

7.2kW Single Phase EVSE Design

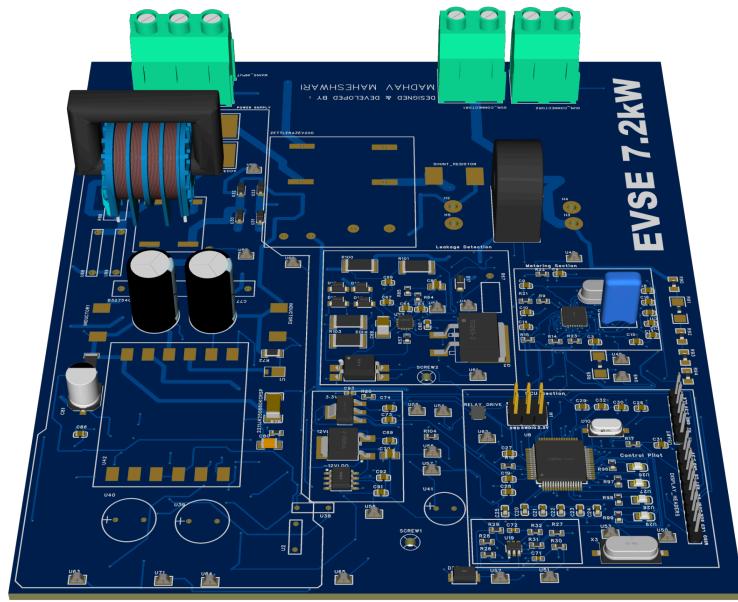
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Introduction

This report describes the design of a single phase 7.2kW Electric Vehicle Supply Equipment Main Relay Board. The design features the STM32F401 as its microcontroller, alongside ADE7953 and AFE3010 for precise energy metering and leakage protection respectively. Future expansion capabilities using UART have also been integrated into the design.

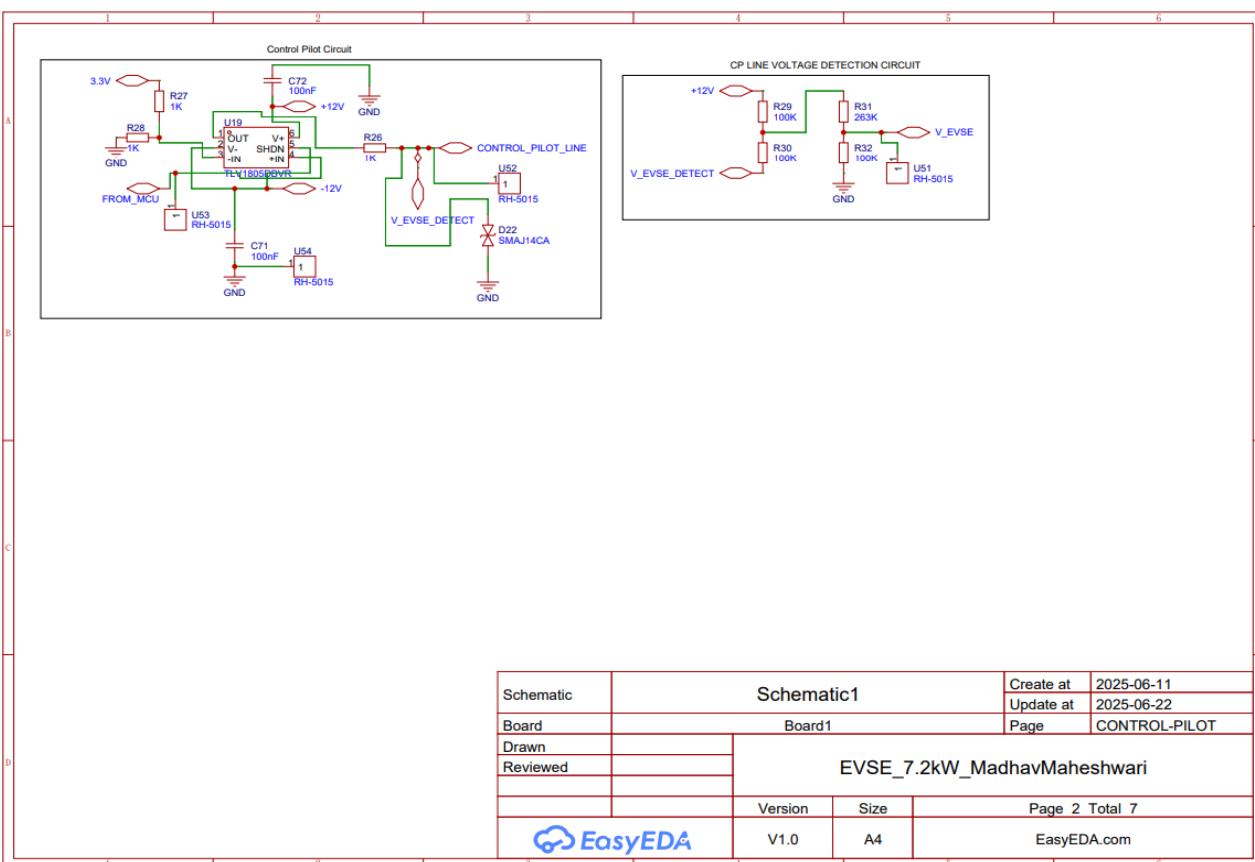
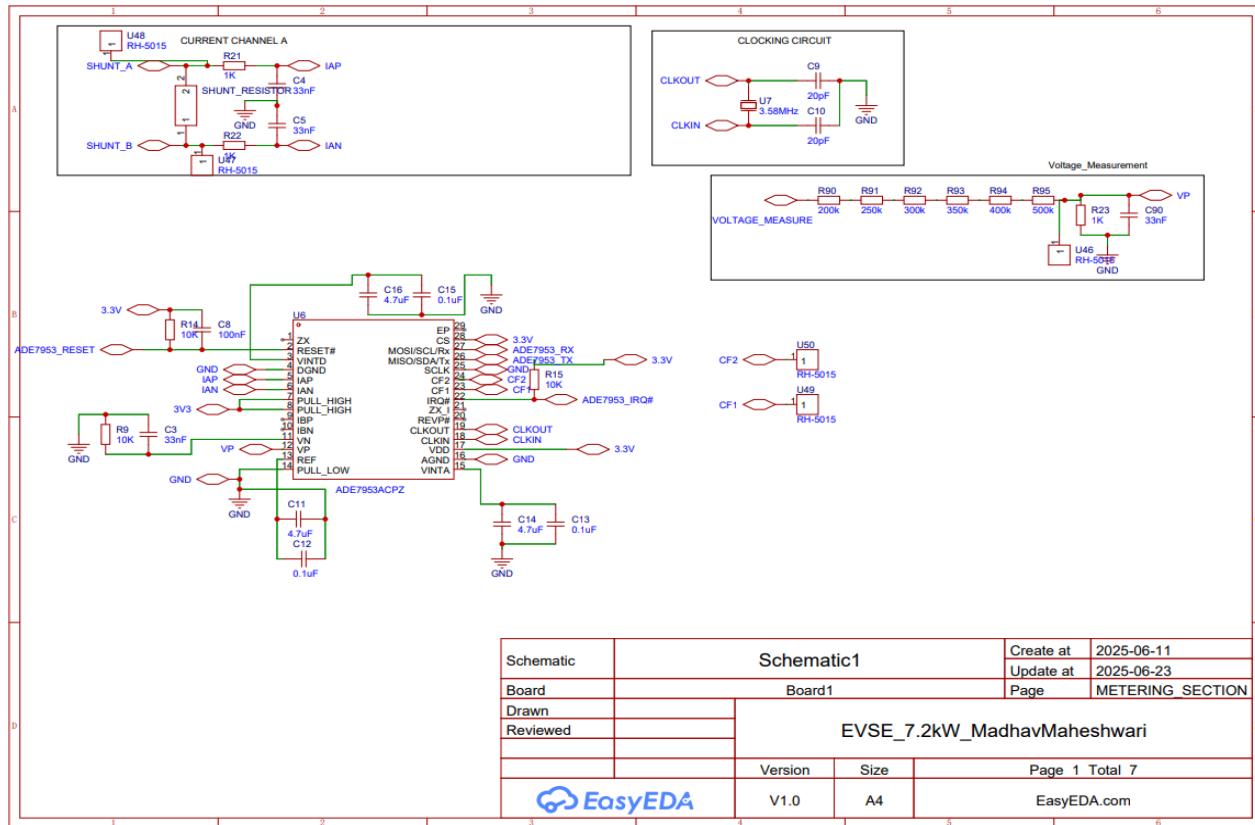


