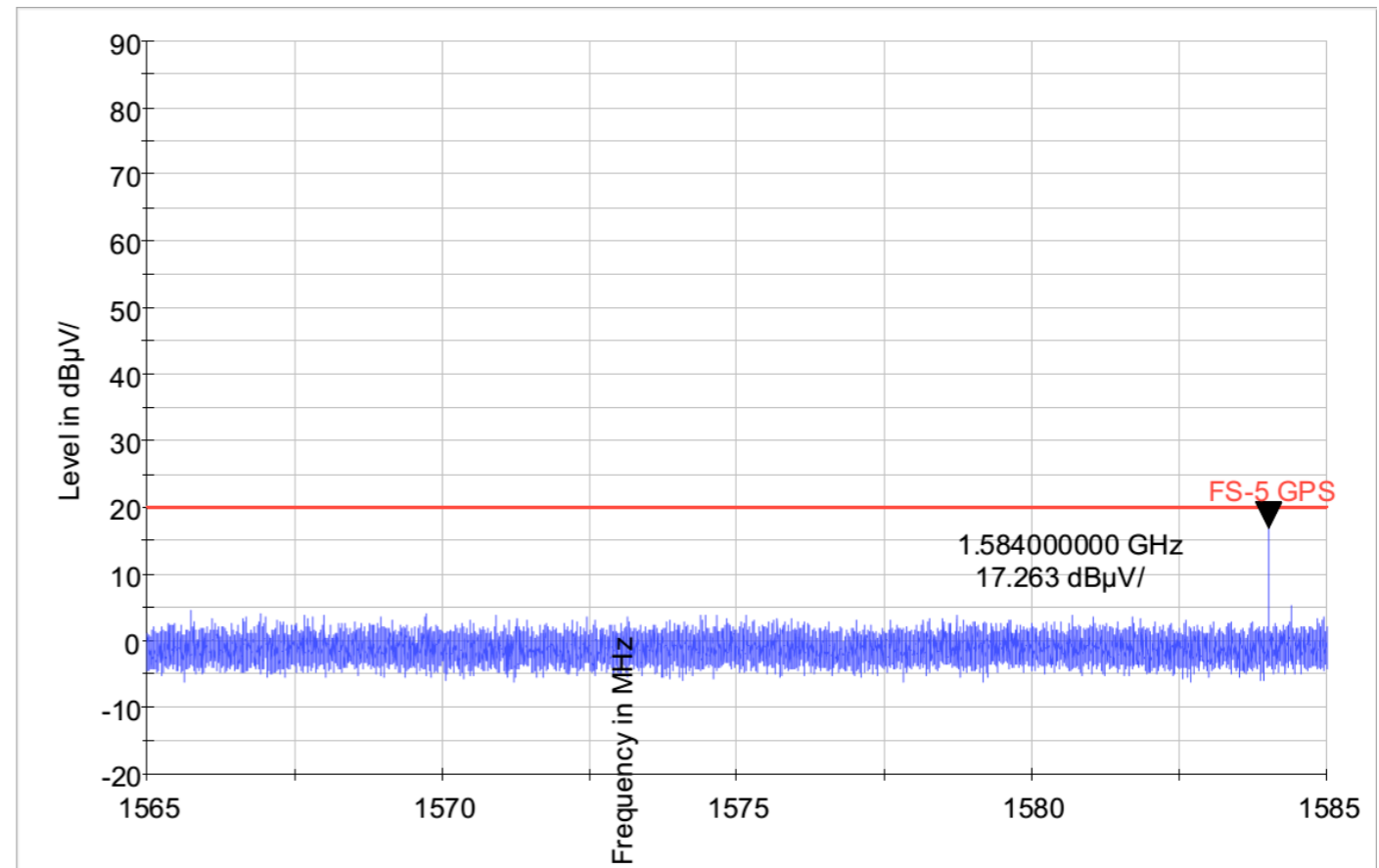
RE with primary controller on for 1,565 MHz to 1,585 MHz in horizontal position.



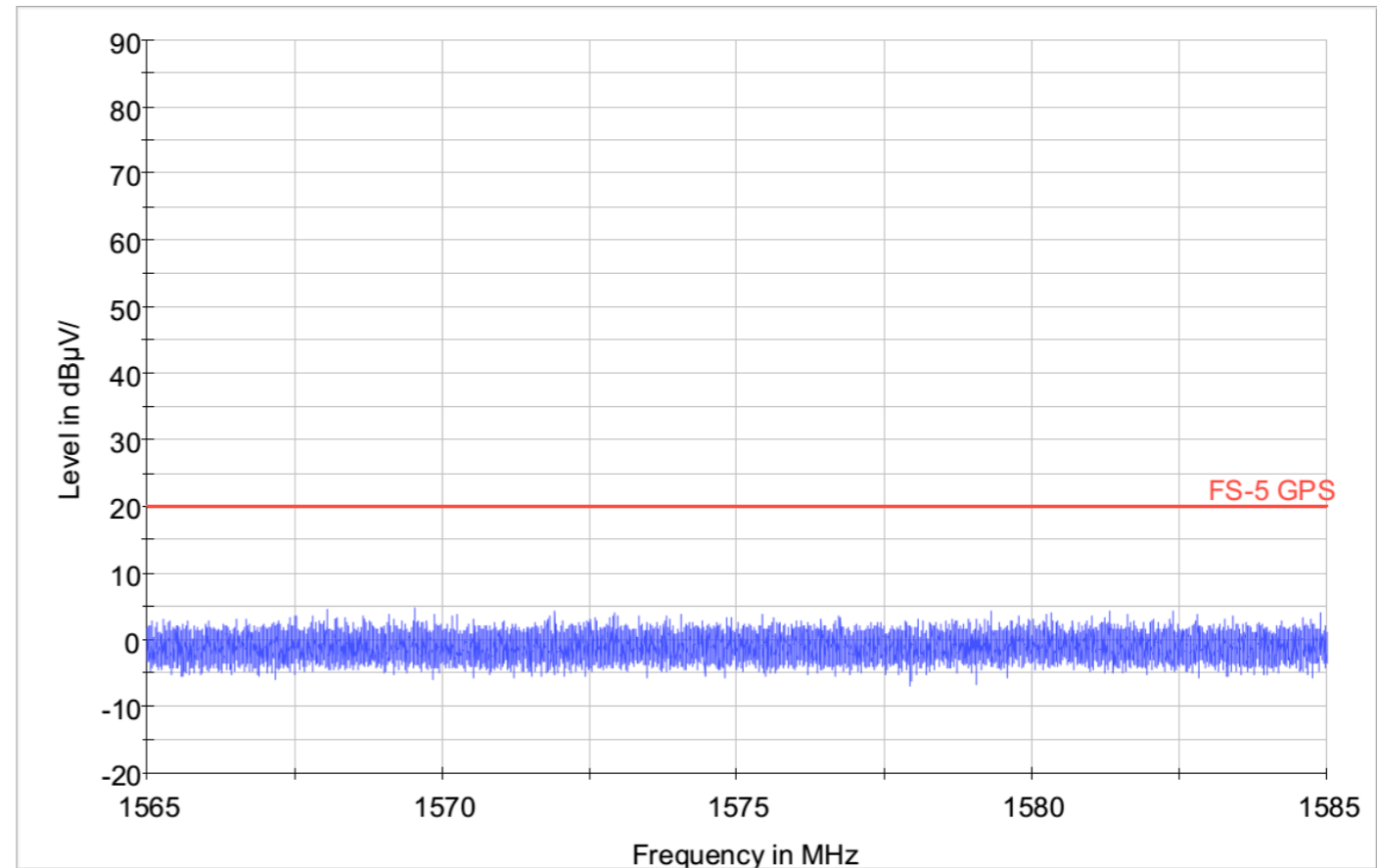
RE with redundant controller on for 1,565 MHz to 1,585 MHz in horizontal position.



RE for 1,565 MHz to 1,585 MHz in vertical position.



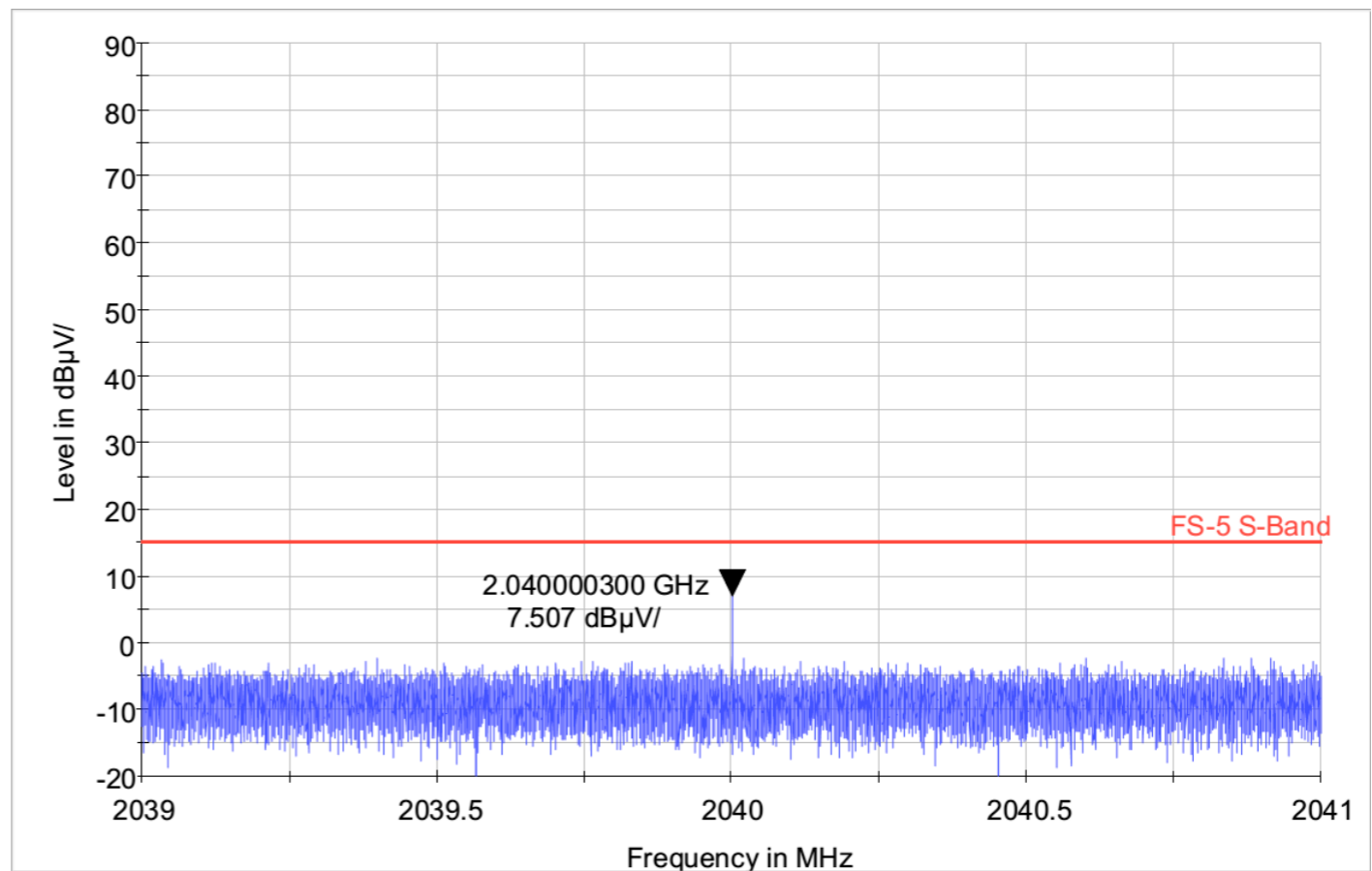
RE with primary controller on for 1,565 MHz to 1,585 MHz in vertical position.



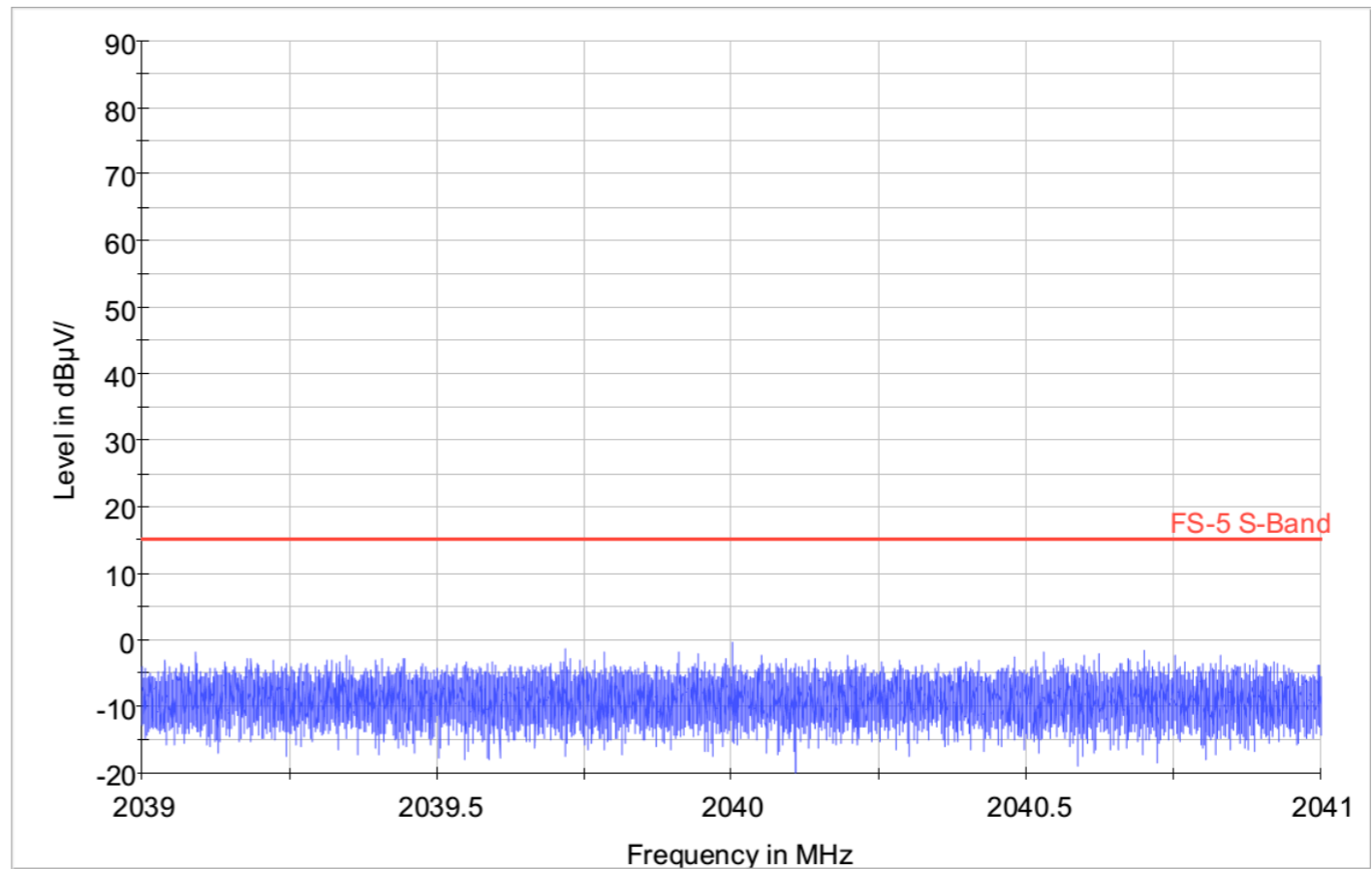
RE with redundant controller on for 1,565 MHz to 1,585 MHz in vertical position.



RE for 2,039 MHz to 2,041 MHz in horizontal position.



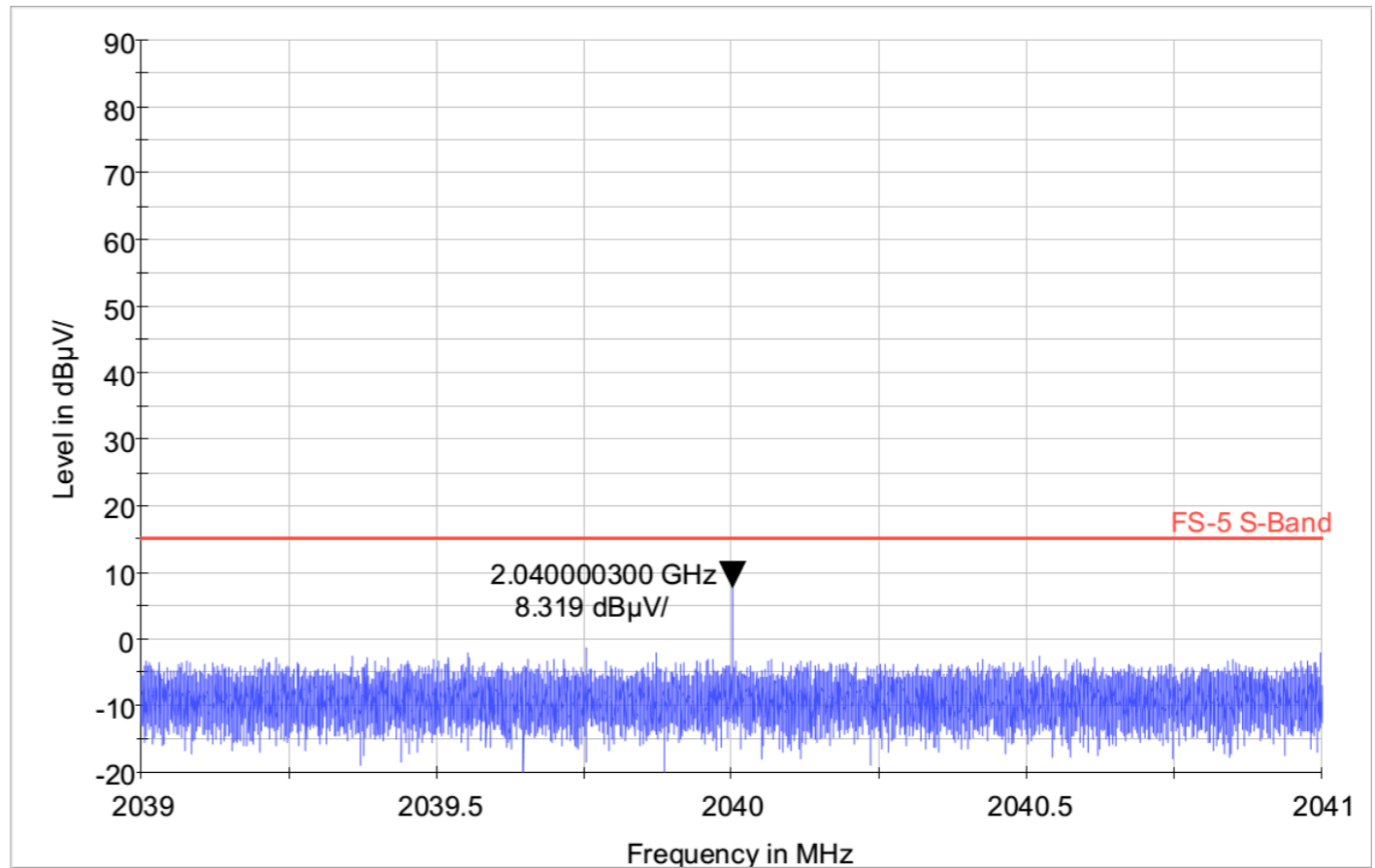
RE with primary controller on for 2,039 MHz to 2,041 MHz in horizontal position.



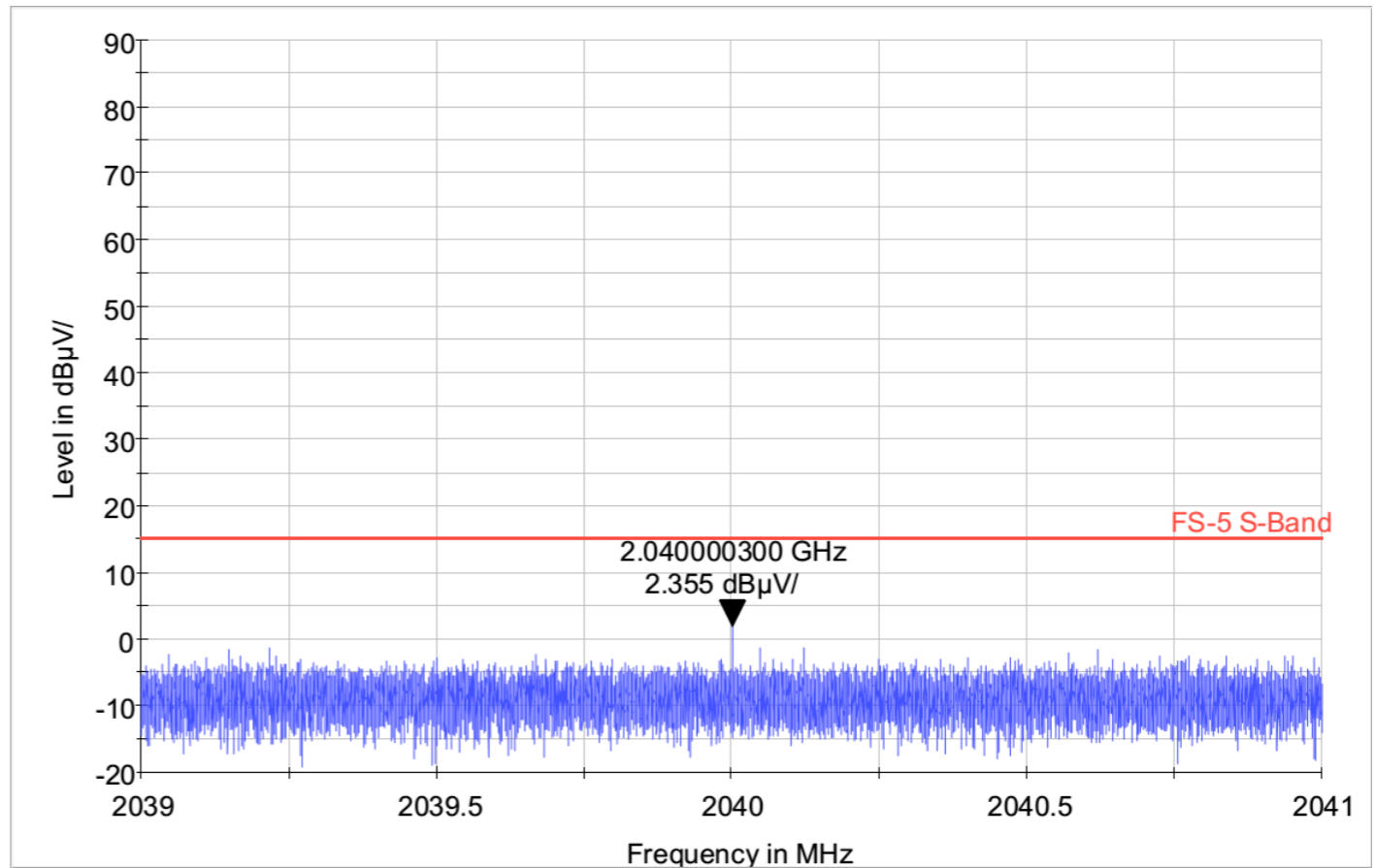
RE with redundant controller on for 2,039 MHz to 2,041 MHz in horizontal position.



RE for 2,039 MHz to 2,041 MHz in vertical position.



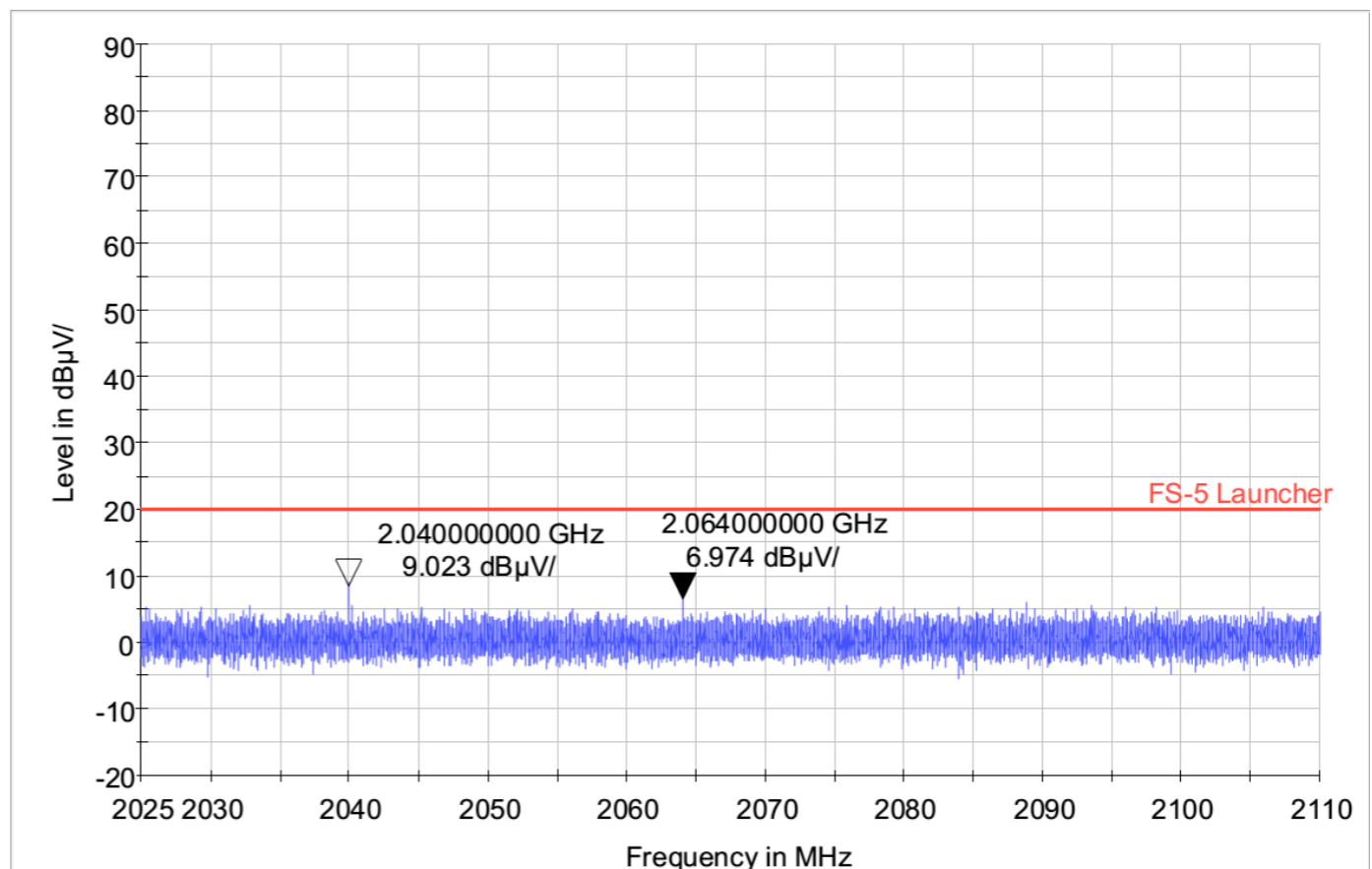
RE with primary controller on for 2,039 MHz to 2,041 MHz in vertical position.



