Boundary Conduction Mode PFC and Quasi-Resonant Flyback Converter with Analog-Digital Hybrid Control Evaluation Board LogiCoA003-EVK-001

User's Guide

＜High Voltage Safety Precautions＞

◇ Read all safety precautions before use

Please note that this document covers only the BCM-PFC and QR flyback converter with analog-digital hybrid control evaluation board (LogiCoA003-EVK-001) and its functions. For additional information, please refer to the Application Note [6].

To ensure safe operation, please carefully read all precautions before handling the evaluation board

Depending on the configuration of the board and voltages used,

Potentially lethal voltages may be generated.

Therefore, please make sure to read and observe all safety precautions described in the red box below.

Before Use

[1] Verify that the parts/components are not damaged or missing (i.e. due to the drops).
[2] Check that there are no conductive foreign objects on the board.
[3] Be careful when performing soldering on the module and/or evaluation board to ensure that solder splash does not occur.
[4] Check that there is no condensation or water droplets on the circuit board.

During Use

[5] Be careful to not allow conductive objects to come into contact with the board.
[6] **Brief accidental contact or even bringing your hand close to the board may result in discharge and lead to severe injury or death.**
Therefore, DO NOT touch the board with your bare hands or bring them too close to the board.
In addition, as mentioned above please exercise extreme caution when using conductive tools such as tweezers and screwdrivers.
[7] If used under conditions beyond its rated voltage, it may cause defects such as short-circuit or, depending on the circumstances, explosion or other permanent damages.
[8] Be sure to wear insulated gloves when handling is required during operation.

After Use

[9] The ROHM Evaluation Board contains the circuits which store the high voltage. Since it stores the charges even after the connected power circuits are cut, please discharge the electricity after using it, and please deal with it after confirming such electric discharge.
[10] Protect against electric shocks by wearing insulated gloves when handling.

This evaluation board is intended for use only in research and development facilities and should by handled **only by qualified personnel familiar with all safety and operating procedures.**
We recommend carrying out operation in a safe environment that includes the use of high voltage signage at all entrances, safety interlocks, and protective glasses.

LogiCoA™ Power Solutions

Boundary Conduction Mode PFC and Quasi-Resonant Flyback Converter with Analog-Digital Hybrid Control Evaluation Board LogiCoA003-EVK-001

(24V, 4A Output)

Introduction

LogiCoA™ is a power solution that implements analog-digital hybrid control to a switching power supply. This User's Guide describes the steps required to operate and evaluate the evaluation board of LogiCoA™ power solution Boundary Conduction Mode PFC (BCM-PFC) and Quasi-Resonant (QR) Flyback Converter EVK LogiCoA003-EVK-001. The documentation includes peripheral components, operating procedures and application data.

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1 Outline of the LogiCoA™ Power Solutions

Figure 1 shows the overview of LogiCoA™ power solution. LogiCoA™ is a power solution that implements analog-digital hybrid control to a switching power supply and consists of 3 elements, (1) a microcontroller for power supply control (LogiCoA™ microcontroller) ML62Q203x/ML62Q204x (subsequently referred to ML62Q20xx group), (2) an operating system for power supply control microcontroller, RMOS, and (3) a power supply application. Please refer to Analog-Digital Hybrid Control Innovating Switching Power Supply Design [1] for detailed information on analog-digital hybrid control.