Power Supply Specifications

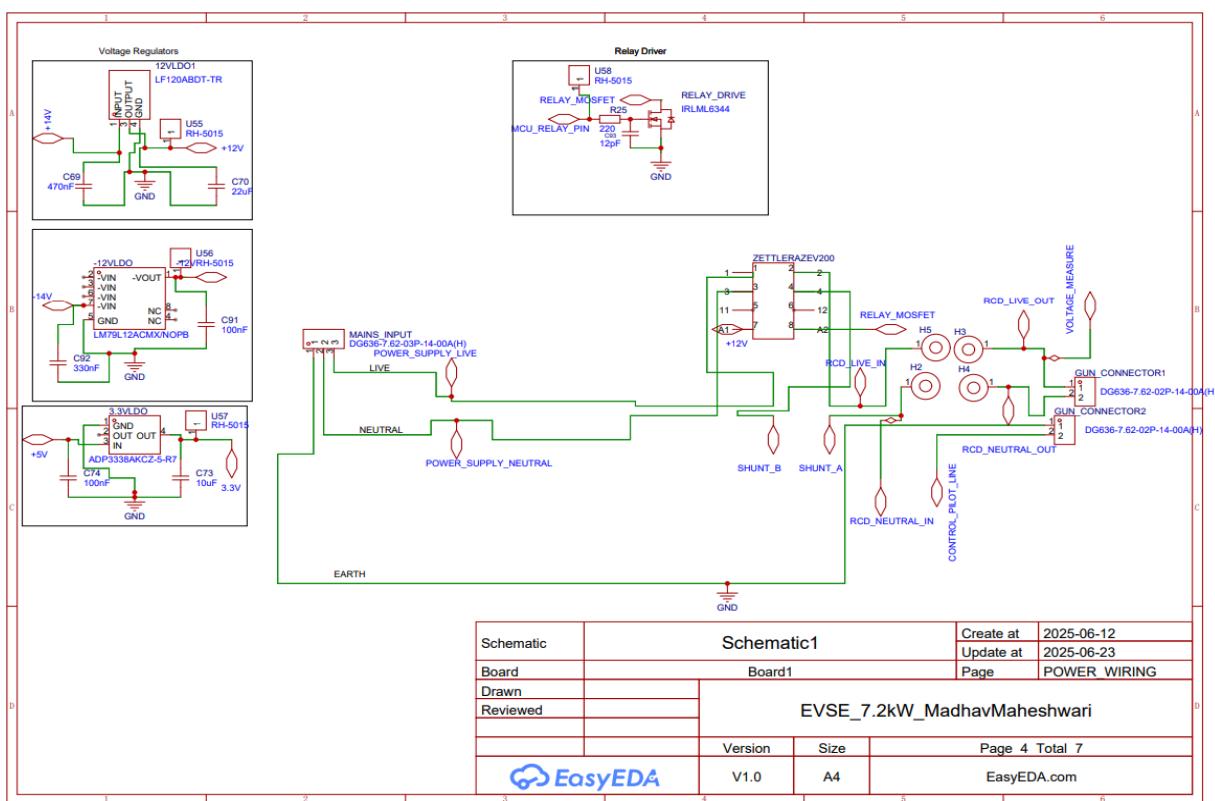
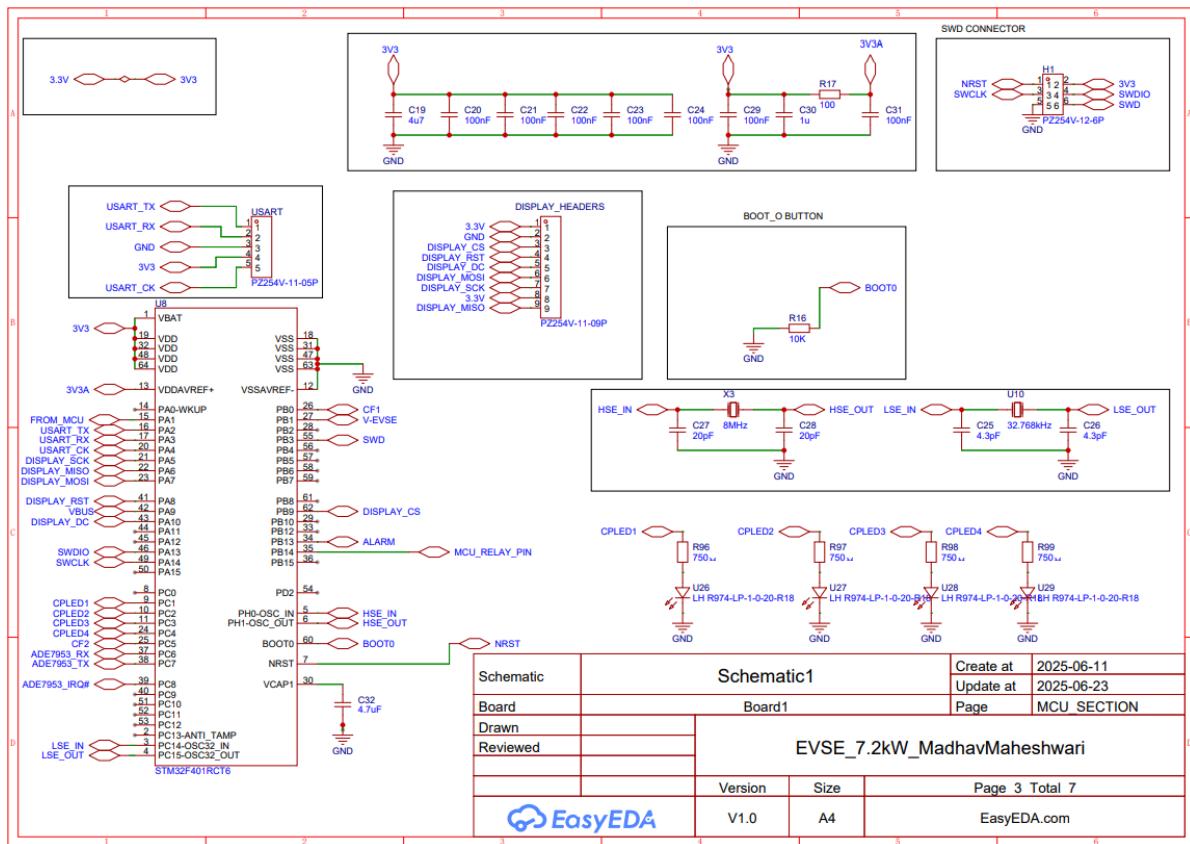
The board consists of a dedicated flyback topology based power supply to power the onboard electronic components. The supply is rated for an input voltage range of **90-230VAC**.