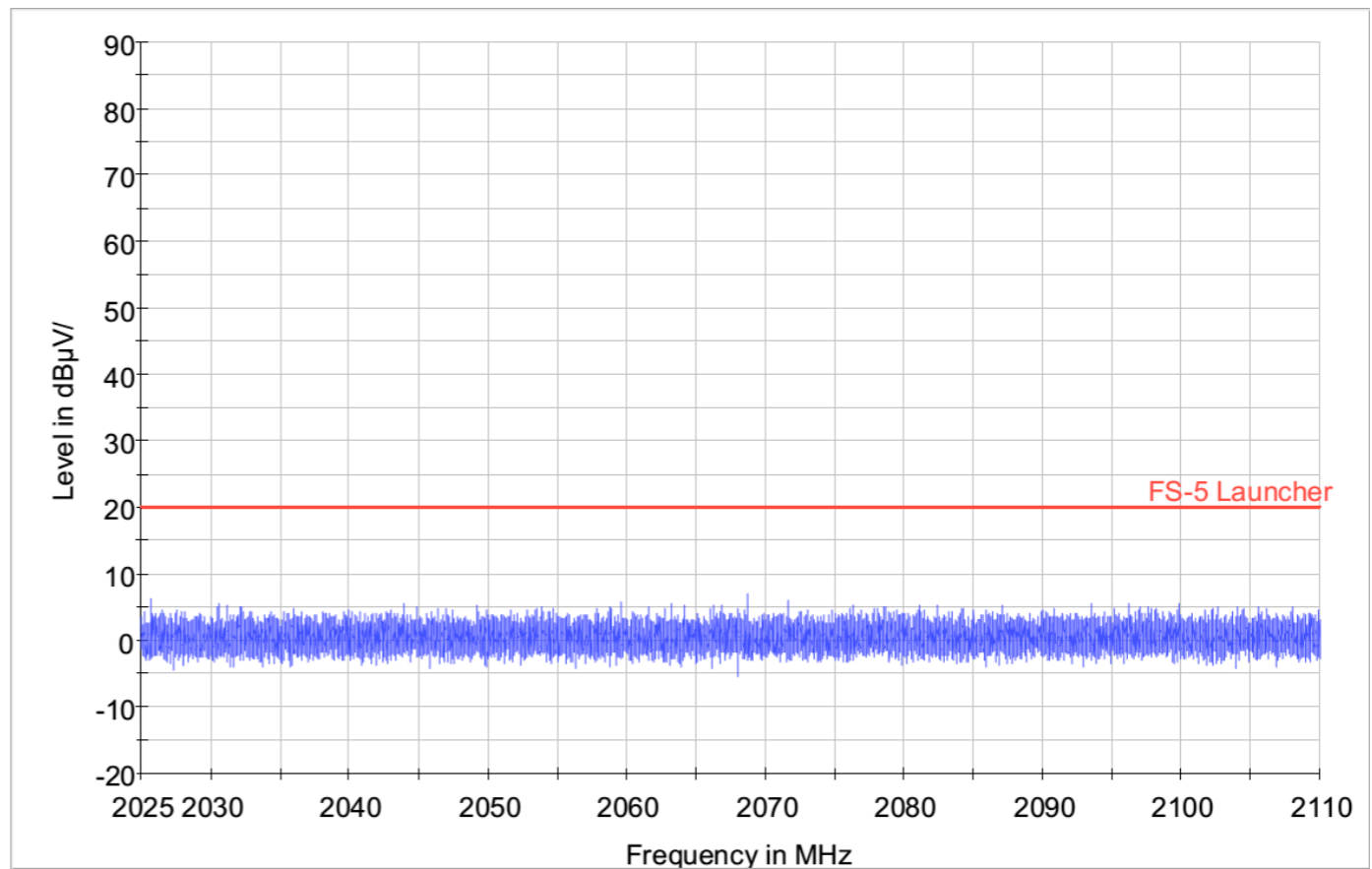
RE with redundant controller on for 2,039 MHz to 2,041 MHz in vertical position.



RE for 2,025 MHz to 2,110 MHz in horizontal position.



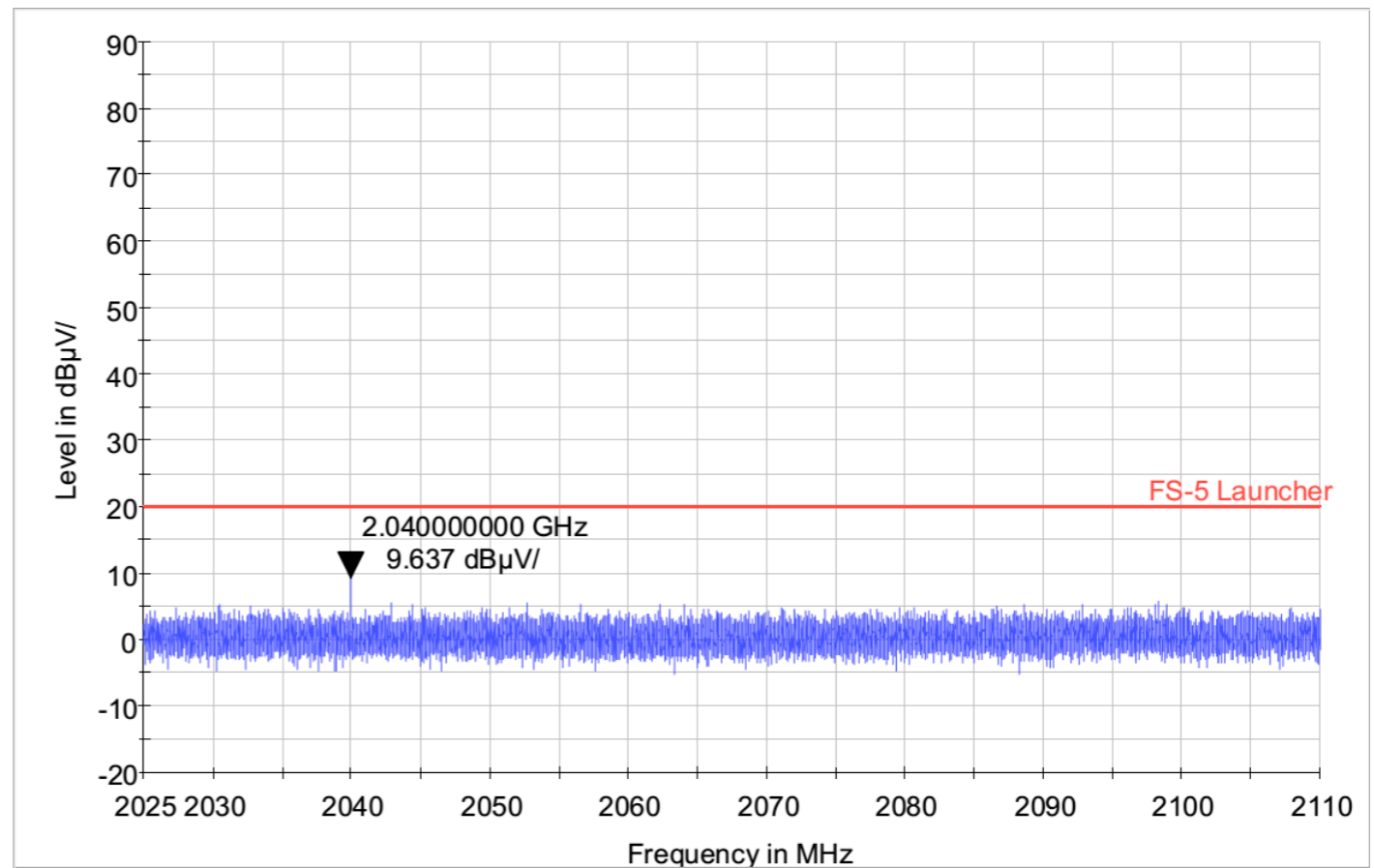
RE with primary controller on for 2,025 MHz to 2,110 MHz in horizontal position.



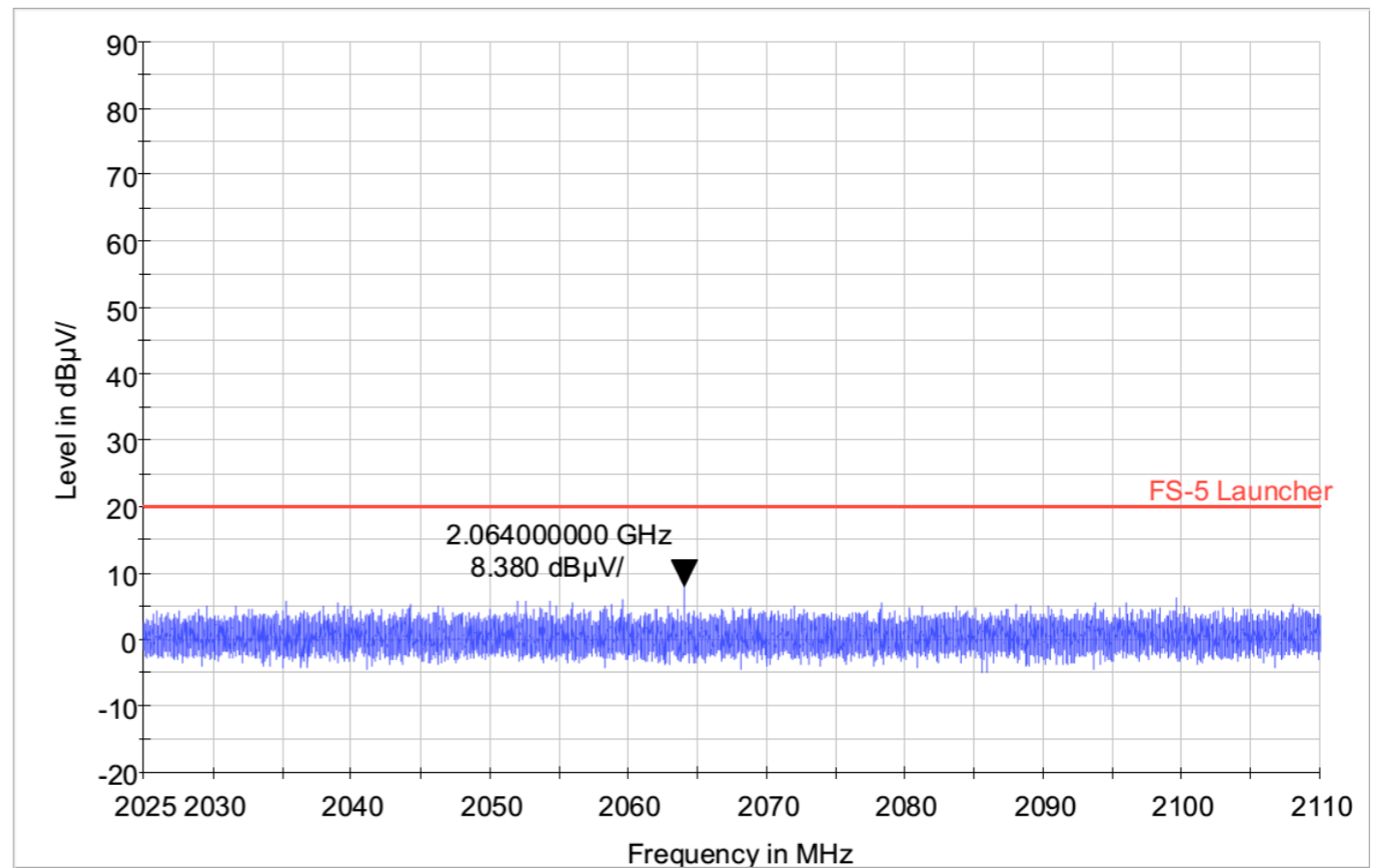
RE with redundant controller on for 2,025 MHz to 2,110 MHz in horizontal position.



RE for 2,025 MHz to 2,110 MHz in vertical position.



RE with primary controller on for 2,025 MHz to 2,110 MHz in vertical position.



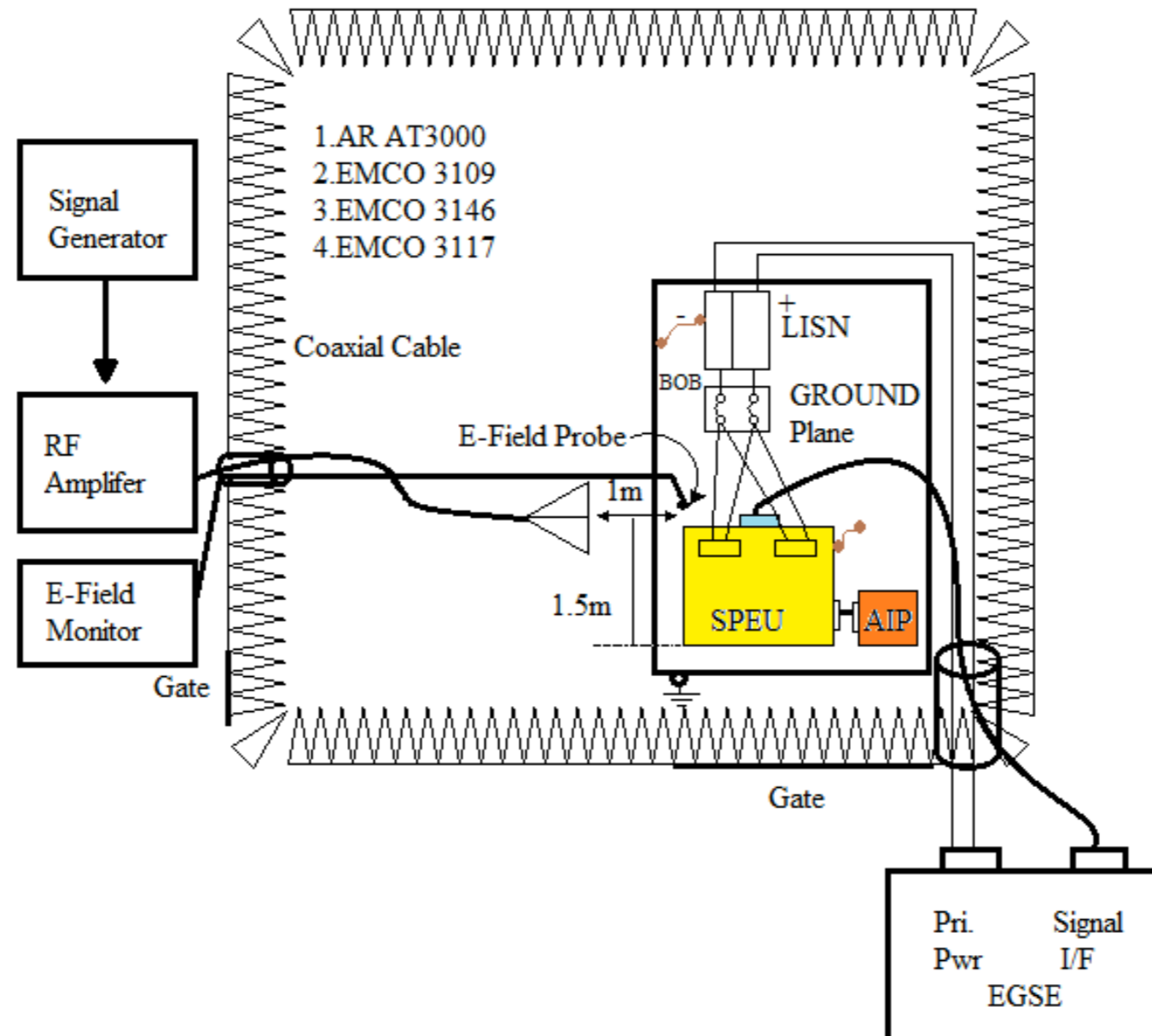
RE with redundant controller on for 2,025 MHz to 2,110 MHz in vertical position.

Radiated Susceptibility Test

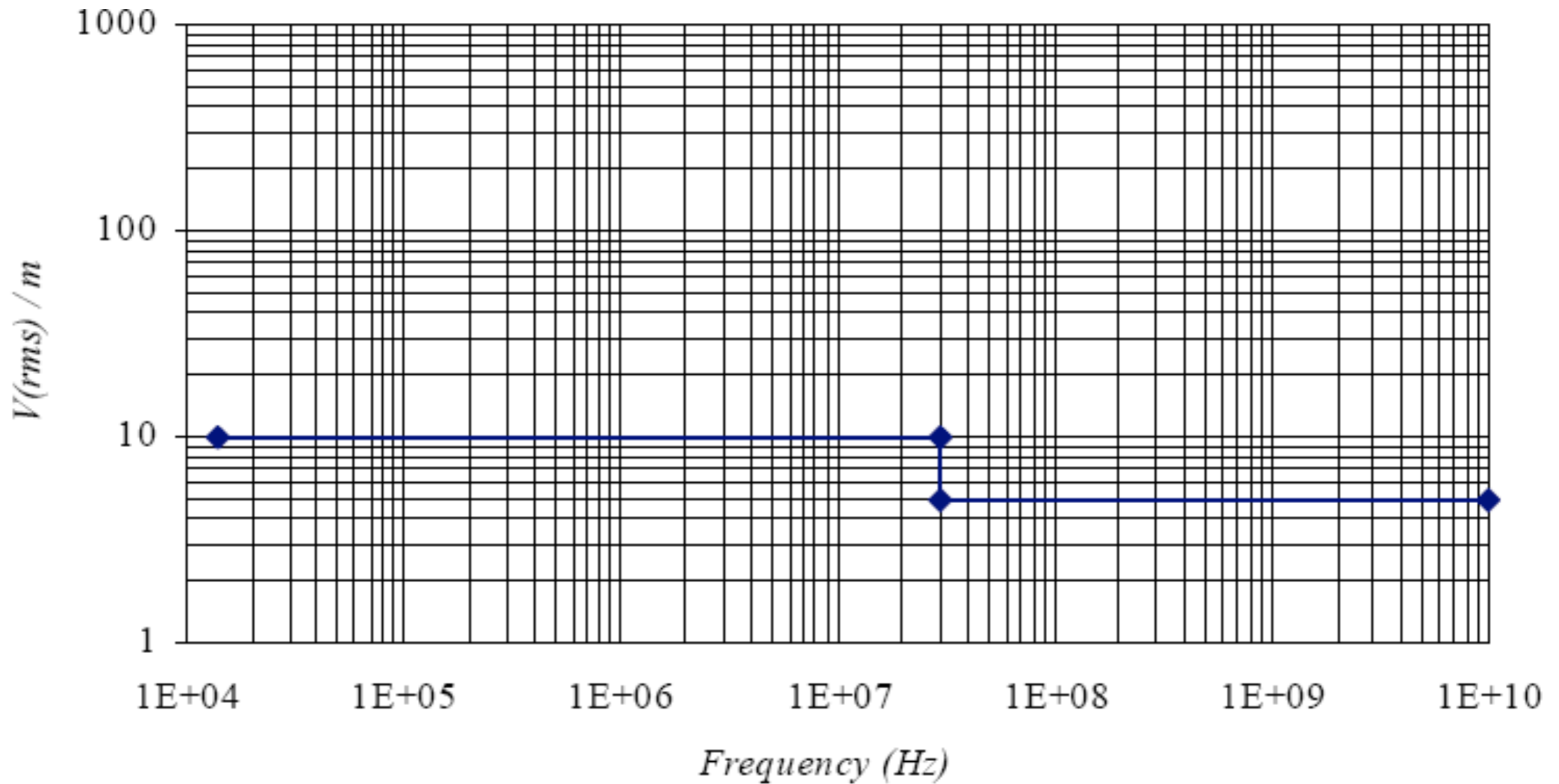
Vertical Polarization

14KHz~30MHz@10Vrms/m, PM

設置



RS Electric Field Level



Step	Action
1	將設備如圖所示擺設好，只連接J1A（J1B不連接）。將E-Field（AT3000）產生器設置成垂直方位。
2	確認AIP測試的設置與接線。請參考FS5SPL-CT-PROC的3.4.3.1節。
3	確認EMC設備已上電。
4	在EGSE方面，確認功能測試程序。請參考FS5SPL-CT-PROC的3.4.3.2節。
5	在EGSE方面，監控指令與遙傳介面與科學資料是否異常。
6	設置EMC32的檔案為FS5_RS_14K-30M。
7	14KHz~30MHz@10Vrms/m，PM。輻射RF訊號。
8	監控AIP是否有異常現象。
9	完成量測，將檔案存檔，檔名：RS_AIP_14K-30M_A。
10	打開正極電源（紅線）BOB開關。
11	將設備如圖所示擺設好，連接J1B（J1A不連接）。將E-Field（AT3000）產生器設置成垂直方位。重複步驟1-10。

Vertical Polarization

30MHz~200MHz@5Vrms/m, PM

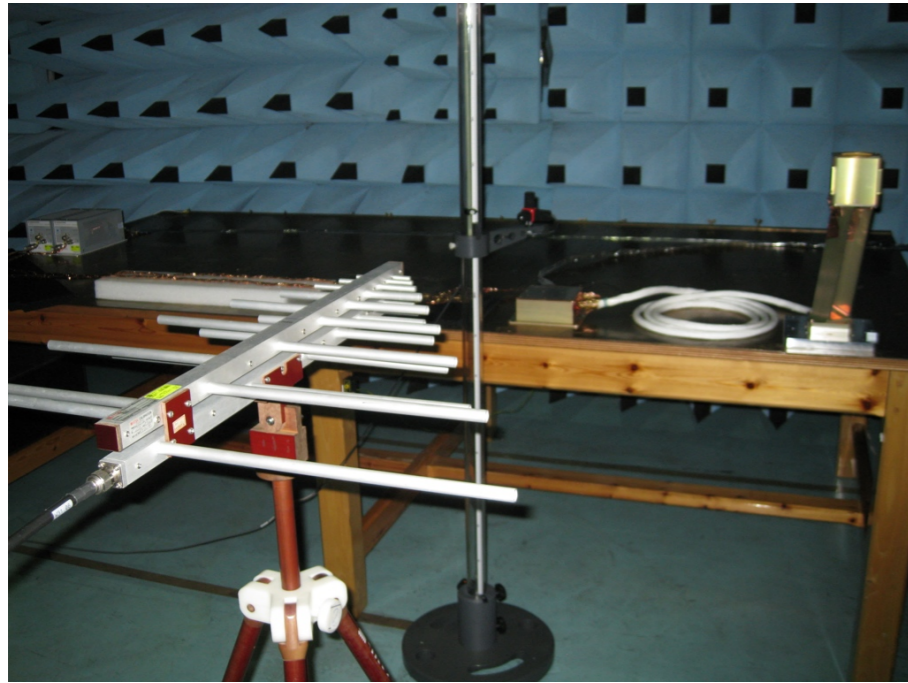
200MHz~1GHz@5Vrms/m, PM

1GHz~2GHz@5Vrms/m, PM

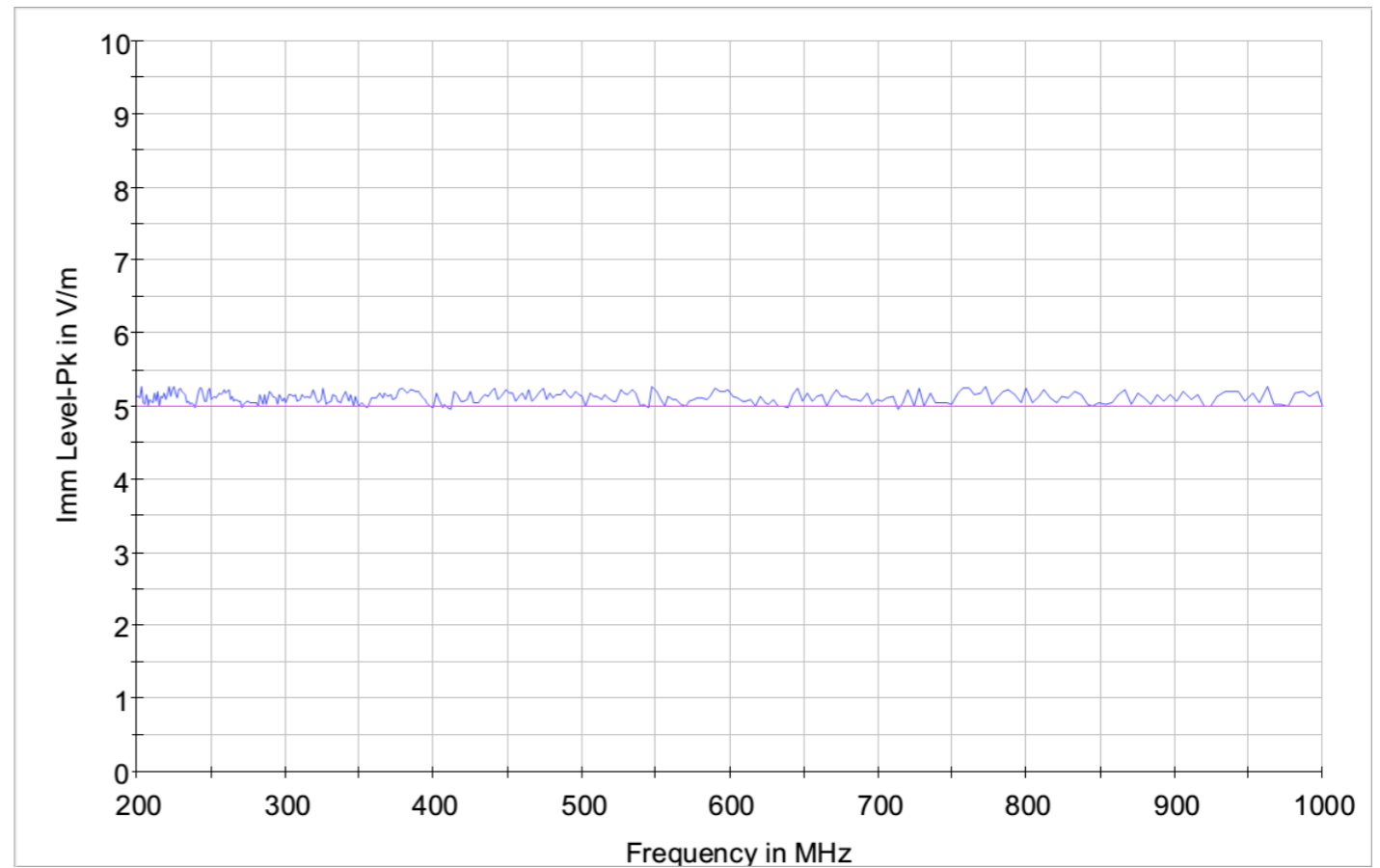
2GHz~10GHz@5Vrms/m, PM

Step	Action
1	將設備如圖所示擺設好，只連接J1A（J1B不連接）。將Biconical antenna (3109) 設置成垂直方位。
2	確認AIP測試的設置與接線。請參考FS5SPL-CT-PROC的3.4.3.1節。
3	確認EMC設備已上電。
4	在EGSE方面，確認功能測試程序。請參考FS5SPL-CT-PROC的3.4.3.2節。
5	在EGSE方面，監控指令與遙傳介面與科學資料是否異常。
6	設置EMC32的檔案為FS5_RS_30M-200M。
7	30MHz~200MHz@5Vrms/m，PM。輻射RF訊號。
8	監控AIP是否有異常現象。
9	完成量測，將檔案存檔，檔名：RS_AIP_30M-200M_V_A。
10	打開正極電源（紅線）BOB開關。
11	將設備如圖所示擺設好，連接J1B（J1A不連接）。將Biconical antenna (3109) 設置成垂直方位。重複步驟1-10。

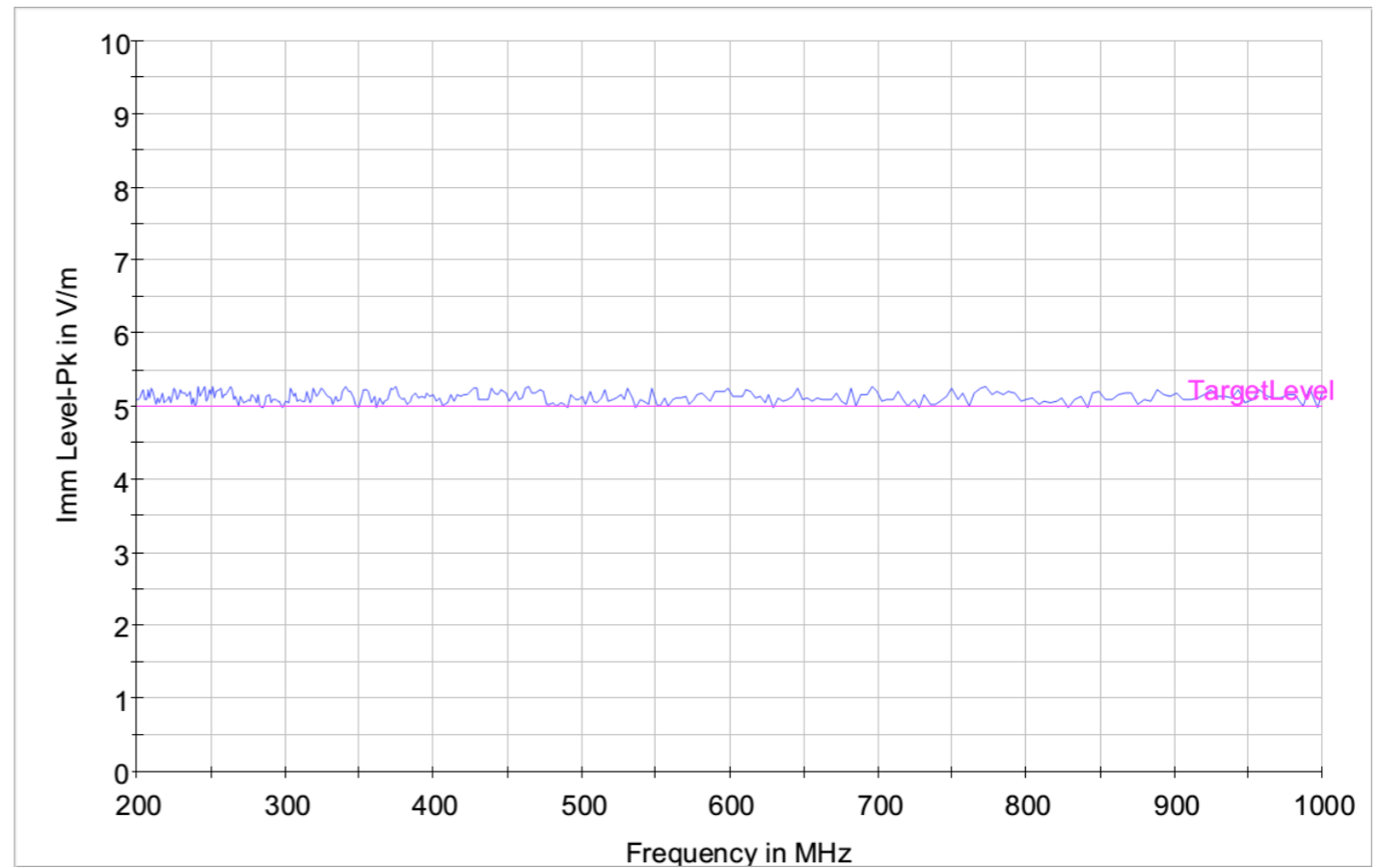
Antenna	EMC Test File	RF Signal	檔名
Biconical antenna (3109)	FS5_RS_30M-200M	30MHz~200MHz@ 5Vrms/m, PM.	RS_AIP_30M-200M_V_A
			RS_AIP_30M-200M_V_B
			RS_AIP_30M-200M_H_A
			RS_AIP_30M-200M_H_B
Log.periodic antenna	FS5_RS_200M-1G	200MHz~1GHz@ 5Vrms/m, PM.	RS_AIP_200M-1G_V_A
			RS_AIP_200M-1G_V_B
			RS_AIP_200M-1G_H_A
			RS_AIP_200M-1G_H_B
Double ridge horn antenna	FS5_RS_1G-2G	1GHz~2GHz@ 5Vrms/m, PM.	RS_AIP_1G-2G_V_A
			RS_AIP_1G-2G_V_B
			RS_AIP_1G-2G_H_A
			RS_AIP_1G-2G_H_B
	FS5_RS_2G-10G	2GHz~10GHz@ 5Vrms/m, PM.	RS_AIP_2G-10G_V_A
			RS_AIP_2G-10G_V_B
			RS_AIP_2G-10G_H_A
			RS_AIP_2G-10G_H_B



RS for 200 MHz to 1 GHz in horizontal position.



