AL5958QEV2-EMC User Guide

48-Channel Matrix LED Driver with NMOS Switches, up to 32 Scans

General Description

This user manual provides a detailed description of the AL5958Q RGB LED driver evaluation board, a 48channel, constant current LED driver controlled via an SPI compatible serial interface. It includes hardware and software initialization procedures, full schematic documentation, the bill of materials, PCB layout diagrams, and reference images of the evaluation hardware, constant-current LED driver controlled via an SPI-compatible serial interface. It includes hardware and software initialization procedures, full schematic documentation, the bill of materials, PCB layout diagrams, and reference images of the evaluation hardware.

The evaluation board is designed to characterize the electrical performance and functional behavior of the AL5958Q device, enabling verification of current regulation, grayscale dimming, scanning control, and diagnostic features. It supports MCU-based communication for generating high-clarity, high-brightness LED matrix effects under controlled test conditions.

Applications

- Central information displays
- Cluster displays
- Head-up displays
- Grill lights
- Body mini-LED panels
- Interior lights, rear lights

Key Features

- AEC-Q100 (Grade 1) qualification
- Two Separated Power Supply: VR and VGB
  - VR Supply Range 2.8V to 5V
  - VGB Supply Voltage Range 3V to 5V
- 48 Output Current Sources:
  - 0.5mA to 20mA Constant Current Output Range
  - Current Setting by 3 External Resisters
  - 6-Bit Global Current Control for Each Color Group
  - ±1.5% (typ) LED Current Accuracy Between Channels
  - ±1.5% (typ) LED Current Matching Between Devices
  - Output Staggered Delay
- Built-in 16 NMOS Scan Switches
  - For Static and Dynamic Systems from 0 Scan to 1/32 Scan
  - Flexible Scan Sequence
- Grayscale PWM Dimming
  - 16-Bit PWM Dimming Resolution
  - High Refresh Rate Achieved by Multiplex Pulse Density Modulation (M-PDM) Technology
  - Selectable Single or Double Edge Trigger Grayscale Clock for EMI Reduction
- Diagnosis and Protections
  - LED Open/Short
  - Grayscale Clock Watchdog, Undervoltage Lockout (UVLO)
- Built-in Intelligent Matrix Display Functions
  - Automatic Black Frame Insertion
  - Last Scan and Next Scan Line Ghost Image Abatement
  - Low Brightness Uniformity Compensation
  - Short LED Caterpillar & Open LED Fail Line Abatement
- Daisy-Chained Capability
- Sleep Mode to Save Power

Specifications

Parameter	Value
Input Voltage	USB-PD / Power connector
Output Current	4.34mA
Output Voltage	5V
Number of LEDs	W48*H16 = 768 LEDs H16=16 multiplexing
Dimension	100mm*125mm*20mm
RoHS Compliance	Yes

Evaluation Board

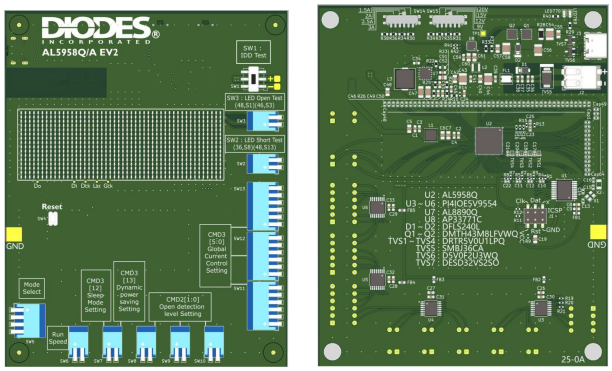


Figure 1: Top and Bottom View

Connection Instructions:

- DC Input: USB-PD / Power connector

General Description

This development kit offers a comprehensive solution for matrix LED application, powered via USB-PD3.1 or external input voltage. The EV board uses an automotive grade 32bit Arm M0 core, designed for reliable performance in automotive environments.

The inclusion of USB-PD power simplifies the development process（AP33771C_USB PD3.1 EPR Sink Controller *1 and AL8890Q_60V Synchronous Buck *2）, ensuring a modern, reliable power interface. This kit provides developers with the tools needed to build high-performance matrix LED display systems for both automotive and commercial applications, offering flexibility, scalability, and precision. With durable automotive-grade components, the kit ensures reliability across a wide range of use cases, making it ideal for projects requiring dynamic and accurate matrix LED display control.

The kit is particularly suited for a range of automotive applications, such as:

- Central information displays
- Cluster displays
- Head-up displays
- Grill lights
- Body mini-LED panels
- Interior lights, rear lights

*1) AP33771C

The AP33771C is a highly integrated USB Type-C ® PD3.1 sink controller to support Extended Power Range (EPR)/Adjustable Voltage Supply (AVS) up to 28V and Standard Power Range (SPR)/ Programmable Power Supply (PPS) up to 21V. The device is targeted for DC power request and control for Type-C Connector-equipped Devices (TCDs) through simple external resistor settings.

*2) AL8890Q

The AL8890Q/AL88902Q is a synchronous buck converter with internal compensation and switching frequency adjustable up to 2.5MHz. The device integrates a 120mΩ high-side power MOSFET and a 55mΩ low-side power MOSFET to provide high-efficiency DC-DC conversion.

Hardware description

The evaluation kit is shown in Figures 1 to 4 and Tables 1 to 3. The AL5958QEV2 integrates the Power supply、MCU and LED unit. The AL5958QEV2 operating power can be supplied either via USB-PD or an external DC power source (only one can be used at a time). And users can connect to the NU-Link programmer via a pin header on the back side of EV2 for firmware updates.