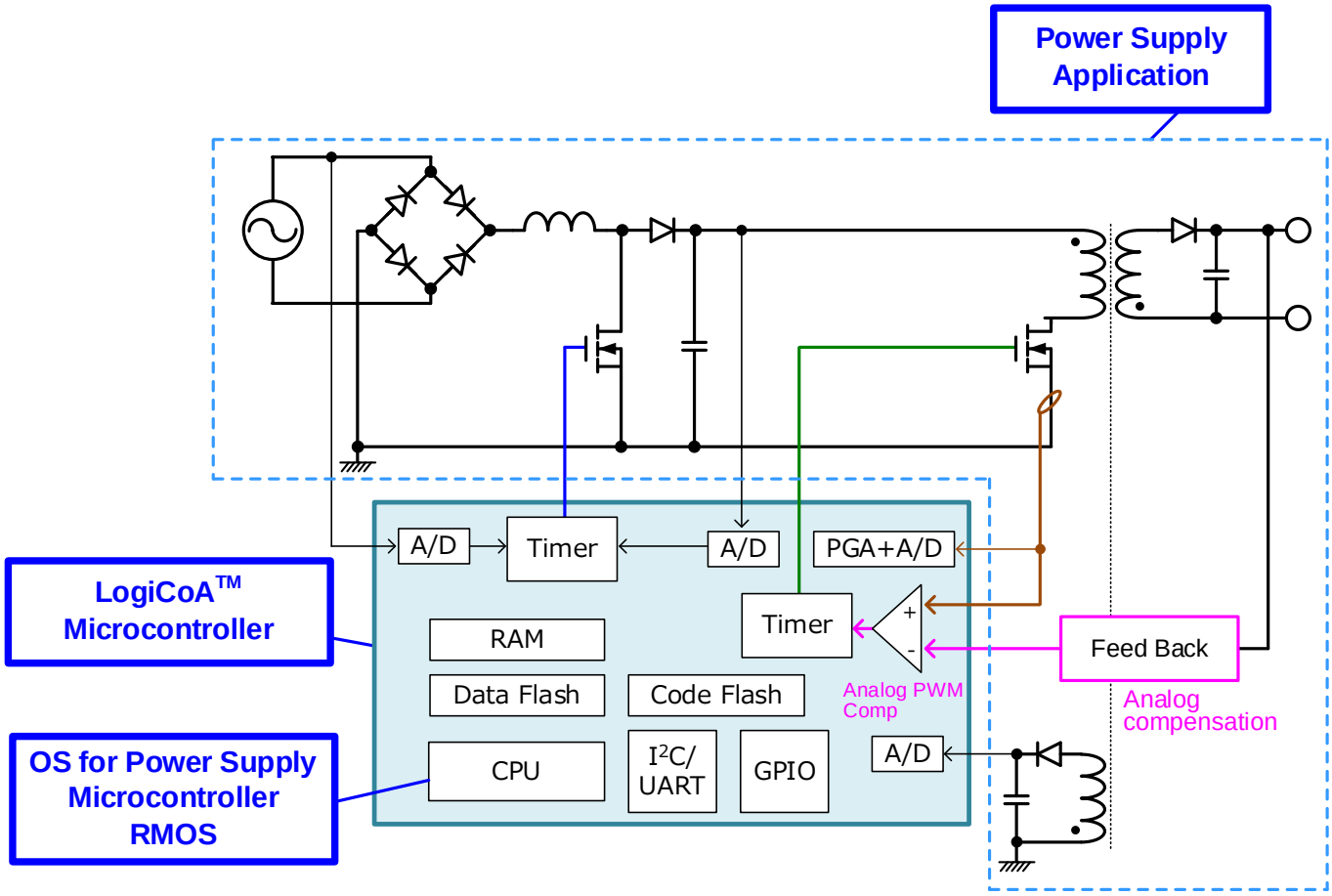

Figure 1. Outline of LogiCoA™ Power Solution

(1) Microcontrollers for power supply control (LogiCoA™ microcontroller)

LogiCoA™ microcontrollers are suitable for power supply with analog-digital hybrid control. ML62Q2033/2035 and ML62Q2043/2045 have been released. (at the time this document is released). ML62Q2035 is mounted on LogiCoA003-EVK-001. Please refer to '4.2 MCU,' ML62Q2033/2035/2043/2045 Datasheet [2], and ML62Q2033/2035/2043/2045 User's Manual [3] for more detailed information about ML62Q2035.

(2) Operating system for power supply control microcontroller Real-time Micro Operating System (RMOS)

RMOS is a multitasking, and a real-time operating system developed to control switching power supplies with LogiCoA™. It operates on ML62Q20xx group. Please refer to Operating System for Switching Power Control MCU "RMOS" [4] for more detailed information about RMOS.

(3) Power Supply Application

Power supply applications are application circuits that support various power supply topologies. LogiCoA003-EVK-001 includes external components such as gate driver, MOSFET, diode, LDO, transformer, etc. as application circuits for BCM-PFC and QR flyback converter.

2 Operating Condition

Below are the operating conditions of LogiCoA003-EVK-001. These are typical values and do not guarantee the characteristics.

(Unless otherwise specified Ta=25°C, Vin=100V_{AC})

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Input Voltage Range	Vin	85	-	264	V_{AC}	
Input Frequency	f_{LINE}	47	50/60	63	Hz	
Startup Voltage	Vstart	-	80	-	V_{AC}	Initial settings, adjustable
Startup Voltage Range	Vstart_r	80	-	120	V_{AC}	
Stop Voltage	Vstop	-	65	-	V_{AC}	Initial settings, adjustable
Stop Voltage Range	Vstop_r	65	-	105	V_{AC}	
Output Voltage	Vo	-	24.0	-	V	Initial settings, adjustable
Output Voltage Range	Vo_r	21.6	-	26.4	V	
Output Current *(Note 1)*	Io	0	-	4.0	A	Vo=24V
Over Current Protection	Iocp	-	4.4	-	A	Initial settings, adjustable
Over Current Protection Range	Iocp_r	2.0	-	4.8	A	
Power Supply Efficiency	η	-	87	-	%	Vin=100V_{AC}, Io=4A
Power Factor	PF	-	0.97	-	-	Io=4A

(Note 1) Adjust the load application time or cool with a fan as necessary to ensure that the surface temperature of the components does not exceed 105°C.

3 Firmware

The LogiCoA003-EVK-001 provides the source code of RMOS and power supply control along with the evaluation board. These can be downloaded from the URL below.

Table 3. RMOS Download URL and File Name

Download URL	https://www.rohm.com/reference-designs/ref67004
Reference Program Name	LogiCoA™Solution BCMPFC+QR flyback Converter Reference Program
File Name	RMOS-PSFW101.zip

4 Block Diagram and Block Operation Description

4.1 Block Diagram

Figure 4 shows the application block diagram of LogiCoA003-EVK-001.