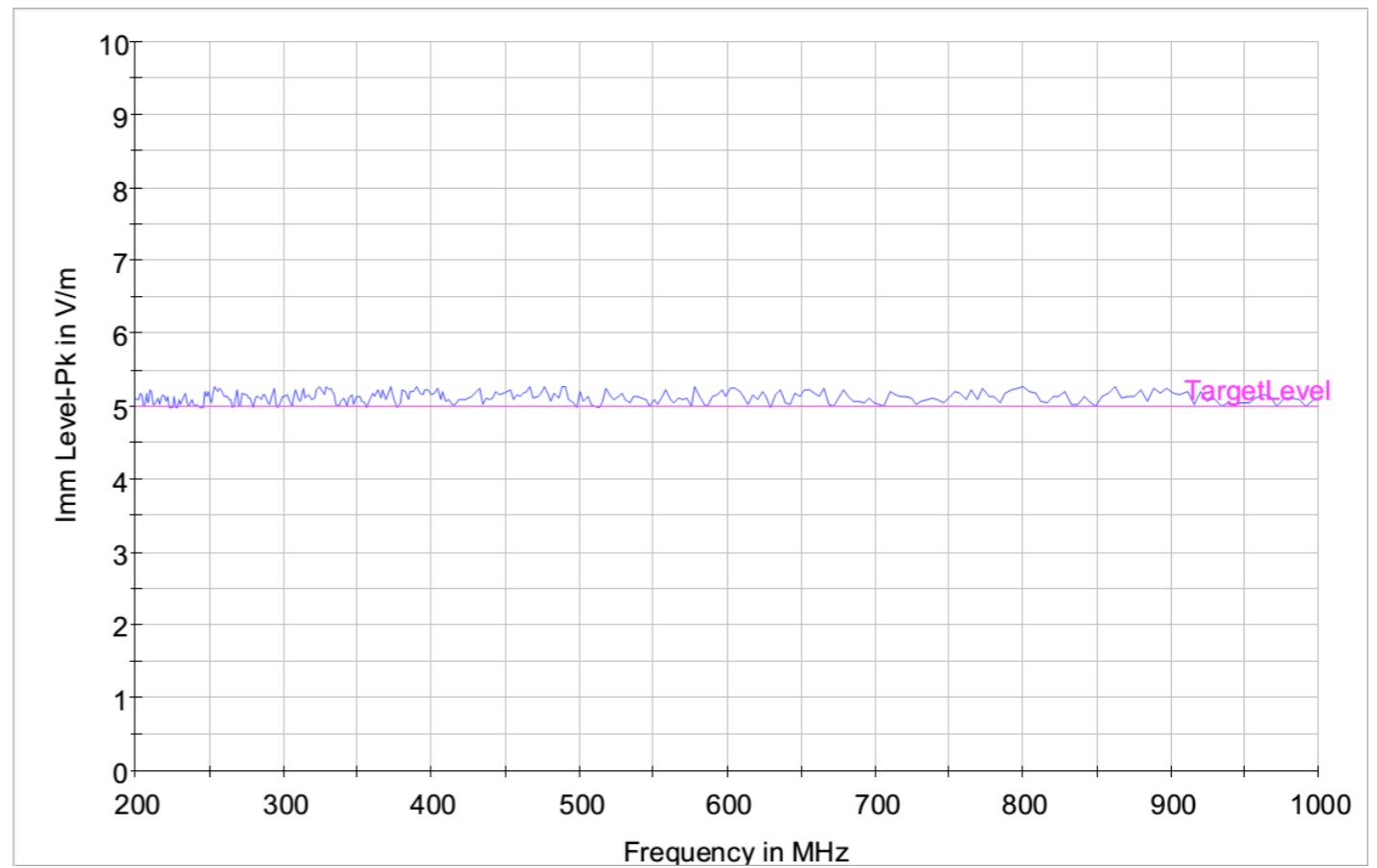
RS with primary controller on for 200 MHz to 1 GHz in horizontal position.



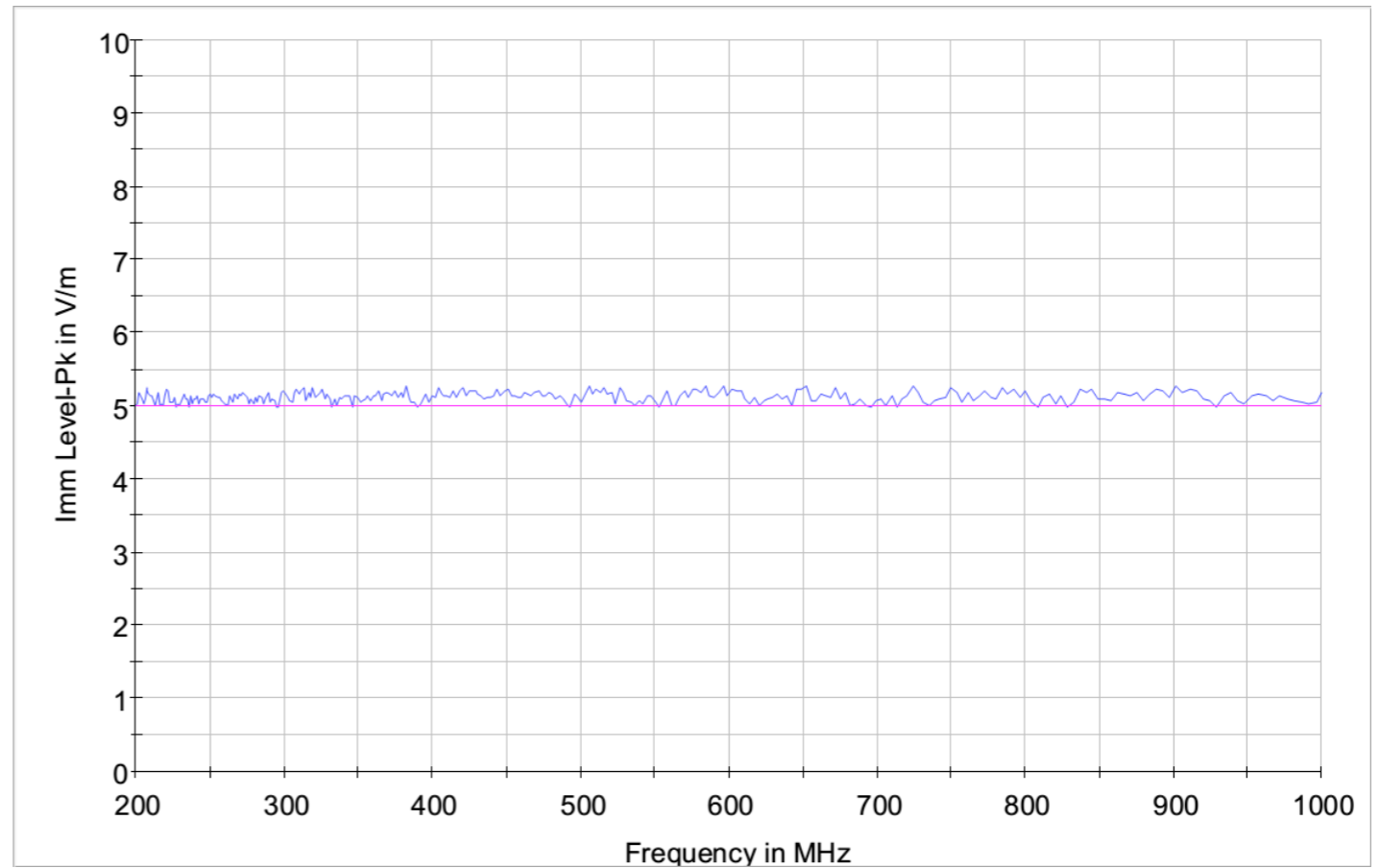
RS with redundant controller on for 200 MHz to 1 GHz in horizontal position.



RS for 200 MHz to 1 GHz in vertical position.



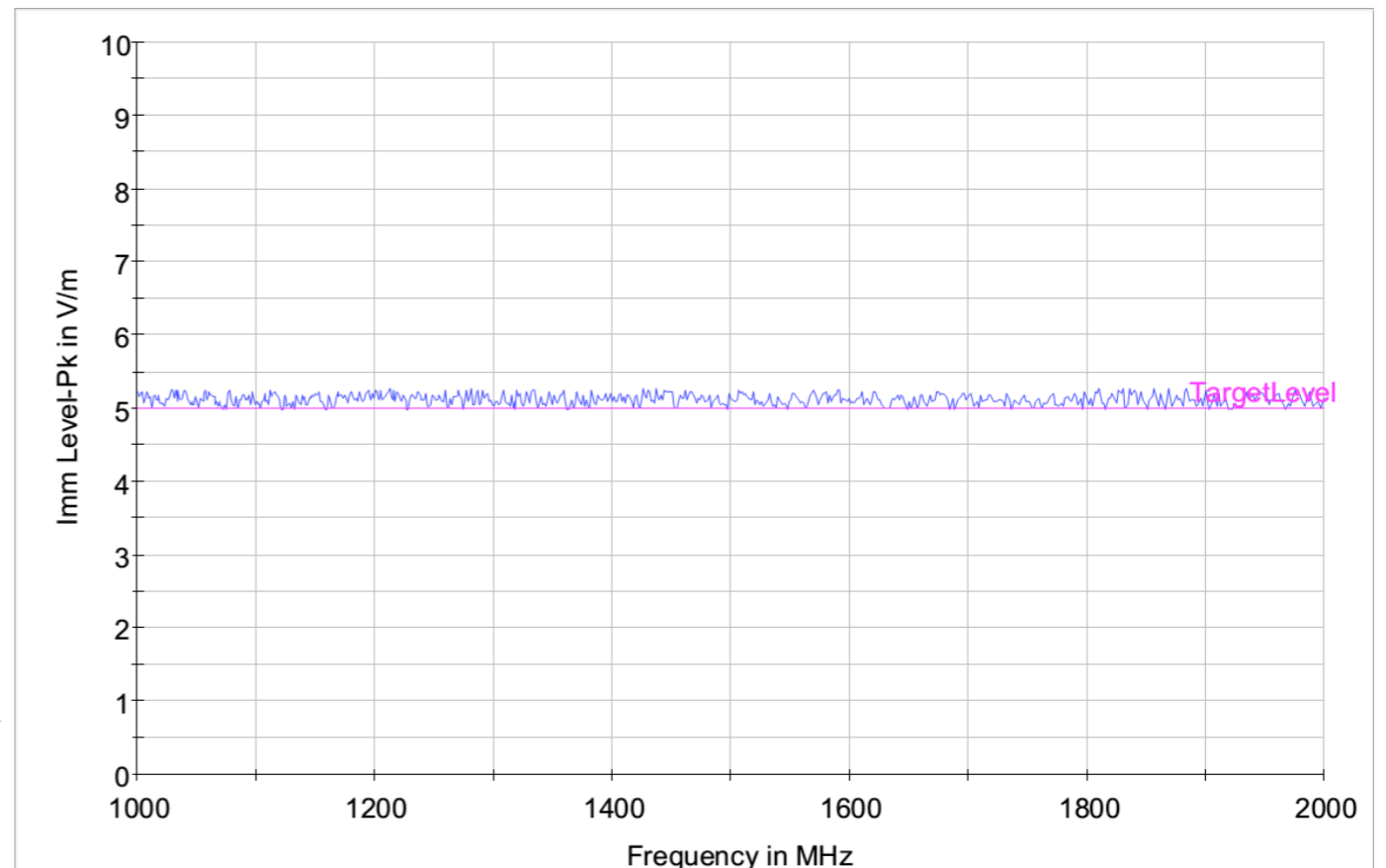
RS with primary controller on for 200 MHz to 1 GHz in vertical position.



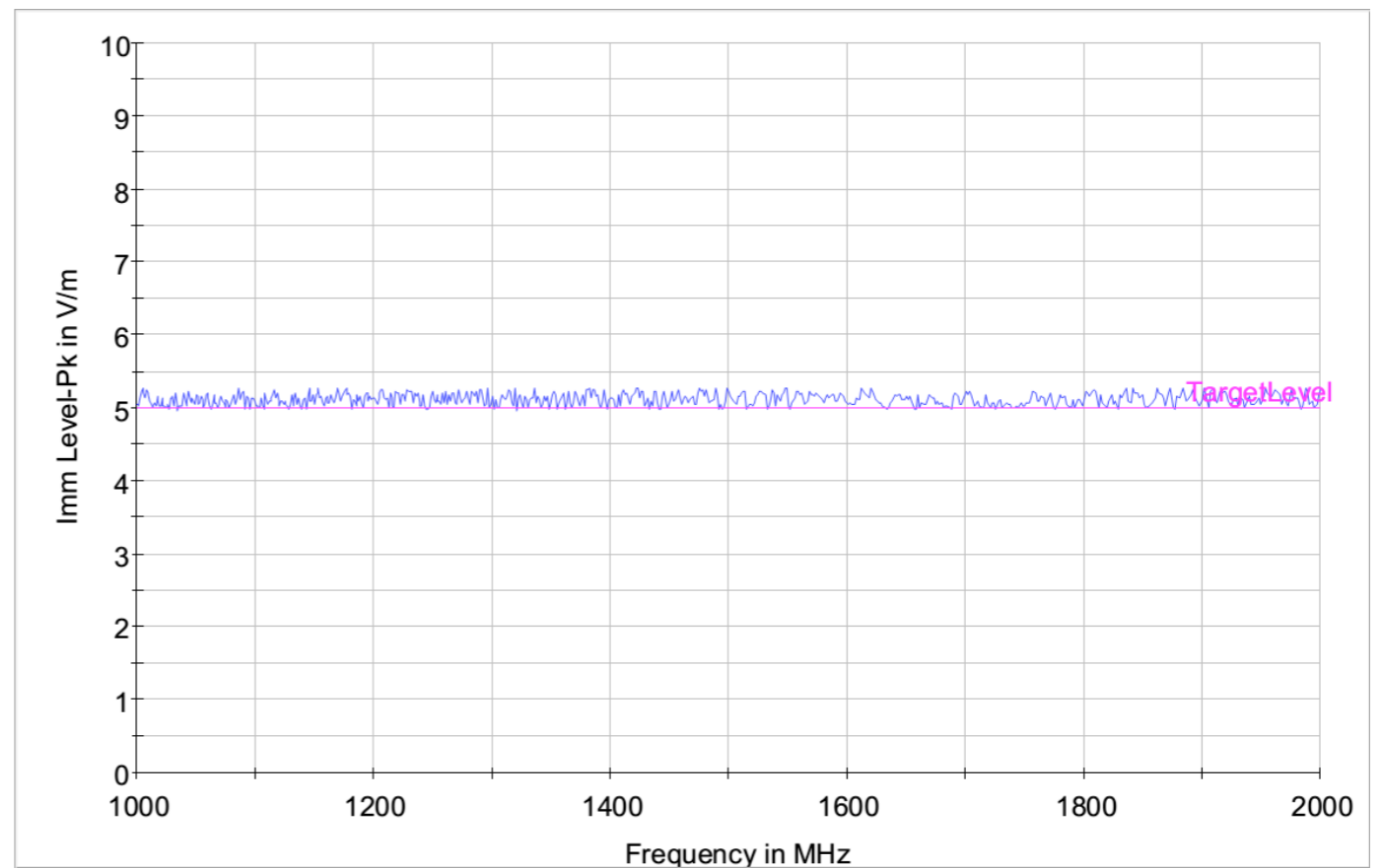
RS with redundant controller on for 200 MHz to 1 GHz in vertical position.



RS for 1 GHz to 2 GHz in horizontal position (the following tests used this antenna in the horizontal position).



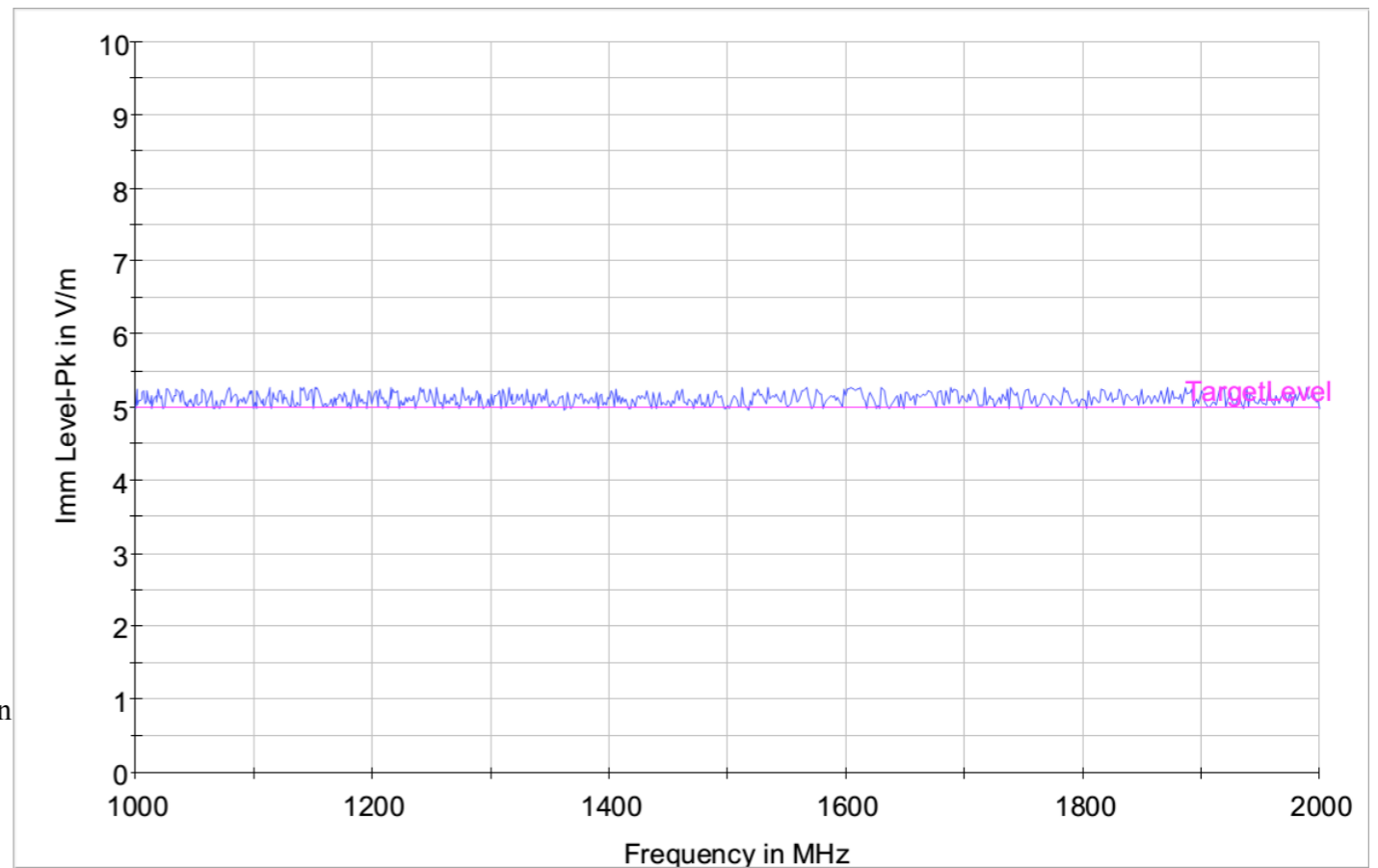
RS with primary controller on for 1 GHz to 2 GHz in horizontal position.



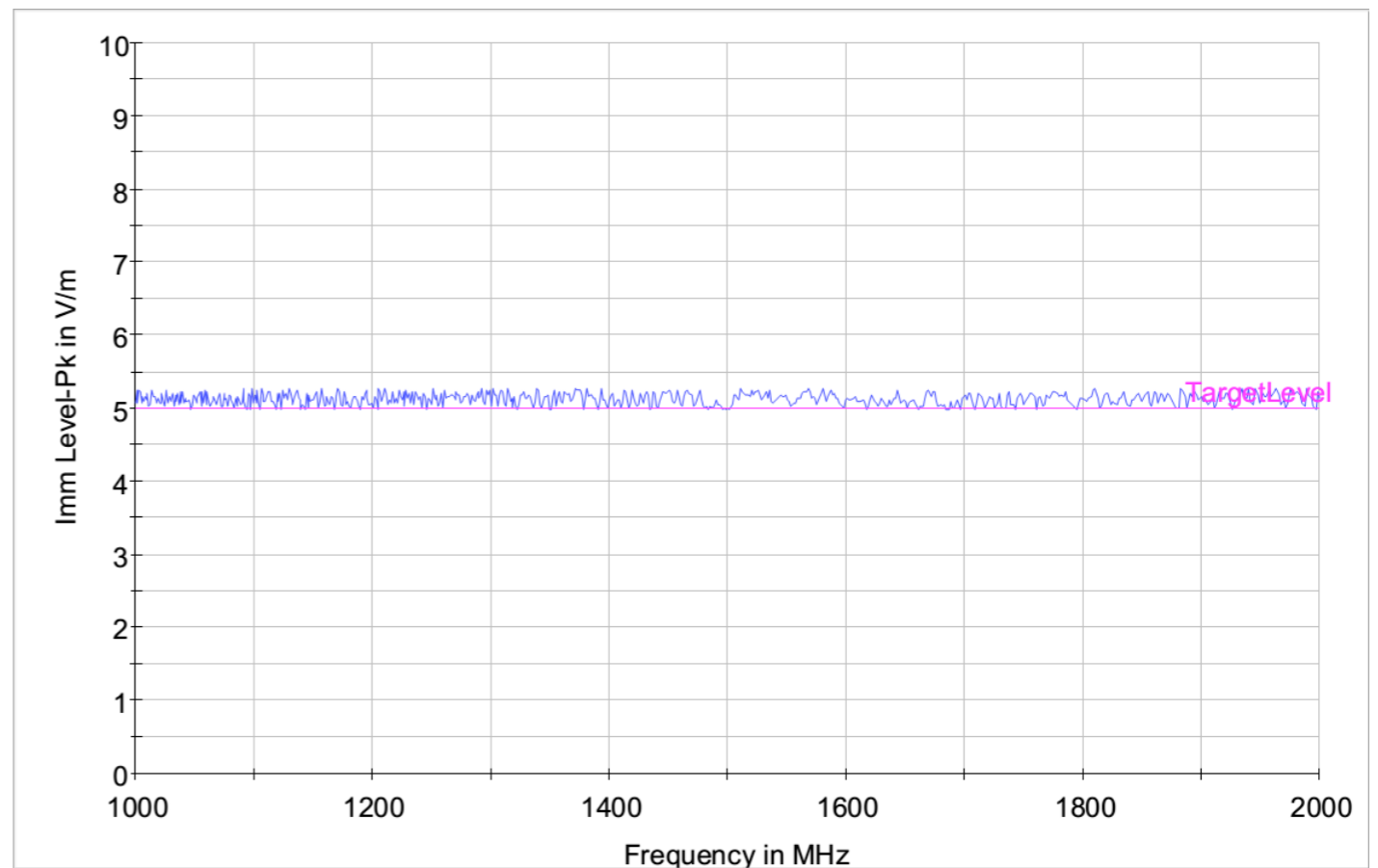
RS with redundant controller on for 1 GHz to 2 GHz in horizontal position.



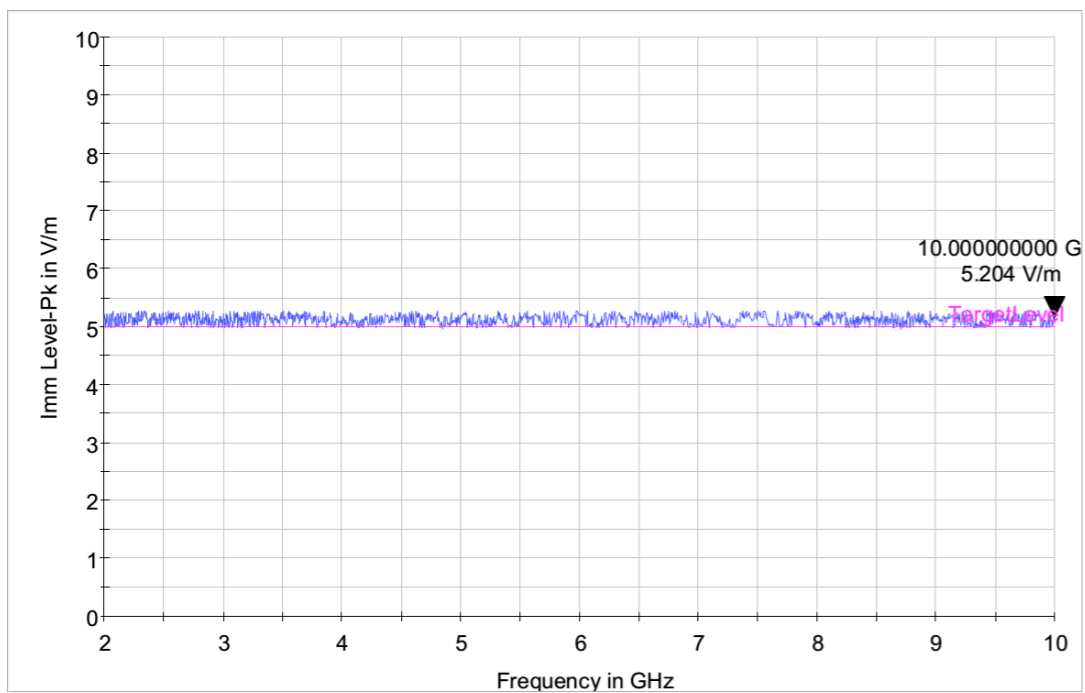
RS for 1 GHz to 2 GHz in vertical position (the following tests used this antenna in the vertical position).



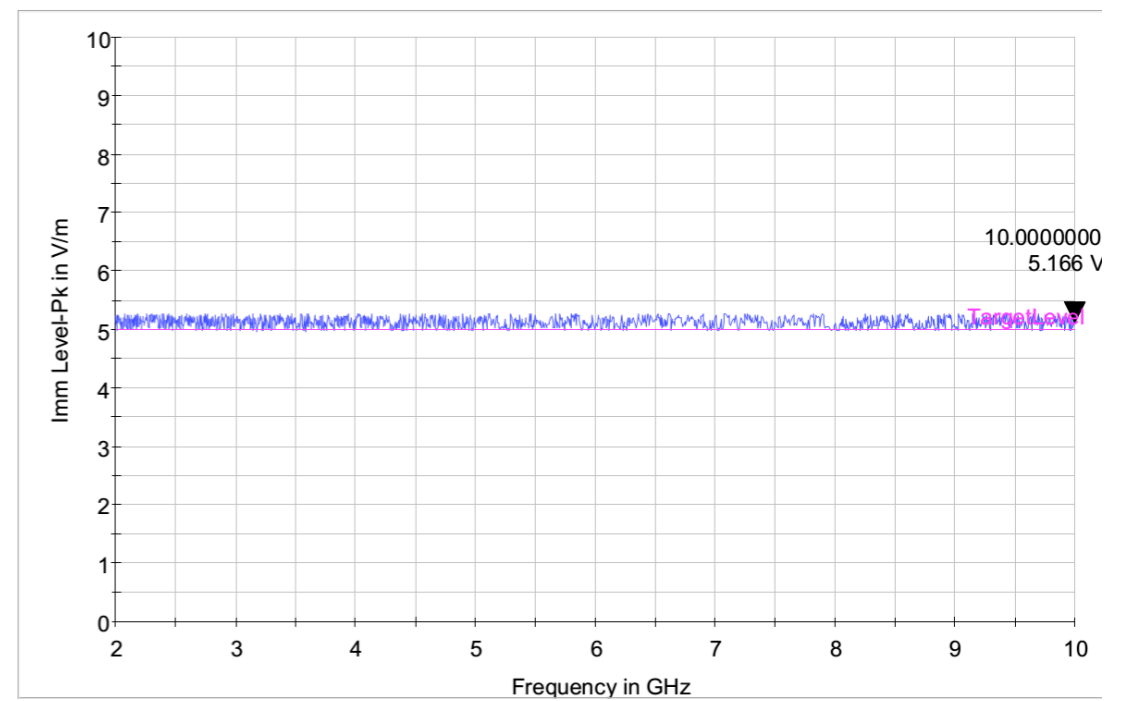
RS with primary controller on for 1 GHz to 2 GHz in vertical position.