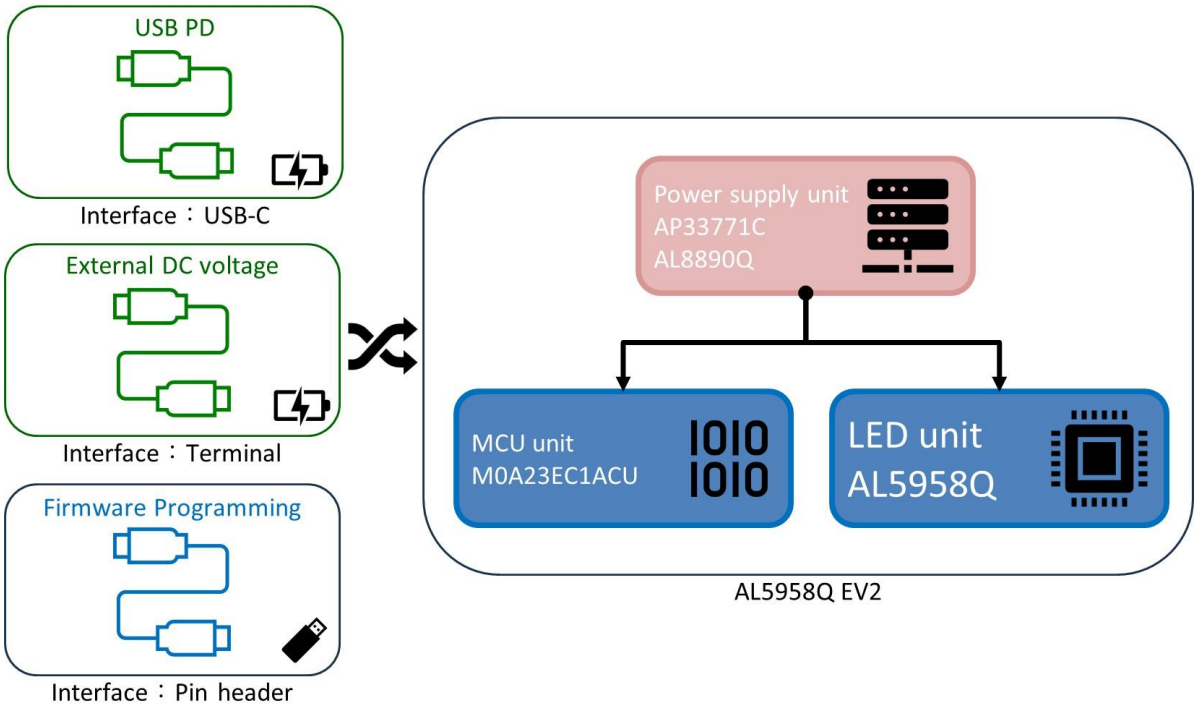


Figure 2: Top Section Description

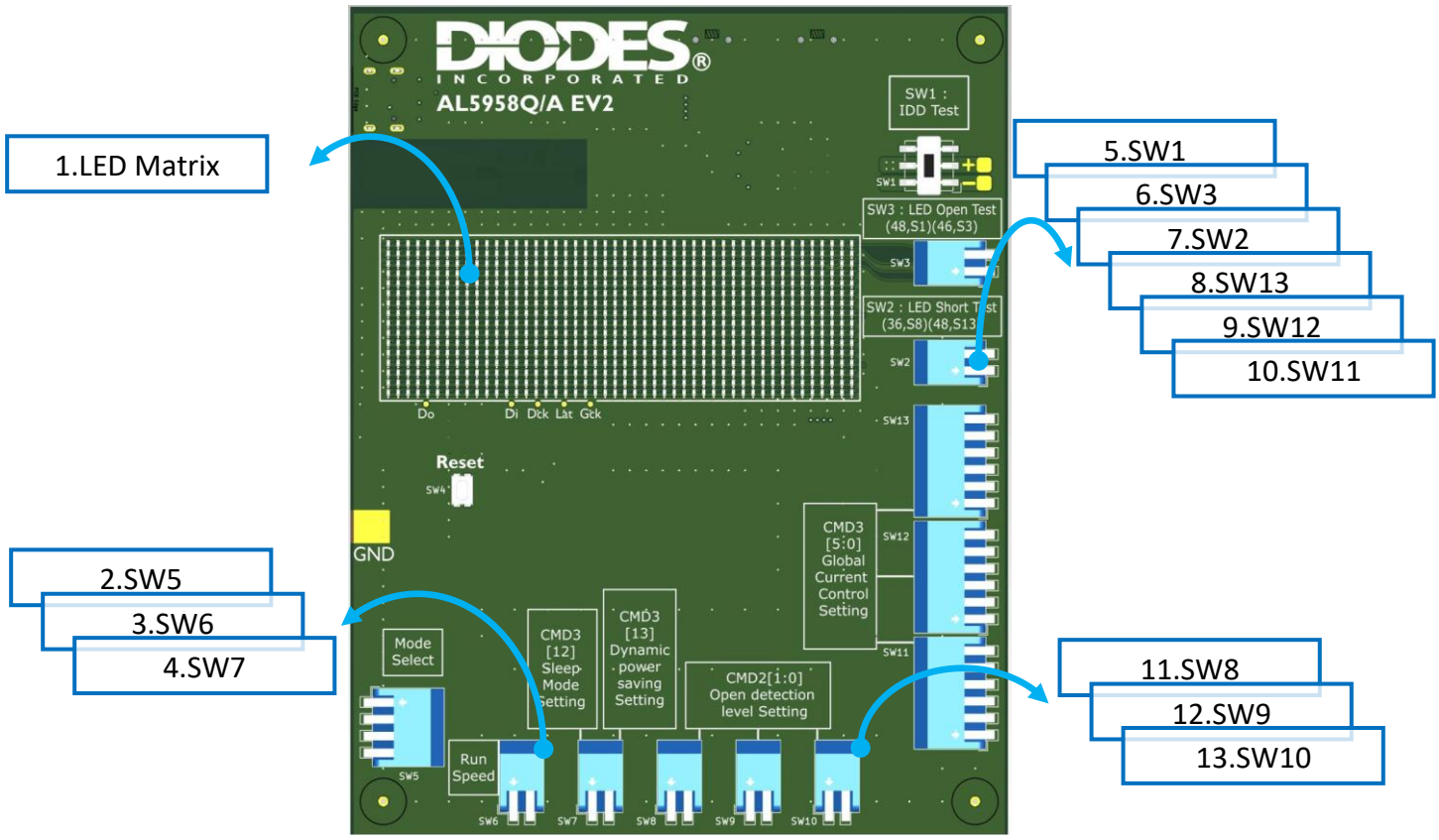


Figure 3: Top Section Description

Number	Name	Description	Default Setting
1	LED Matrix	LED Display area 48 x 16 Dots , LED Pitch 1.5mm	-
2	SW5	Mode select switch From bottom to top, the switches are mapped to the MSB and LSB.	0001 Switch pressed down = logic level '1'.
3	SW6	Animation speed setting	00
4	SW7	Enable the Sleep mode function of AL5958Q	00
5	SW1	IVGB current measurement switch Switch flipped down：The voltage is directly connected to the VGB pin. Switch flipped up：The voltage is disconnected from VGB pin.	Toggle the switch downward for normally operation
6	SW3	LED open test , LED open at XY(48,S1) and XY(46,S3)	00
7	SW2	LED short test , LED short at XY(36,S8) and XY(48,S13)	00
8	SW13	Reserved	00_0000
9	SW12	Current gain setting , Current gain = (GCC[5:0]+1) / 64	01_1111 From bottom to top
10	SW11	Reserved	00_0000
11	SW8	Open detection level setting	00
12	SW9	Open detection level setting	00
13	SW10	Open detection level setting	00

Table 1: EVB Section Description

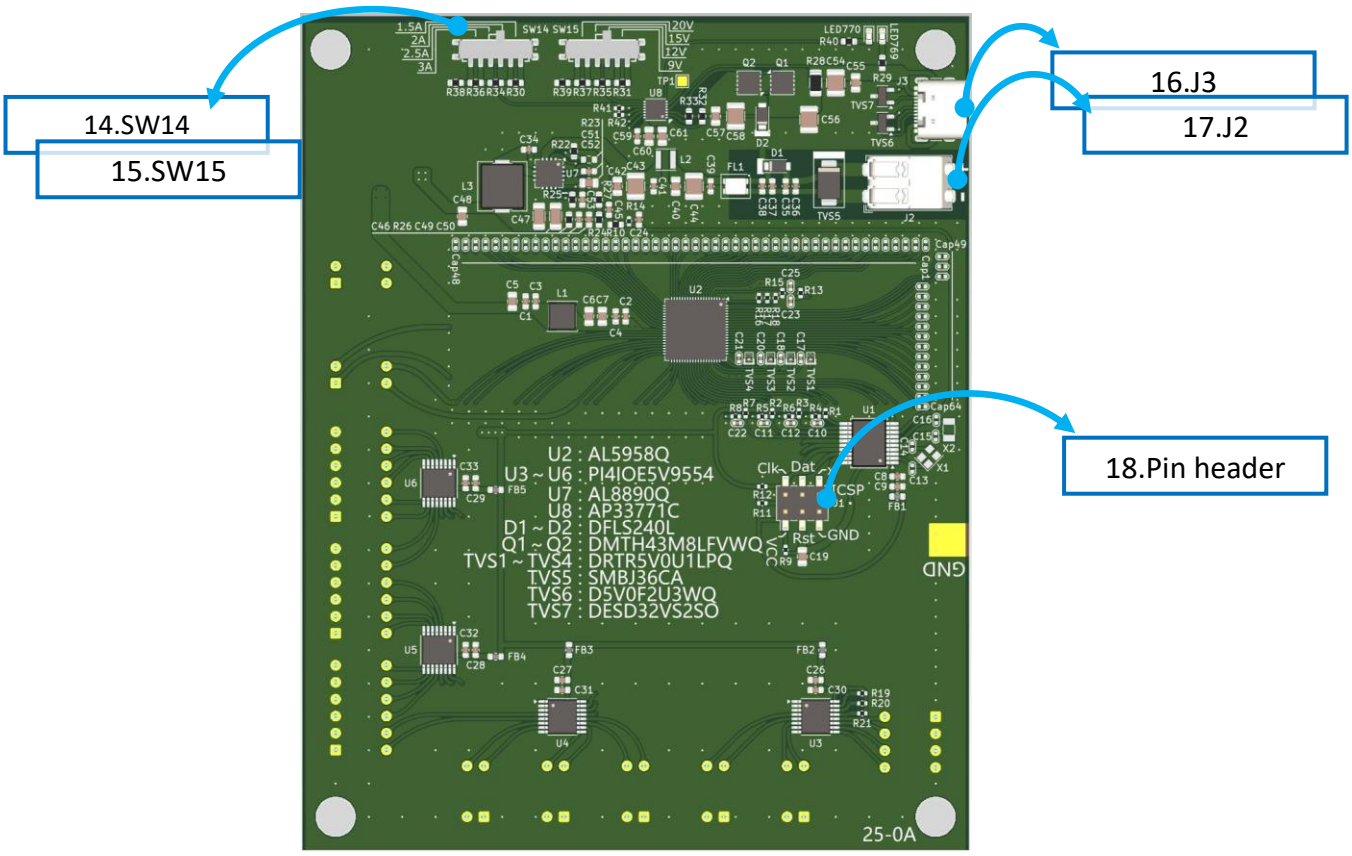


Figure 4: Bottom Section Description

Number	Name	Descrition	Default Setting
14	SW14	Current select：1.5A、2.0A、2.5A、3.0A	1.5A
15	SW15	Voltage select：9V、12V、15V、20V	12V
16	J3	The operating voltage for the AL5958QEV2 is supplied via the Type-C connector connected to a USB PD power source. *Only either J2 or J3 can be used at a time. *USB PD3.1	-
17	J2	The operating voltage for the AL5958QEV2 is supplied via the connector connected to a DC9-20V power source. *Only either J2 or J3 can be used at a time.	-
18	Pin header	For MUC programming, Connect the VCC、GND、Clk、Dat and Rst Pins from the NU-Link to the header socket on the AL5958QEV2. *Remove J2 and J3 before connecting to NU-Link.	-

Table 2: EVB Section Description

Power Supply Options:

The device features two power supply options:

1. J3 Type-C connector：USB PD（USB Power Delivery）.
2. J2 connector：Input DC9V to 20V.

Note: The two power supply methods cannot be used simultaneously.

Quick Start Guide

Once the power is applied to the EVB, the LED Matrix Display defaults（SW5_Mode select switch=00） to static displaying the Diodes logo. Please refer to the settings in the table below for related displays.

Pressed down = logic '1', released = logic '0'.

SW5	Mode	Description	Remarks
0000	LED off	LED matrix display all off	
0001	Display-1	LED matrix display the static Diodes logo	
0010	Display-2	LED matrix display the Diodes logo animation	Diodes Logo Scroll from right to left
0011	Display-3	LED matrix display all on	This mode demonstrates the uniformity of LED static brightness and refresh rate
0100	Display-4	LED matrix display fade in and fade out effects	This mode showcases the uniformity of brightness and refresh rate during dynamic scenes
0101	Display-5	LED matrix display slash line（from bottom left to top right）	This mode showcases the ability to eliminate residual images during scanning
0110	Display-6	LED matrix display slash line（from top left to bottom right）	
0111	Display-7	LED matrix display LED flash	This mode showcases the uniformity of brightness and refresh rate during dynamic scenes and the ability to eliminate residual images during scanning
1000	Display-8	LED matrix display color gradient with gamma 1.0	This mode showcases the smoothness of grayscale gradients, while different gamma settings demonstrate the wide range of adjustability
1001	Display-9	LED matrix display color gradient with gamma 2.2	
1010	Display-10	LED matrix display color gradient with gamma 2.6	
1011	Display-11	LED matrix display color gradient with gamma 1.0 -> 2.2 -> 2.6 - update by frame	
1100	Display-12	LED matrix display color gradient with gamma 1.0 -> 2.2 -> 2.6 - update by row	
1101	Display-13	LED matrix display mix mode	
1110	Display-14	LED open detection	To be used in conjunction with SW3 operation
1111	Display-15	LED short detection	To be used in conjunction with SW2 operation

Table 3: EVB Section Description

Software Programming Procedure:

The universal board uses the M0A23EC1ACU automotive 32-bit microcontroller based on Arm® Cortex®-M0 core as the control unit. You can download the latest demo program update from the Diodes official website, or modify and test your own program.

Before proceeding, please make sure you have the Nu-Link Debug Adapter and ICP programming tool installed, for more details, please refer to the Nu-Link Debug Adapter User's Manual.

1 Hardware Requirements

Minimum system requirements for PC shown in Table 4:

No.	Description	Requirement
1	OS	Windows 7, Windows 10, or later (64-bit recommended)
2	CPU	Intel Core i3 or higher
3	RAM	2GB RAM minimum (4GB recommended)
4	Storage	500MB free disk space
5	USB Port	One free USB 2.0/3.0 port

Table 4: PC minimum requirements

2 Installation and Setup

2.1 Installing the NuMicro ICP Programming Tool

Install Nu-Link Driver: If you haven't already installed the Nu-Link driver, it can be found in the same download section from Nuvoton's website. This driver is required for the Nu-Link Debug Adapter to communicate with the PC.

NuMicro_ICP_Programming_Tool_V3.17.7691r

2.2 Download and Install: After downloading the NuMicro ICP Programming Tool, run the installer and follow the on-screen instructions to complete the setup.

3 Hardware Connections

Nu-Link to AL5958Q EV2 Pin Mapping:

3.1 To correctly program the M0A23EC1ACU using the Nu-Link Debug Adapter, follow this pin mapping:

- Nu-Link VCC (Pin 1) → AL5958Q EV2 5V
- Nu-Link DAT (Pin 2) → AL5958Q EV2 DAT
- Nu-Link CLK (Pin 4) → AL5958Q EV2 CLK
- Nu-Link RESET (Pin 6) → AL5958Q EV2 RESET
- Nu-Link GND (Pin 8) → AL5958Q EV2 GND

3.2 Ensure that all connections between the Nu-Link and the universal board are accurate and secure, as shown in Figure 5.