Board Schematics

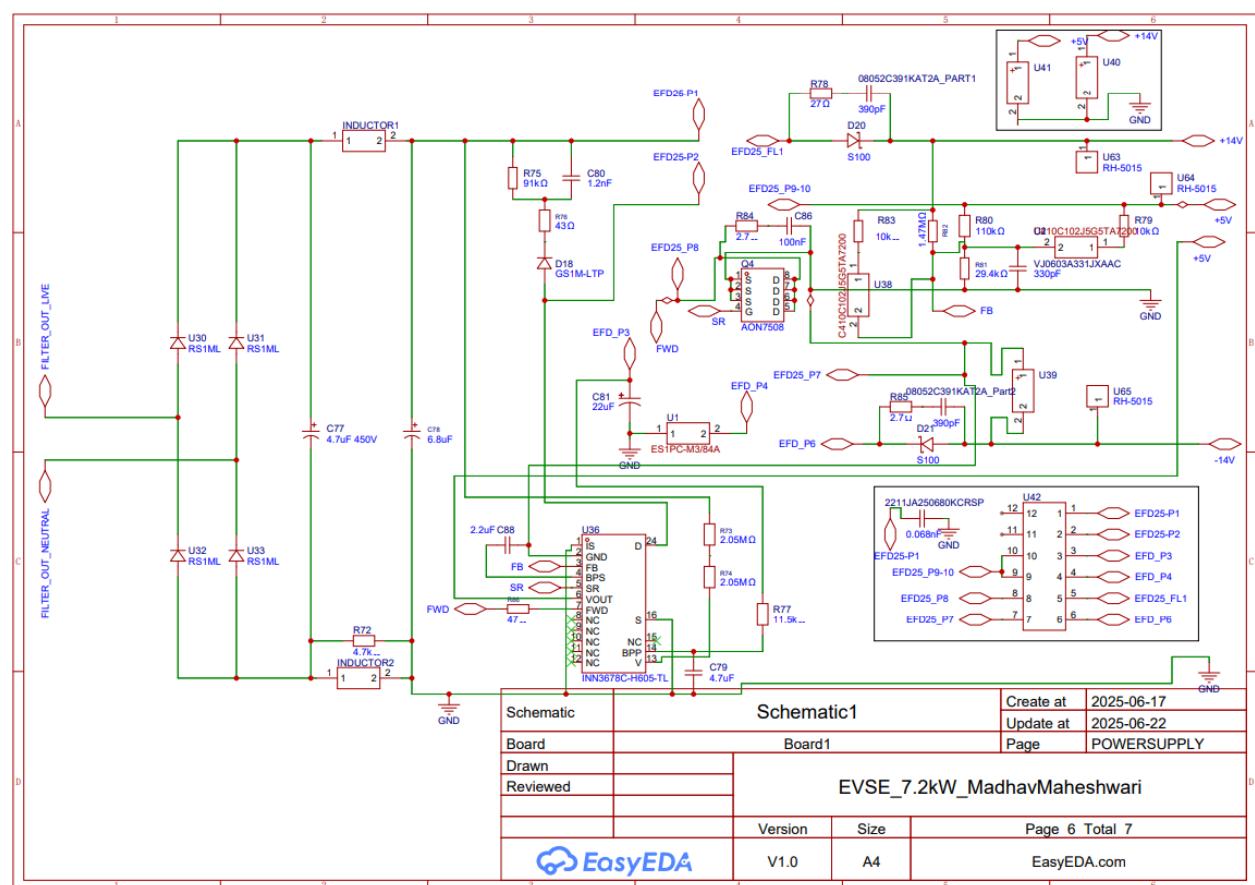
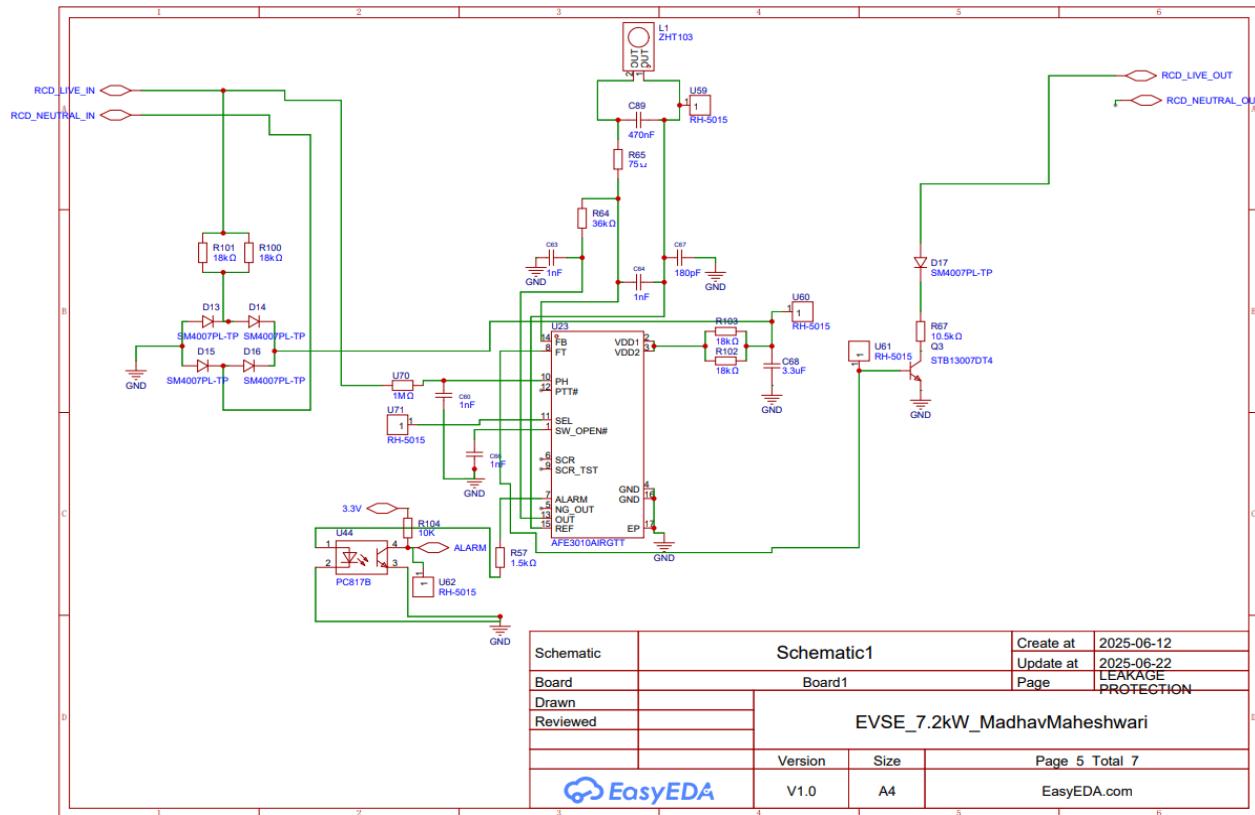
The schematics for the PCB Design have been provided below :