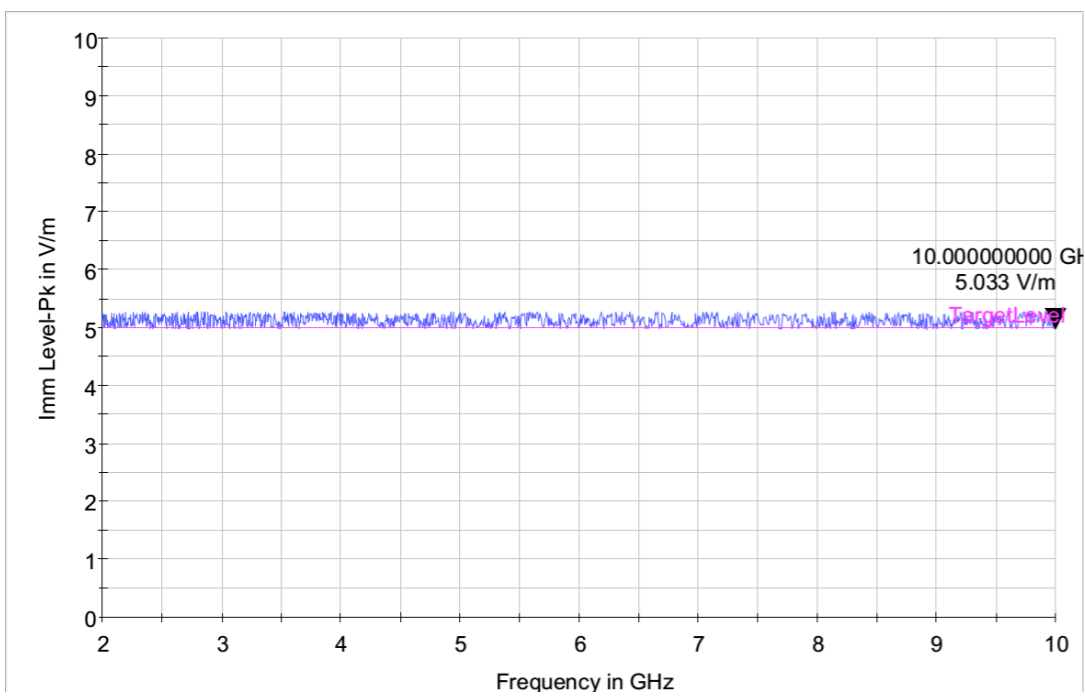
RS with redundant controller on for 1 GHz to 2 GHz in vertical position.



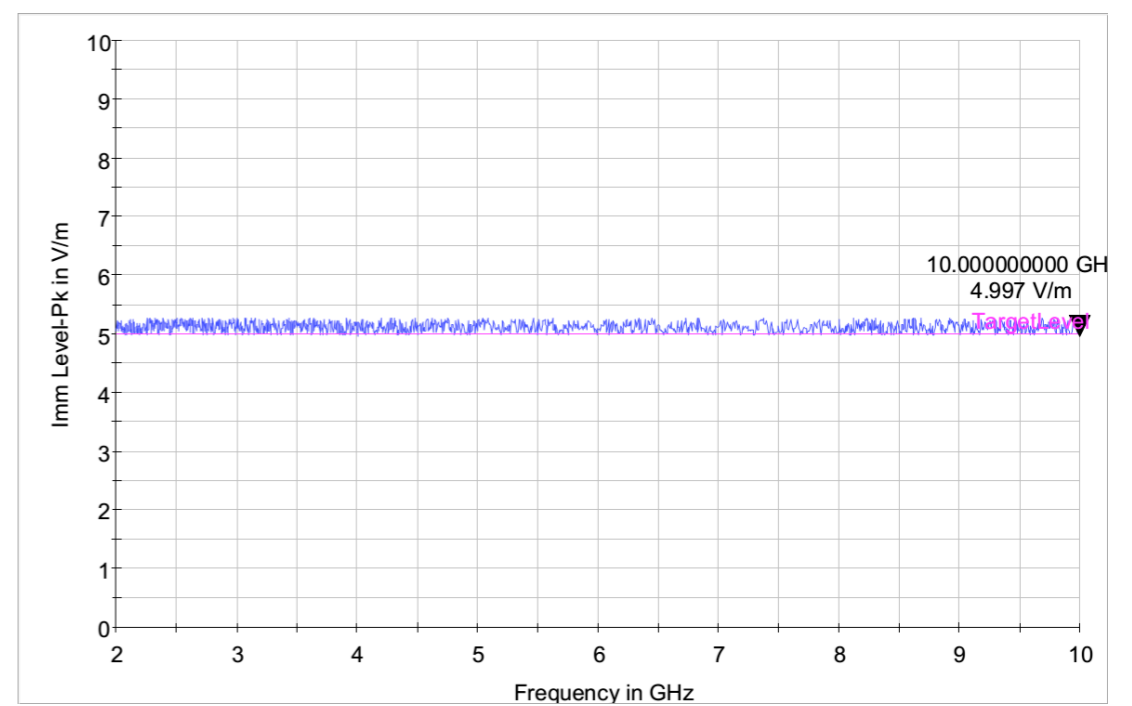
RS with primary controller on for 2 GHz to 10 GHz in horizontal position.



RS with primary controller on for 2 GHz to 10 GHz in vertical position.



RS with redundant controller on for 2 GHz to 10 GHz in horizontal position.



RS with redundant controller on for 2 GHz to 10 GHz in vertical position.

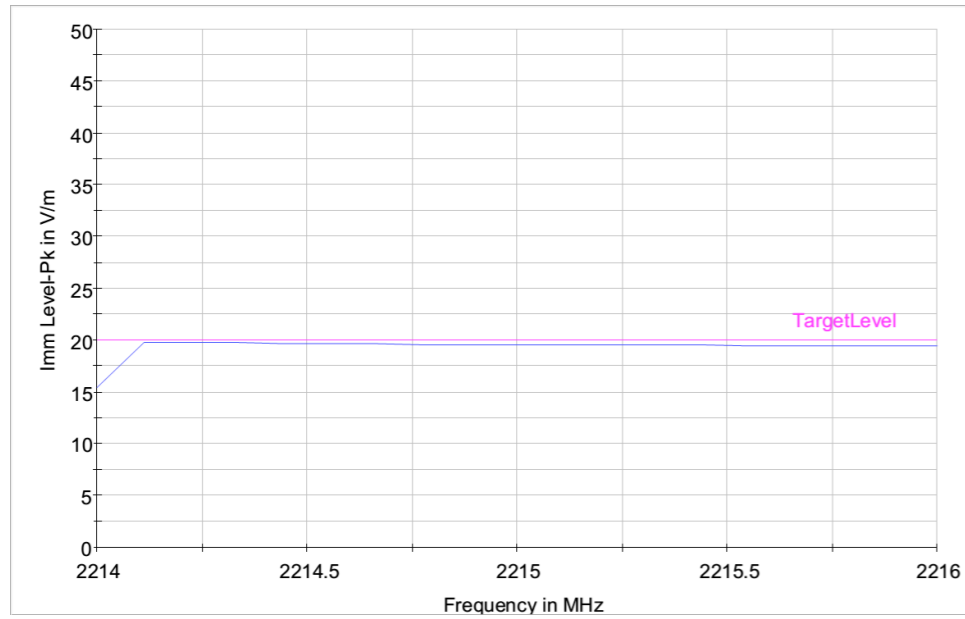
Local E-Field by Bus Antenna

2214MHz~2216MHz@20Vrms/m, PM.

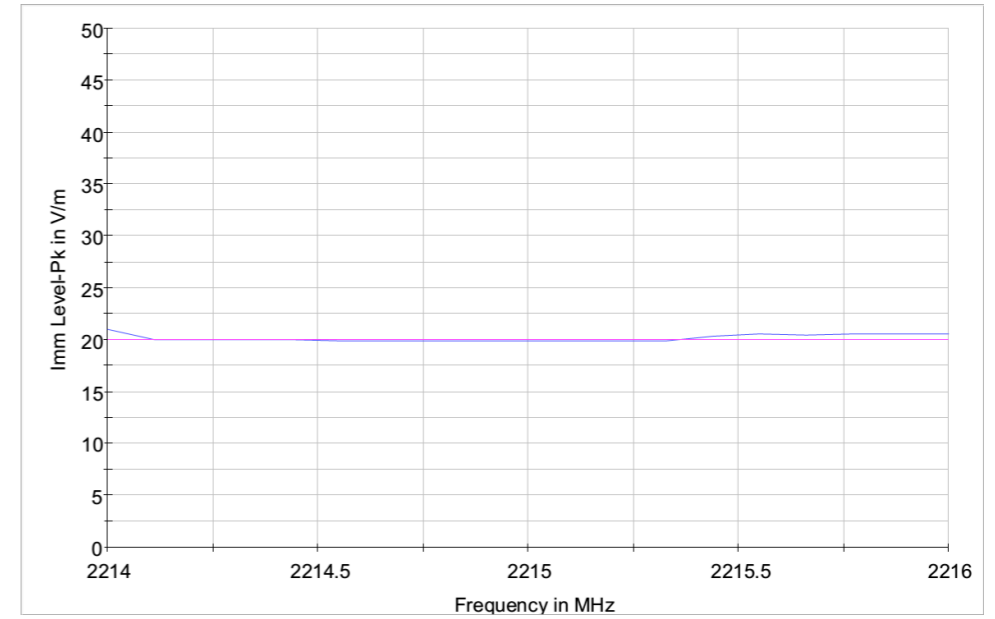
8GHz~8.4GHz@40Vrms/m, PM.

Step	Action
1	將設備如圖所示擺設好，只連接J1A（J1B不連接）。將Double ridge horn antenna (3117) 設置成垂直方位。
2	確認AIP測試的設置與接線。請參考FS5SPL-CT-PROC的3.4.3.1節。
3	確認EMC設備已上電。
4	在EGSE方面，確認功能測試程序。請參考FS5SPL-CT-PROC的3.4.3.2節。
5	在EGSE方面，監控指令與遙傳介面與科學資料是否異常。
6	設置EMC32的檔案為FS5_RS_2214M-2216M。
7	2214MHz~2216MHz@20Vrms/m，PM。輻射RF訊號。
8	監控AIP是否有異常現象。
9	完成量測，將檔案存檔，檔名：RS_AIP_2214M-2216M_V_A。
10	打開正極電源（紅線）BOB開關。
11	將設備如圖所示擺設好，連接J1B（J1A不連接）。將Double ridge horn antenna (3117) 設置成垂直方位。重複步驟1-10。

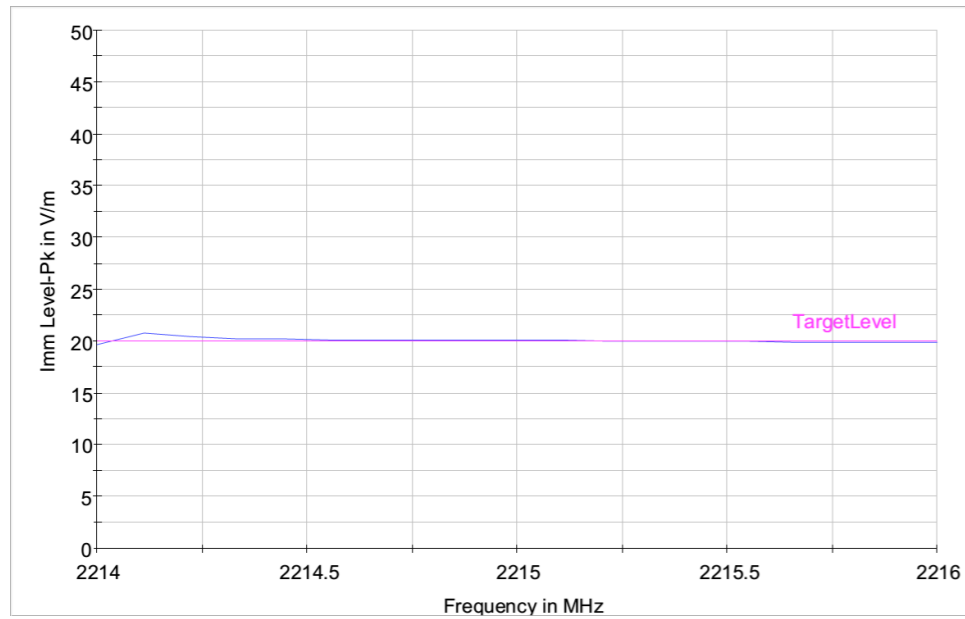
Antenna	EMC Test File	RF Signal	檔名
Double ridge horn antenna (3117)	FS5_RS_2214M-2216M	2214MHz~2216MHz@ 20Vrms/m, PM.	RS_AIP_2214M-2216M_V_A
			RS_AIP_2214M-2216M_V_B
			RS_AIP_2214M-2216M_H_A
			RS_AIP_2214M-2216M_H_B
	FS5_RS_8000M-8400M	8GHz~8.4GHz@ 40Vrms/m, PM.	RS_AIP_8G-8.4G_V_A
			RS_AIP_8G-8.4G_V_B
			RS_AIP_8G-8.4G_H_A
			RS_AIP_8G-8.4G_H_B



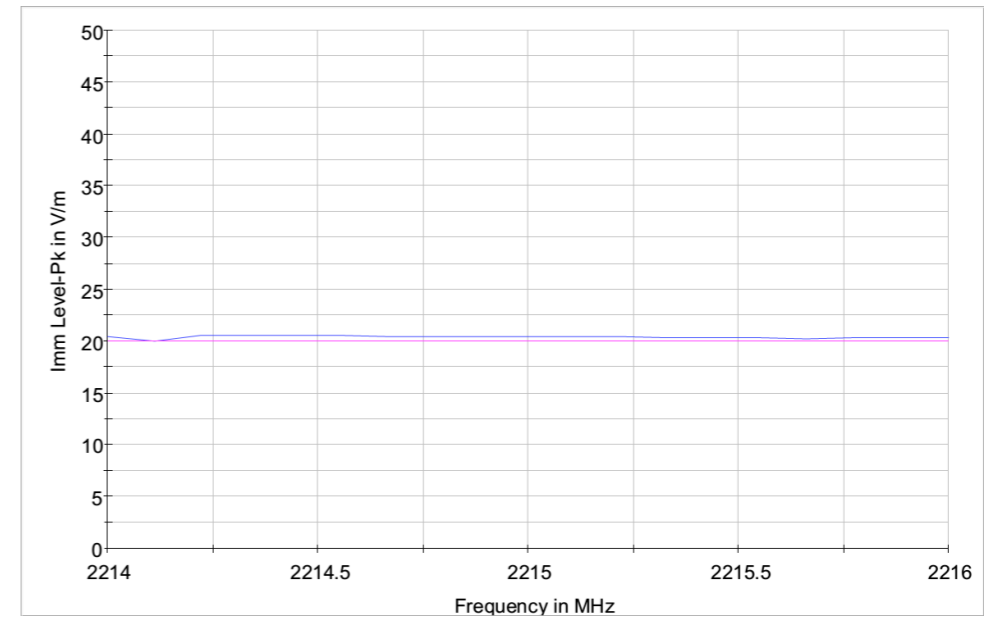
RS with primary controller on for 2,214 MHz to 2,216 MHz in horizontal position.



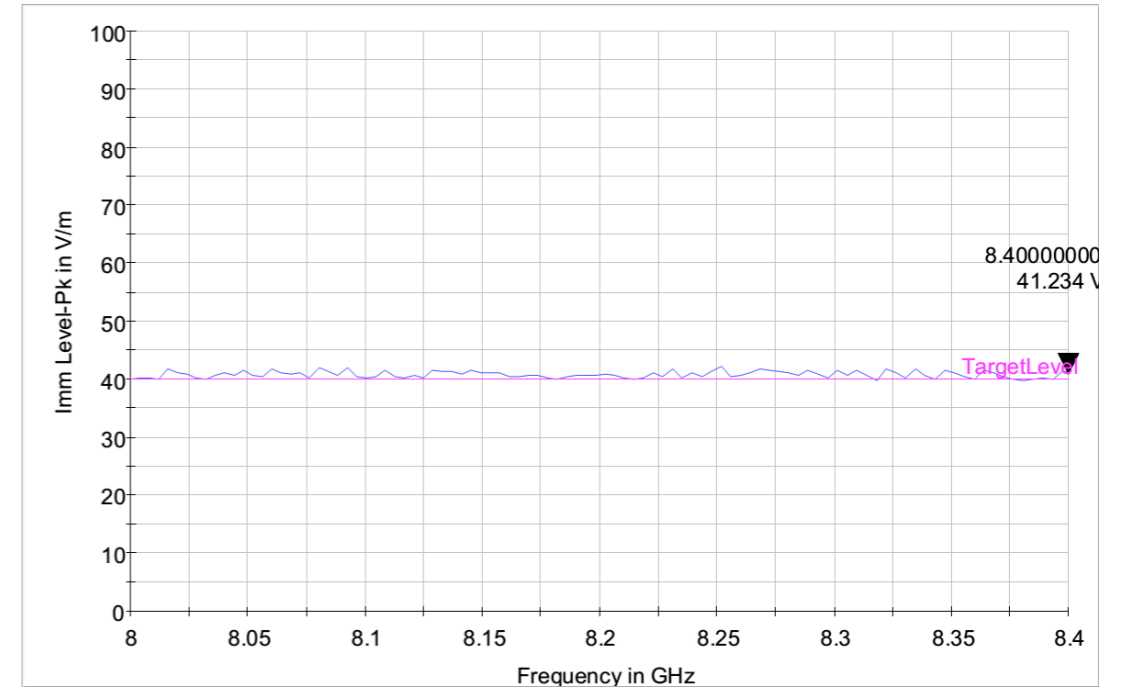
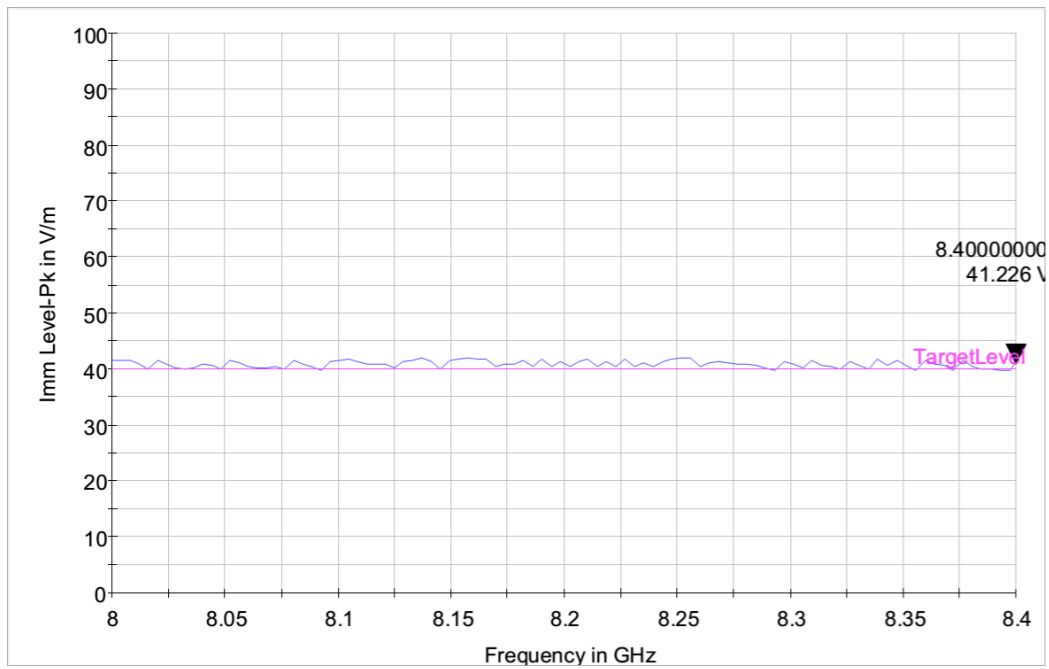
RS with primary controller on for 2,214 MHz to 2,216 MHz in vertical position.



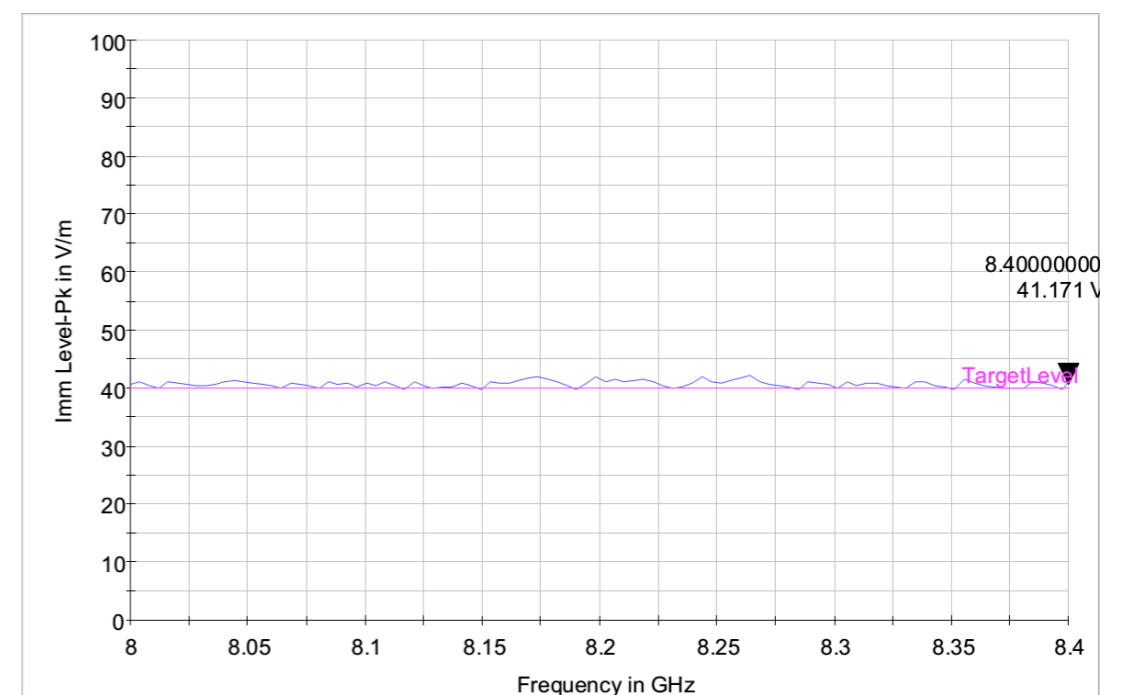
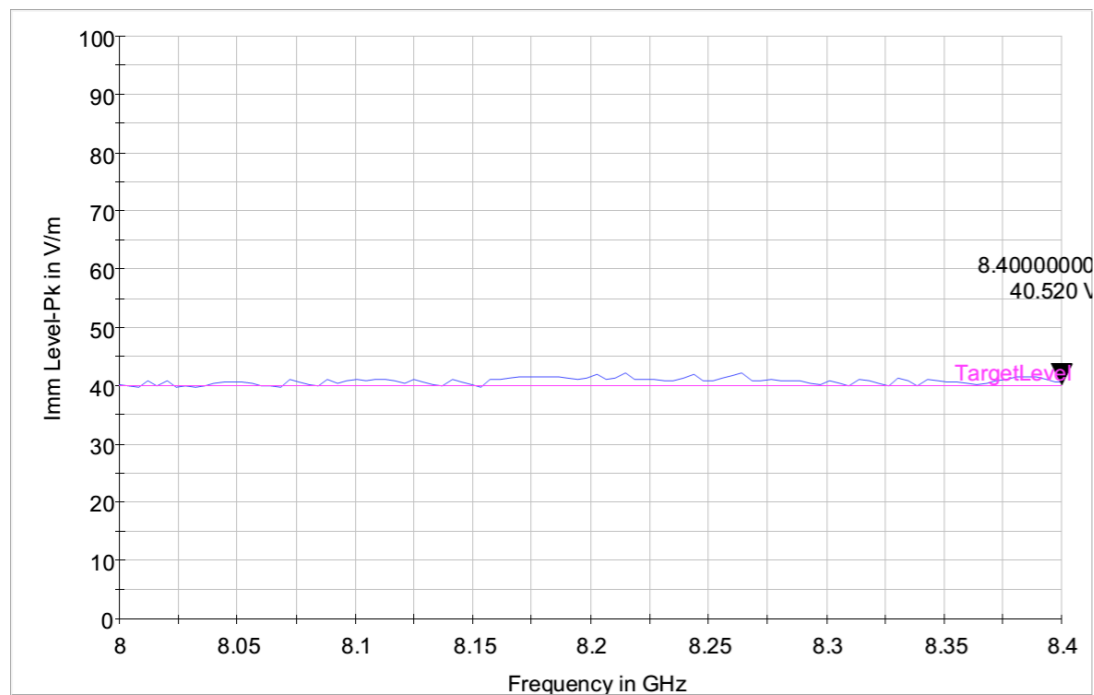
RS with redundant controller on for 2,214 MHz to 2,216 MHz in horizontal position.



RS with redundant controller on for 2,214 MHz to 2,216 MHz in vertical position.



RS with primary controller on for 8.0 GHz to 8.4 GHz in horizontal position. RS with redundant controller on for 8.0 GHz to 8.4 GHz in horizontal position.



RS with redundant controller on for 8.0 GHz to 8.4 GHz in vertical position. RS with primary controller on for 8.0 GHz to 8.4 GHz in vertical position.

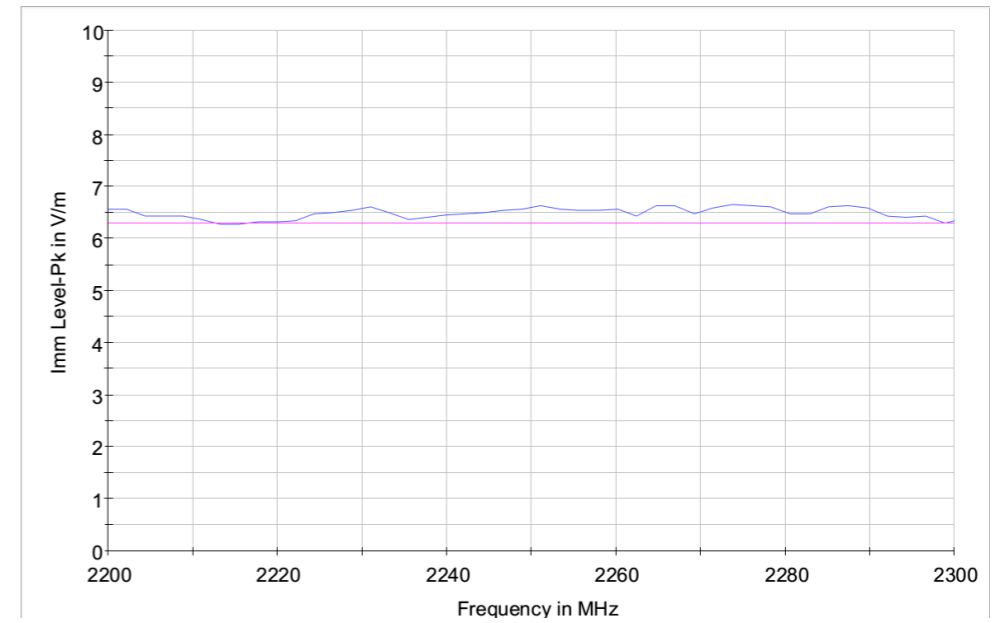
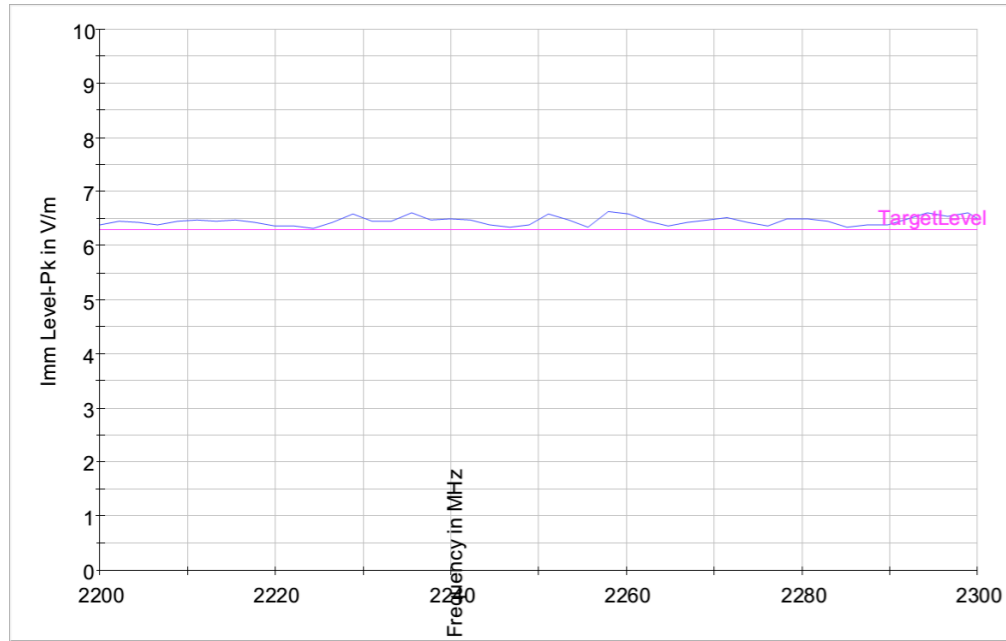
Launcher Environment

2200MHz~2300MHz@6.3Vrms/m, PM.