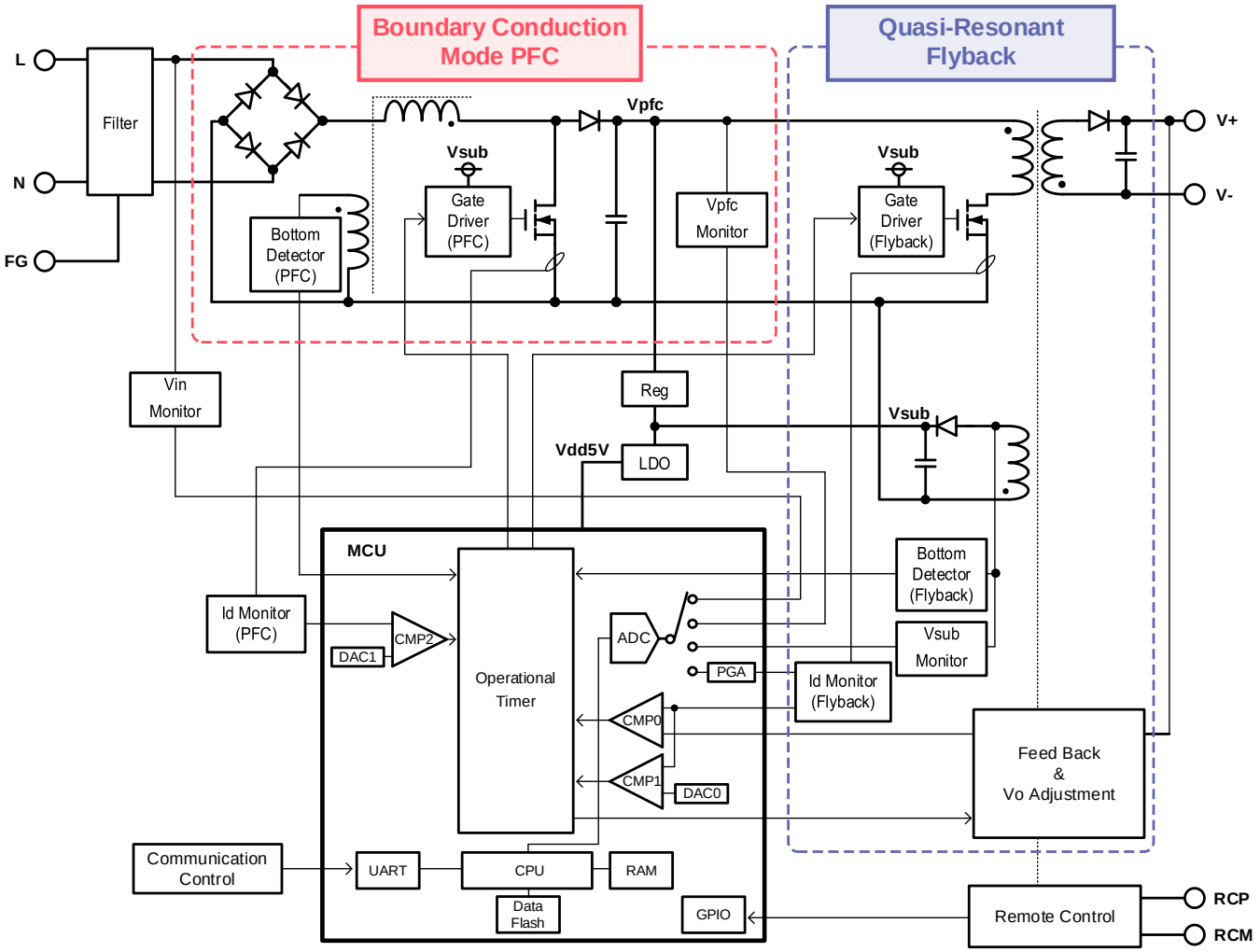

Figure 4. Application Block Diagram

4.2 MCU

The LogiCoA003-EVK-001 utilizes LogiCoA™ MCU ML62Q2035 as its power supply controller, which controls two converters, the BCM-PFC converter, and the QR flyback converter. The MCU's power supply, VDD is supplied from the control block power supply, Vdd5V. Once the supply voltage exceeds the power on reset rising threshold voltage of 4.10V (typ), the MCU starts up and RMOS starts its operation. The function of each pin of ML62Q2035 and their function in LogiCoA003-EVK-001 is listed in Table 4-1.

Table 4-1. Pin list of ML62Q2035

Pin No.	Pin Name	1st Function	2nd Function	3rd Function	4th Function	5th Function	6th Function	7th Function	8th Function
		GPI/EXI	UART	I2C	OTM	CMP/DAC	ADC	CMP	CMP/ADC
19	VDD	—	—	—	—	—	—	—	—
18	VSS	—	—	—	—	—	—	—	—
17	VDDL	—	—	—	—	—	—	—	—
16	P01	—	—	—	—	CMP0P	—	CMP0P /CMP1P	CMP0P
15	P02	—	—	—	OTO4B	CMP0M	—	CMP0M /CMP1M	CMP0M
14	P03	EXI0	—	—	OTO0A	—	—	—	—
13	P04	EXI1	—	—	OTO0B	—	—	—	—
12	P05	EXI1	—	—	OTO1A	—	—	—	—
11	P06	EXI2	—	—	—	—	—	—	—
10	P10	EXI3	RXD1, (/TXD1)	—	OTO3A	—	—	—	—
9	P11	—	—	—	OTO4A	CMP2P	—	CMP2P	CMP2P
8	P12	—	RXD0, (/TXD0)	SDAU0	OTO1B	—	—	—	—
7	P00/TEST0	EXI3	—	—	—	—	—	—	—
6	P13	EXI2	TXD0	SCLU0	OTO5B	—	—	—	—
5	RESET_N	—	—	—	—	—	—	—	—
4	P14	—	—	—	—	CMP1P	AIN0	CMP1P /CMP2P	AIN0 /CMP1P
3	P15	—	—	—	—	CMP1M	AIN1	CMP1M /CMP2M	AIN1 /CMP1M
2	P16	—	—	—	—	CMP2M	AIN2	CMP2M	AIN2 /CMP2M
1	P17	EXI0	—	—	—	—	AIN3	—	—
20	P23	—	TXD1	—	OTO5A	DACOUT0	—	—	—

selected function in LogiCoA003-EVK-001

Table 4-2 shows the main specifications of ML62Q2035. Please refer to ML62Q2033/2035/2043/2045 Datasheet [2] and ML62Q2033/2035/2043/2045 User's Manual [3] for more information on ML62Q2035.

Table 4-2. Main Specifications of ML62Q2035

Part Number		ML62Q2035
CPU		16bit RISC CPU Core(nx-U16/100), Max operating frequency 16MHz
Memory		Code Flash: 32KB, Data Flash: 4KB(Erase Unit:128B), RAM: 2KB
Analog Comparator		3ch(asynchronous to clock), Response time: Max 100ns
Timer		16bit timer with PWM/Capture × 6 counters, 10 outputs
		Max 64MHz operation(Resolution 15.625ns)
AD Converter		12bit SA-ADC: 5ch
DA Converter		8bit, 2ch
Programmable Gain Amplifier		1ch, Gain Setting: 4 steps (×4/×8/×16/×32)
Serial I/F		I2C×1, UART×2
I/O Port		I: 1, I/O: 15
External Interrupt		4
Other		Multiplication/Division Unit, Temperature Sensor, Power ON Reset
Clock	Low	Internal RC Oscillator: 32.768kHz ± 1.5%*
	High	PLL: 64MHz ± 1.5%*, CPU: 16MHz to 125kHz ± 1.5%*
		PWM/Capture: 64MHz to 500kHz ± 1.5%*
Current Consumption(CPU)		Stop: 80μA, Halt: 90μA, Active: 3.3mA@16MHz
Operating Supply Voltage		4.5V to 5.5V
Operating Temperature		Ta=-40°C to +105°C(Tj=115°C) (Absolute maximum ratings:Tjmax=125°C)
Package		TSSOP20