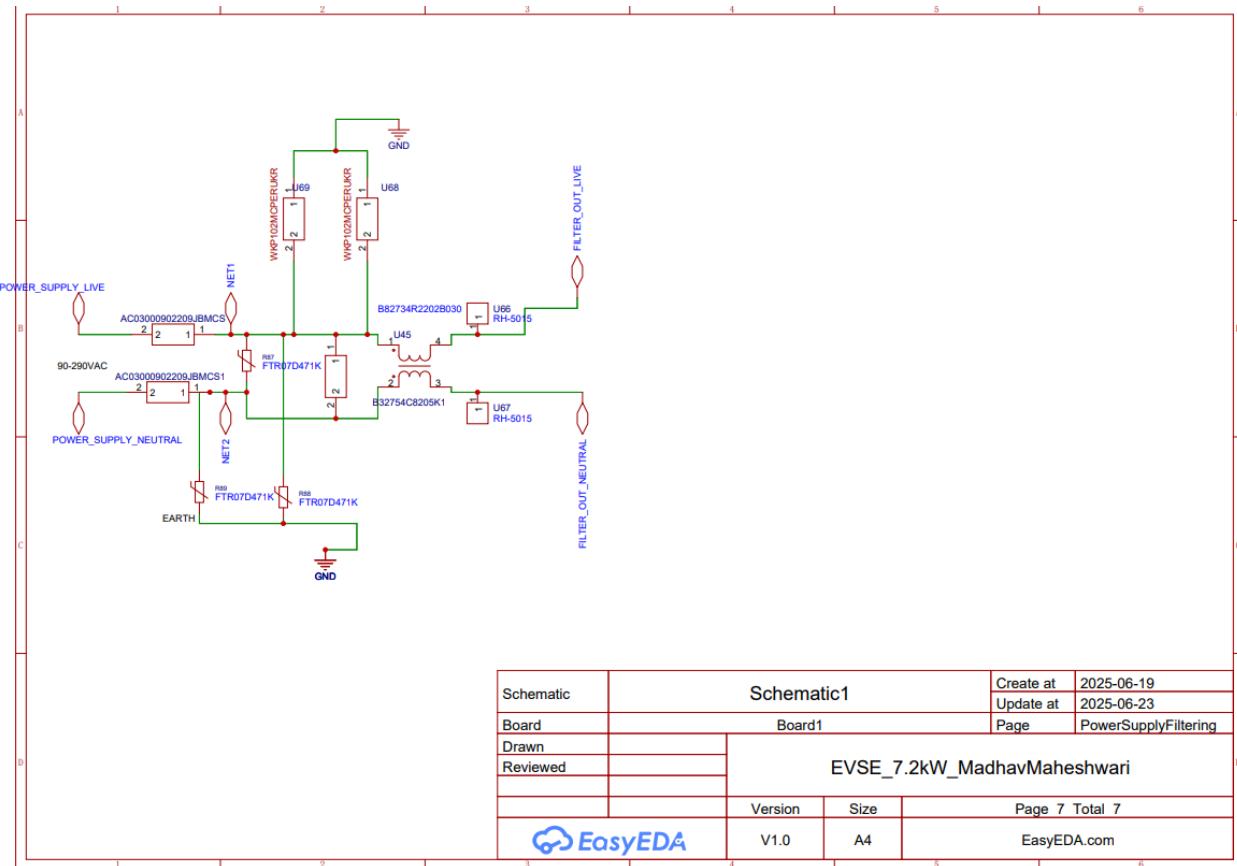


EVSE BOARD DOCUMENTATION



EVSE BOARD DOCUMENTATION





Circuit Description

STM32F401 Microcontroller Unit

The STM32F401 microcontroller on the board can be programmed via dedicated SWDIO connectors provided on the PCB. Additionally, the board includes expansion headers that enable future interfacing with the MCU using USART communication. It features four programmable LEDs that can be configured to indicate charging status, faults, and other system states. SPI connectors are also available, allowing for the integration of SPI-based TFT displays to support graphical and animated outputs.

ADE7953 Based Metering Unit

The design employs an ADE7953 based energy metering unit allowing for accurate measurement of various parameters of the charging process such as power being consumed, reactive power, power factors etc. using the 3 sigma-delta ADCs available on-board the IC and communicates with the STM32F401 MCU through UART communication, connected to **USART 6** of microcontroller.

The ADE7953 is configured to measure the current through a shunt resistor of 2milliohm placed on the neutral line through its current channel A. The channel B for current measurement is **not implemented on this board**.

More detailed information regarding the metering unit and component value calculations can be found on the following link : [ADE795 Energy Metering IC](#)

Leakage Protection

The board integrates the **AFE3010** IC from Texas Instruments to provide ground fault leakage protection. In this implementation, the AFE3010 is configured to operate in ALARM/LED driver mode and does not directly control the main contactor relay. Instead, the IC's alarm output is routed to the STM32F401 microcontroller, which processes the signal and determines the appropriate control actions based on the detected fault.

Note: Ground-to-neutral fault detection is not supported in the current version of the board.

Control Pilot Signalling Unit

The design includes a Control Pilot signaling circuit to enable communication between the EVSE and the electric vehicle, in accordance with standard charging protocols. A **TLV1805DBVR** rail-to-rail operational amplifier is used to generate the required $\pm 12V$ signaling levels, based on input signals from the STM32F401 microcontroller.

In addition, a dedicated voltage detection circuit has been implemented to allow the microcontroller to monitor the Control Pilot line. This circuit safely steps down the Control Pilot voltage to levels compatible with the MCU's ADC input range.

Main Contactor Relay

The main contactor relay used to control the connection between the EV and the mains supply is the Zettler AZEV200. This relay is rated for 50,000 switching cycles and carries CC2 certification, making it a reliable and appropriate choice for the application. It is designed to handle a maximum current of 40 A. The relay is driven by the STM32F401 microcontroller via an IRLML6344 logic-level MOSFET, ensuring safe and efficient switching.