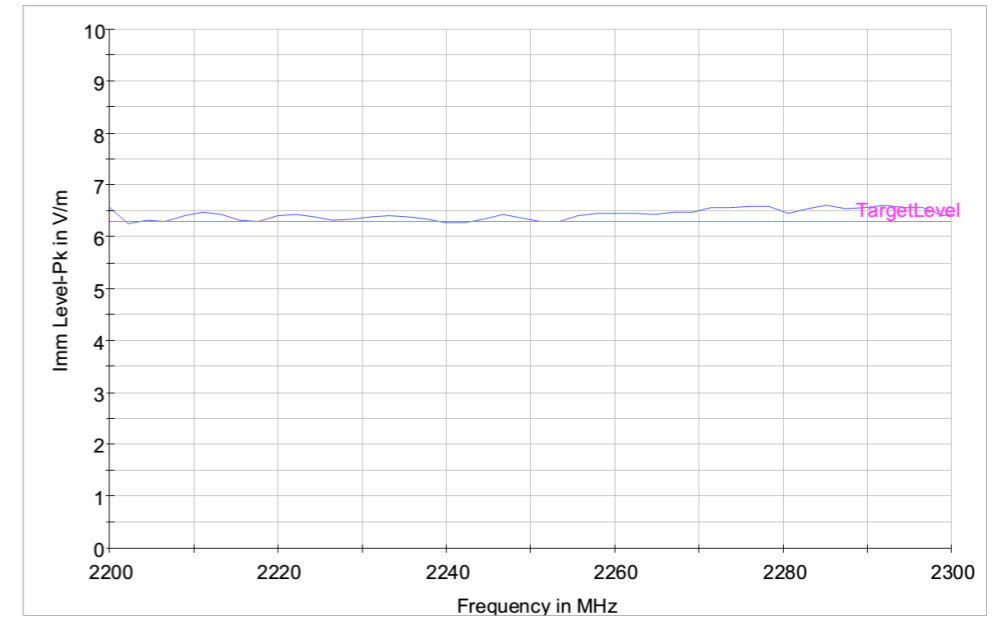
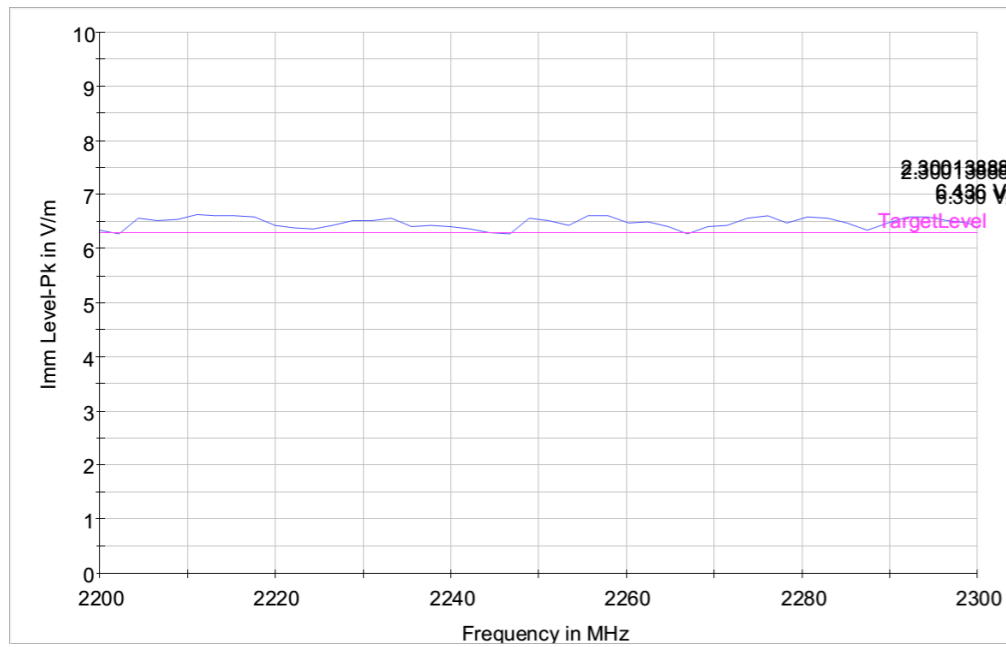
5400MHz~5900MHz@63.1Vrms/m, PM.

Step	Action
1	將設備如圖所示擺設好，只連接J1A（J1B不連接）。將Double ridge horn antenna（3117）設置成垂直方位。
2	確認AIP測試的設置與接線。請參考FS5SPL-CT-PROC的3.4.3.1節。
3	確認EMC設備已上電。
4	在EGSE方面，確認功能測試程序。請參考FS5SPL-CT-PROC的3.4.3.2節。
5	在EGSE方面，監控指令與遙傳介面與科學資料是否異常。
6	設置EMC32的檔案為FS5_RS_2200M-2300M。
7	2200MHz~2300MHz@6.3Vrms/m，PM。輻射RF訊號。
8	監控AIP是否有異常現象。
9	完成量測，將檔案存檔，檔名：RS_AIP_2200M-2300M_V_A。
10	打開正極電源（紅線）BOB開關。
11	將設備如圖所示擺設好，連接J1B（J1A不連接）。將Double ridge horn antenna（3117）設置成垂直方位。重複步驟1-10。

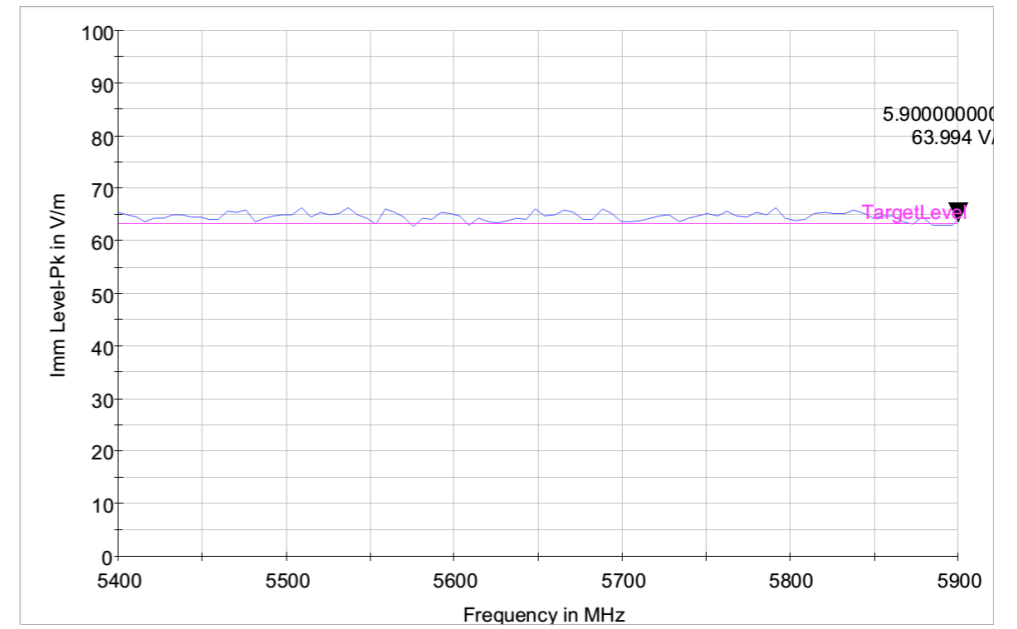
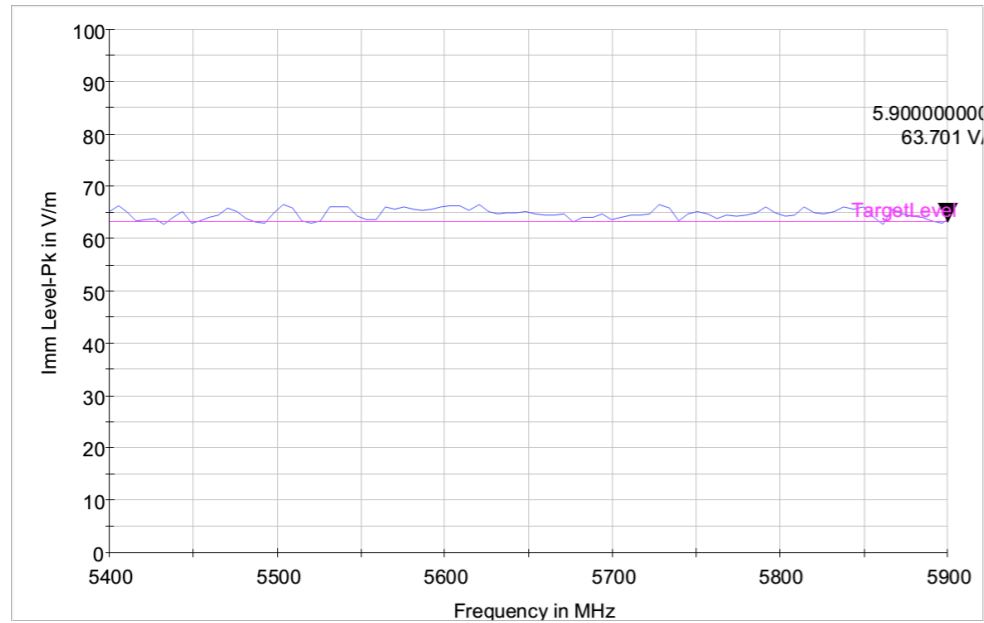
Antenna	EMC Test File	RF Signal	檔名
Double ridge horn antenna (3117)	FS5_RS_2200M-2300M	2200MHz~2300MHz@ 6.3Vrms/m, PM.	RS_AIP_2200M-2300M_V_A
			RS_AIP_2200M-2300M_V_B
			RS_AIP_2200M-2300M_H_A
			RS_AIP_2200M-2300M_H_B
	FS5_RS_5400M-5900M	5400MHz~5900MHz@ 63.1Vrms/m, PM.	RS_AIP_5400M-5900_V_A
			RS_AIP_5400M-5900_V_B
			RS_AIP_5400M-5900_H_A
			RS_AIP_5400M-5900_H_B



RS with primary controller on for 2,200 MHz to 2,300 MHz in horizontal position. RS with primary controller on for 2,200 MHz to 2,300 MHz in vertical position.

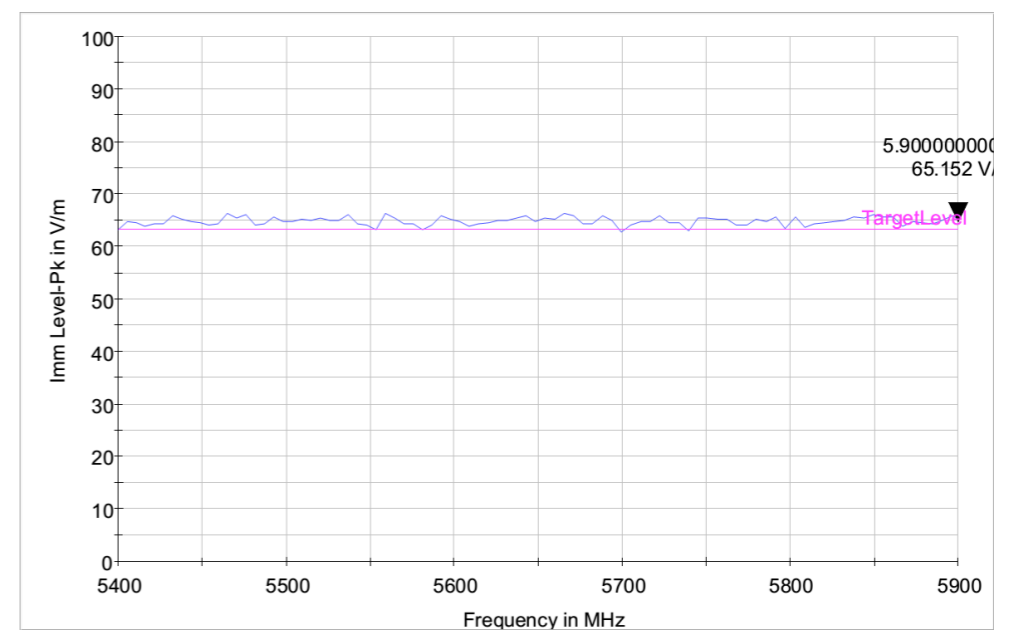
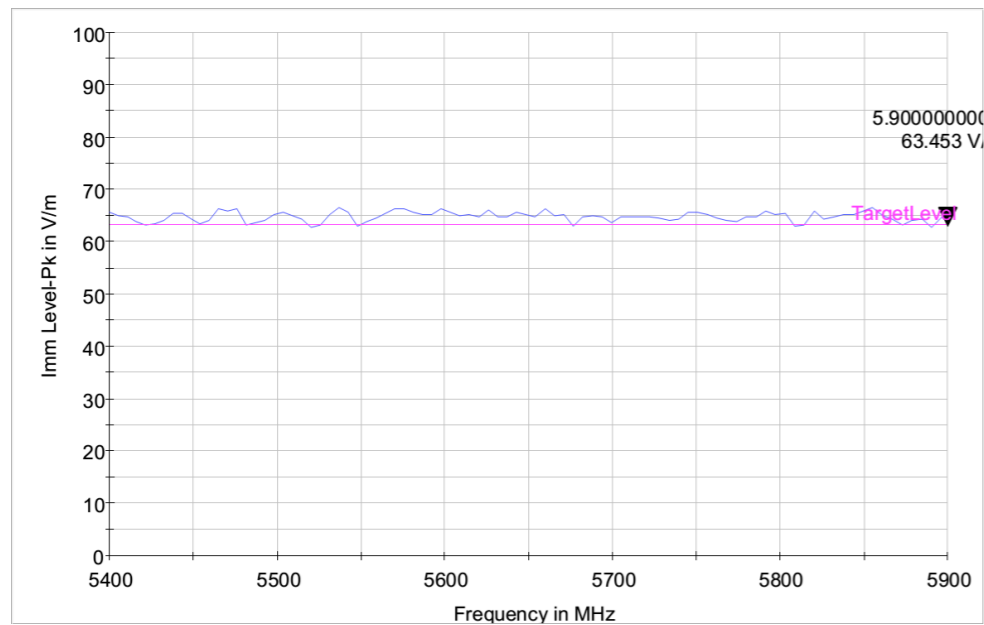


RS with redundant controller on for 2,200 MHz to 2,300 MHz in horizontal position. RS with redundant controller on for 2,200 MHz to 2,300 MHz in vertical position.



RS with primary controller on for 5,400 MHz to 5,900 MHz in horizontal position.

RS with primary controller on for 5,400 MHz to 5,900 MHz in vertical position.



RS with redundant controller on for 5,400 MHz to 5,900 MHz in horizontal position.

RS with redundant controller on for 5,400 MHz to 5,900 MHz in vertical position.

結論

- 電機設備和電子產品在使用過程中可能產生電磁輻射，以致干擾其他設備之正常運作。因此各國已在過去二十年期間先後立法規範，要求任何產品符合EMC法規標準，否則不準上市銷售。
- 近年來隨著無線通訊的快速發展，法規標準也日趨嚴格。由於現代的電子產品，功能越來越強，操作速度也越來越快，電子線路也越來越密集與複雜。所以EMC問題也變成了設計上主要挑戰。
- 解決EMC問題必須是在設計電路之初即以系統觀點考慮可能的EMC問題。更要事先進行原因分析評估，事後進行補救所花費的成本將更可觀。

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EMC Test on Advanced Ionospheric Probe

Chi-Kuang Chao

Graduate Institute of Space Science, National Central University

May 5, 2016



Electrical specifications

- Input voltage: **28 ± 6 VDC** (wider than +26 V to +34 V).
- Power on: 23.8 to 26.9 W and 0.85 to **0.96 A** (≤ 1.3 A, limited by PCDU) for +28 V.
- Operation: **11.9 W** in average.
- Sensor: **7.11 W** (< 11.3 W in analysis), 0.12 A for +28 V and 0.25 A for +15 V.
- SPEU (without sensor load): **4.76 W** (< 8.15 W in analysis), 0.17 A for +28 V.
- Average power per orbit: can be reduced to 5 W if the duty cycle of AIP can be reduced to **42 %** (≥ 30 %).
- Single event latch-up (over-current) protection.

Functional tests



- **Circuit protection test** (T&C, 8/13/2013): FS5SPL-CPT-PROC/RPT.
- **Power measurement** (NCU, 8/22/2013): FS5SPL-PMT-PROC/RPT.

Requirements for circuit protection test



- 為保護AIP受到單粒子閃鎖效應的影響，當PCDU供給AIP的電流量高於AIP最大操作電流的1.75倍，並且持續時間高於1毫秒，此時AIP須關閉來自PCDU的電源。過了0.3秒後，AIP須自動開啟來自PCDU的電源。
- 為能有效進行閃鎖效應的保護，可依照元件的電流量，分組進行過量電流偵測。



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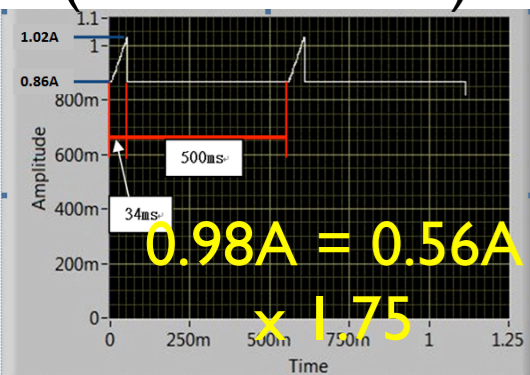
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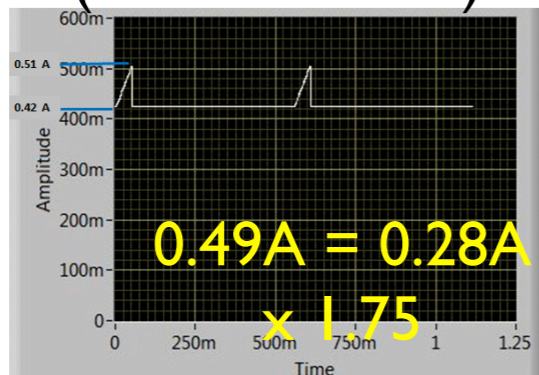
Circuit protection test

Setup

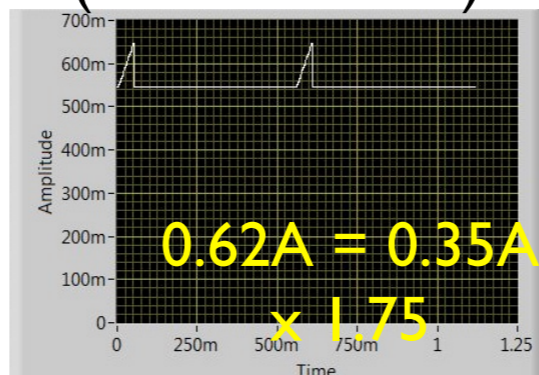
28 V to sensor
(0.86A → 1.02A)



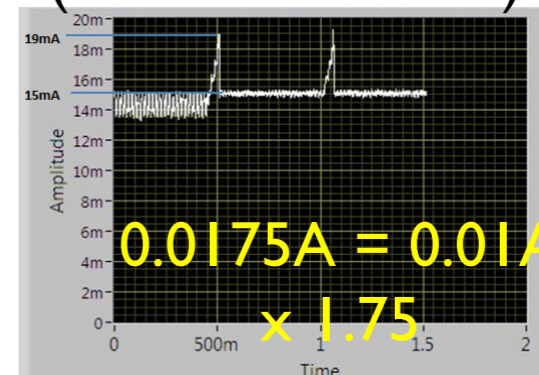
15 V to sensor
(0.42A → 0.51A)



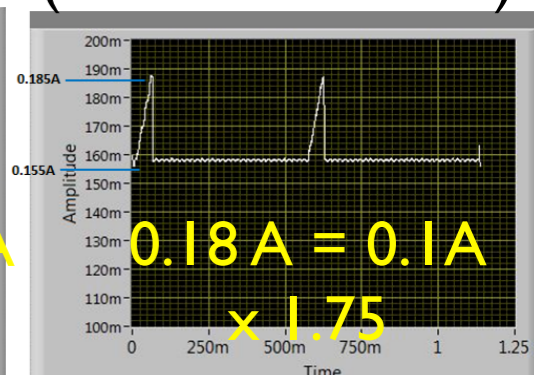
3.3 V to FPGA
(0.54A → 0.65A)



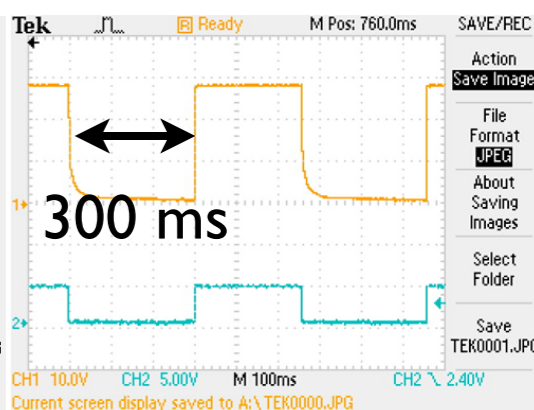
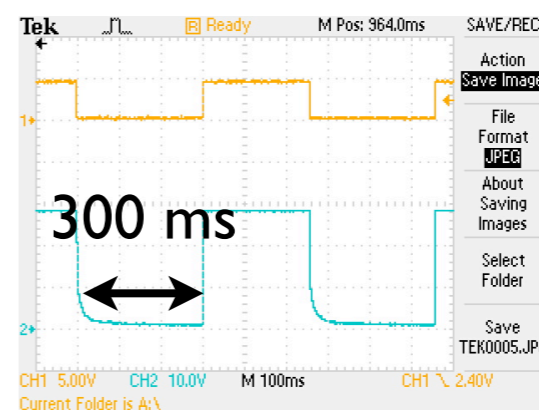
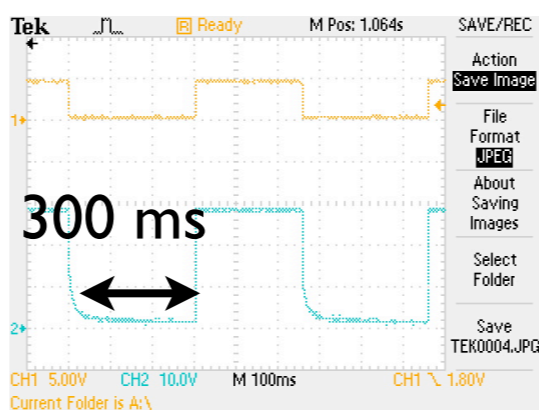
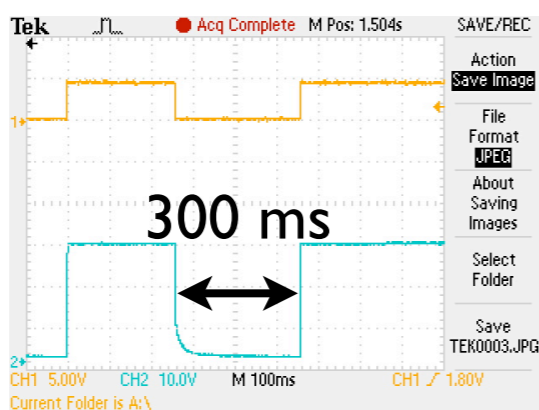
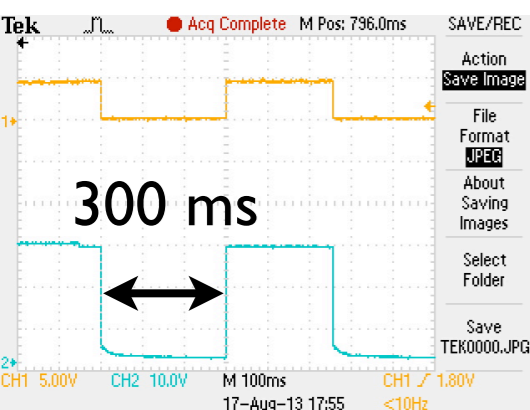
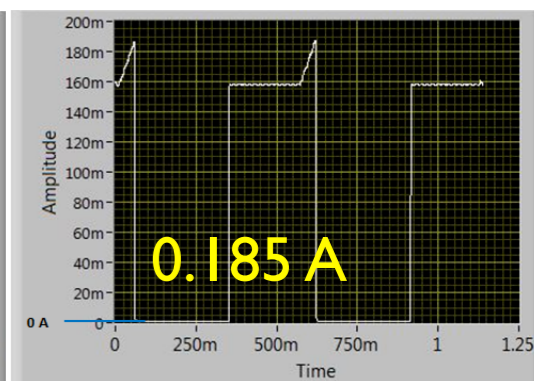
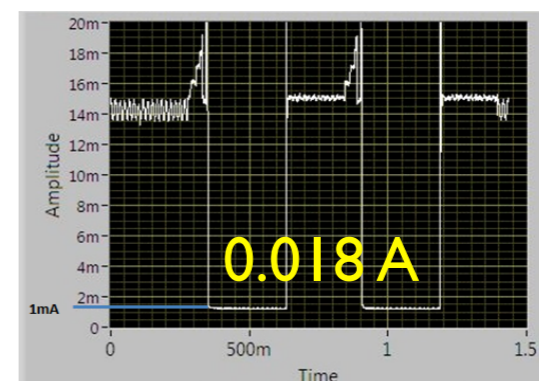
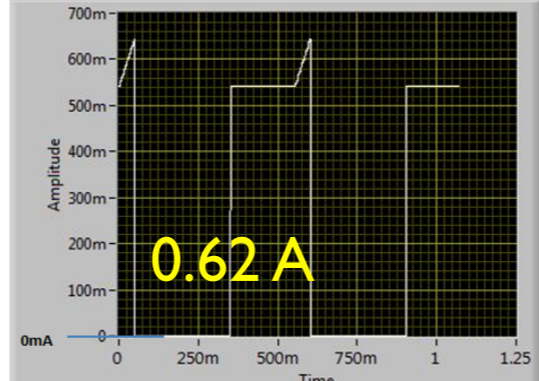
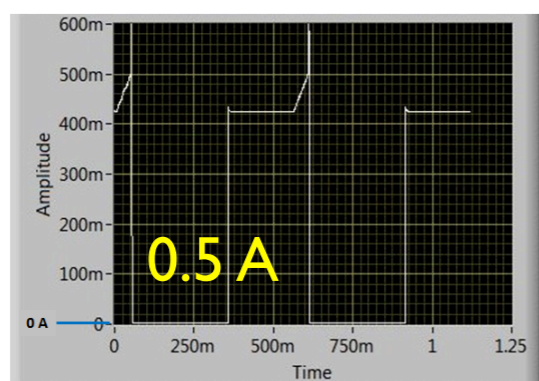
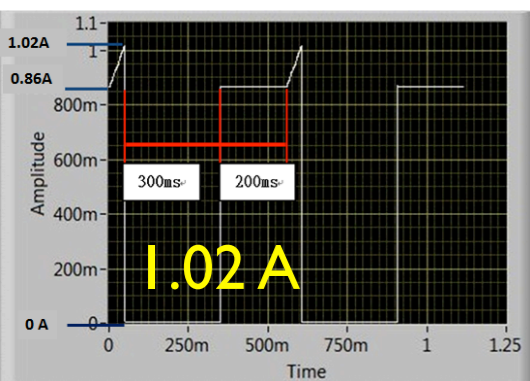
3.3 V to FLASH
(0.015A → 0.019A)