*: Ta=-20°C to +85°C

4.3 BCM-PFC Converter

The PFC converter in the first stage of LogiCoA003-EVK-001 operates in Boundary Conduction Mode (BCM). In boundary conduction mode operation, MOSFET is turned on at the timing when the inductor current I_L is zero, thereby reducing switching losses. Additionally, the BCM-PFC converter in LogiCoA003-EVK-001 is dynamically controlled according to the power supply condition by full digital control using a microcontroller. This makes it possible to adjust the PFC output voltage variably, such as lowering it according to the input voltage, thereby maximizing the efficiency of the power supply circuit.

When the input voltage exceeds 80VAC (typ), BCM-PFC converter starts operating. When the input voltage is below 65VAC (typ), BCM-PFC converter stops operating. The startup and stop voltage threshold can be changed by modifying the firmware or the communication GUI provided in Microsoft Excel. For details on communication control, please refer to '8 Serial Communication' which will be discussed later.

4.4 QR Flyback Converter

The flyback converter in the last stage of the LogiCoA003-EVK-001 operates in Quasi-Resonant (QR) mode. In QR mode operation, it turns on MOSFET when the drain voltage is low, which helps to reduce switching losses. The QR flyback converter of the LogiCoA003-EVK-001 uses an analog compensator for output voltage control, forming a control circuit in combination with a microcontroller.

The LogiCoA003-EVK-001 drives the QR flyback circuit using the output voltage Vpfc of the previous stage BCM-PFC converter as its input. The QR flyback converter starts operating when Vpfc exceeds 300V (typ). Conversely, when Vpfc falls below 180V (typ), the QR flyback converter stops operating. The threshold values for the startup and stop voltages can be changed through firmware modification. Additionally, the ON/OFF state of the output can be controlled while applying the input voltage by preparing a remote control circuit. For more details on the remote control circuit, please refer to '6.1 Input Connector TB1 and Output Connector TB2.'

The LogiCoA003-EVK-001 is equipped with a block for adjusting the output voltage. This block allows the adjustment of the output voltage without changing component values by adjusting the parameters of the microcontroller. The output voltage setting value can be changed by modifying the firmware or by using the communication GUI provided in Microsoft Excel. For communication control, please refer to '8 Serial Communication,' and for details on the block for adjusting the output voltage, please refer to the EVK operation manual [5].

4.5 LED Indicators

The LogiCoA003-EVK-001 is equipped with two LEDs, LED391 (red) and LED392 (orange). Each blinking pattern indicates different operating states listed on Table 4-3 and 4-4.

Table 4-3. LED391(Red) Blinking Pattern and Operating State

LED391	State
Off	-
Blinking	Program writing / Accessing the MCU

Table 4-4. LED392(Orange) Blinking Pattern and Operating State

LED392	State
Long off and two short flashes	Input voltage is below the startup voltage (Vin off state)
Long off and one short flash	Input voltage is above the startup voltage, output is stopped by RC (RC standby state)
Long flashes	Normal operating state/Output current is less than 20% of the rated
Long on and one short flash	Normal operating state/Output current is 20% to 40% of rated
Long on and two short flashes	Normal operating state/Output current is 40% to 60% of rated
Long on and three short flashes	Normal operating state/Output current is 60% to 80% of rated
Long on and four short flashes	Normal operating state/Output current is more than 80% of rated
Short flashes	Abnormal stop state, LVP is detected
Long on and short off	Abnormal stop state, OVP is detected

5 Overview of EVK

Figure 5-1. LogiCoA003-EVK-001(Top View)

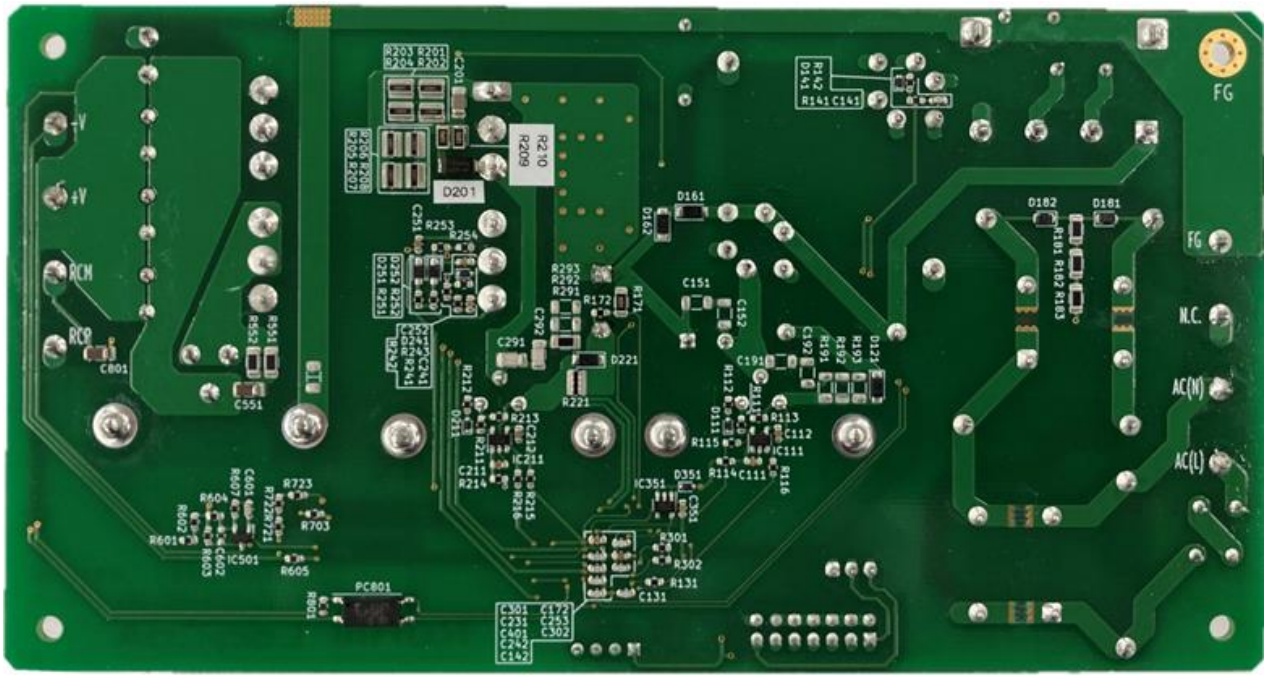

Figure 5-2. LogiCoA003-EVK-001(Bottom View)