Bill Of Materials

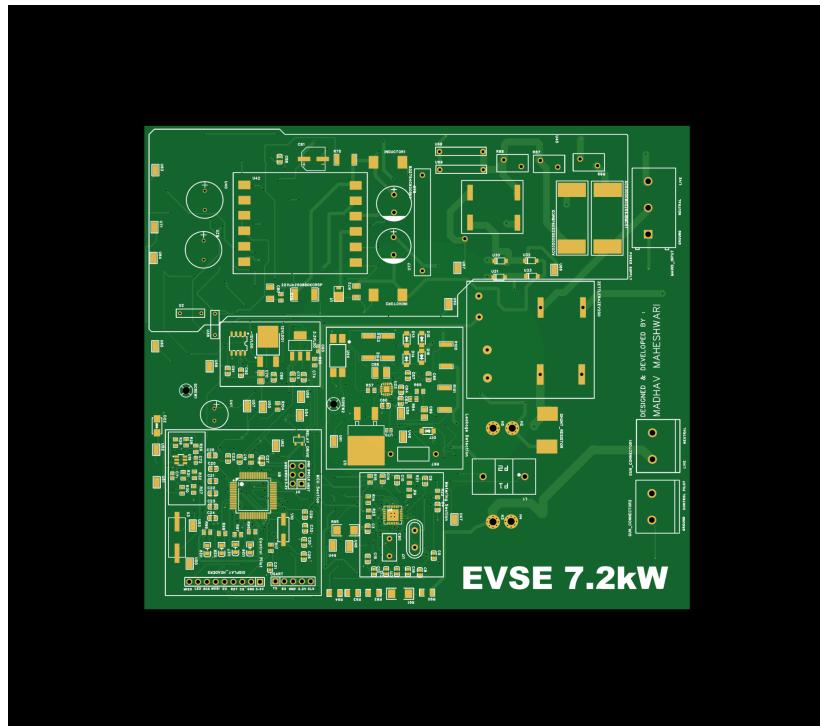
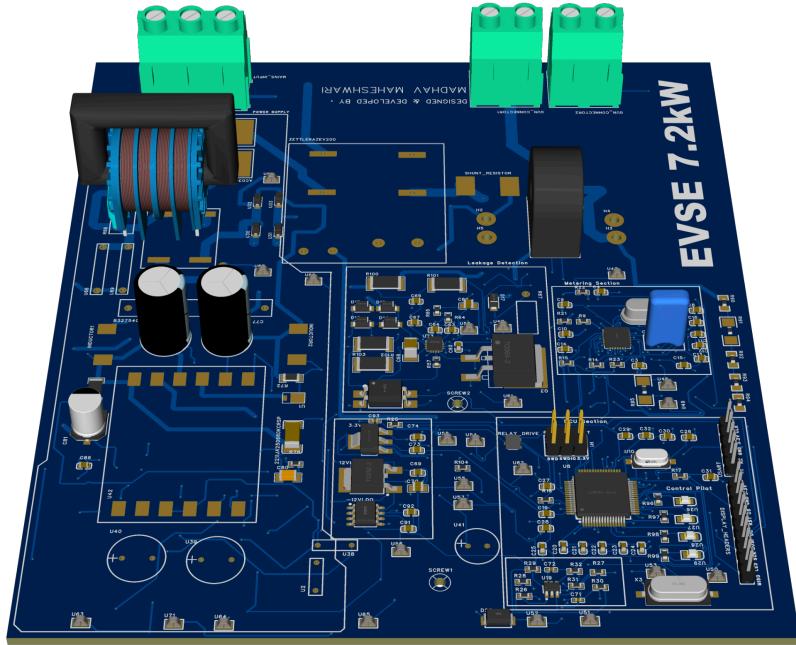
No.	Quantity	Comment	Designator	Footprint	Value	Manufacturer Part	Manufacturer	Supplier Part	Supplier
1	1	ADP3338AKCZ-5-R7	3.3VLD0	SOT-223-3_L6.5-W3.4-P		ADP3338AKCZ-5-R7	ADI(亚德诺)	C659191	LCSC
2	1	LF120ABDT-TR	12VLD01	DPAK_L6.5_W6.0_P2.29		LF120ABDT-TR	ST(意法半导体)	C222115	LCSC
3	1	0.068nF	2211A25D0680KCRSP	C2211	0.068nF	FK21X222KS02EGG	PSA(信昌电陶)		LCSC
4	2	390pF	08052C391KAT2A_PART0805	C0805	390pF	CC0805KRX7R9BB104	YAGEO(国巨)		LCSC
5	1	LM79L12ACMX/NOPB	-12VLD0	SOIC-8_L4.9-W3.9-P1.27		LM79L12ACMX/NOPB	TI(德州仪器)	C2869494	LCSC
6	2	AC03000902209IBMCS_AC03000902209IBMCS_AC03000902209IBMCS_				AC03000902209IBMCS	Vishay	594-AC03000902209J	ouser
7	1	B32754C8205K000_Filt	B32754C8205K000_Foot	B32754C8205K000		B32754C8205K000	EPCOS/TDK	871-B32754C8205K000	ouser
8	3	33nF	C3,C4,C5	C0603	33nF				
9	11	1.00nF	C8,C20,C21,C22,C23,C24	C0603	100nF				
10	4	20pF	C9,C10,C27,C28	C0603	20pF				
11	4	4.7uF	C11,C14,C16,C32	C0603	4.7uF				
12	3	0.1uF	C12,C13,C15	C0603	0.1uF				
13	1	4u7	C19	C0603	4u7				
14	2	4.3pF	C25,C26	C0603	4.3pF				
15	1	1u	C30	C0603	1u				
16	4	1nF	C60,C63,C64,C66	C0603	1nF	CC0603KRX7R9BB102	YAGEO(国巨)	C100040	LCSC
17	1	1.80pF	C67	C0603	180pF	CC0603RNPO9BN181	YAGEO(国巨)	C107041	LCSC
18	1	3.3uF	C68	C1210	3.3uF	GRM32DR71H33SKA88LmuRata(村田)	C397310	LCSC	
19	1	4.70nF	C69	C0603	470nF	CL10B474KABNNC	SAMSUNG(三星)	C1623	LCSC
20	1	122uF	C70	C0805	22uF	CL1A226MVANNNE	SAMSUNG(三星)	C602037	LCSC
21	2	1.00nF	C71,C72	C0402	100nF	0402B104K250T	FH(风华)	C56392	LCSC
22	1	1.0uF	C73	C0603	10uF				
23	1	4.7uF_450V	C77	CAP-TH_BD10_0-P5.00_E-4.7uF_450V		KMR47M450G125A	CapXon(丰润)		LCSC
24	1	6.8uF	C78	CAP-TH_BD10_0-P5.00_E-6.8uF		EGD2W/MGR86120TG	AISHI(艾华集团)	C106335	LCSC
25	1	4.7uF	C79	C0603	4.7uF	C1608X7S1A75K080A0C_TDK	C5331011	LCSC	
26	1	1.2nF	C80	C1206	1.2nF	CGA574C062J122J085A_TDK	C2170351	LCSC	
27	1	222uF	C81	CAP-SMD_BD6.3-L6.6-W222uF		EEHZC1H220P	PANASONIC(松下)	C178643	LCSC
28	1	2.2uF	C88	C0805	2.2uF	CGA413X7R1C225K125A_TDK	C183896	LCSC	
29	1	470nF	C89	C0805	470nF	CC0805KXTR9B8474	YAGEO(国巨)	C520080	LCSC
30	1	33nF	C90	CAP-TH_L7_7-W4.0-P5.033nF		MPP33RK26105105LC	SRD(圣洁达)	C109705	LCSC
31	1	330nF	C92	C0603	330nF				
32	1	12pF	C93	C0402	12pF	CC0402RNPO9BN120	YAGEO(国巨)	C106201	LCSC
33	5	SM4007PL-TP	D13,D14,D15,D16,D17	SOD-123_L2.8-W1.8-L53		SM4007PL-TP	MCC(美封科)	C78741	LCSC
34	1	G51M-LTP	D18	DO-214AC_I4.3-W2.7-L		G51M-LTP	MCC(美封科)	C435833	LCSC
35	2	S100	D20,D21	DO-214AC_I4.3-W2.7-L		S100	onsemi(安森美)	C556396	LCSC