1.2 V to FPGA
(0.155A → 0.185A)

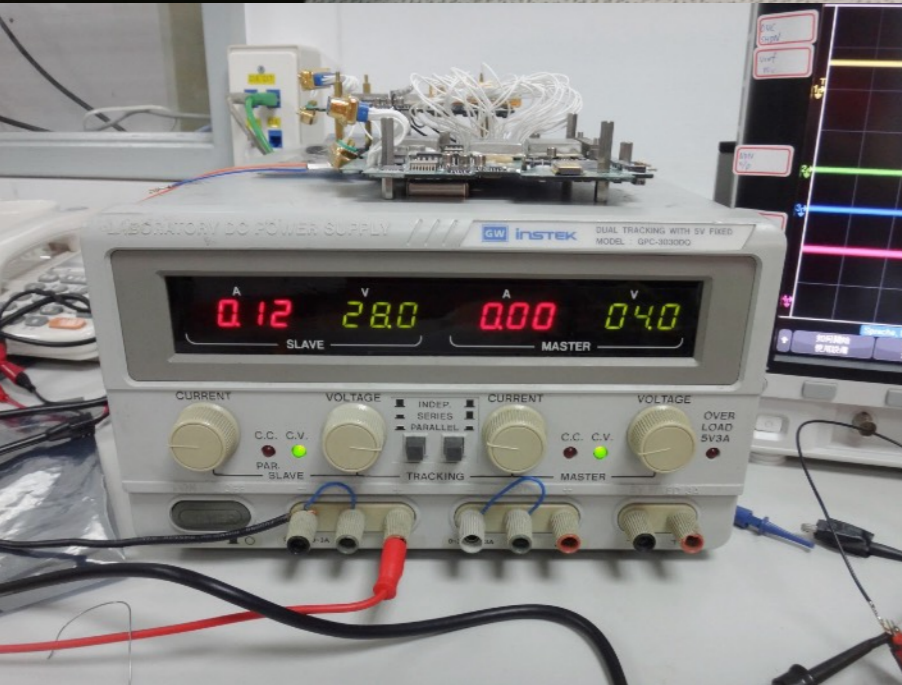
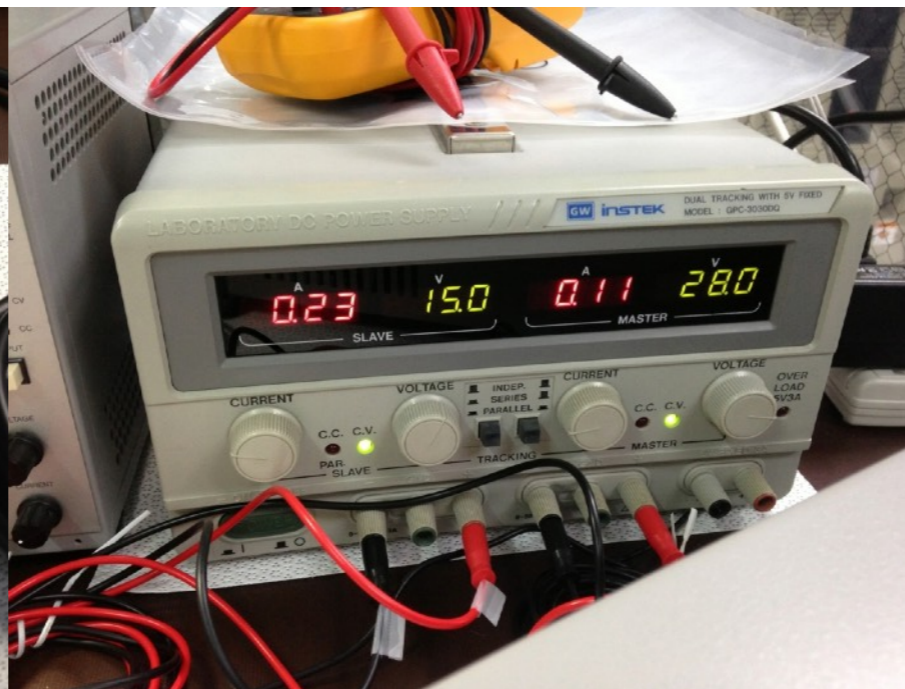
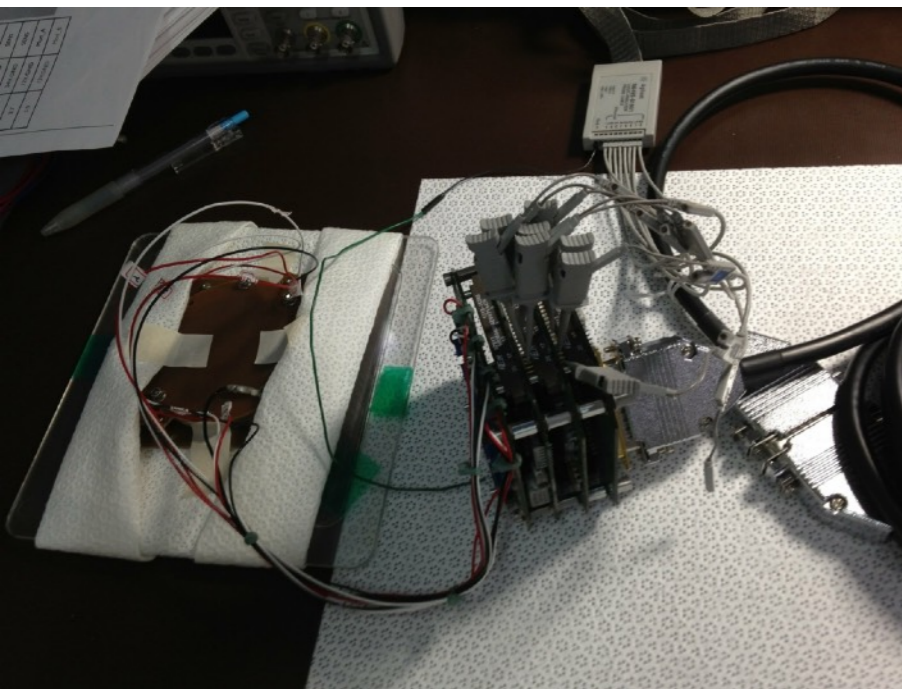


Measurement



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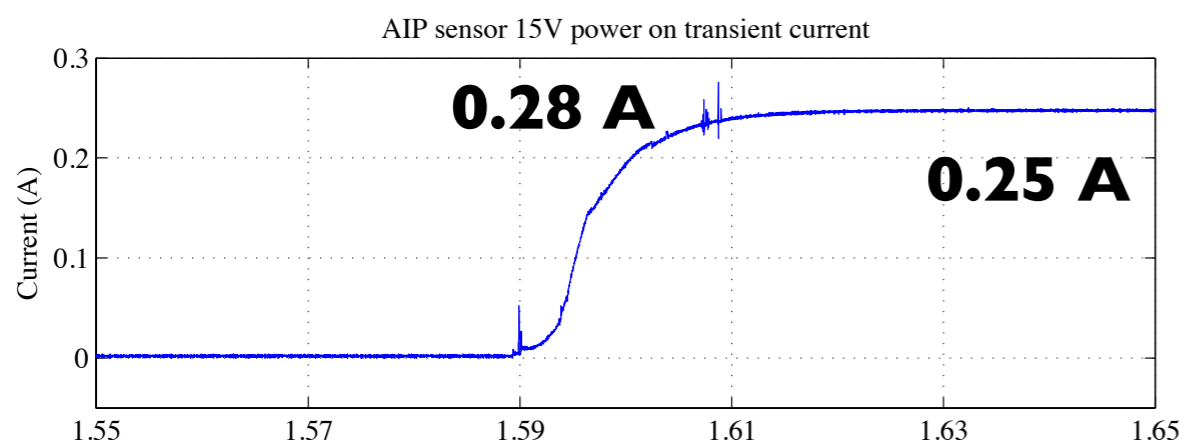
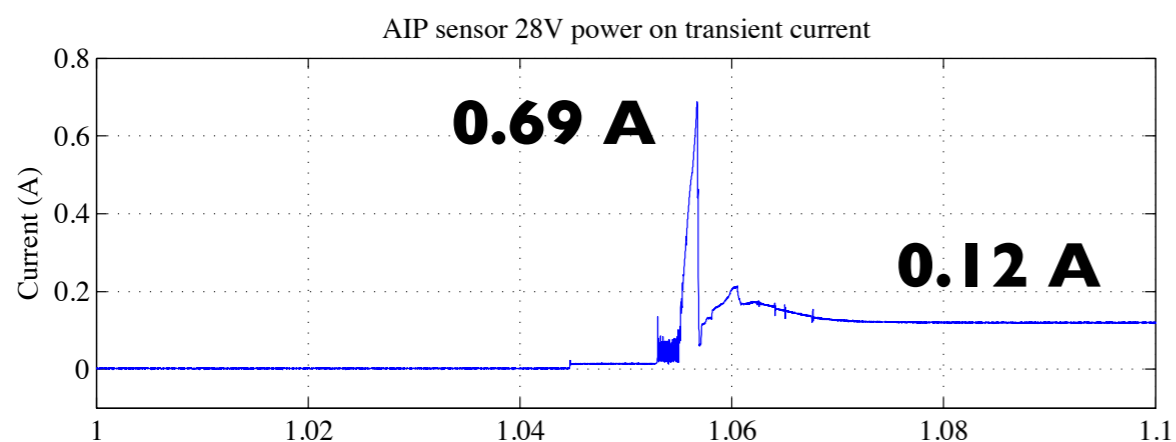
Power measurement



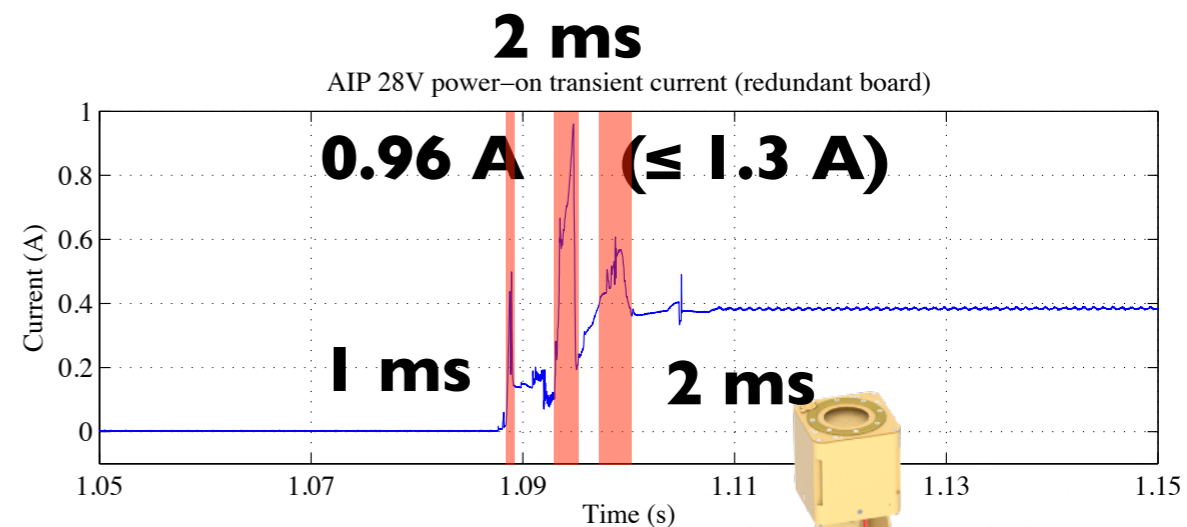
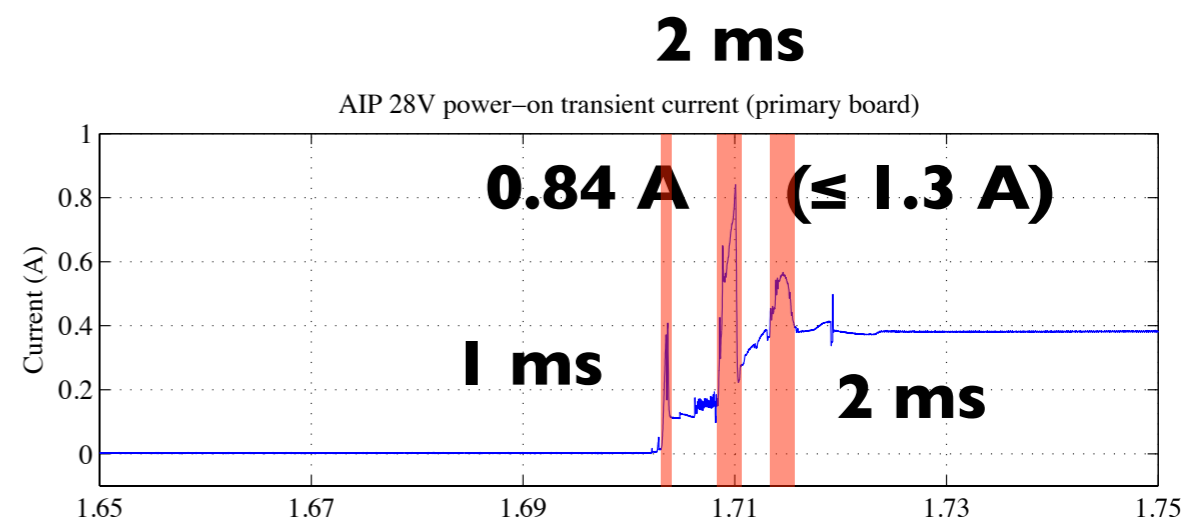
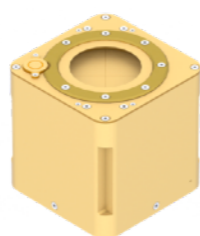


Power measurement (cont.)

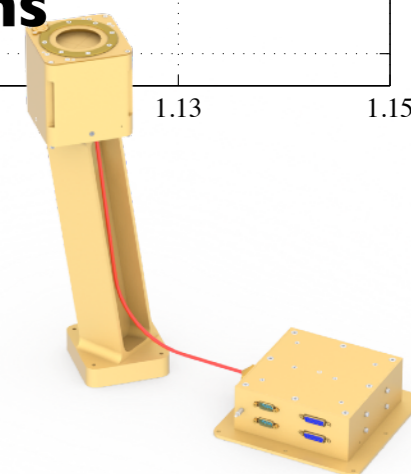
The switch-on current shall return to nominal current level within 5 ms.



Sensor



AIP



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Environmental tests



- **EMC test** (NSPO, 9/16/2013 to 9/18/2013 & 9/23/2013 to 9/27/2013): FS5SPL-CEMC-PROC/RPT and FS5SPL-REMC-PROC/RPT.

EMC test



- **Conducted EMC**
 - Grounding and isolation.
 - CE on transient voltage and in-rush current - time domain, on primary power lines - frequency domain, and on signal lines - time domain.
 - CS on primary power lines - sine wave and spike injection.
- **Radiated EMC**
 - RE - 14 KHz to 10 GHz, GPS receiver, S band receiver, and launcher receiver.
 - RS - 200 MHz to 10 GHz, local E-field by bus antennas, and launcher environment (under a conclusion of TRR meeting on EMC, 14 KHz to 200 MHz could be performed after an amplifier for this radio band returns to NSPO).



Grounding

- 接地：由接頭的腳位連接。這裡所指 AIP 的主要電源，係包括衛星 PCDU 所提供的主要電源與備援電源。而 AIP 的次要電源，係指由 AIP 的主要電源再轉換成其他電壓（如使用 DC/DC Converter）的電源供應。衛星與 AIP 的接地方式採用分散式星狀點接地（Distributed Star-Point Ground, DSPG）。
- 主要電源接地：AIP 的主要電源需使用單點接地（Single Point Grounding, SPG）。主要電源不可使用 SPEU 的外殼底座（Chassis）為電源迴路。AIP 的主要電源線路（火線與迴路）與 SPEU 外殼底座間的直流隔絕和主要電源線路與次要電源線路間的直流電阻要高於 $1\text{ M}\Omega$ 。



Grounding

- 次要電源接地：AIP 的次要電源應該遵守單點接地，並且次要電源迴路須直接與 SPEU 的外殼底座或是與探測器的外殼底座相連。其間的直流電阻值亦須小於 $20\text{ m}\Omega$ ，且次要電源迴路與外殼底座間的電容應小於 10 nF 。
- 外殼底座接地：探測器的外殼底座與螺釘間的直流電阻值須小於 $100\text{ m}\Omega$ 。螺釘為 M4 規格，最小長度為 10 mm ，本身的直流電阻值須小於 $20\text{ m}\Omega$ 。SPEU 的外殼底座，須以乾淨的金屬對金屬面，與衛星結構電導接觸。外殼底座的最大直流電阻須小於 $100\text{ m}\Omega$ 。探測器與 SPEU 的接頭，其金屬外殼需與外殼底座相接，其直流電阻值亦須小於 $100\text{ m}\Omega$ 。

Grounding



- 地面測試系統接地：AIP 地面測試系統的外殼底座均需與測試接地面相連，測試接地面需與衛星的星狀點接地相連。
- 接地連線：探測器與 SPEU 的外殼底座將經由連線接頭的外殼，透過纜線的保護層，與衛星本體接地。其直流電阻值亦須小於 100 mΩ。
- 訊號迴路：AIP 訊號電路接收端需與次要電源迴路和外殼底座相隔絕。其隔絕電阻需大於 150 kΩ（RS-422 界面除外）。當使用單端訊號傳輸，需提供獨立的訊號迴路，不可使用接地端當作訊號迴路（除非使用同軸電纜）。相同類型的訊號迴路，可使用共同訊號迴路。例如：類比訊號可共用類比接地端，數位訊號可共用數位接地端，但類比接地端與數位接地端不可相連。

Grounding and isolation

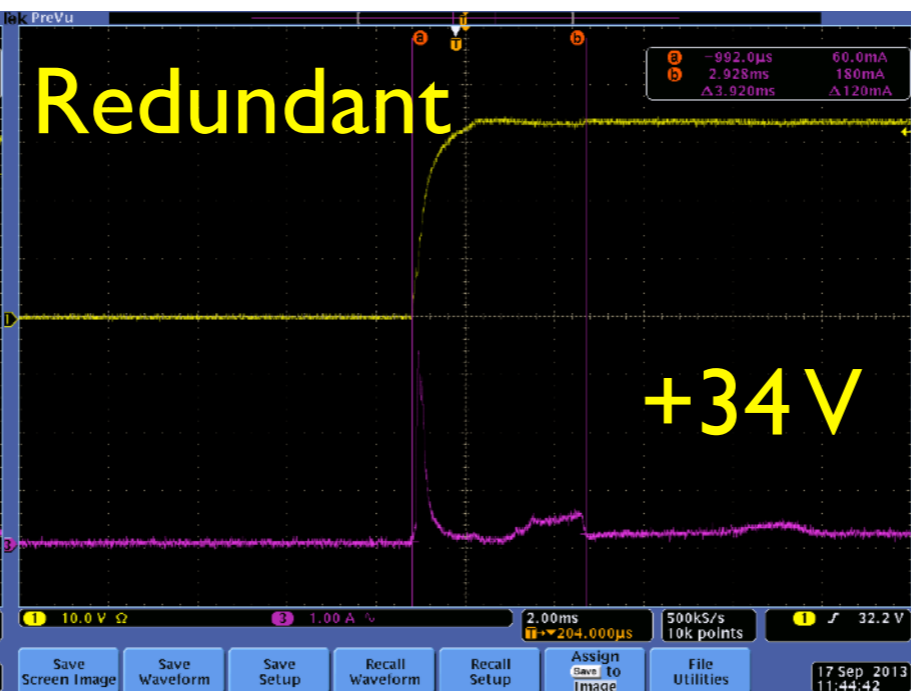
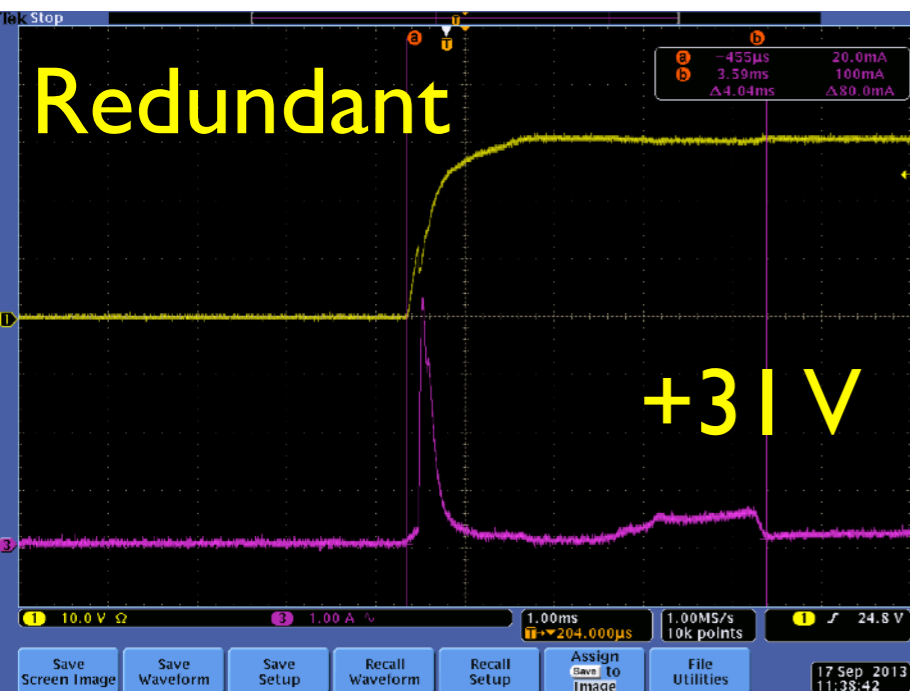
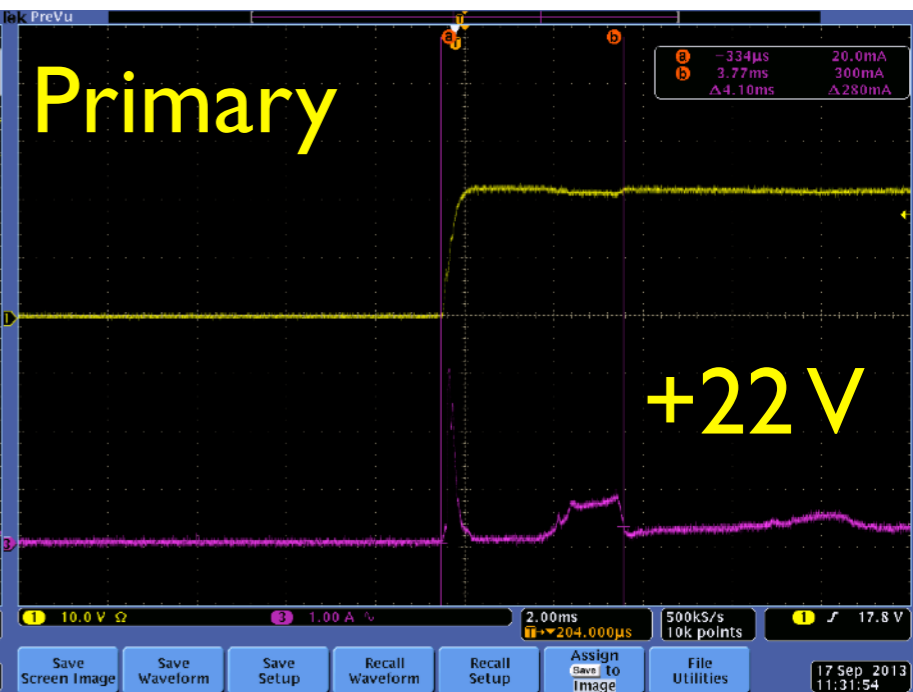
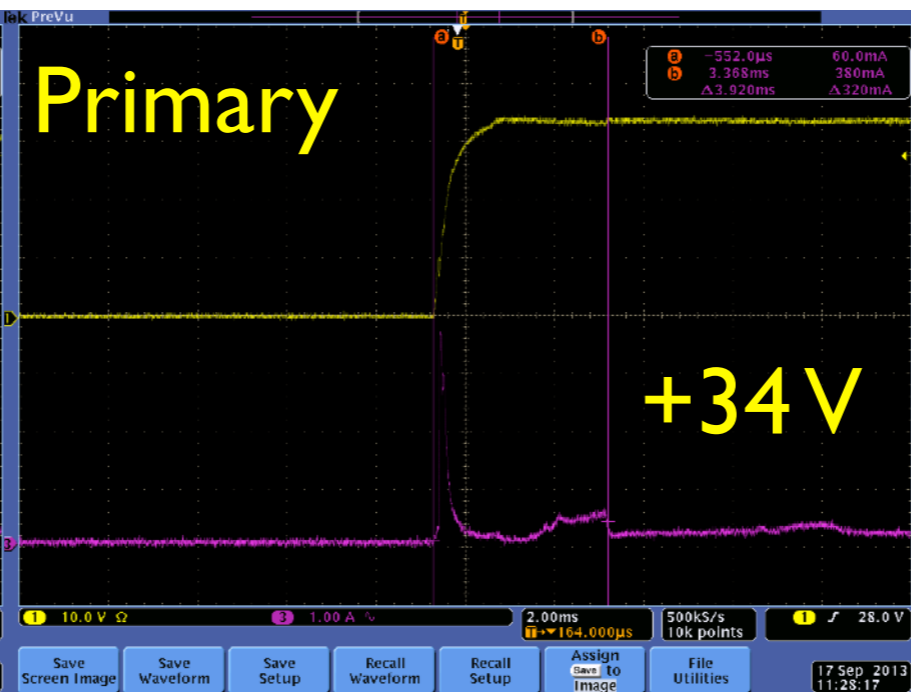
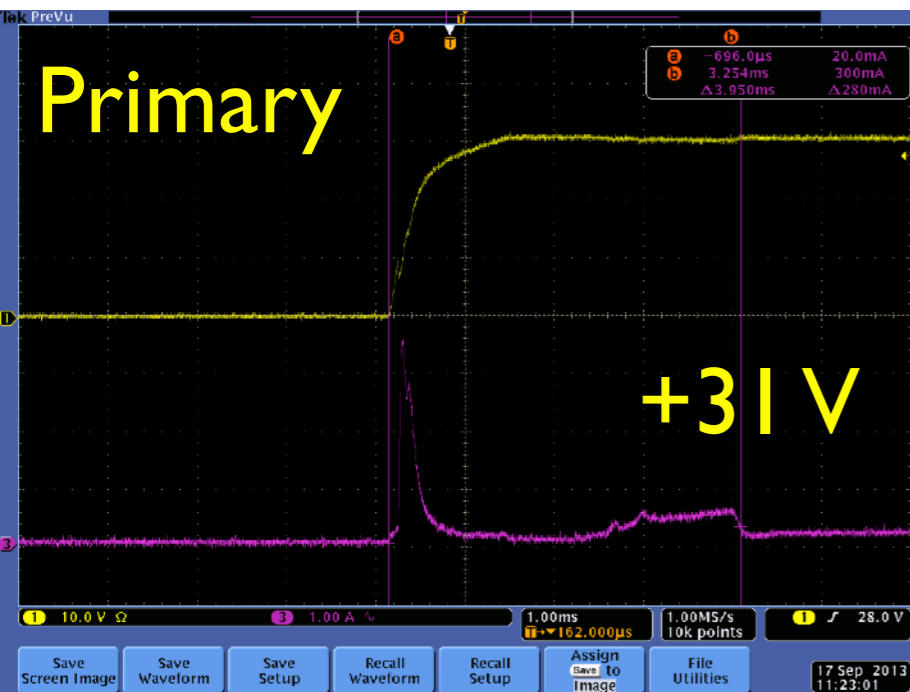


Resistance	Requirement	Measurement
Resistance between SPEU chassis and the test bench	< 100 mΩ	6.8 mΩ
Resistance between SPEU chassis and secondary ground	≤ 100 mΩ	ND
Resistance between SPEU chassis and primary power +28 V of primary controller	> 1 MΩ	OL
Resistance between SPEU chassis and primary power +28 V of redundant controller	> 1 MΩ	OL
Resistance between SPEU chassis and primary power ground of primary controller	> 1 MΩ	OL
Resistance between SPEU chassis and primary power ground of redundant controller	> 1 MΩ	OL
Resistance between primary power +28 V of primary controller and the secondary power +15 V	> 1 MΩ	OL
Resistance between primary power +28 V of redundant controller and the secondary power +15 V	> 1 MΩ	OL
Resistance between primary power ground of primary controller and the secondary power +15 V	> 1 MΩ	OL
Resistance between primary power ground of redundant controller and the secondary power +15 V	> 1 MΩ	OL