6 EVK Function Descriptions

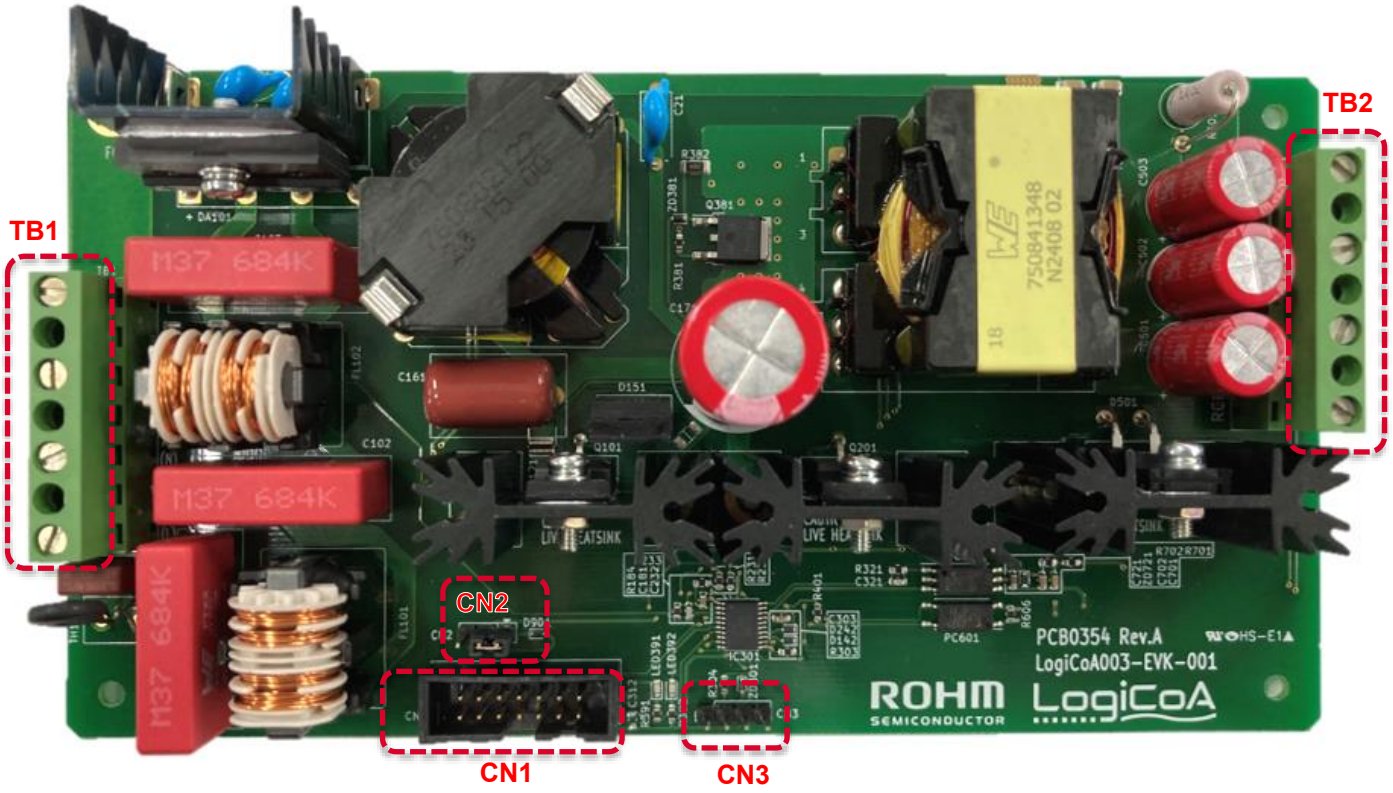

Figure 6-1. LogiCoA003-EVK-001 Connectors (Top View)

6.1 TB1 Connector for Input and TB2 Connector for Output

Table 6-1 shows the pin list for the input connector TB1 and Table 6-2 shows the pin list for the output connector TB2. Figure 6-2 shows the pin assignments of TB1 and TB2 in this EVK.

Table 6-1. TB1 Pin list and Functions

Pin Number	Pin Name	Function
1	FG	Frame ground
2	N.C.	Not Connected
3	AC(N)	AC Input (N)
4	AC(L)	AC Input (L)

Table 6-2. TB2 Pin list and Functions

Pin Number	Pin Name	Function
1	RCP	Remote-control (+)
2	RCM	Remote-control (-)
3	V+	DC Output (+)
4	V-	DC Output(-)