36	1	SMA114CA	D22	SMA_L4_W2.6-L55.0-B		SMA114CA	AnBon(安邦)	C435539	LCSC
37	1	P2Z54V-11-09P	DISPLAY_HEADERS	HDR-TH_9P-P2.54-V.M		P2Z54V-11-09P	XFCN(兴飞)	C492408	LCSC
38	2	DG636-7.62-02P-14-00A-GUN_CONNECTOR1_GUICONTH_DG636-7.62-2		TO-263-2_L10.1-W9.1-P		DG636-7.62-02P-14-00A-DEGSON(高正/高松)	C581137	LCSC	
39	1	P2Z54V-12-6P	H1	HDR-TH_6P-P2.54-V.M		P2Z54V-12-6P	XFCN(兴飞)	C492420	LCSC
40	4	RCD_Connector2	H2,H3,H4,H5	RCD_Connector2_Footp					
41	2	B82464A4105K000_Peris_INDUCTOR1_INDUCTOR	B82464A4105K000_Foot			B82464A4105K	EPCOS/TDK	871-B82464A4105K	ouser
42	1	ZHT103	L1	IND-TH_L18.2-W10.2-P1		ZHT103	ZHT(瑞恒通)	C293536	LCSC
43	1	DG636-7.62-03P-14-00A MAINS_INPUT	CONN-TH_DG636-7.62-I			DG636-7.62-03P-14-00A-DEGSON(高正/高松)	C691864	LCSC	
44	1	STB13007DT4	Q3	TO-263-2_L10.1-W9.1-P		STB13007DT4	ST(恩法半导体)	C500928	LCSC
45	1	AOA7N508	Q4	POFN-8_L3.0-W3.0-P0.6		AOA7N508	AOS	C131410	LCSC
46	5	10k	R9,R14,R15,R16,R104	R0603	10k				
47	1	100	R17	R0603					
48	6	1k	R21,R22,R23,R26,R27,R2	R0603	1k				
49	1	220	R25	R0603					
50	3	100K	R29,R30,R32	R0603	100K				
51	1	263K	R31	R0603	263K				
52	1	1.5kΩ	R57	R0603	1.5kΩ	0603WAF1501T5E	UNI-ROYAL(原声)	C22843	LCSC
53	1	36kΩ	R64	R0603	36kΩ	0603WAF3602T5E	UNI-ROYAL(原声)	C23147	LCSC
54	1	75Ω	R65	R0603	75Ω	0603WAF7501T5E	UNI-ROYAL(原声)	C4275	LCSC
55	1	10.5kΩ	R67	RES-TB_BD3.9-L9.0-P13.10kΩ		FMP200FRF52-10KS	YAGEO(国巨)	C1758640	LCSC
56	1	4.7kΩ	R72	R1206	4.7kΩ	FRC1206I472T5	FOJAN(富佳)	C2907499	LCSC
57	2	2.05MΩ	R73,R74	R1206	2.05MΩ	1206W4F2054T5	UNI-ROYAL(原声)	C407291	LCSC
58	1	191kΩ	R75	R2010	91kΩ	2010W2V0913T45	UNI-ROYAL(原声)	C20469	LCSC
59	1	430	R76	R0603	430	ERJPA3A430V	PANASONIC(松下)	C445801	LCSC
60	1	11.5kΩ	R77	R0805	11.5kΩ	FRC0805F1152TS	FOJAN(富佳)	C2933288	LCSC
61	1	27Ω	R78	R1210	27Ω	1210W2F270T5E	UNI-ROYAL(原声)	C620672	LCSC
62	2	10kΩ	R79,R83	R0805	10kΩ	0805W8F100T5E	UNI-ROYAL(原声)	C17414	LCSC
63	1	110kΩ	R80	R0805	110kΩ	0805F05F110T5	FOJAN(富佳)	C2907221	LCSC
64	1	29.4kΩ	R81	R0805	29.4kΩ	0805W8F294T5E	UNI-ROYAL(原声)	C17602	LCSC
65	1	1.47MΩ	R82	R0805	1.47MΩ	0805W8F1474T5E	UNI-ROYAL(原声)	C189666	LCSC
66	2	2.7Ω	R84,R85	R0805	2.7Ω	FRC0805J2R7T5	FOJAN(富佳)	C2933542	LCSC
67	1	47Ω	R86	R0805	47Ω	0805W8F0470T5E	UNI-ROYAL(原声)	C25315	LCSC
68	3	FTR07D471K	R87,R88,R89	RES-TB_L9_0-W5.0-P5.0		FTR07D471K	FTR(乔光电子)	C693450	LCSC
69	1	200k	R90	R0204	200k	MLF21JT2D000	SE/Stackpole	C6092691	LCSC
70	1	250k	R91	R0207	250k	MMB2075D1004B20C_Vishay/Dale	MMB2075D1004B20C_Vishay/Dale	594-MMB2075D1004B	ouser
71	1	300k	R92	R0204	300k	MMA0240C3003FB300_Vishay/Dale	MMA0240C3003FB300_Vishay/Dale	594-MMA0240C3003FB	ouser