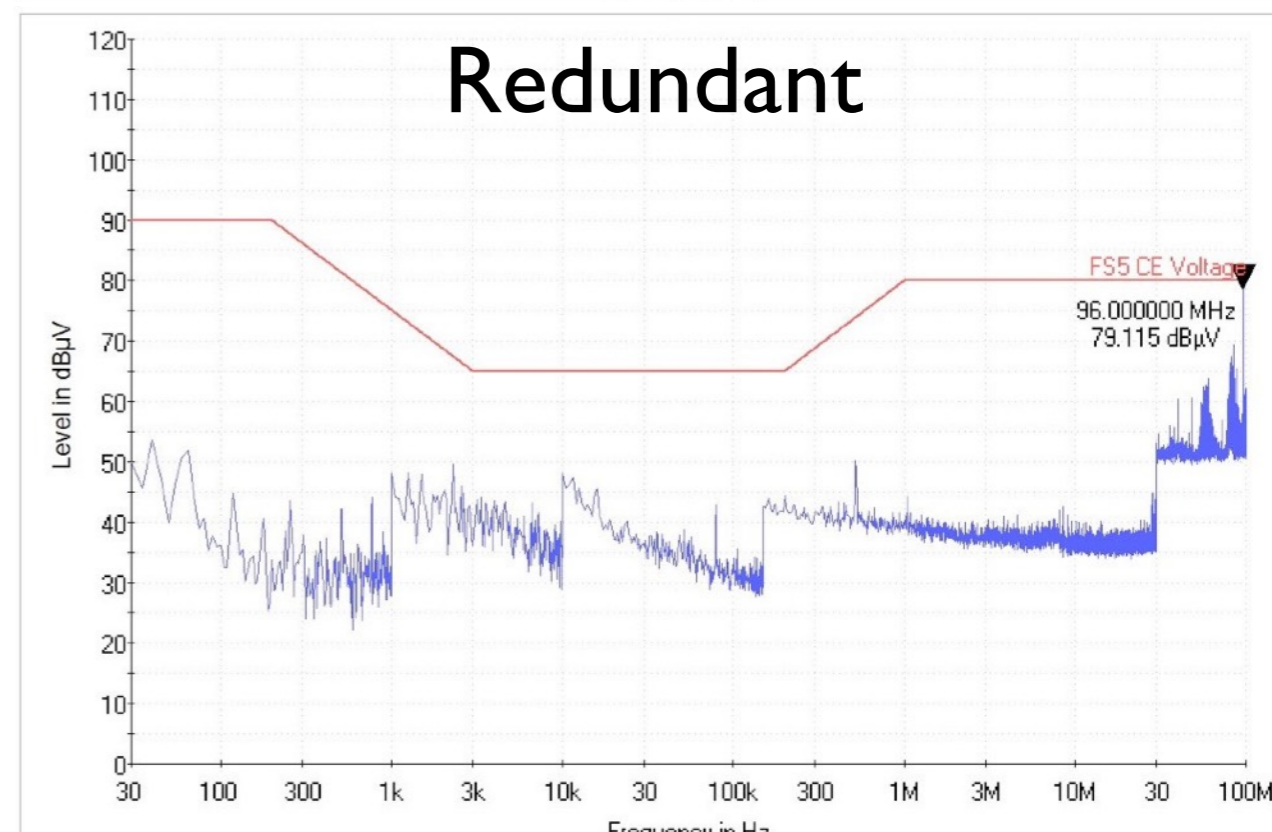
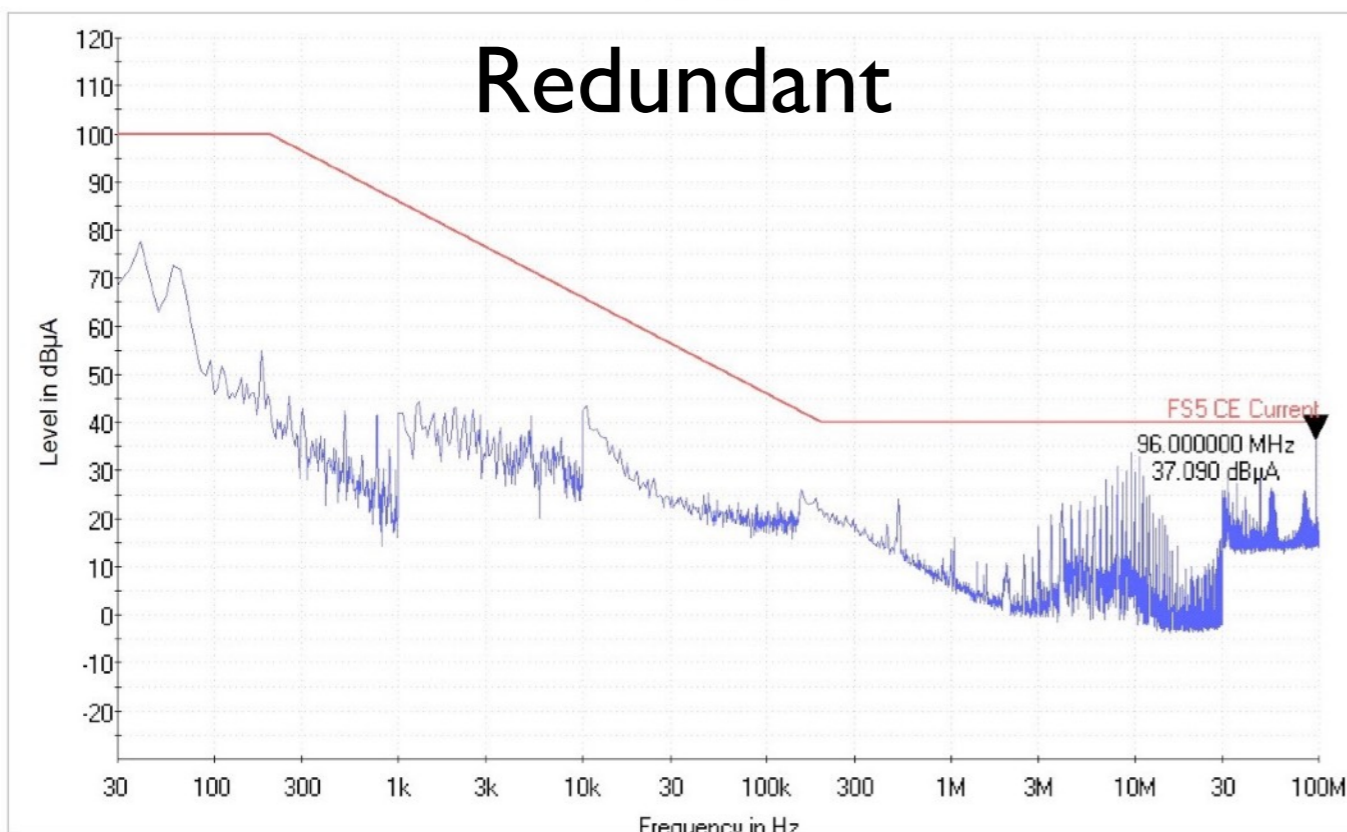
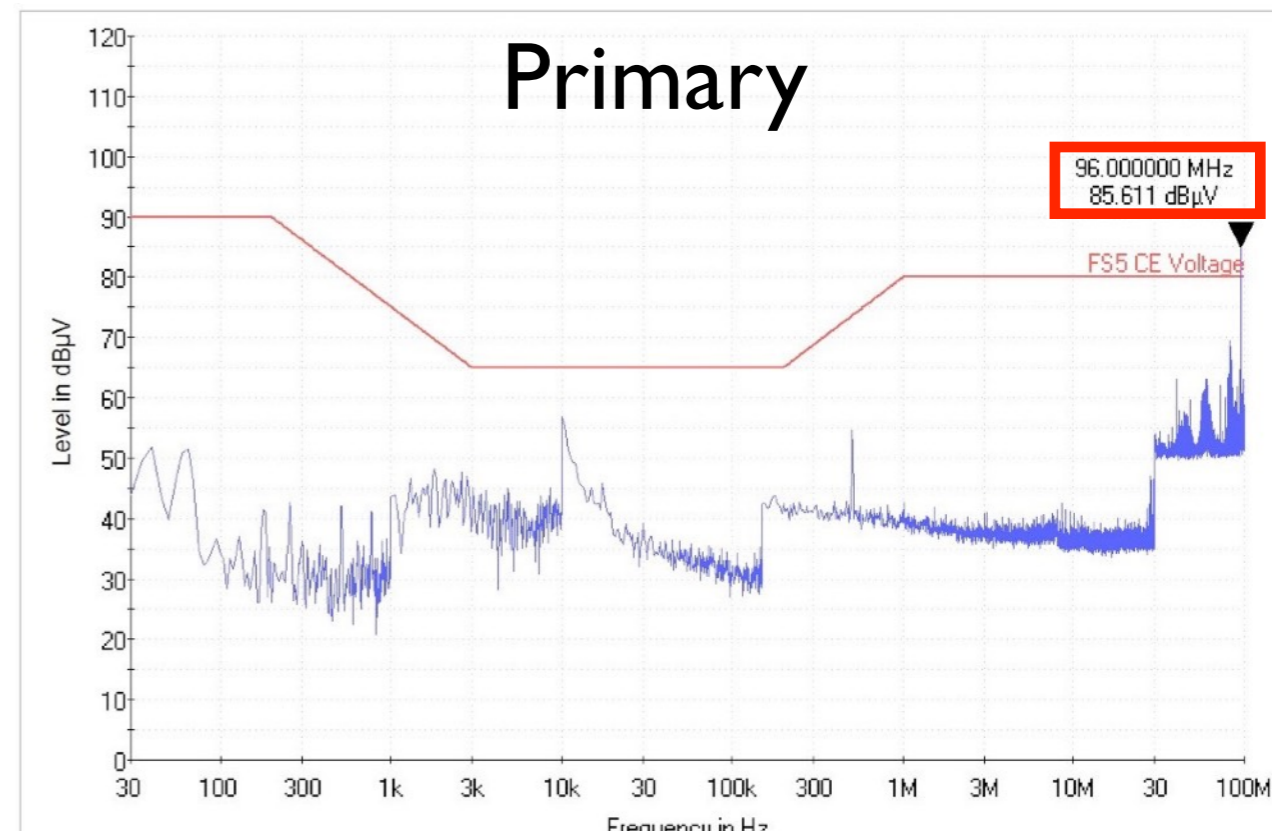
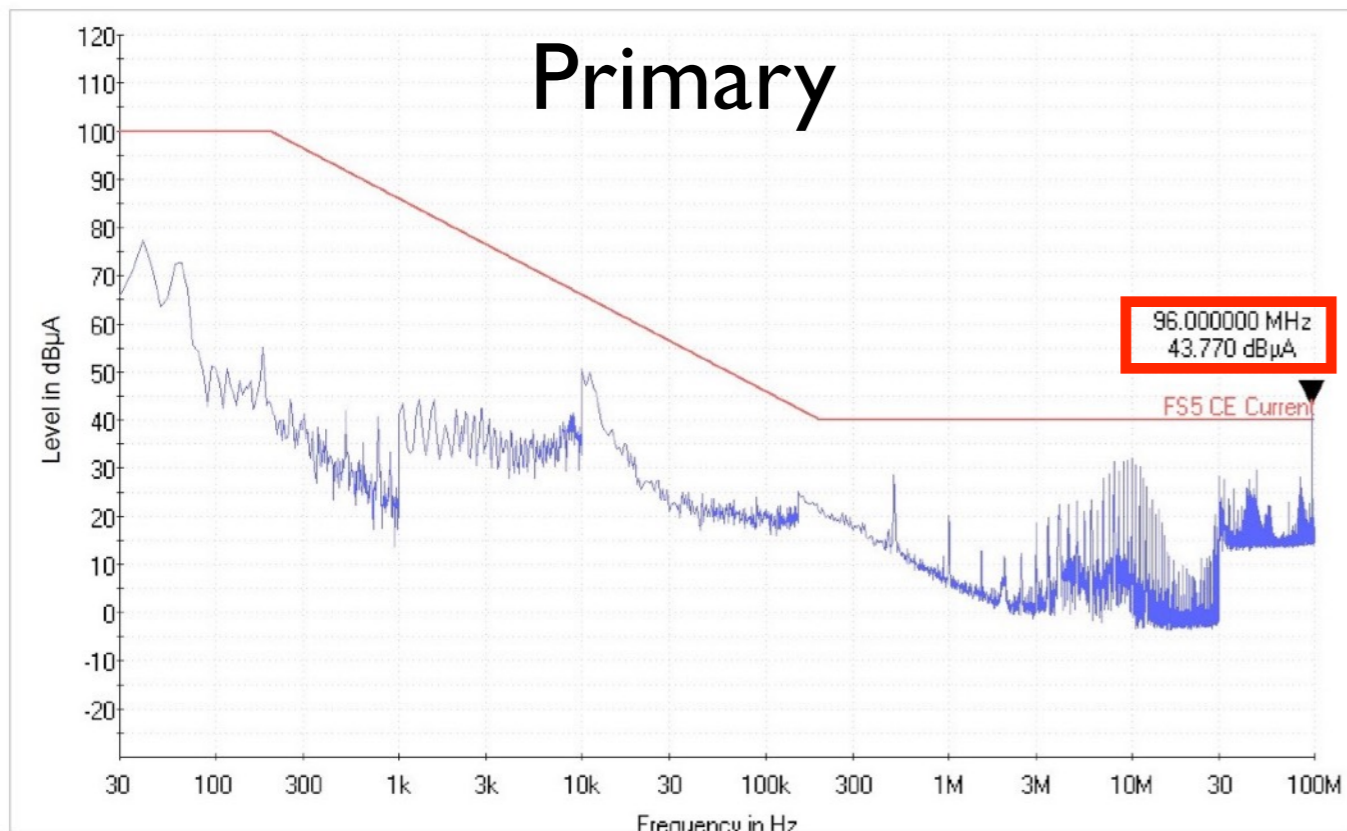
FS-5/AIRCE on transient voltage and in-rush current - time domain



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CE on primary power lines - frequency domain



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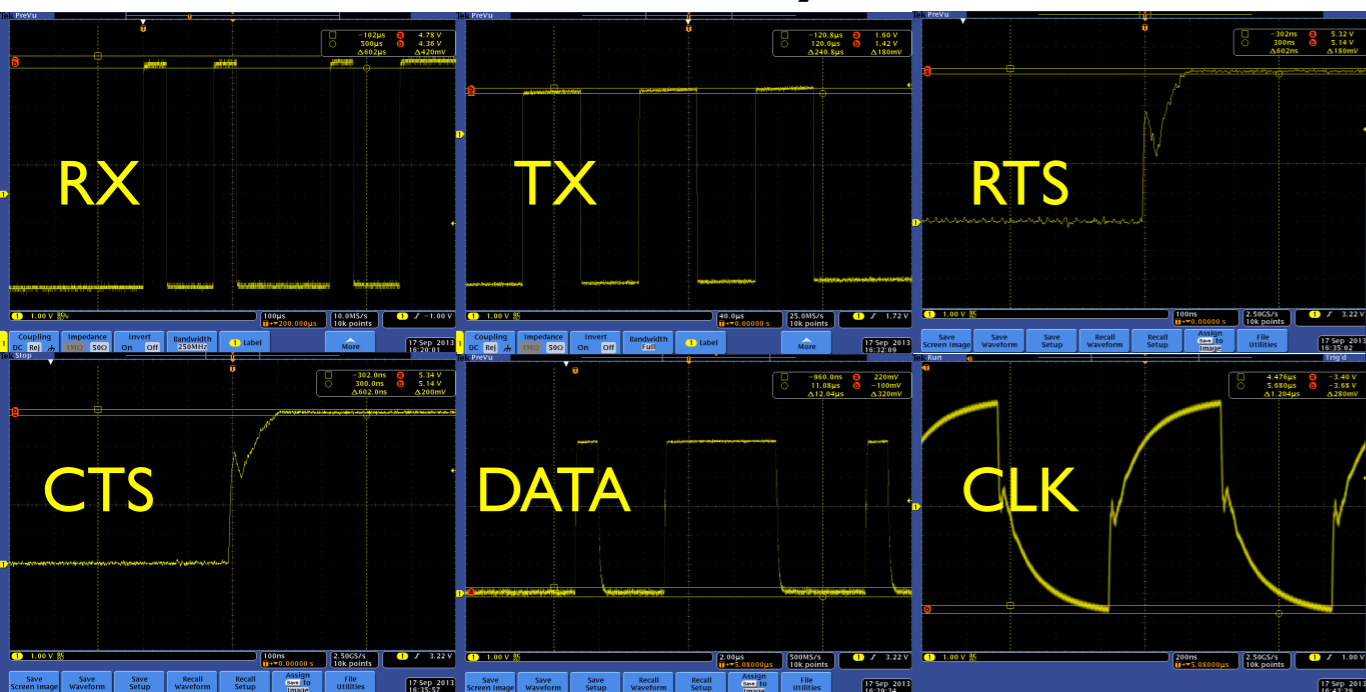
FS5SPL-CDRL-1014

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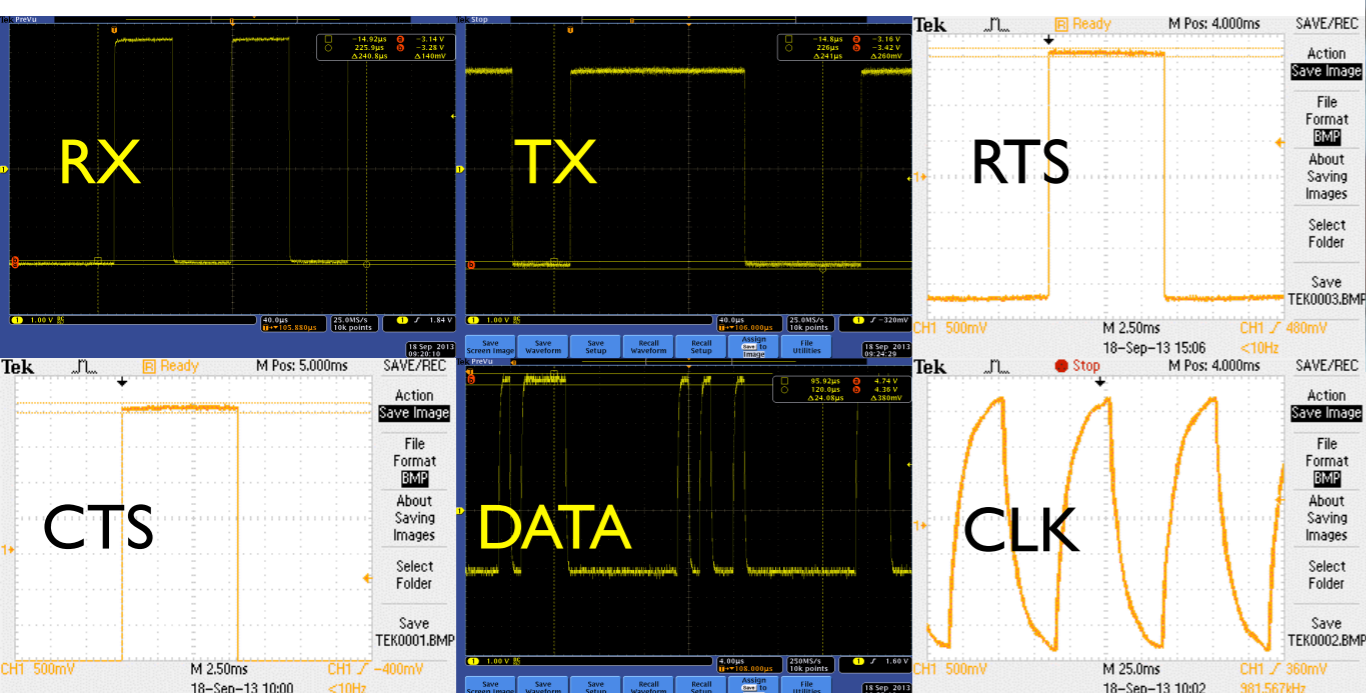
CE on signal lines - time domain



Primary



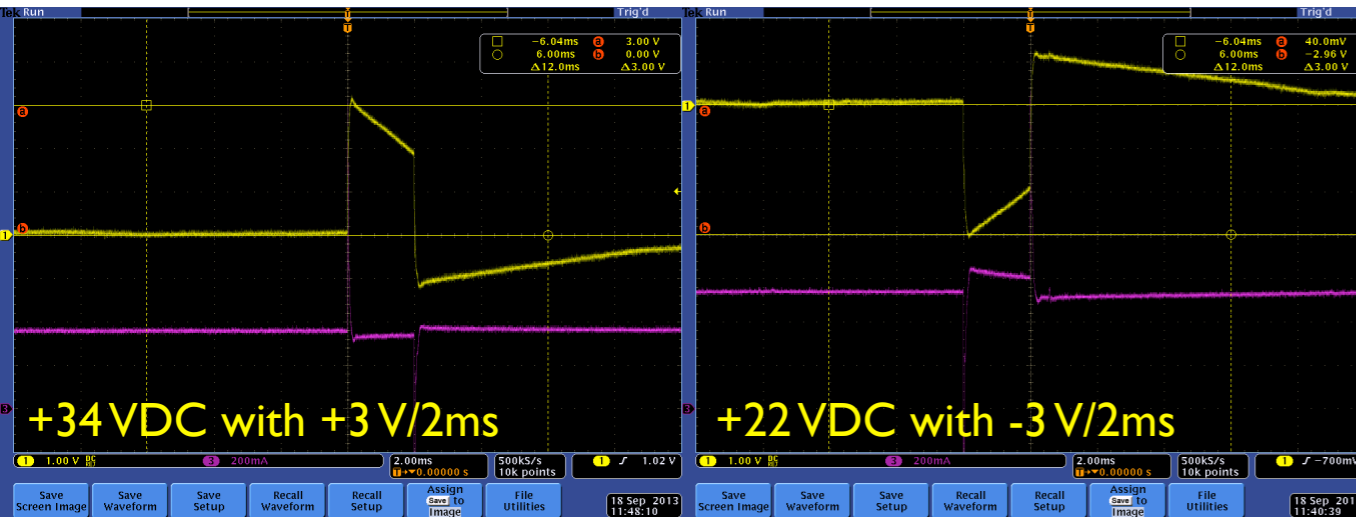
Redundant



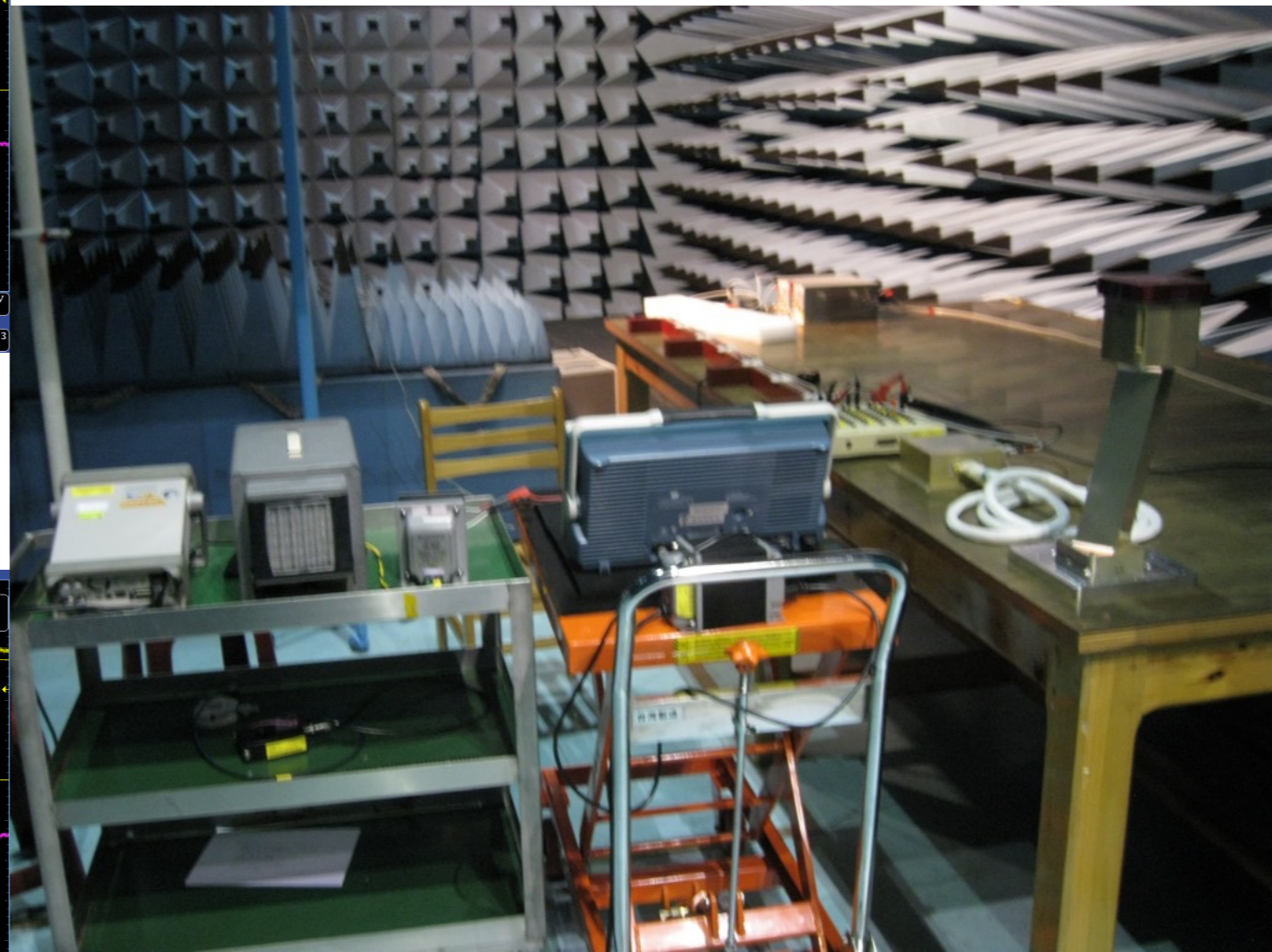
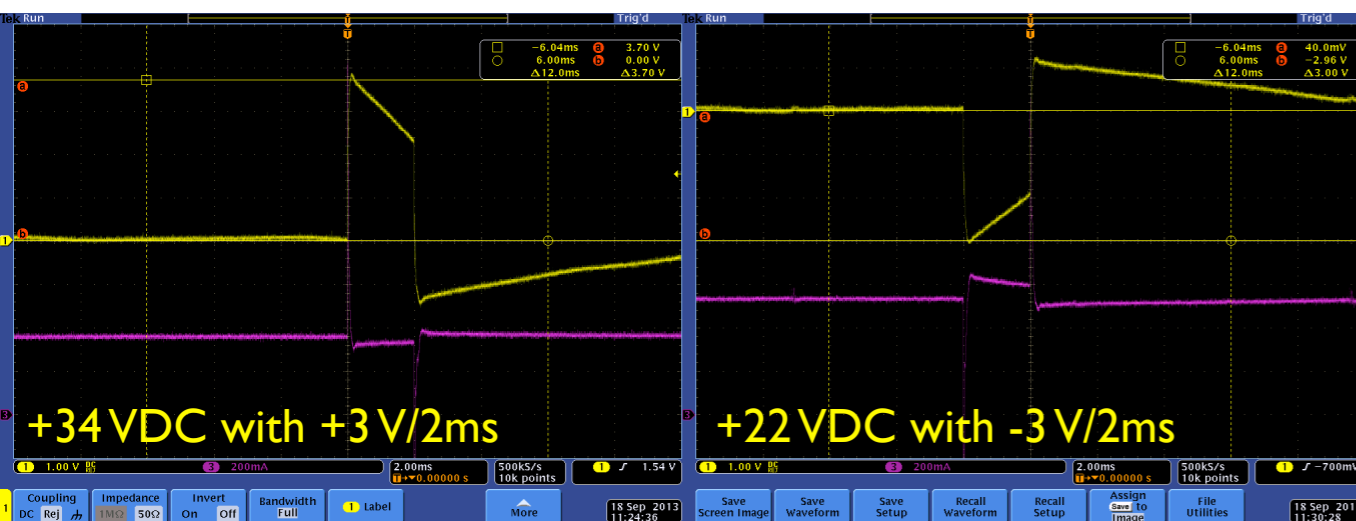
CS on primary power lines - sine wave and spike injection



Primary



Redundant



Spike injection

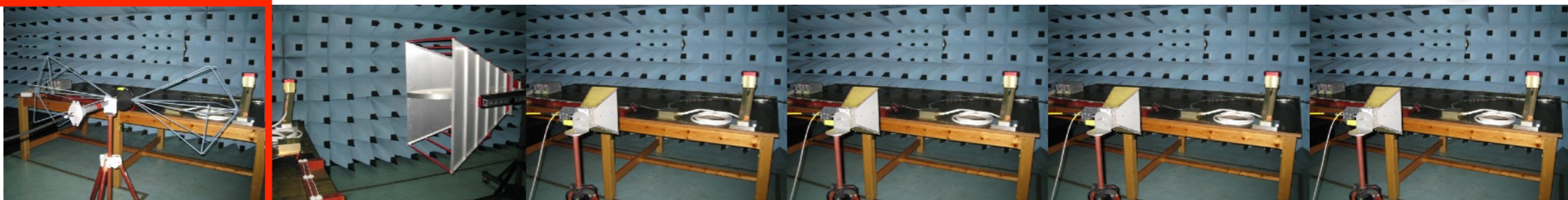
FS-5/AIP

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RE (14 KHz to 10 GHz)