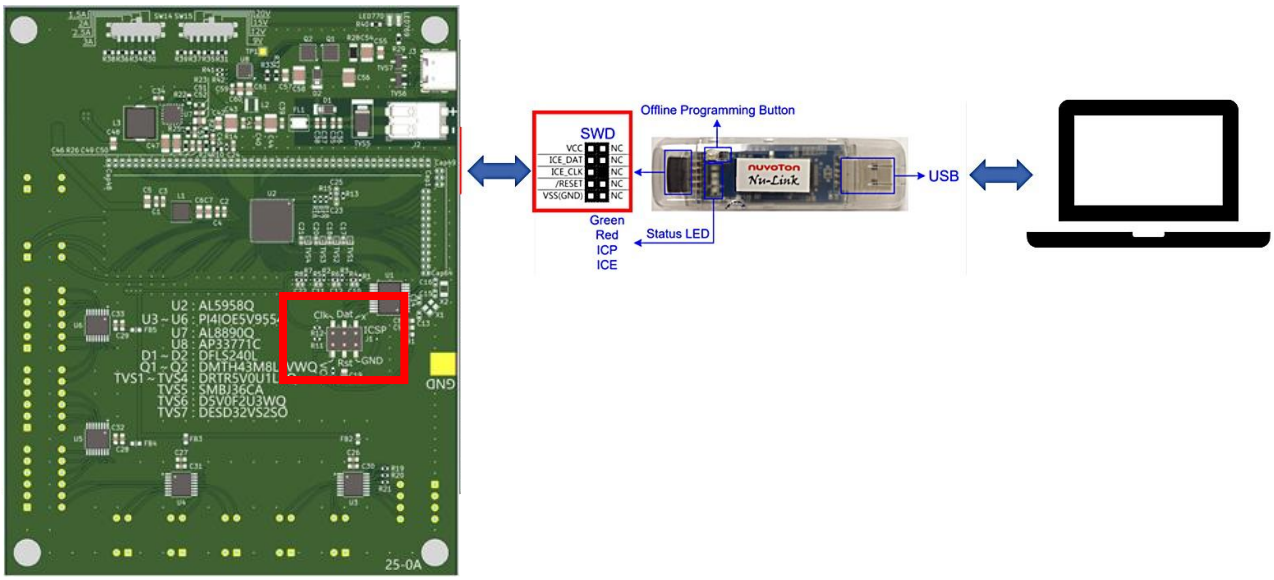


Figure 5. Hardware Connections

4 Update Firmware

4.1 Open NuMicro ICP Programming Tool: After hardware setup, launch the NuMicro ICP Programming Tool on your PC, as shown in Figure 6.

4.2 Select Target Chip: In the tool, select M0A21/M0A23 series from the device list.

4.3 Connect: Link the Nu-Link Debug Adapter

4.4 Load Fire: Click APROM to choose the firmware hex (.hex) file, which you downloaded from the Diodes website.

4.5 Program the Device: Click Start to start flashing the firmware onto the M0A23EC1ACU. The software will indicate the progress and completion of the process.