72	1	350k	R93	R0204	350k	MMA0240SD3523B300_Vishay/Dale	MMA0240SD3523B300_Vishay/Dale	71-MA2040AC3523B300	ouser
73	1	400k	R94	R0204	400k	MMA0240C423FB300_Vishay/Dale			
74	1	500k	R95	R0207	500k	MMB2075D4993B20C_Vishay/Dale			
75	4	750Ω	R96,R97,R98,R99	R0603	750Ω	FRC003F750T5	FOJAN(富佳)	C2907066	LCSC
76	1	18kΩ	R100,R101,R102,R103	R2512	18kΩ	CRH2512J18K0E04Z	EVER OHMHS(英天科技)	C175472	LCSC
77	1	IRMLM6344_RELAY_DRIVE		SOT-23-3_L3.0-W1.7-P0		IRMLM6344	Hotech(台积科)	C5364313	LCSC
78	1	WSR211000EB_Shunt		WSR211000EB_Shunt		WSR211000EB	Vishay/Dale		
79	1	E51PC-M3/84A_person1_U1		E51PC-M3/84A_Footpri		E51PC-M3/84A_Footpri	Vishay General Semicon		
80	2	C410C102J5GSTA7200_I	C410C102J5GSTA7200_I			C410C102J5G57A7200_I	Kemet	80-C410C102J5G-TR	LCSC
81	1	ADE7953ACPZ_U6		LFCS2-P5.0-W5.0-P0		ADE7953ACPZ_U6	ADI(亚德诺)	C49590	LCSC
82	1	3.58MHz	U7			SiC35800ZWJAC_U7	JVIE	C282665	LCSC
83	1	STM32F401RCT6	U8	HC-49S_L11.0-W4.7-P4..3.58MHz		STM32F401RCT6	ST(意法半导体)	C74524	LCSC
84	1	32.768kHz	U10			CRYSTAL-SMD_L7.0-W3.2768kHz	HUAUXIN(华芯)	C19723458	LCSC
85	1	TLV1805DBVR	U19			TLV1805DBVR	TI(德州仪器)	C702104	LCSC
86	1	AFE3010AIRGTT	U23	VOFNF-16_L3.0-W3.0-P0		AFE3010AIRGTT	TI(德州仪器)	C17543686	LCSC
87	4	LH R974-LP-1-0-20-R18	U26,U27,U28,U29	LED0805-RD		LH R974-LP-1-0-20-R18	OSRAM(欧司朗)	C2899895	LCSC
88	4	RS1ML	U30,U31,U32,U33	SOD-123_L1.8-W1.8-L53		RS1ML	CJ(江苏长电-长晶)	C2842723	LCSC
89	1	INN3678C-H605-TL	U36	INSP0-24D_INN3678C-I		INN3678C-H605-TL	Power Integrations(帕	C17179554	LCSC
90	2	A759MS686M1HAAE03;U39,U40		A759MS686M1HAAE03;		A759MS686M1HAAE03;Kemet	17179554		
91	1	PR70J221MDN1_Person1_U4		PR70J221MDN1_Footpr		PR70J221MDN1	Nichicon	399-A759MS686M1HAA_DigitKey	
92	1	EF25_Personal	U42	EF25_Footprint					
93	1	PC817B	U44	SOP-4_L6.5-W4.6-P2.54		PC817B	Sikor(萨科微)	C2936042	LCSC
94	1	B82734R220B030	U45	FILTER-TH_B82734R22		B82734R220B030	TDK	C1534172	LCSC
95	23	RH-5015	U46,U47,U48,U49,U50	SMD_RH-5015		RH-5015	秉和	C5199798	LCSC
96	2	WKP102MCPERUKR	U68,U69	WKP102MCPERUKR_Foc		WKP102MCPERUKR	Vishay Beyschlag/Dralon	C313361	DigiKey
97	1	1MΩ	U70	R0402	1MΩ	CRCW04021M00FKEDHVISHAY(威世)		C492404	LCSC
98	1	P2Z54V-11-05P	USART	HDR-TH_5P-P2.54-V-M		P2Z54V-11-05P	XFCN(兴飞)	C492404	LCSC
99	1	330pF	VJ0603A331JXAAC	C0603	330pF	VJ0603A331JXAAC	Vishay/Vitarmont	77-VJ0603A331JXAAC	ouser
100	1	1.8MHz	X3	HC-49S_L11.4-W4.8	8MHz	X495M8MSD2SI	YXC(扬兴晶振)	C106809	LCSC
101	1	AZEV200_V1	ZETTLERAZEV200	AZEV200_FOOTPRINT_V		AZEV200-2A18-6D	Zettler	3385-AZEV200-2A18-6DigiKey	