30 MHz - 200 MHz

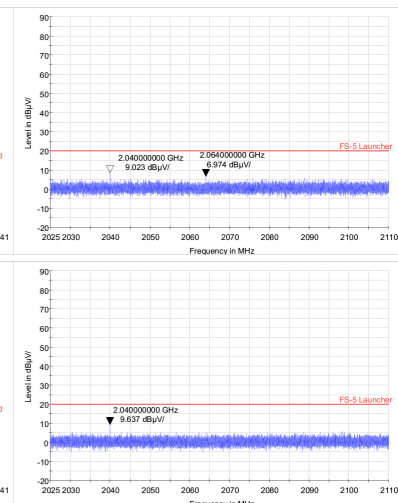
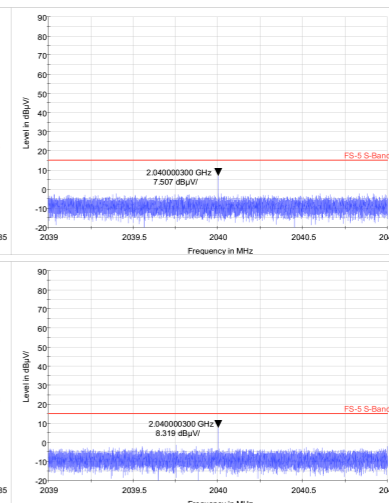
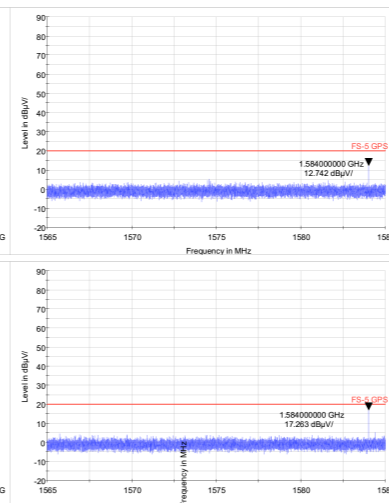
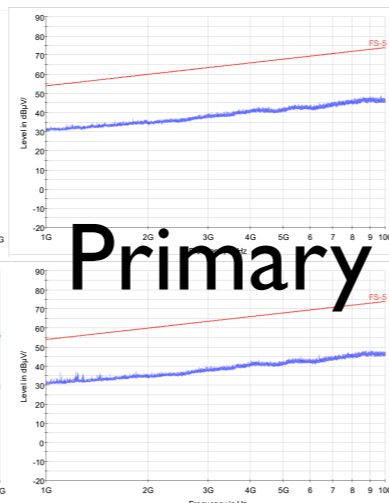
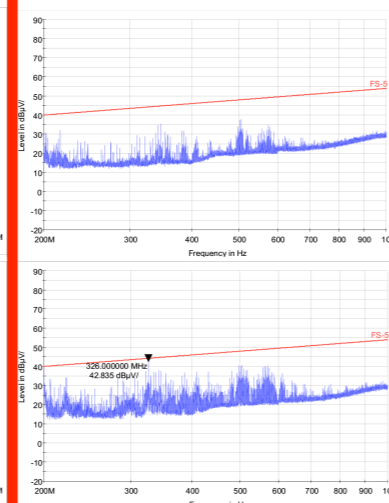
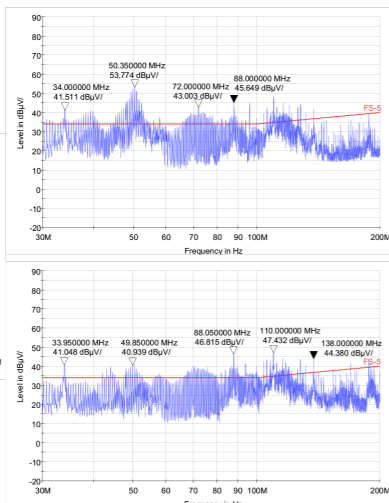
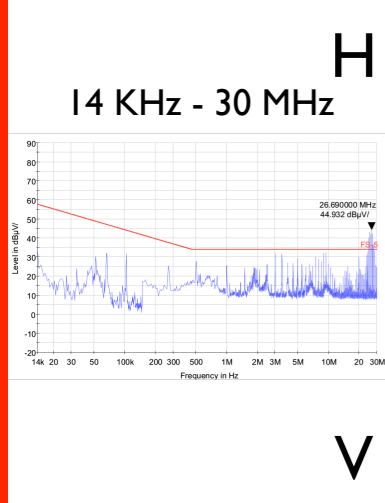
200 MHz - 1 GHz

1 GHz - 10 GHz

1,565 MHz - 1,585 MHz

2,039 MHz - 2,041 MHz

2,025 MHz - 2,110 MHz



Primary



30 MHz - 200 MHz

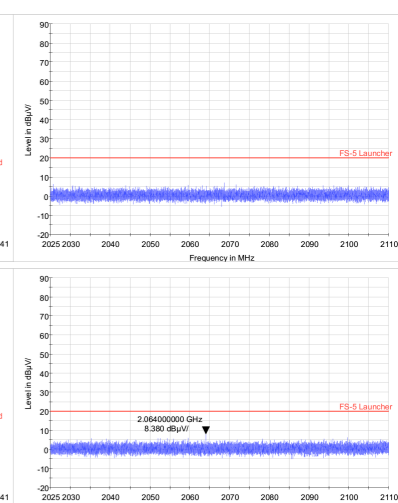
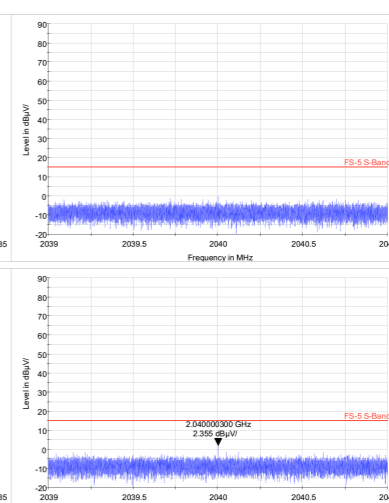
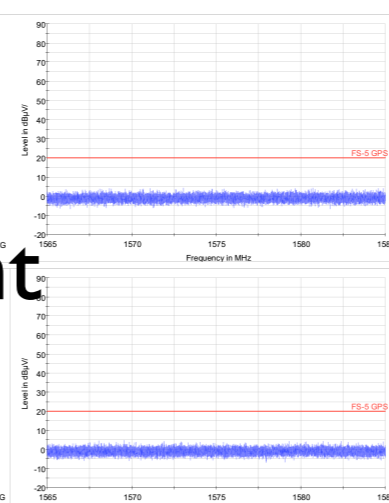
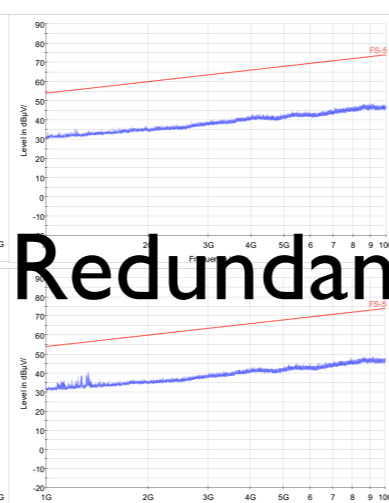
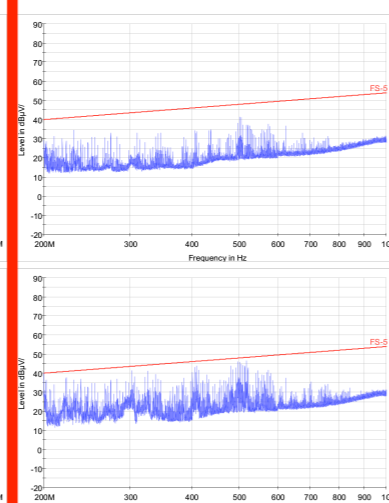
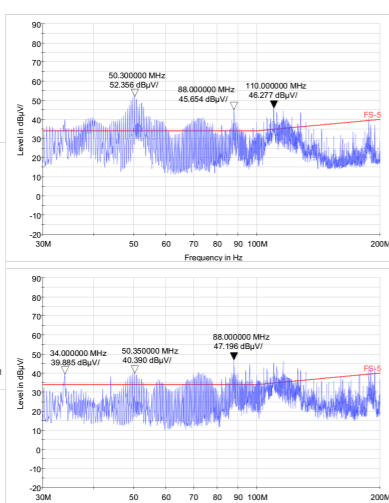
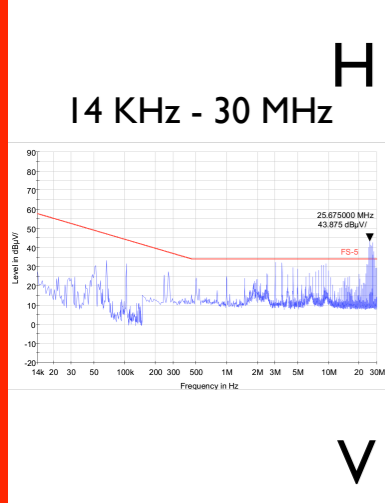
200 MHz - 1 GHz

1 GHz - 10 GHz

1,565 MHz - 1,585 MHz

2,039 MHz - 2,041 MHz

2,025 MHz - 2,110 MHz



Redundant

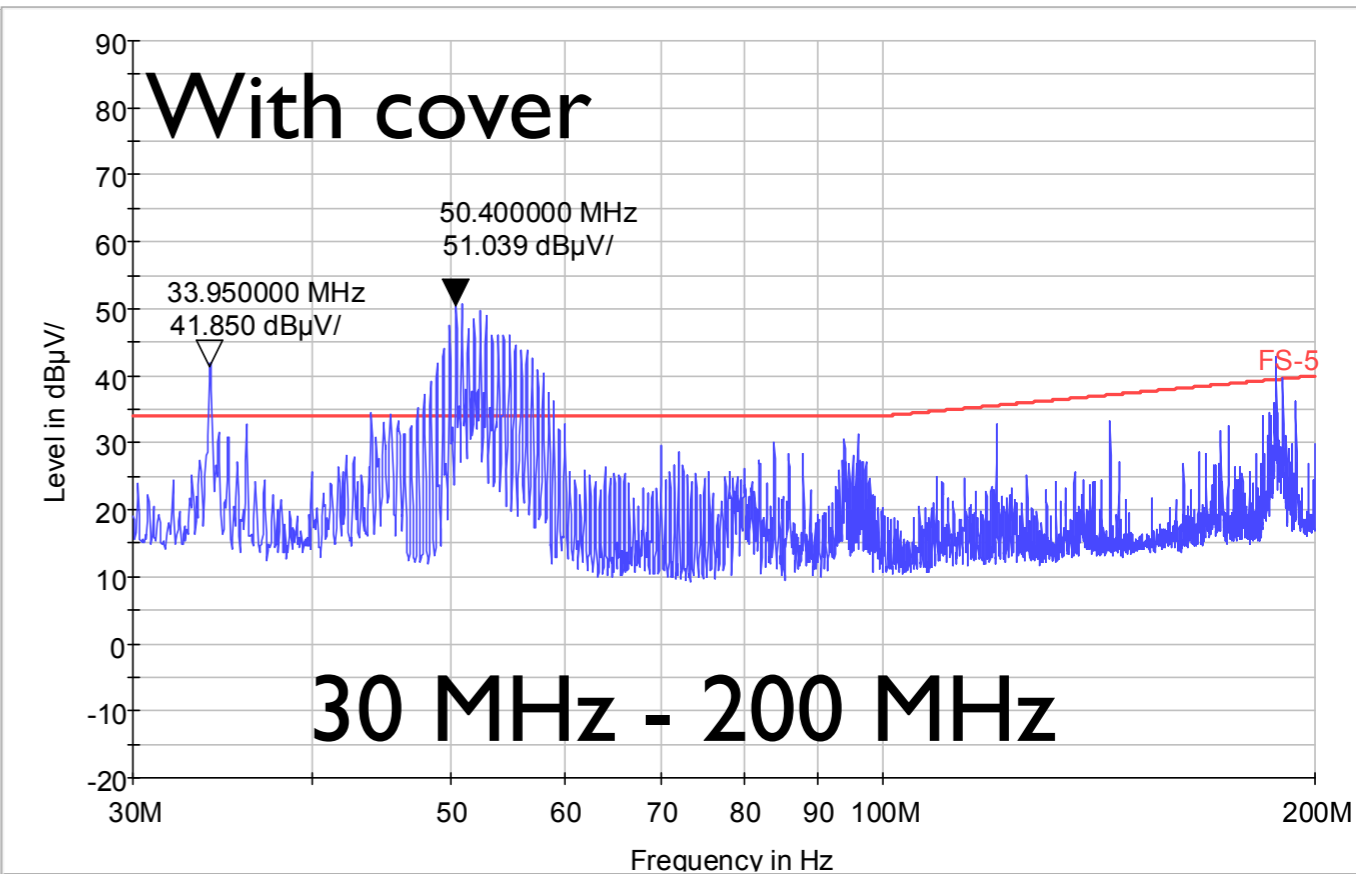
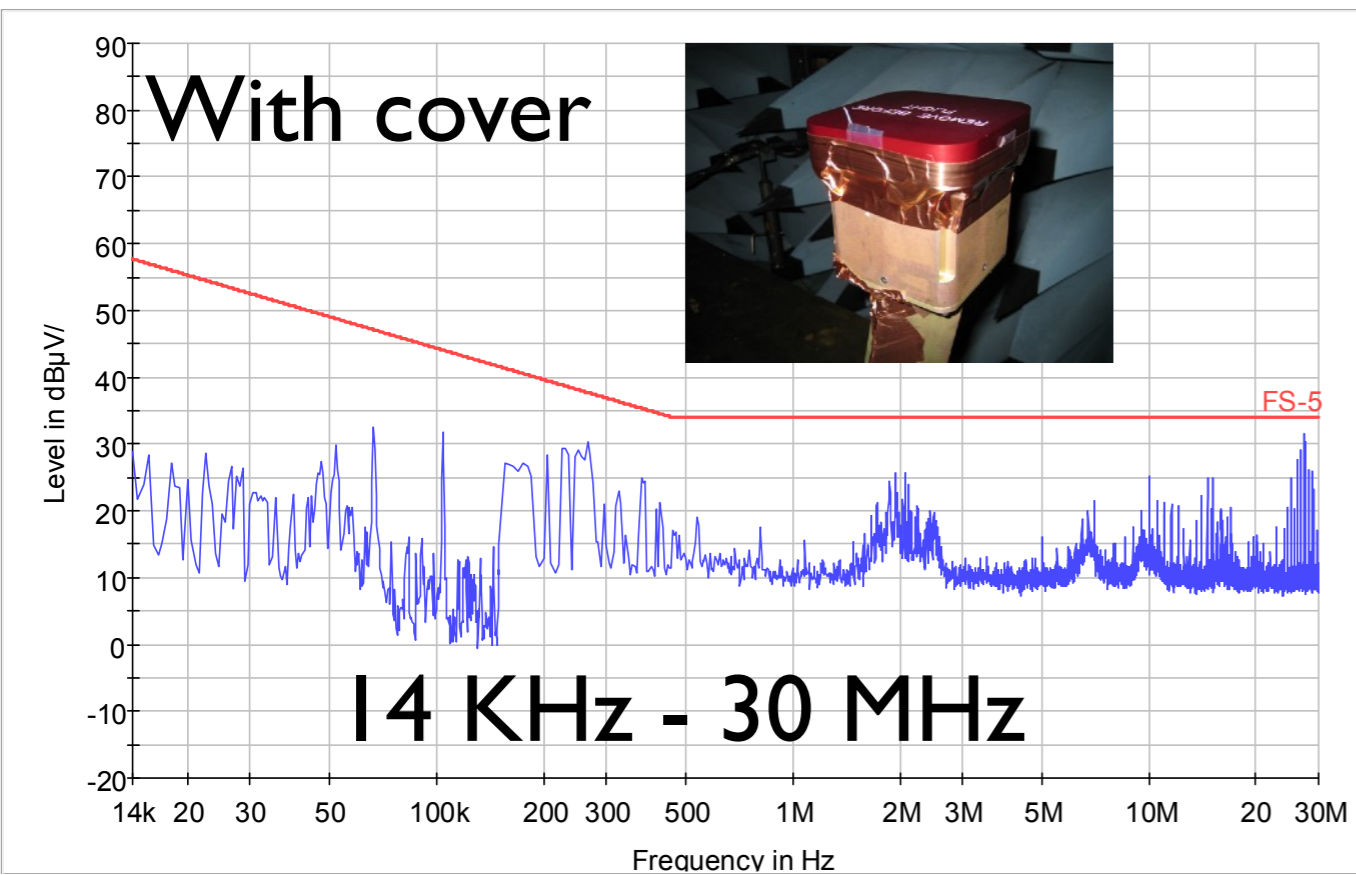
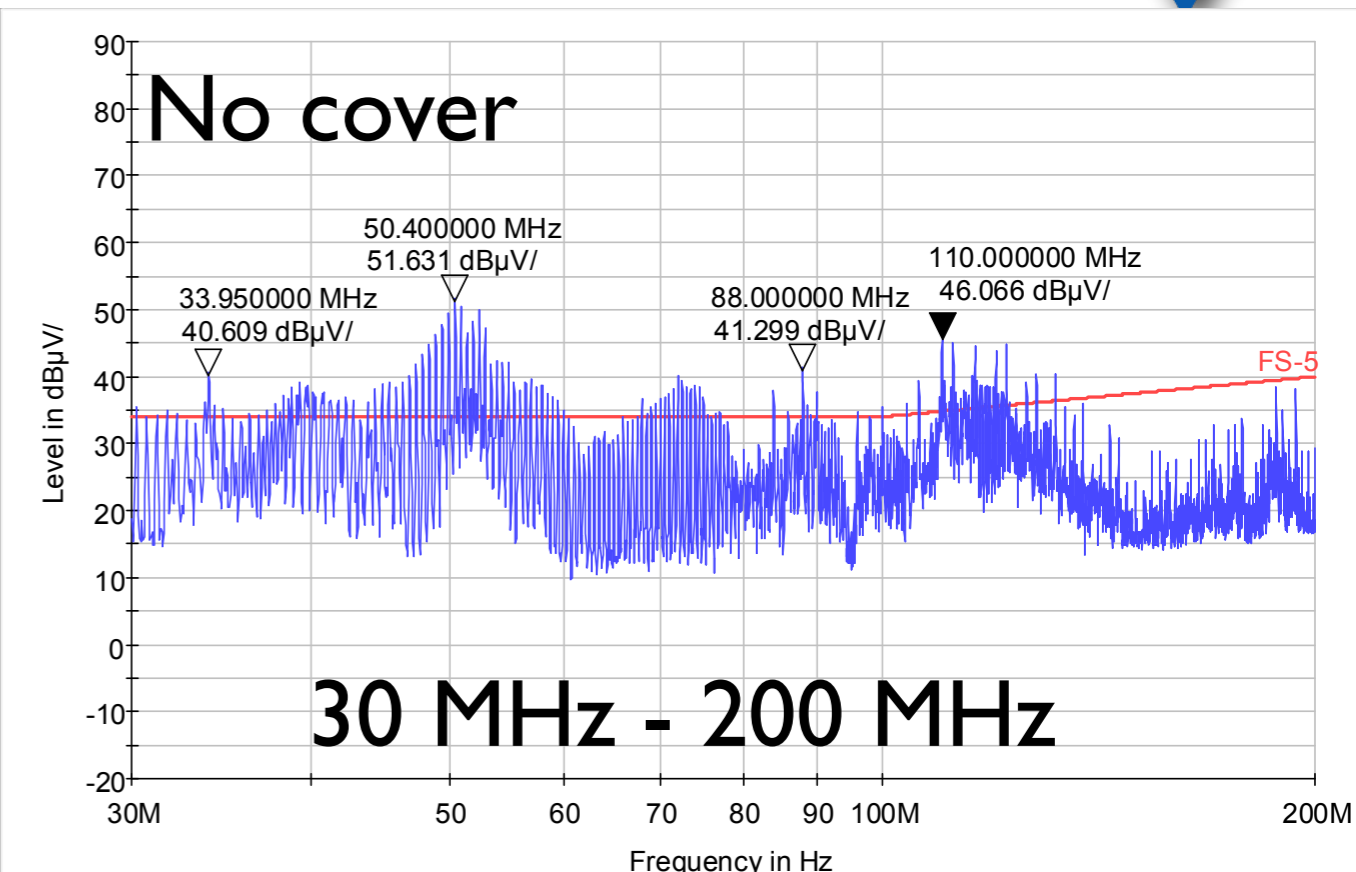
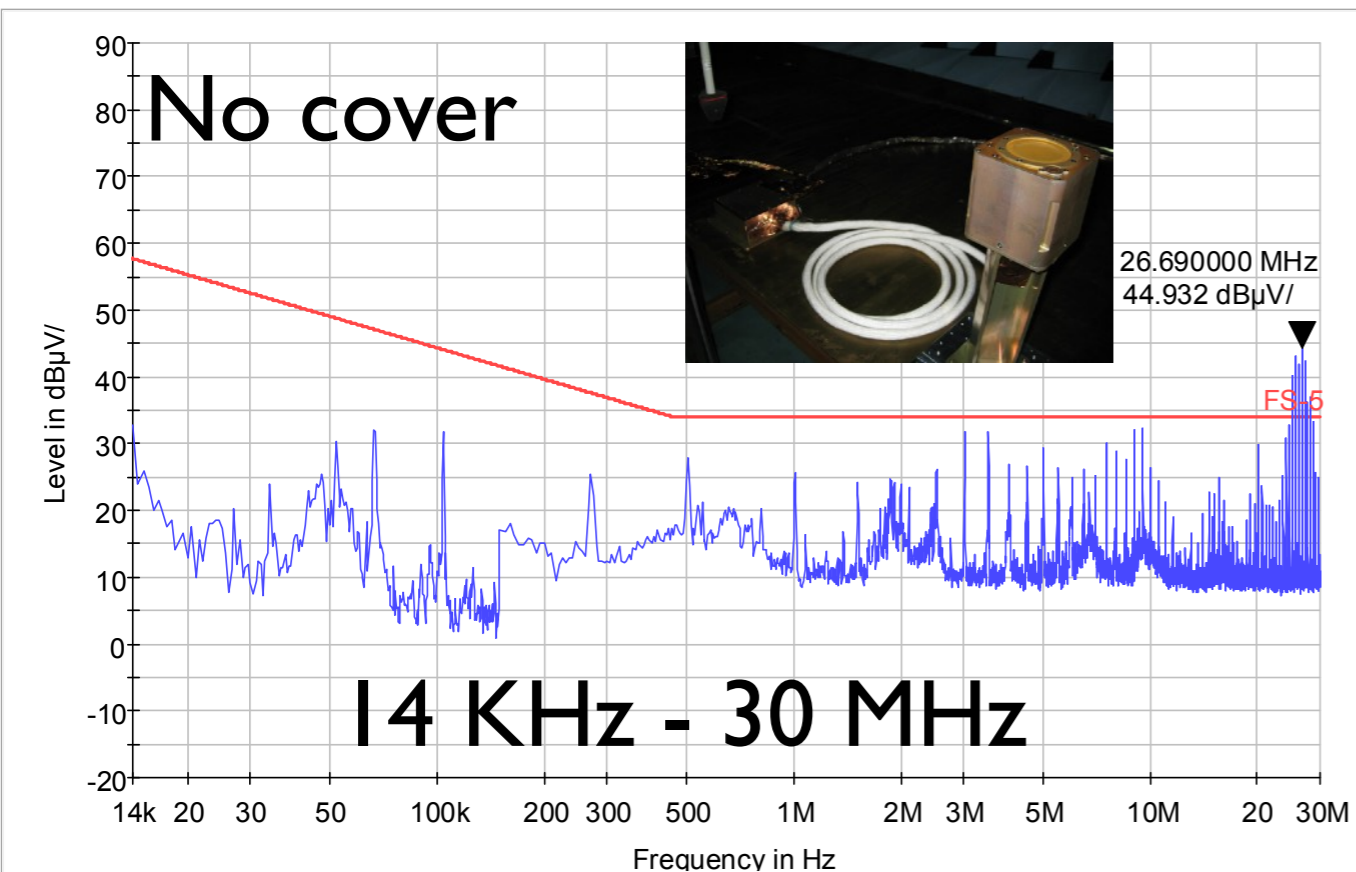
FS-5/AIP

PAR

FS5SPL-CDRL-1014

137f 50,0001, 2013/10/03

With or without cover on sensor



FS-5/AIP

PAR

FS5SPL-CDRL-1014

138f 50, 0001, 2013/10/03

RS (200 MHz to 10 GHz)



200 MHz - 1 GHz

1 GHz - 2 GHz

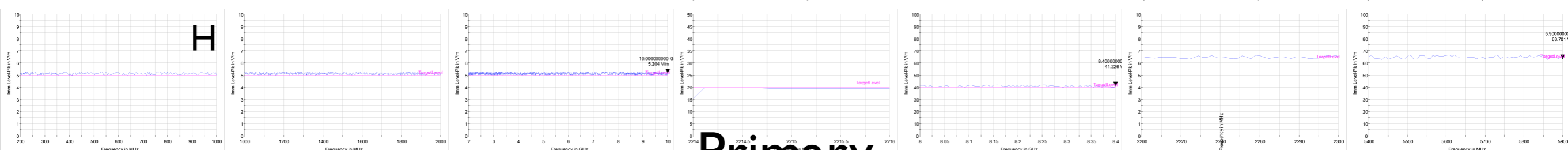
2 GHz - 10 GHz

2,214 MHz - 2,216 MHz

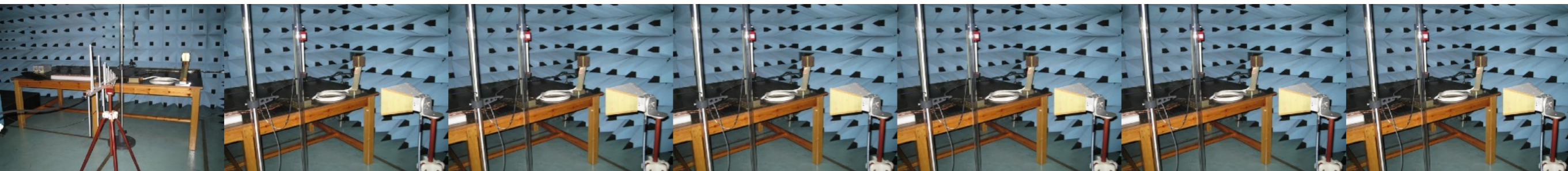
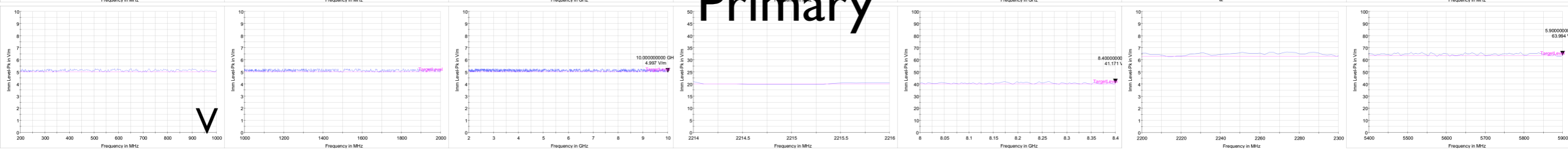
8.0 GHz - 8.4 GHz

2,200 MHz - 2,300 MHz

5,400 MHz - 5,900 MHz



Primary



200 MHz - 1 GHz

1 GHz - 2 GHz

2 GHz - 10 GHz

2,214 MHz - 2,216 MHz

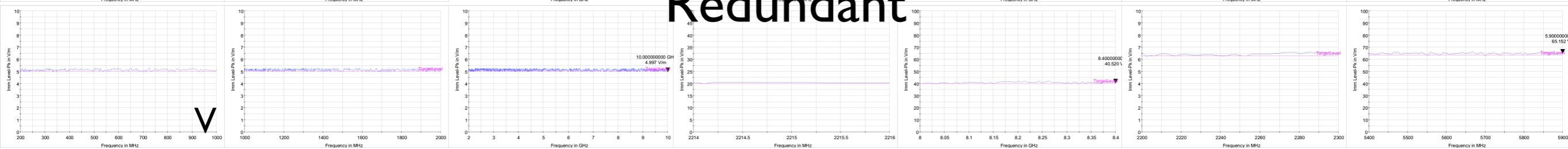
8.0 GHz - 8.4 GHz

2,200 MHz - 2,300 MHz

5,400 MHz - 5,900 MHz



Redundant





Summary

- All specifications of AIP/FM can meet the requirements in FS5-IRD-0001 document and follow the guidelines of FS5SPL-CDRL-1003, 1005 and 1009 documents except for mass property, temperature sensor anomaly on ADDA board, and EMC issues (CE at 96 MHz, RE within 26.7 MHz and 110 MHz, and RS within 14 KHz and 200 MHz). These NCRs were presented at PAR meetings and requests for waiver have been submitted.