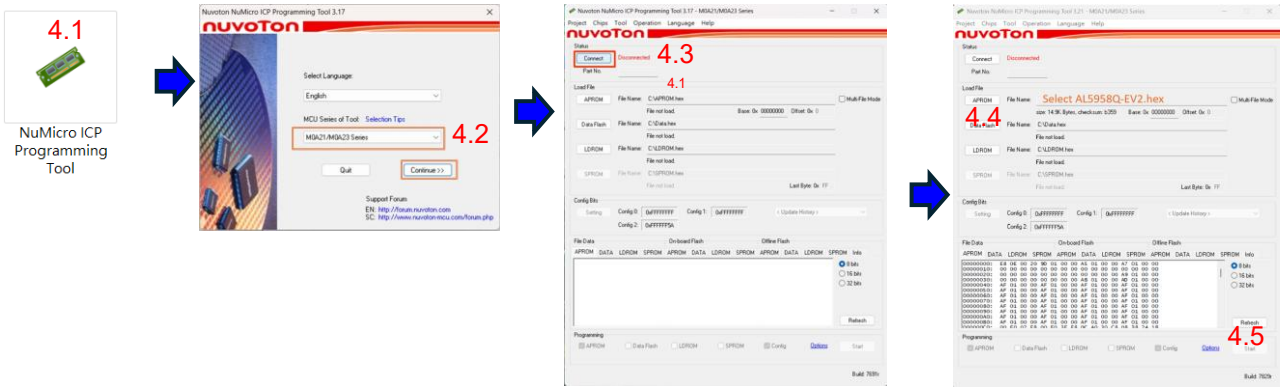


Figure 6. NuMicro ICP Programming Tool setting

Evaluation Board Schematic

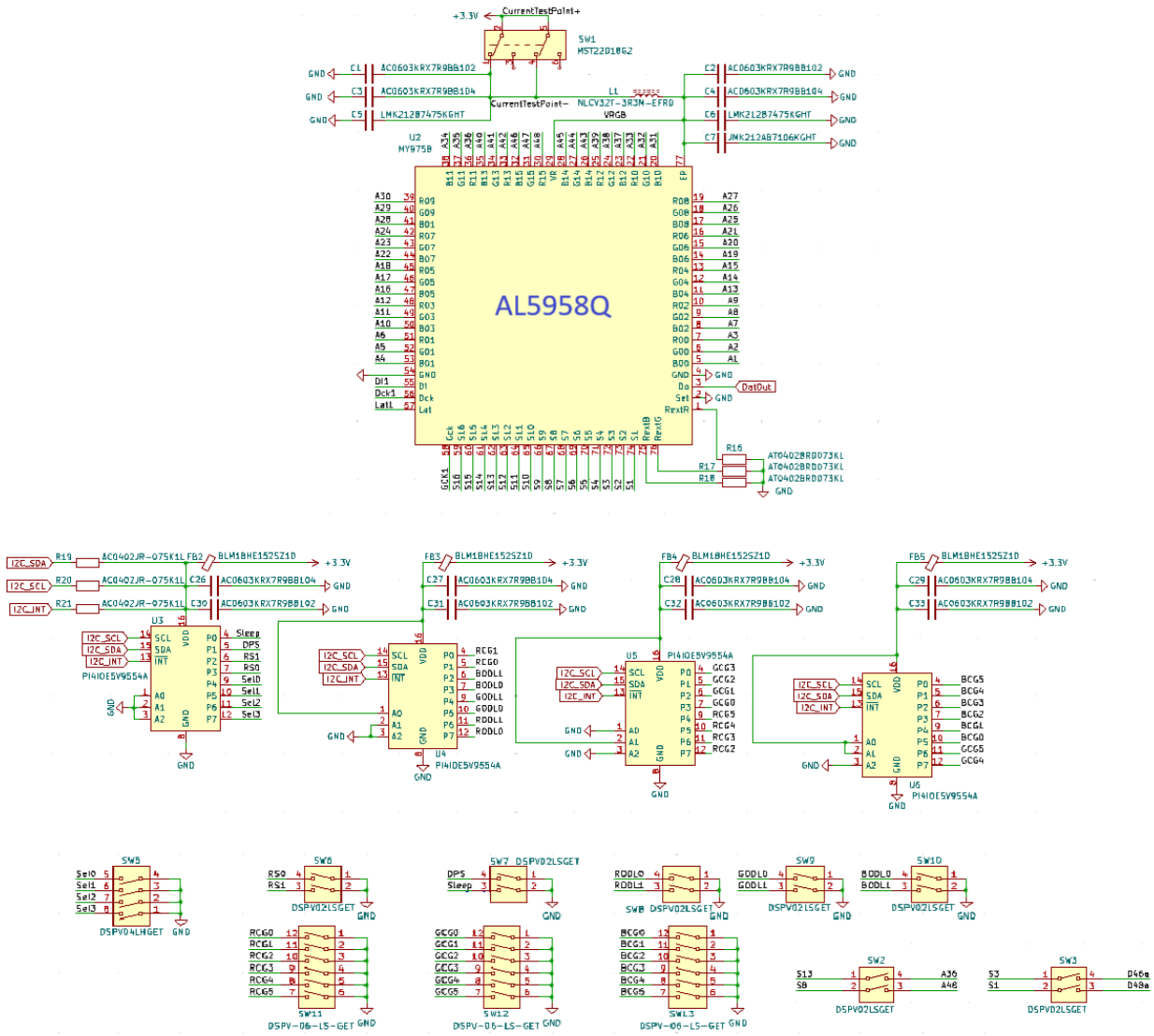


Figure 7: AL5958Q EV2 Schematic 1

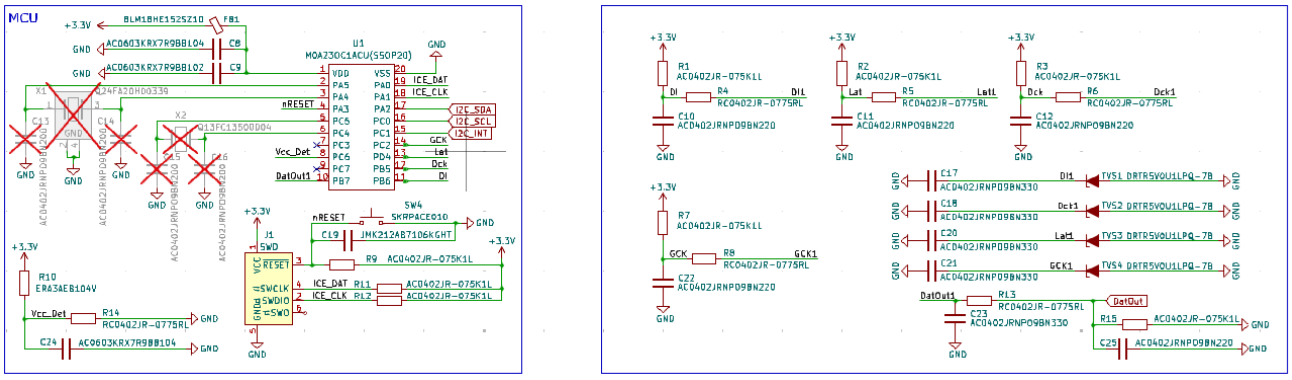


Figure 8: AL5958Q EV2 Schematic 2

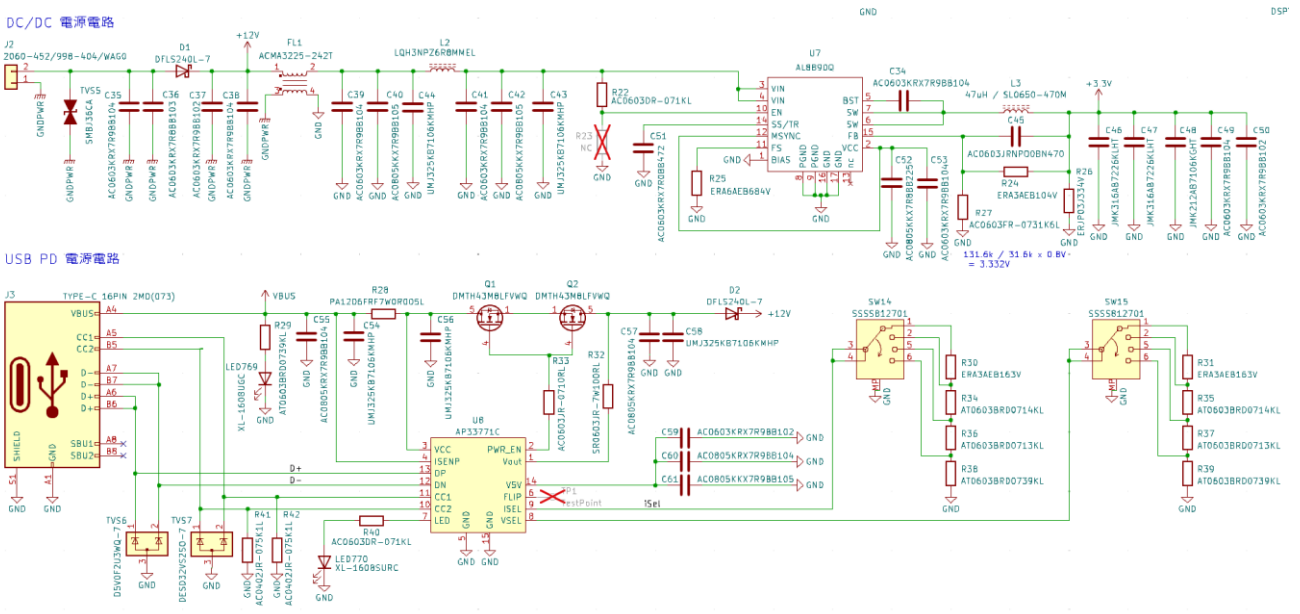


Figure 9: AL5958Q EV2 Schematic 3

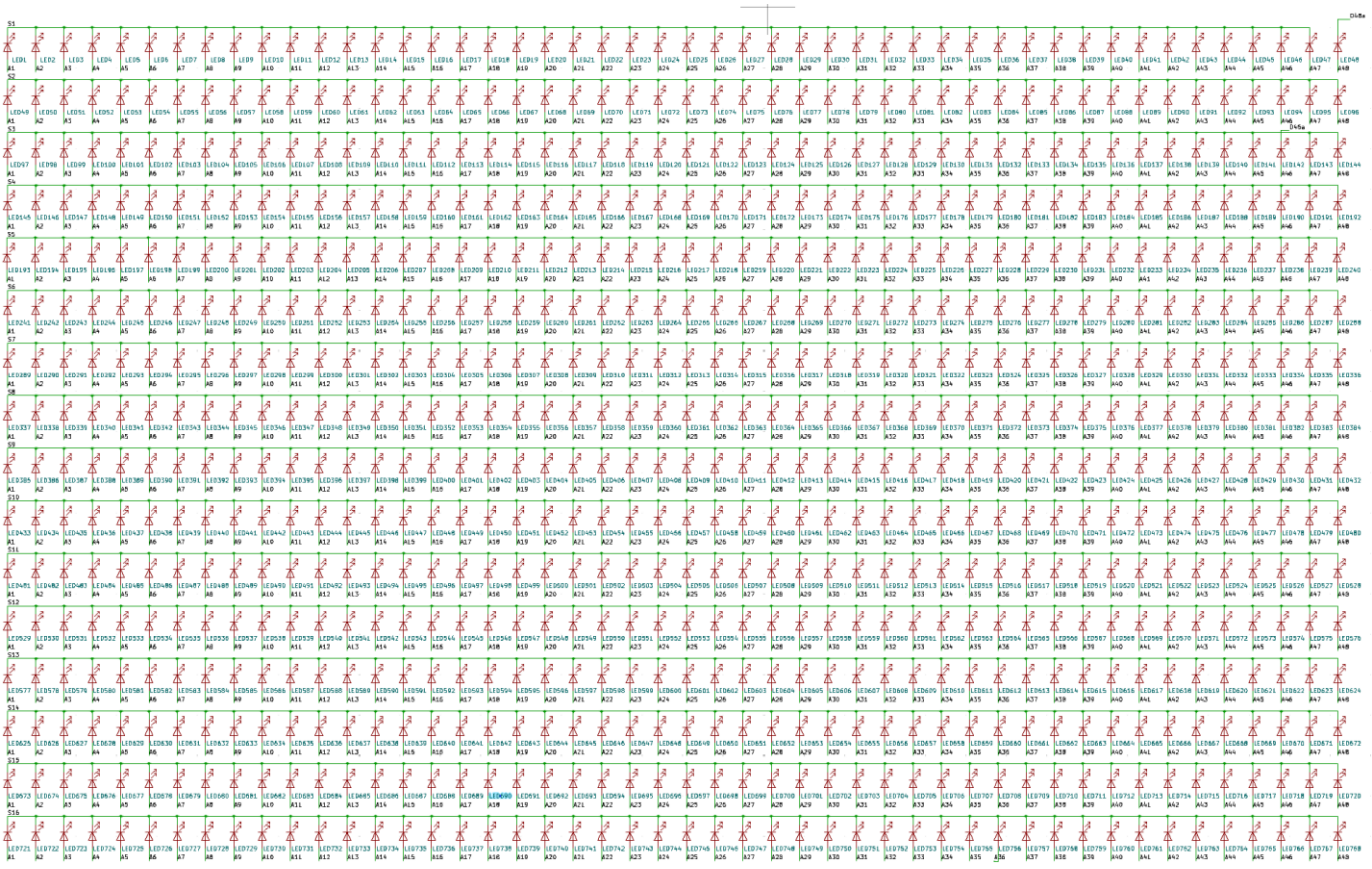


Figure 10: AL5958Q EV2 Schematic 4

Evaluation Board Layout

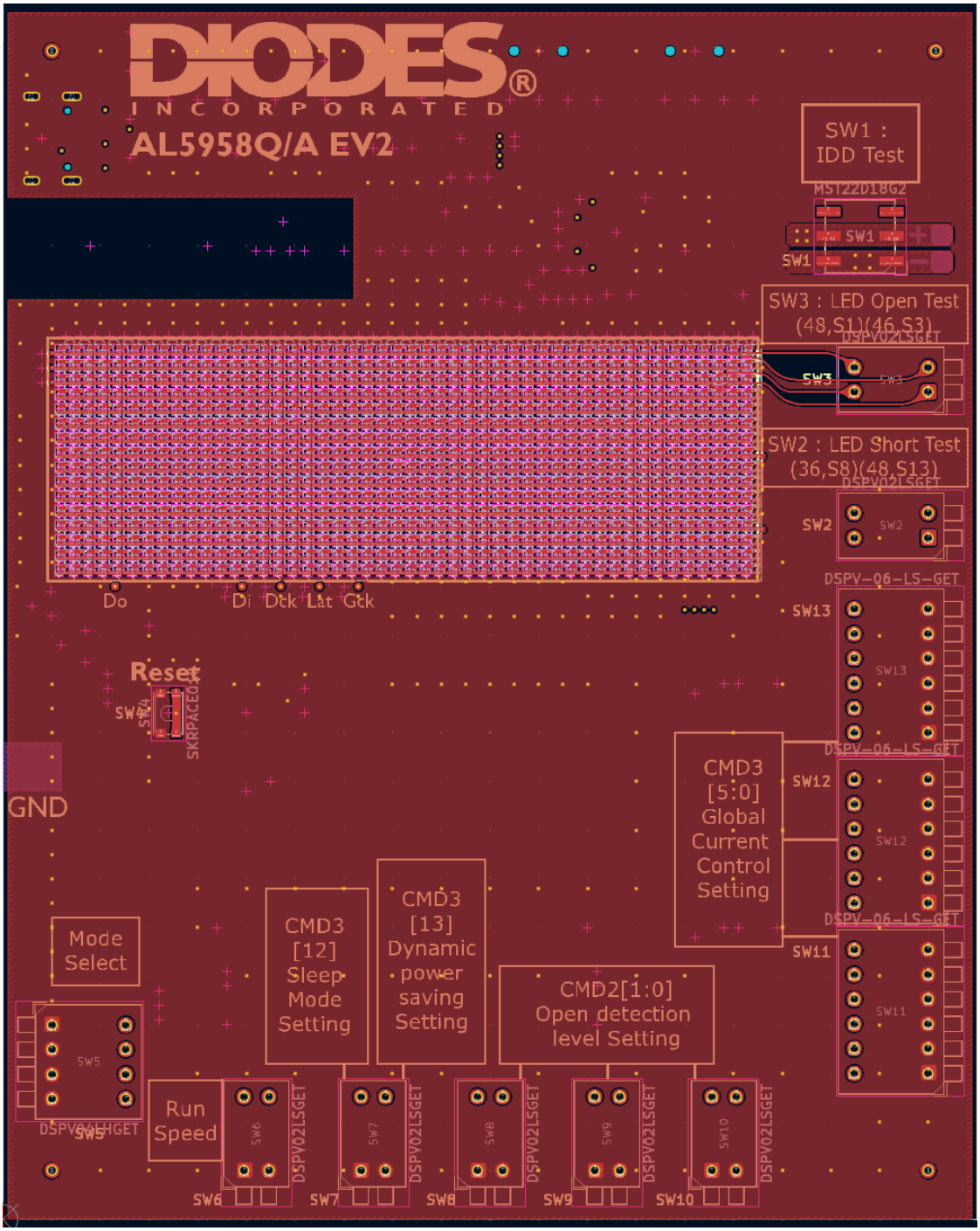


Figure 11: PCB Top Layer

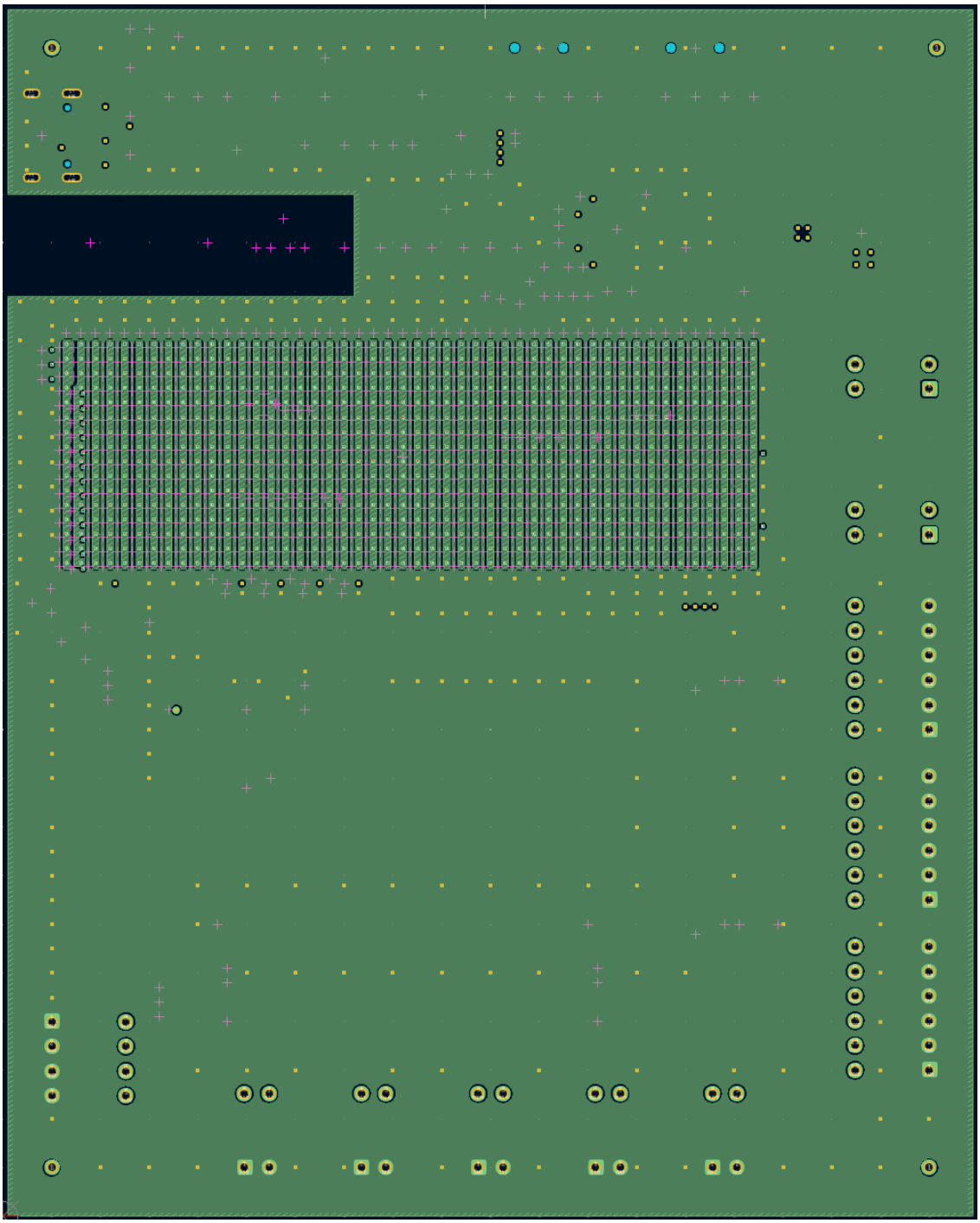


Figure12: PCB Inner Layer1

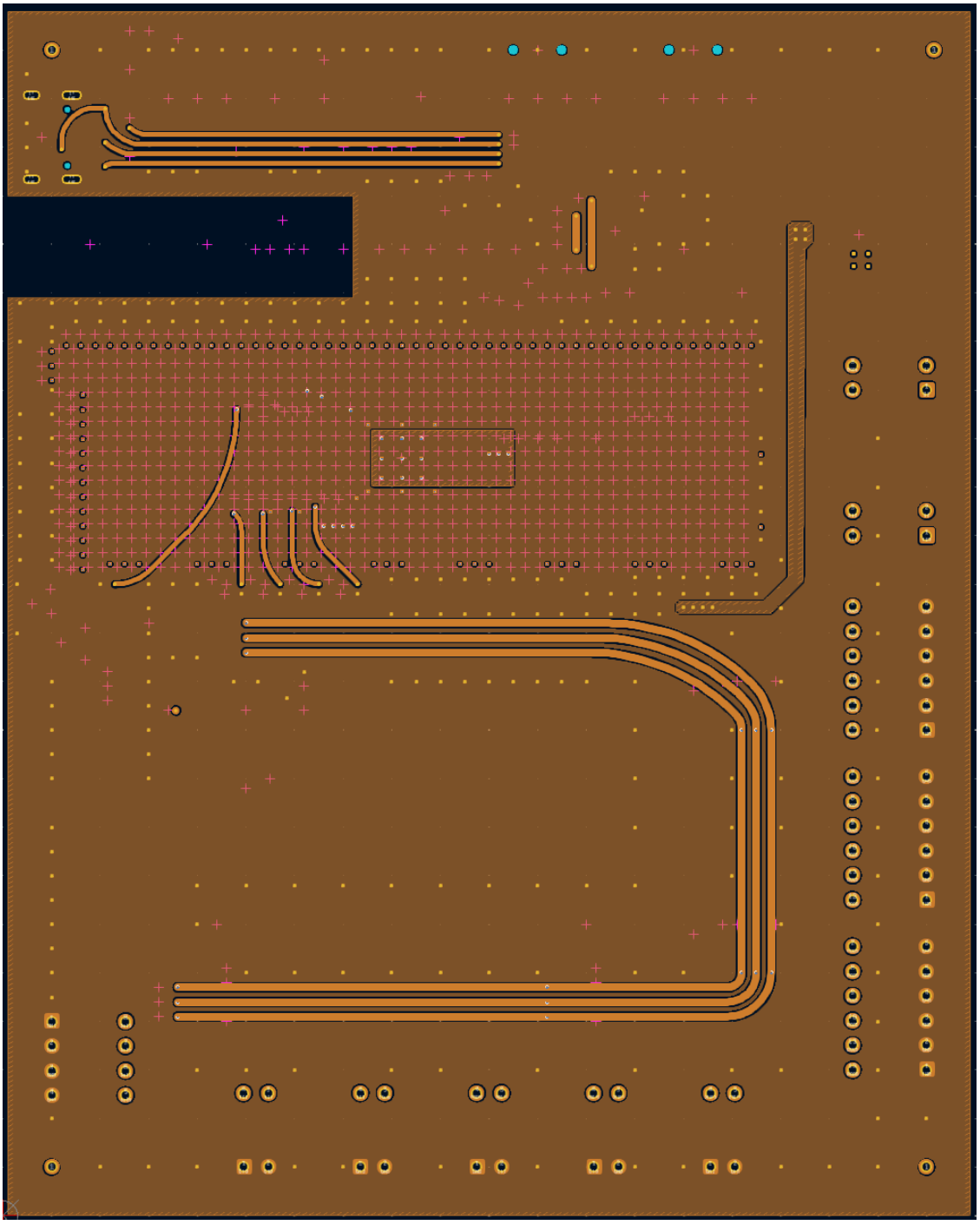


Figure 13: PCB Inner Layer2

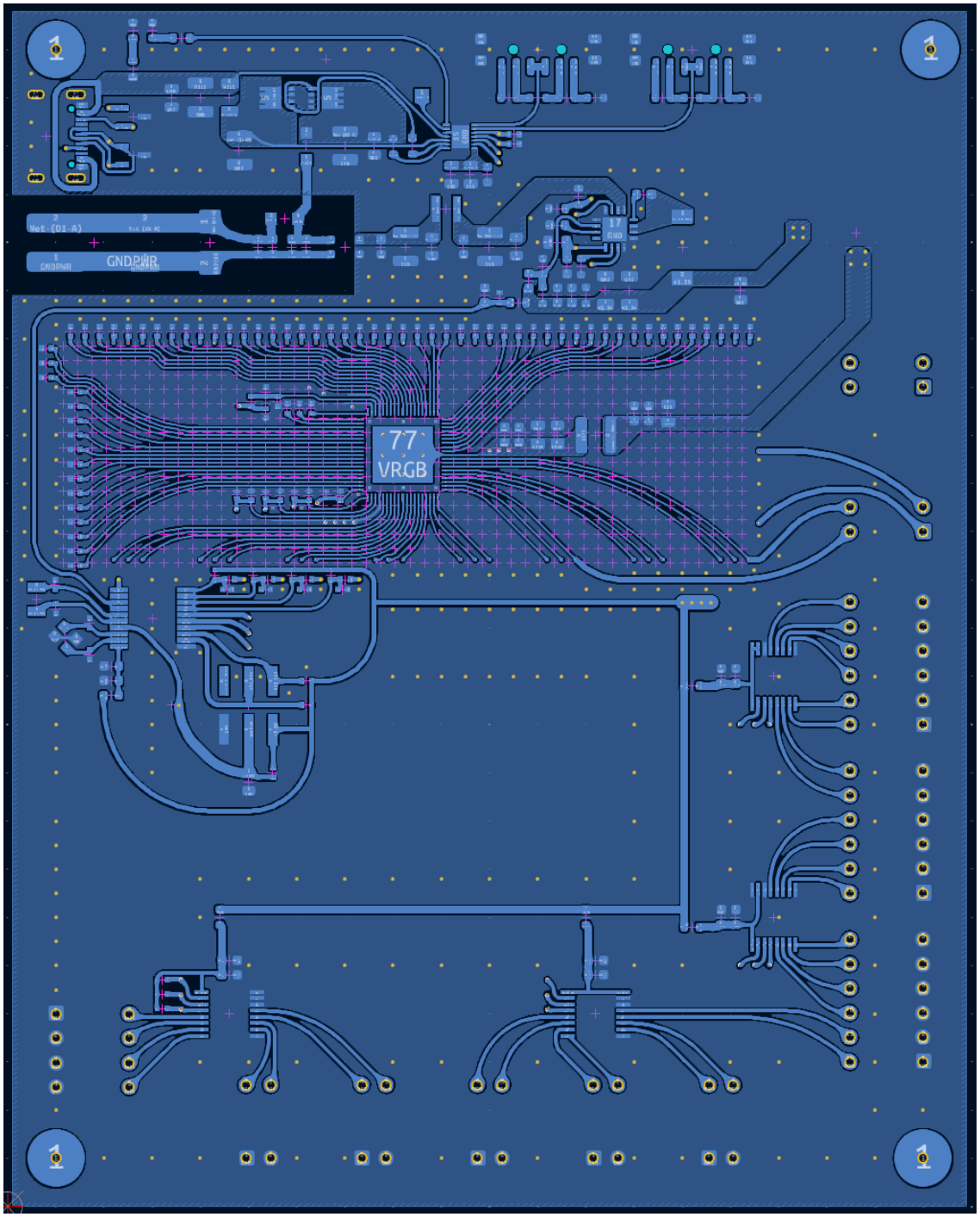


Figure 14: PCB Bottom Layer

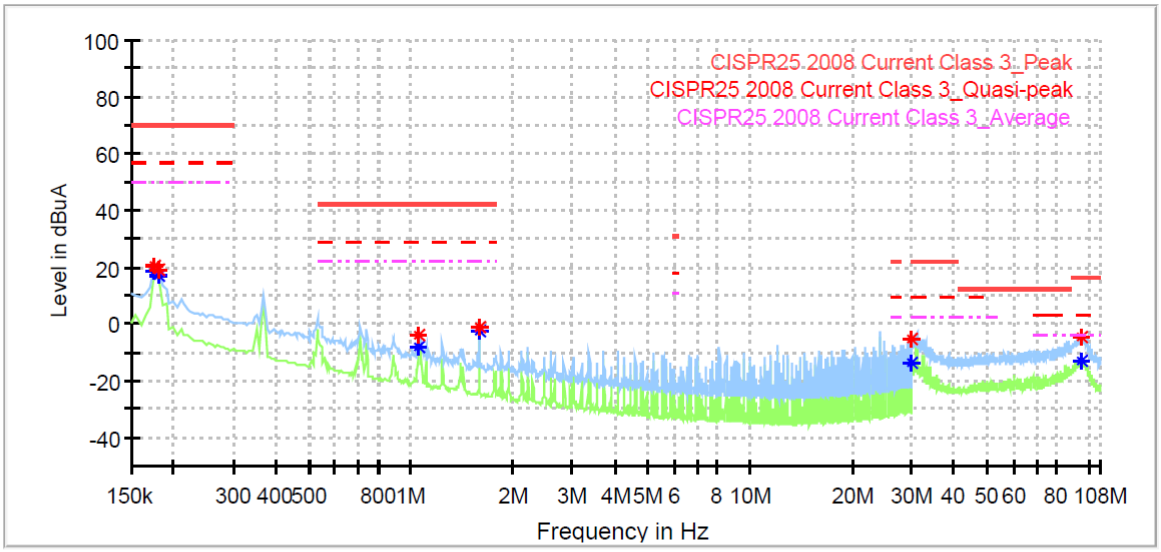
Bill of Material

No.	Ref	Part Number	Package	Quantity
1	U1	M0A23OC1ACU(SSOP20)	SSOP-20_5.3x7.2mm_P0.65mm	1
2	U2	AL5958Q	QFN-76-1EP_9x9mm_P0.4mm	1
3	U3, U4, U5, U6	PI4IOE5V9554A	TSSOP-16_4.4x5mm_P0.65mm	4
4	U7	AL8890Q	QFN-16-1EP_4x4mm_P0.65mm	1
5	U8	AP33771C	DFN-14-1EP_3x3mm_P0.4mm	1
6	R1, R2, R3, R7, R9, R11, R12, R15, R19, R20, R21, R41, R42	AC0402JR-075K1L	R_0402_1005Metric	13
7	R4, R5, R6, R8, R13, R14	RC0402JR-0775RL	R_0402_1005Metric	6
8	R10, R24	ERA3AEB104V	R_0603_1608Metric	2
9	R16, R17, R18	AT0402BRD073KL	R_0402_1005Metric	3
10	R22, R40	AC0603DR-071KL	R_0603_1608Metric	2
11	R23	NC	R_0603_1608Metric	1
12	R25	ERA6AEB684V	R_0603_1608Metric	1
13	R26	ERJP03J334V	R_0603_1608Metric	1
14	R27	AC0603FR-0731K6L	R_0603_1608Metric	1
15	R28	PA1206FRF7W0R005L	R_1206_3216Metric	1
16	R29, R38, R39	AT0603BRD0739KL	R_0603_1608Metric	3