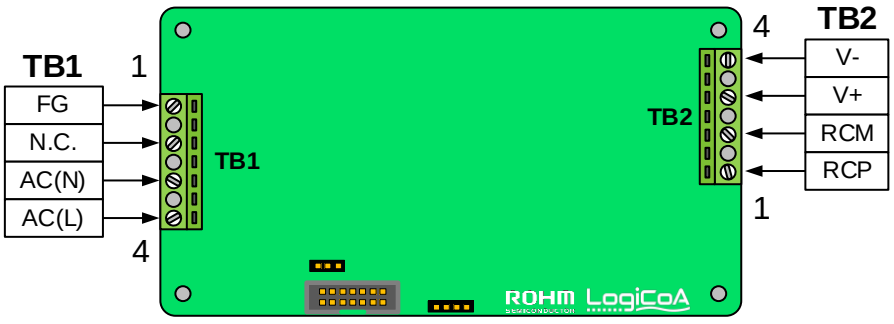

Figure 6-2. Pin assignment of input connector TB1 and output connector TB2

The LogiCoA003-EVK-001 is equipped with a remote control (RC) function. An example of an external remote control circuit is shown in Figure 6-3. By preparing a remote control circuit, the ON/OFF state of the output can be controlled while applying the input voltage. The remote control circuit is isolated from the input and output. When the input voltage is above the startup voltage, the output will be ON by default when the voltage V_{RC} specified in Table 6-3 is applied between RCP and RCM from an external power source. When the output is OFF, the circuit operation of the QR flyback converter stops, and the system transitions from normal operation mode to a low-power mode that reduces the microcontroller's power consumption. For details on low-power operation, please refer to Operating System for Switching Power Control MCU "RMOS" [4].

With LogiCoA003-EVK-001, the output logic of the remote control that controls the output can be inverted by modifying the firmware or by using the communication GUI provided in Microsoft Excel. For more details on communication control, please refer to '8 Serial Communication' which will be discussed later.

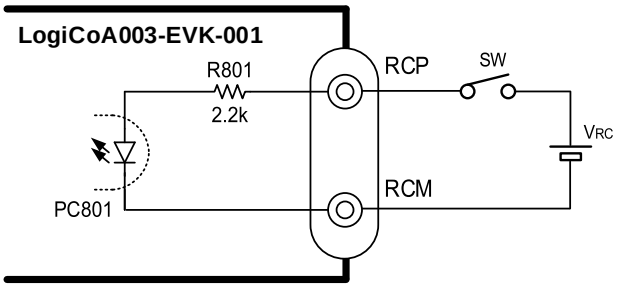

Figure 6-3. Example of Remote Control Circuit

Table 6-3. RCP/RCM Terminals (RC Switch) and Operating States

V_{RC}	Output
4.5V to 12.5V *(Note 1)*	ON (Normal Operation Mode) *(Note 2)*
0V to 0.5V / OPEN	OFF (Low-power Mode) *(Note 2)*

(Note 1) If the external voltage VRC exceeds 12.5V, please add a limiting resistor to reduce the inflow current (recommended inflow current is 5mA or less).
(Note 2) It depends on the remote control output logic set by the firmware (the Initial setting is as described above).

6.2 CN1 Connector for Debugging

CN1 is a debugging connector. Table 6-4 shows the pin list of CN1 and Figure 6-4 shows the pin assignment of CN1. The LogiCoA003-EVK-001 is pre-installed with the firmware and can be evaluated independently. Additionally, preparing an on-chip emulator EASE1000 V2 and the comprehensive development environment LEXIDE-Ω allows for the development and debugging of switching power supply control programs using RMOS. Please refer to '9 Program Development and Debugging Work' below for more details information about developing or debugging of switching power supply control program with RMOS.

Table 6-4. TB1 Pin list and Functions

Pin Number	Pin Name	Function
1	Vref	MCU control power (+)
2	Vss	MCU control power (-)
3	N.C.	Not Connected
4	Vss	MCU control power (-)
5	RST	Debug signal
6	Vss	MCU control power (-)
7	SDATA	Debug signal
8	Vss	MCU control power (-)
9	N.C.	Not Connected
10	Vss	MCU control power (-)
11	N.C.	Not Connected
12	Vss	MCU control power (-)
13	5VOUT	5V out to emulator
14	N.C.	Not Connected

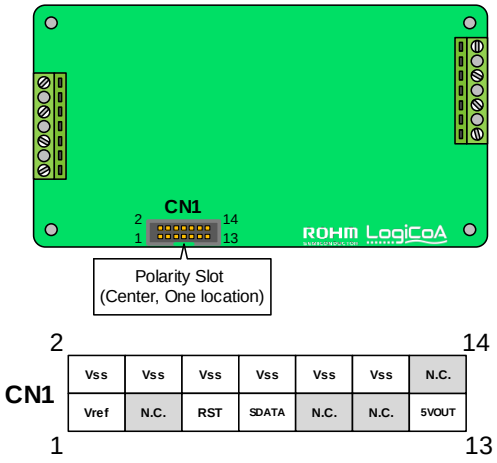

Figure 6-4. Pin assignment of Debugging Connector CN1

To use the on-chip emulator EASE1000 V2, connect EASE1000 V2 to USB terminal of the PC and to the debug pins of ML62Q203x/4x group. With EASE1000 V2 and LEXIDE-Ω, debugging operations (such as writing to the MCU, execution, stopping, stepping, internal memory reading, and so on) can be performed.

To protect the equipment when a PC is connected for debugging, it is recommended to use the isolator for EASE1000 V2 (OB-EASE1000V2-ISO) between LogiCoA003-EVK-001 and the on-chip emulator EASE1000 V2. If LogiCoA003-EVK-001 accidentally fails during debugging, high voltage from LogiCoA003-EVK-001 may be directly applied to the USB port of the PC connected to EASE1000 V2, potentially damaging the PC and other equipment. By connecting the isolator for EASE1000 V2, which has an isolation circuit configuration, even if the LogiCoA003-EVK-001 fails during debugging, high voltage will not be directly applied to the PC and other equipment, preventing damage. For more details on the isolator for EASE1000 V2, please refer to OB-EASE1000V2-ISO User's Manual [6].