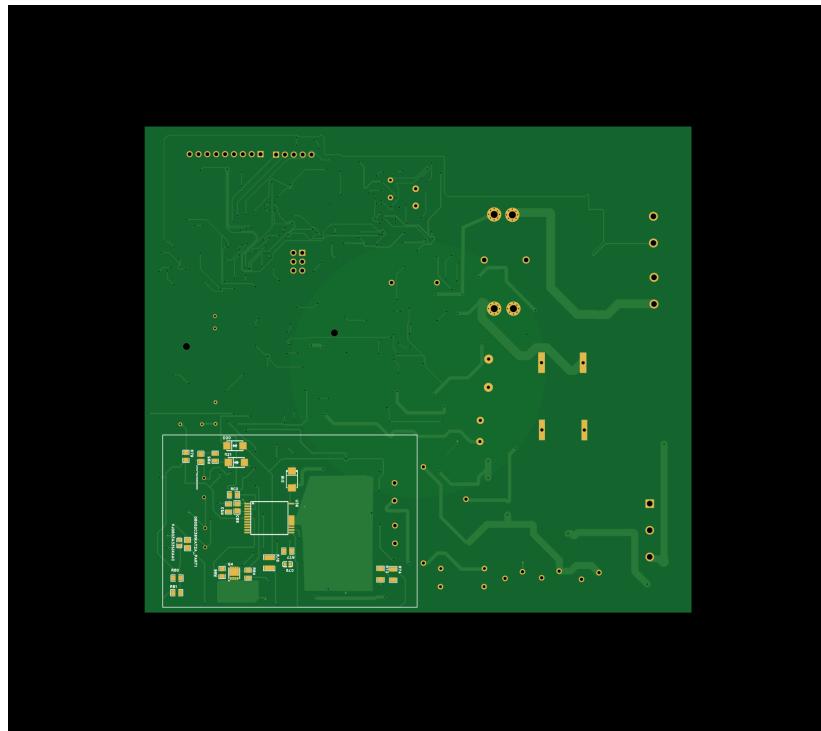
Microcontroller Pin Mapping

The table given below describes the connections of various units on the board to the MCU.

PA1	Control Pilot Signal Control		Control Pilot
PA2	USART Header TX		USART Header Connections
PA3	USART Header RX		
PA4	USART Header Clock		
PA5	SPI Display Header - SCK		External SPI Display Header
PA6	SPI Display Header - MISO		
PA7	SPI Display Header - MOSI		
PA8	SPI Display Header - Reset		
PA10	SPI Display Header - DC		
PA13	SWDIO		MCU Programming Connector
PA14	SWCLK		
PC1	Control Pilot Status Led 1		Programmable Status LEDs
PC2	Control Pilot Status Led 2		
PC3	Control Pilot Status Led 3		
PC4	Control Pilot Status Led 4		
PC5	ADE7953 CF2 Signal		ADE7953 Indicator Connections
PB0	ADE7953 CF1 Signal		
PC6	ADE7953 RX		USART 6
PB7	ADE7953 TX		
PC8	ADE7953 IRQ		ADE7953 Interrupt
PB1	Control Pilot Voltage Detection		Control Pilot
PB3	SWD		MCU Programming
PB9	SPI Display CS		SPI Display Header
PB13	AFE3010 Alarm Fault Detection		Leakage Detection
PB14	MCU Main Relay Control		Charging Control

Board Images





Additional Information Documents

1. [Power Supply Requirements](#)
2. [Implementation Of Main Contact Relay](#)
3. [Control Pilot PWM Generation and State Detection](#)
4. [ADE795 Energy Metering IC](#)
5. [Power Supply Design](#)