17	R30, R31	ERA3AEB163V	R_0603_1608Metric	2
18	R32	SR0603JR-7W100RL	R_0603_1608Metric	1
19	R33	AC0603JR-0710RL	R_0603_1608Metric	1
20	R34, R35	AT0603BRD0714KL	R_0603_1608Metric	2
21	R36, R37	AT0603BRD0713KL	R_0603_1608Metric	2
22	C1, C2, C9, C30, C31, C32, C33, C59	GRM188Z71A106KA73D	C_0603_1608Metric	8
23	C3, C4, C8, C24, C26, C27, C28, C29, C34, C38, C39, C41, C49, C53	AC0603KRX7R9BB104	C_0603_1608Metric	14
24	C5, C6	GRT21BR60J476ME13L	C_0805_2012Metric	2
25	C7, C19, C48	GRT21BR60J476ME13L	C_0805_2012Metric	3
26	C10, C11, C12, C25	AC0402JRNPO9BN220	C_0402_1005Metric	4
27	C13, C14, C15, C16	AC0402JRNPO9BN200	C_0402_1005Metric	4
28	C17, C18, C20, C21, C23	AC0402JRNPO9BN330	C_0402_1005Metric	5
29	C35、C50	CC0603KRX7R9BB683	C_0603_1608Metric	2
30	C36	CC0603KRX7R9BB223	C_0603_1608Metric	1
31	C37	CC0603KRX7R9BB333	C_0603_1608Metric	1
32	C40, C42, C61	AC0805KKX7R9BB105	C_0805_2012Metric	3
33	C43, C44, C54, C56, C58	UMJ325KB7106KMHP	C_1210_3225Metric	5

No.	Ref	Part Number	Package	Quantity
34	C45	AC0603JRNPO0BN470	C_0603_1608Metric	1
35	C46, C47	JMK316ABJ476MLHT	C_1206_3216Metric	2
36	C51	AC0603KRX7R0BB472	C_0603_1608Metric	1
37	C52	AC0805KKX7R8BB225	C_0805_2012Metric	1
38	C55, C57, C60	AC0805KRX7R9BB104	C_0805_2012Metric	3
39	Cap1-Cap64	AC0402JRNPO9BN101	C_0402_1005Metric	64
40	L1	LQH32PN3R3NN0L	1206_3216 Metric)	1
41	L2	LQH3NPZ6R8MMEL	L_Taiyo-Yuden_MD-3030	1
42	L3	47uH / SL0650-470M	L_7.3x7.3_H4.5	1
43	D1, D2	DFLS240L-7	Nexperia_CFP3_SOD-123W	2
44	X1	Q24FA20H00339	Crystal_SMD_2520-4Pin	1
45	X2	Q13FC13500004	Crystal_SMD_3215-2Pin	1
46	SW1	MST22D18G2	MST22D18G2	1
47	SW2, SW3, SW6, SW7, SW8, SW9, SW10	DSPV02LSGET	SW_DIP_SPSTx02_Piano	7