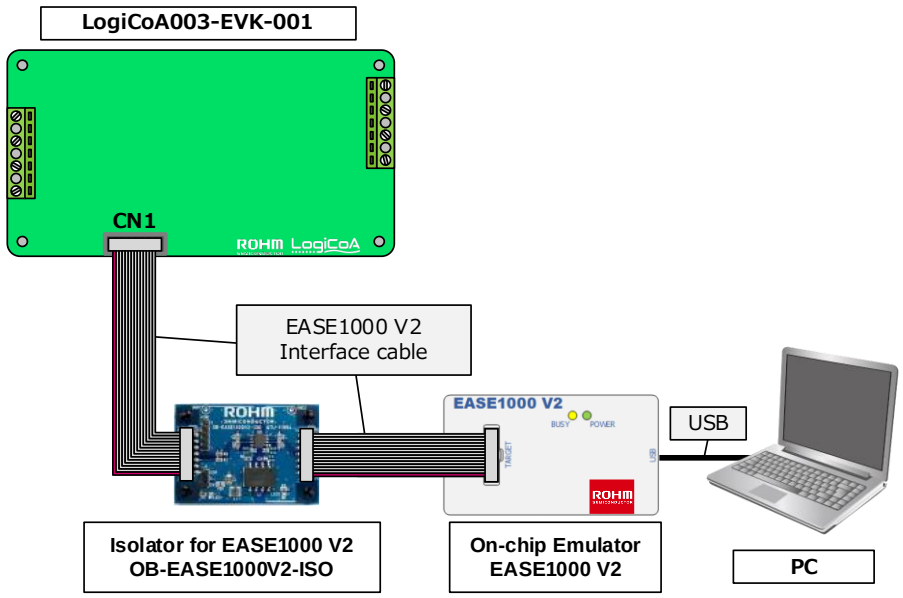

Figure 6-5. EASE1000 V2 Connection Example with LogiCoA003-EVK-001

6.3 CN2 MCU External Power-supply Switch

Figure 6-6 shows the pin arrangement of the MCU external power supply switch CN2, which is used to supply power to the MCU from the EASE1000 V2 isolator when debugging with the EASE1000 V2 isolator connected to debug connector CN1. This allows debugging without applying input voltage. When debugging, CN2 should be used with pins 1 and 2 shorted by jumper pins.

Note that if the on-chip emulator EASE1000 V2 is directly connected to CN1, debugging cannot be performed without applying input voltage because the voltage supplied to the MCU is below the power-on reset rise threshold voltage.

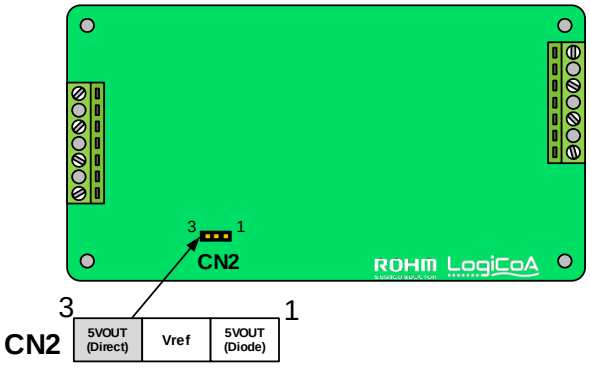

Figure 6-6. Pin assignment of MCU External Power-supply Switch CN2

6.4 CN3 Communication Connector

CN3 is a communication connector, and the pin list of CN3 is shown in Table 6-5 and the pin assignment of CN3 is shown in Figure 6-7. The LogiCoA003-EVK-001 provides communication functions. By preparing a communication board, it is possible to change power control parameters, to perform calibration and to obtain log data by performing serial communication from a PC. For details on serial communication and communication commands, please refer to '8 Serial Communication' which will be discussed later. Figure 6-8 shows an example of the connection between this EVK and a communication board.

Table 6-5. CN31 Pin list and Functions

Pin Number	Pin Name	Function
1	Vref	MCU control power (+)
2	Tx/Rx	Data sent / received
3	Vss	MCU control power (-)
4	N.C.	Not Connected

(Note 1) To prevent damage from reverse socket connection, the connector has a 4-terminal layout.