48	SW4	SKRPACE010	SW_Push_1P1T_NO_CK_KMR2	1
49	SW5	DSPV04LHGET	SW_DIP_SPSTx04_Piano	1
50	SW11, SW12, SW13	DSPV-06-LS-GET	SW_DIP_SPSTx06_Piano	3
51	SW14, SW15	SSSS812701	SW_Push_1P4T-MP_NO_Horizontal	2
52	LED1-LED768	LED	CSP-L1208	768
53	LED769	XL-1608UGC	LED_0603_1608Metric	1
54	LED770	XL-1608SURC	LED_0603_1608Metric	1
55	FB1, FB2, FB3, FB4, FB5	BLM18HE152SZ1D	L_0603_1608Metric	5
56	TVS1, TVS2, TVS3, TVS4	DRTR5V0U1LPQ-7B	D_SOD-882_DFN1006-2	4
57	Q1, Q2	DMTH43M8LFVWQ	Diodes_PowerDI3333-8	2
58	FL1	ACT45B-101-2P-TL003	SMD , horizontal 4-pad case	1
59	TVS5	SMBJ36CA	D_SMB_TVS	1
60	TVS6	D5V0F2U3WQ-7	SOT-23-3	1
61	TVS7	DESD32VS2SO-7	SOT-23-3	1
62	J1	SWD	PinHeader_2x03_P2.54mm	1
63	J2	2060-452/998-404/WAG0	TE_2834006-2_1x02_P4.0mm	1
64	J3	TYPE-C 16PIN 2MD(073)	USB_C_Receptacle_GCT_USB4105-xx-A_16P	1

EMC test report CISPR 25

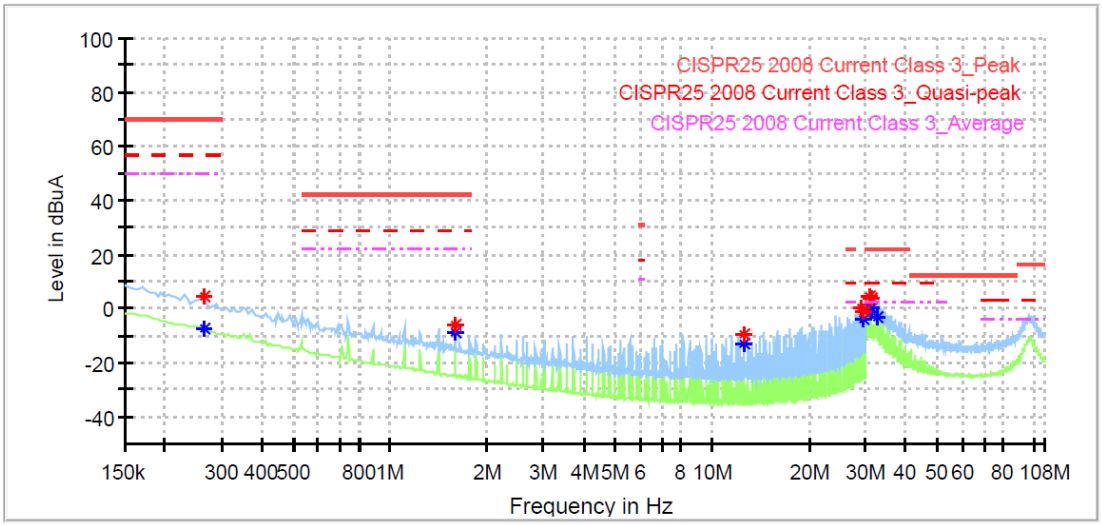
1. CEC 0.15-108MHz 50MM_Pass Class3



Critical_Freqs

Frequency (MHz)	MaxPeak (dBuA)	Average (dBuA)	Limit (dBuA)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)
0.175000	20.43	---	70.00	49.57	50.0	9.000	-7.2
0.175000	---	18.69	50.00	31.31	50.0	9.000	-7.2
0.180000	---	17.10	50.00	32.90	50.0	9.000	-7.5
0.180000	19.32	---	70.00	50.68	50.0	9.000	-7.5
1.060000	-4.03	---	42.00	46.03	50.0	9.000	-24.4
1.060000	---	-8.23	22.00	30.23	50.0	9.000	-24.4
1.595000	---	-2.72	22.00	24.72	50.0	9.000	-27.7
1.595000	-1.08	---	42.00	43.08	50.0	9.000	-27.7
30.000000	---	-13.59	2.00	15.59	5.0	120.000	-38.5
30.000000	-5.05	---	22.00	27.05	5.0	120.000	-38.5
95.480000	---	-12.89	-4.00	8.89	5.0	120.000	-38.4
95.480000	-4.33	---	16.00	20.33	5.0	120.000	-38.4

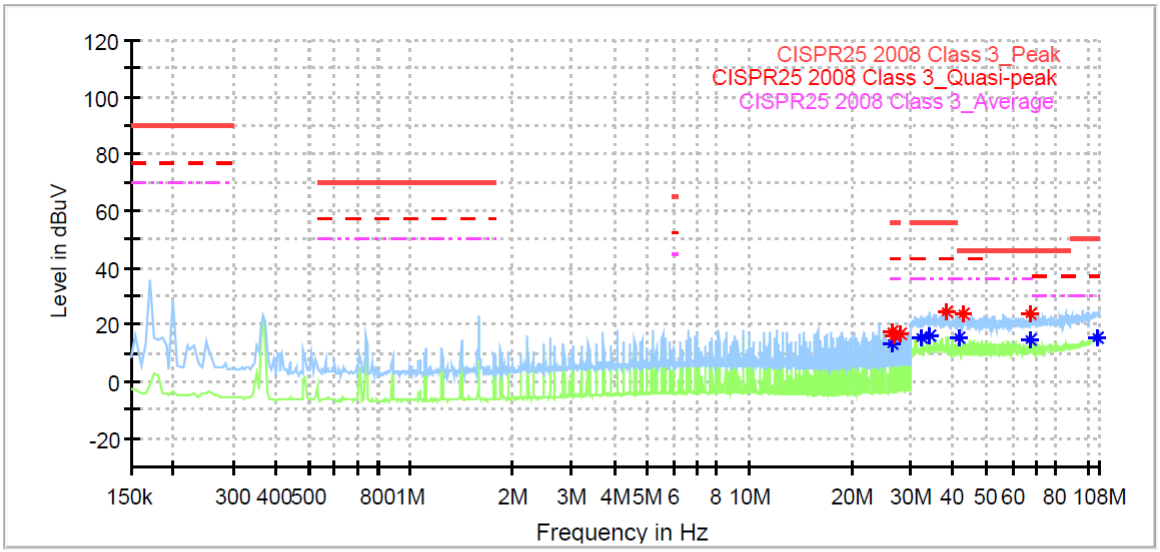
2. CEC 0.15-108MHz 750mm_Pass Class3



Critical_Freqs

Frequency (MHz)	MaxPeak (dBuA)	Average (dBuA)	Limit (dBuA)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)
0.265000	---	-7.38	50.00	57.38	50.0	9.000	-11.4
0.265000	4.17	---	70.00	65.83	50.0	9.000	-11.4
1.595000	---	-8.56	22.00	30.56	50.0	9.000	-27.7
1.595000	-5.74	---	42.00	47.74	50.0	9.000	-27.7
12.580000	-9.79	---	---	---	50.0	9.000	-38.1
12.585000	---	-12.73	---	---	50.0	9.000	-38.1
29.235000	-0.02	---	---	---	50.0	9.000	-38.5
29.600000	-1.15	---	---	---	50.0	9.000	-38.5
29.605000	---	-3.96	---	---	50.0	9.000	-38.5
30.720000	---	0.47	2.00	1.53	5.0	120.000	-38.5
30.720000	4.17	---	22.00	17.83	5.0	120.000	-38.5
31.080000	---	-0.10	2.00	2.10	5.0	120.000	-38.5
31.120000	3.82	---	22.00	18.18	5.0	120.000	-38.5
32.600000	---	-3.47	2.00	5.47	5.0	120.000	-38.5

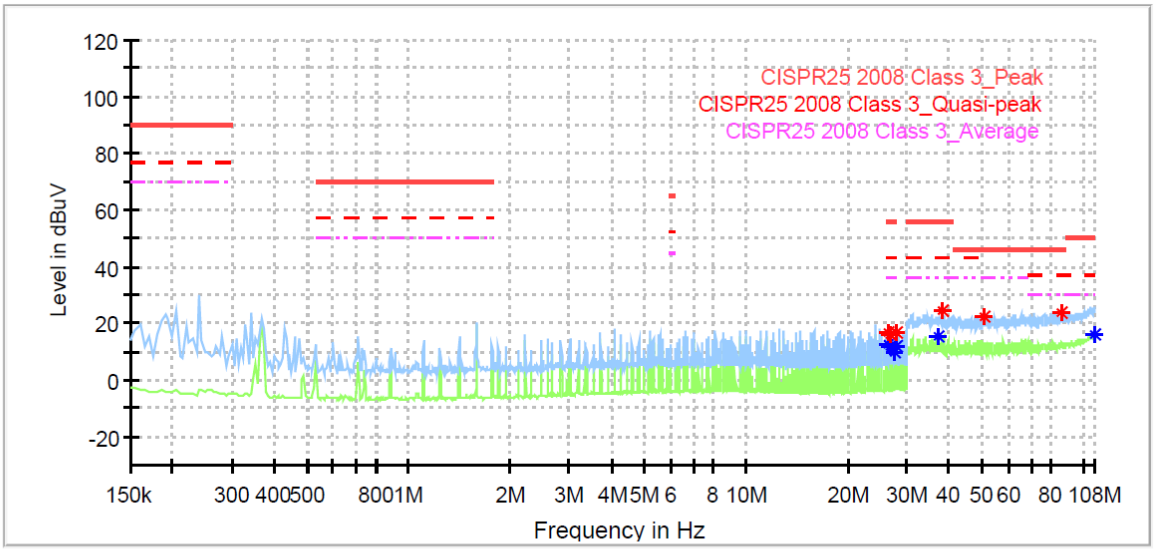
3. CEV 0.15-108MHz PK+AV LV-_Pass Class3



Critical_Freqs

Frequency (MHz)	MaxPeak (dBuV)	Average (dBuV)	Limit (dBuV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)
26.270000	---	13.28	36.00	22.72	50.0	9.000	0.5
26.275000	17.12	---	56.00	38.88	50.0	9.000	0.5
26.645000	15.94	---	56.00	40.06	50.0	9.000	0.5
27.745000	17.04	---	56.00	38.96	50.0	9.000	0.5
32.200000	---	15.45	36.00	20.55	5.0	120.000	0.5
34.050000	---	15.92	36.00	20.08	5.0	120.000	0.6
38.450000	24.55	---	56.00	31.45	5.0	120.000	0.6
41.450000	---	15.04	36.00	20.96	5.0	120.000	0.6
42.950000	23.40	---	46.00	22.60	5.0	120.000	0.6
67.300000	---	14.82	36.00	21.18	5.0	120.000	0.7
67.350000	23.69	---	46.00	22.31	5.0	120.000	0.7
106.200000	---	15.41	30.00	14.59	5.0	120.000	0.9

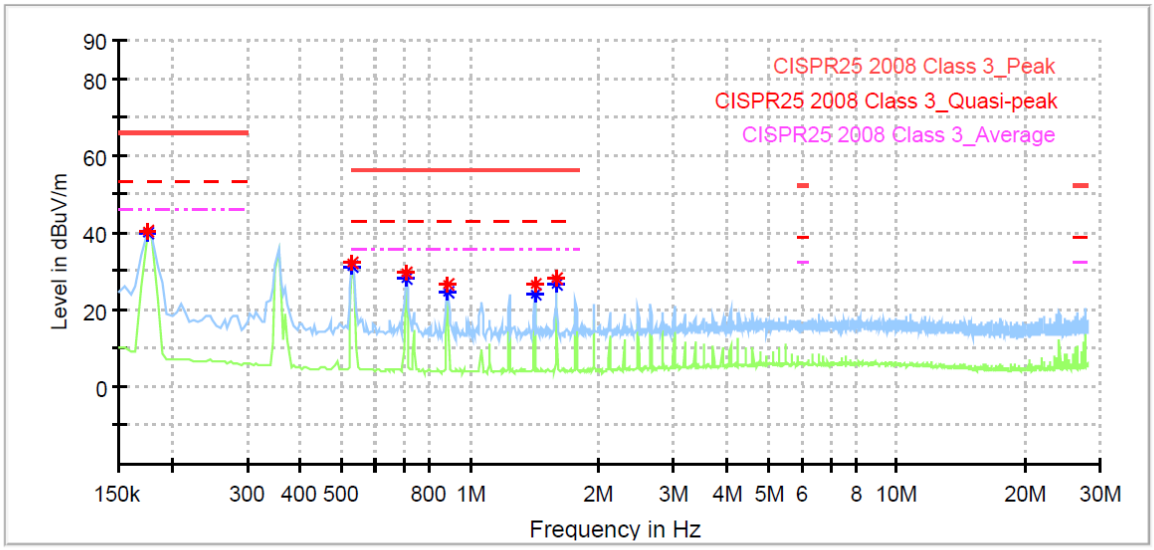
4. CEV 0.15-108MHz PK+AV LV+_Pass Class3



Critical_Freqs

Frequency (MHz)	MaxPeak (dBuV)	Average (dBuV)	Limit (dBuV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)
26.270000	16.81	---	56.00	39.19	50.0	9.000	0.5
26.275000	---	12.44	36.00	23.56	50.0	9.000	0.5
26.645000	16.32	---	56.00	39.68	50.0	9.000	0.5
26.645000	---	11.67	36.00	24.33	50.0	9.000	0.5
27.455000	---	9.90	36.00	26.10	50.0	9.000	0.5
27.755000	---	12.14	36.00	23.86	50.0	9.000	0.5
27.760000	16.51	---	56.00	39.49	50.0	9.000	0.5
37.000000	---	15.19	36.00	20.81	5.0	120.000	0.6
38.100000	24.33	---	56.00	31.68	5.0	120.000	0.6
50.750000	22.64	---	46.00	23.36	5.0	120.000	0.7
86.600000	24.06	---	46.00	21.94	5.0	120.000	0.8
107.700000	---	15.92	30.00	14.08	5.0	120.000	0.9

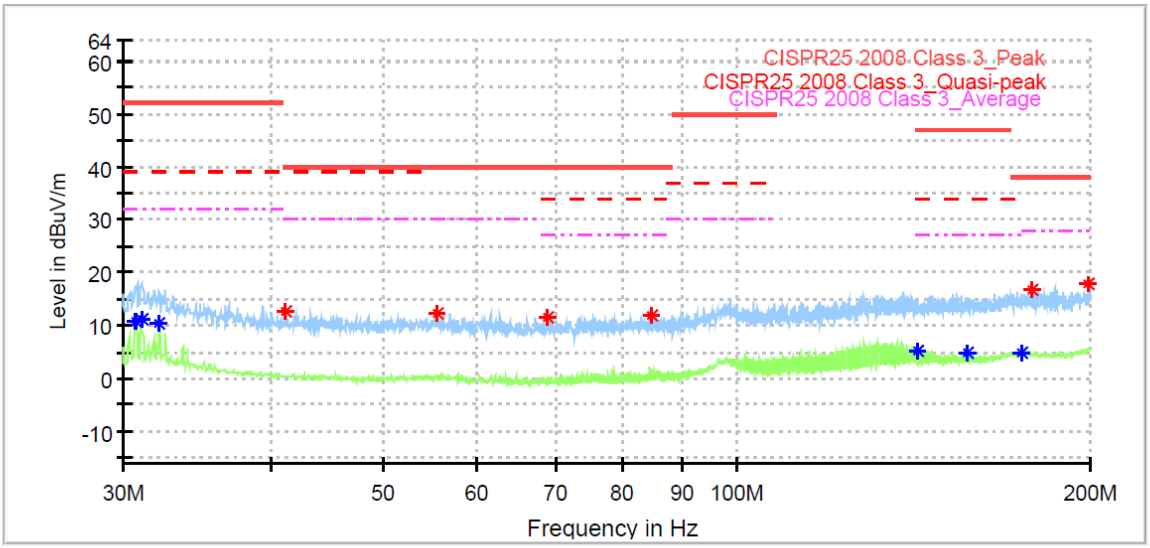
5. RE 0.15-30MHz_Pass Class3



Critical_Freqs

Frequency (MHz)	MaxPeak (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Corr. (dB/m)
0.175000	---	39.68	46.00	6.32	50.0	9.000	V	11.0
0.175000	40.30	---	66.00	25.70	50.0	9.000	V	11.0
0.530000	31.98	---	56.00	24.02	50.0	9.000	V	10.6
0.530000	---	31.04	36.00	4.96	50.0	9.000	V	10.6
0.710000	29.67	---	56.00	26.33	50.0	9.000	V	10.5
0.710000	---	28.33	36.00	7.67	50.0	9.000	V	10.5
0.885000	---	24.66	36.00	11.34	50.0	9.000	V	10.4
0.885000	26.80	---	56.00	29.20	50.0	9.000	V	10.4
1.415000	26.40	---	56.00	29.60	50.0	9.000	V	10.3
1.415000	---	24.06	36.00	11.94	50.0	9.000	V	10.3
1.595000	28.12	---	56.00	27.88	50.0	9.000	V	10.2
1.595000	---	26.39	36.00	9.61	50.0	9.000	V	10.2

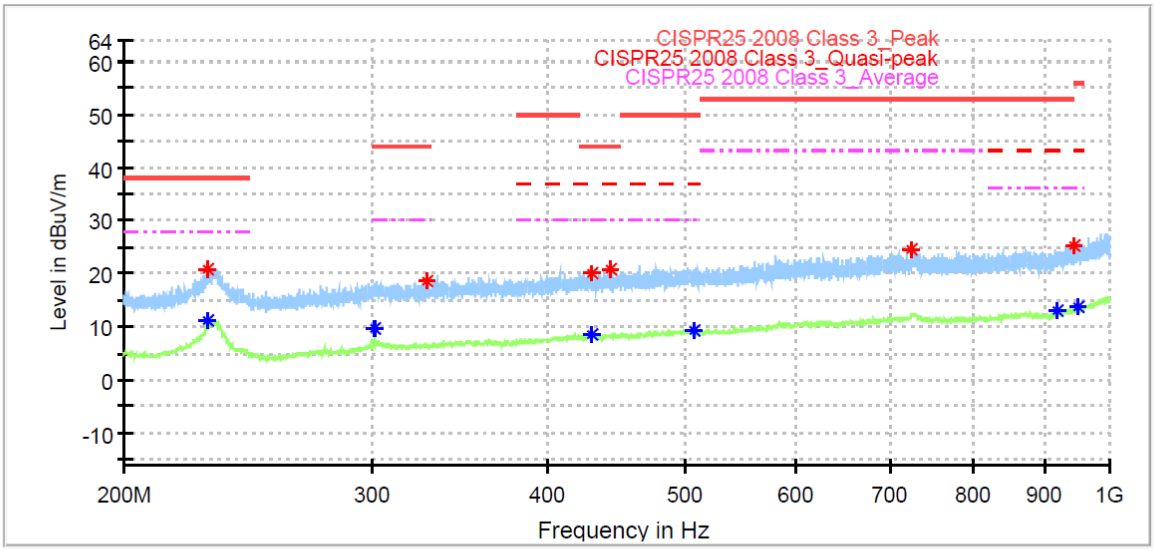
6. RE 30-200MHz_Pass Class3



Critical_Freqs

Frequency (MHz)	MaxPeak (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Corr. (dB/m)
30.750000	---	10.66	32.00	21.34	5.0	120.000	V	-13.2
31.100000	---	10.99	32.00	21.01	5.0	120.000	V	-13.2
32.200000	---	10.45	32.00	21.55	5.0	120.000	V	-13.1
41.300000	12.55	---	40.00	27.45	5.0	120.000	V	-13.5
55.550000	12.26	---	40.00	27.74	5.0	120.000	V	-14.2
69.050000	11.67	---	40.00	28.33	5.0	120.000	V	-15.4
84.700000	12.05	---	40.00	27.95	5.0	120.000	V	-15.1
142.500000	---	5.33	27.00	21.67	5.0	120.000	V	-11.8
157.350000	---	4.67	27.00	22.33	5.0	120.000	V	-11.1
174.500000	---	4.90	27.00	22.10	5.0	120.000	V	-10.2
178.400000	16.57	---	38.00	21.43	5.0	120.000	V	-10.0
199.400000	17.75	---	38.00	20.25	5.0	120.000	V	-8.9

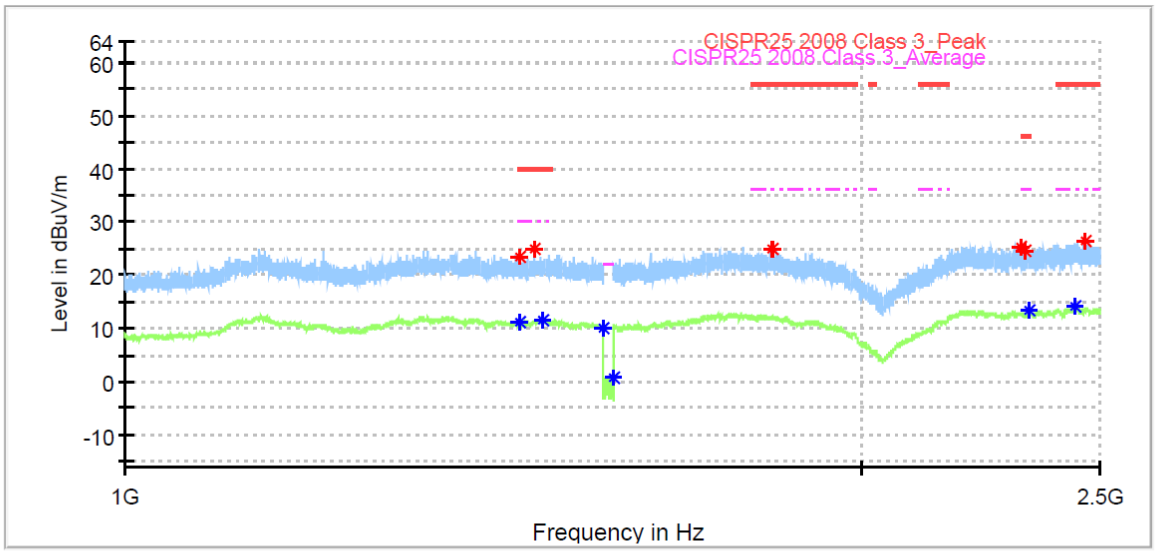
7. RE 200-1000MHz_Pass Class3



Critical_Freqs

Frequency (MHz)	MaxPeak (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Corr. (dB/m)
228.850000	20.84	---	38.00	17.16	5.0	120.000	V	-10.2
228.850000	---	11.19	28.00	16.81	5.0	120.000	V	-10.2
301.100000	---	9.72	30.00	20.28	5.0	120.000	V	-8.0
327.950000	18.65	---	44.00	25.35	5.0	120.000	V	-7.4
428.700000	---	8.50	30.00	21.50	5.0	120.000	V	-6.1
429.700000	20.00	---	44.00	24.00	5.0	120.000	V	-6.1
443.350000	20.84	---	44.00	23.16	5.0	120.000	V	-6.0
506.950000	---	9.45	30.00	20.55	5.0	120.000	V	-5.3
724.250000	24.64	---	53.00	28.36	5.0	120.000	V	-2.6
919.550000	---	12.92	36.00	23.08	5.0	120.000	V	-1.1
943.400000	25.33	---	53.00	27.67	5.0	120.000	V	-0.4
950.750000	---	13.95	36.00	22.05	5.0	120.000	V	-0.2

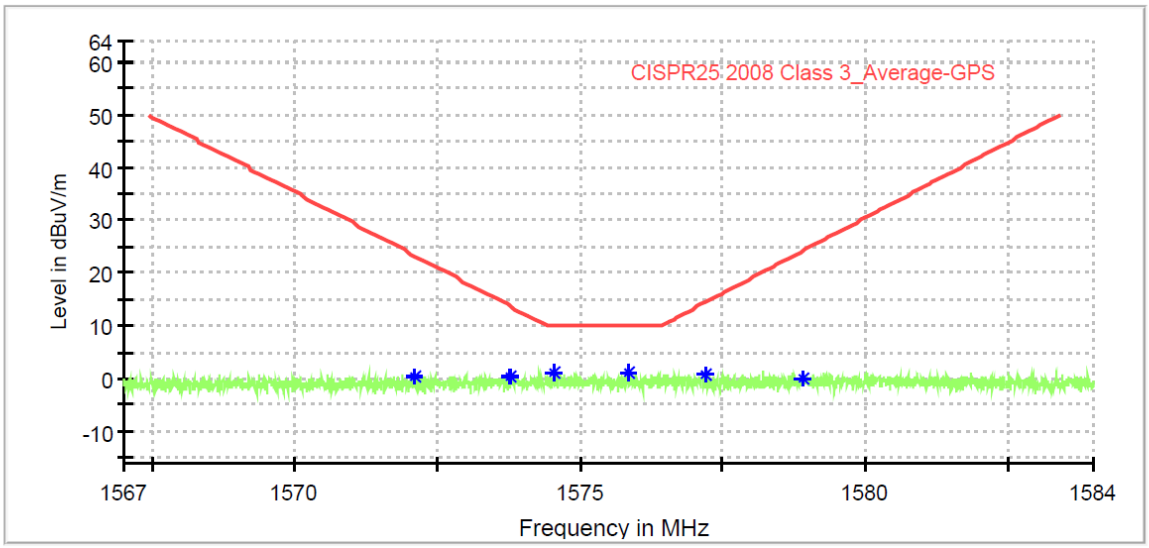
8. RE 1000-2500MHz_Pass Class3



Critical_Freqs

Frequency (MHz)	MaxPeak (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Corr. (dB/m)
1448.550000	23.48	---	40.00	16.52	5.0	120.000	V	-8.7
1449.000000	---	11.24	30.00	18.76	5.0	120.000	V	-8.7
1469.350000	24.85	---	40.00	15.15	5.0	120.000	V	-8.3
1479.750000	---	11.69	30.00	18.31	5.0	120.000	V	-8.2
1567.000000	---	10.09	22.00	11.91	5.0	120.000	V	-8.5
1582.594750	---	0.56	22.00	21.44	5.0	9.000	V	-8.5
1838.100000	25.03	---	56.00	30.97	5.0	120.000	V	-7.3
2320.000000	25.25	---	46.00	20.75	5.0	120.000	V	-5.1
2330.750000	24.63	---	46.00	21.37	5.0	120.000	V	-5.1
2336.650000	---	13.25	36.00	22.75	5.0	120.000	V	-5.1
2443.750000	---	14.15	36.00	21.85	5.0	120.000	V	-4.1
2467.000000	26.60	---	56.00	29.40	5.0	120.000	V	-4.1

9. RE 1567-1584MHz_Pass Class3



Critical_Freqs

Frequency (MHz)	MaxPeak (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Corr. (dB/m)
1572.100000	---	0.22	23.26	23.03	5.0	9.000	V	-8.5
1573.755000	---	0.20	13.80	13.60	5.0	9.000	V	-8.5
1574.525000	---	1.04	10.00	8.96	5.0	9.000	V	-8.5
1575.830000	---	1.01	10.00	9.00	5.0	9.000	V	-8.5
1577.205000	---	0.56	14.49	13.93	5.0	9.000	V	-8.5
1578.920000	---	0.18	24.29	24.11	5.0	9.000	V	-8.5

10. BCI_ISO11452_Pass.

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