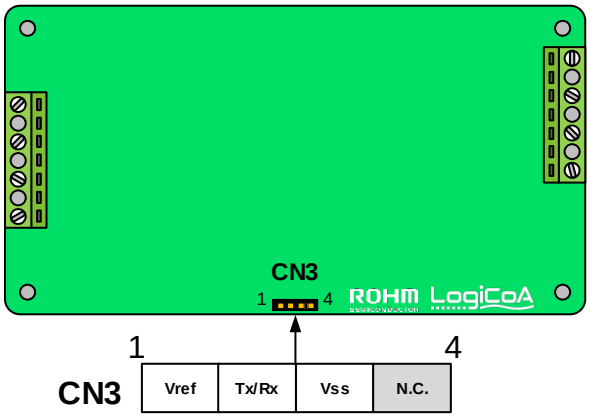

Figure 6-7. Pin assignment of Communication Connector CN3

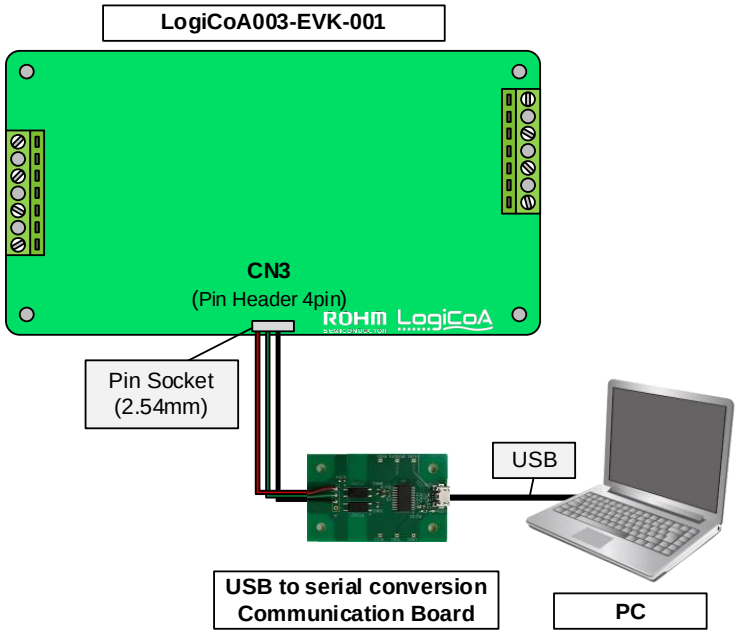

Figure 6-8. LogiCoA003-EVK-001 Communication Board Connection Example

6.4.1 Communication Board

To perform communication control with LogiCoA003-EVK-001, it is necessary to create a communication board to send and receive data between the microcontroller and the PC. An example of the communication board design is shown in Figure 6-9, and the parts list is provided in Table 6-6. The example includes a USB-to-serial communication conversion IC (U1: FTDI FT232RL). By connecting the CN1 USB connector to the PC with a USB cable, power is supplied from the PC to the conversion IC. The connection to this EVK is made by connecting the socket attached to the J4 of the communication board to the communication connector CN3 of this EVK. Additionally, for device protection, the communication board is designed with an isolation circuit configuration.

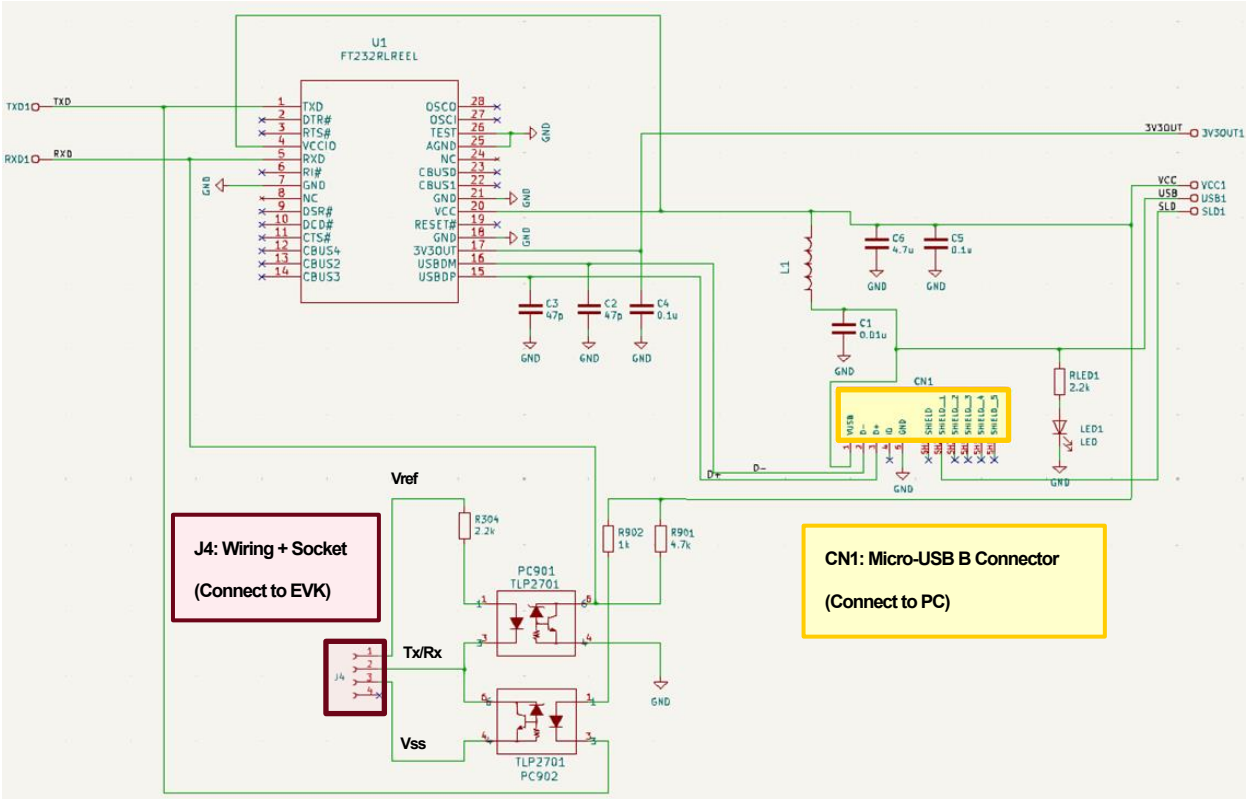

Figure 6-9. Communication Board Example Circuit Diagram

Table 6-6. Communication Board Example Parts List

Qty	Reference Designator	Parts Number	Manufacturer	Value	Description [Unit:Inch(mm)]
1	C1	-	-	0.01μF	0402(1005)
2	C2, C3	-	-	47pF	0402(1005)
2	C4, C5	-	-	0.1μF	0402(1005)
1	C6	-	-	4.7μF	0805(2012)
1	L1	BLM21PG221SN1D	Murata	-	0805(2012)
2	PC901, PC902	TLP2701	Toshiba	-	4pin SO6L_TOS
1	LED1	CSL1901UW	ROHM	Red	0603(1608)
1	R901	MCR01SMQPF4701	ROHM	4.7kΩ	0402(1005)
1	R902	MCR01SMQPF1001	ROHM	1kΩ	0402(1005)
1	RLED1	MCR01SMQPF2201	ROHM	2.2kΩ	0402(1005)
1	CN1	10118192-0001LF	AMPHENOL	-	Micro-USB B Connectors
1	U1	FT232RL	FTDI	-	SSOP28
1	J4	61300411821	Wurth Elektronik	-	Pin Socket 1x04 P2.54mm The wire is connected between the pin socket and the board

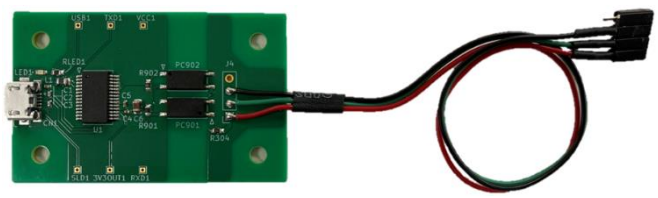

Figure 6-10. Communication Board Example

7 Operation Procedure

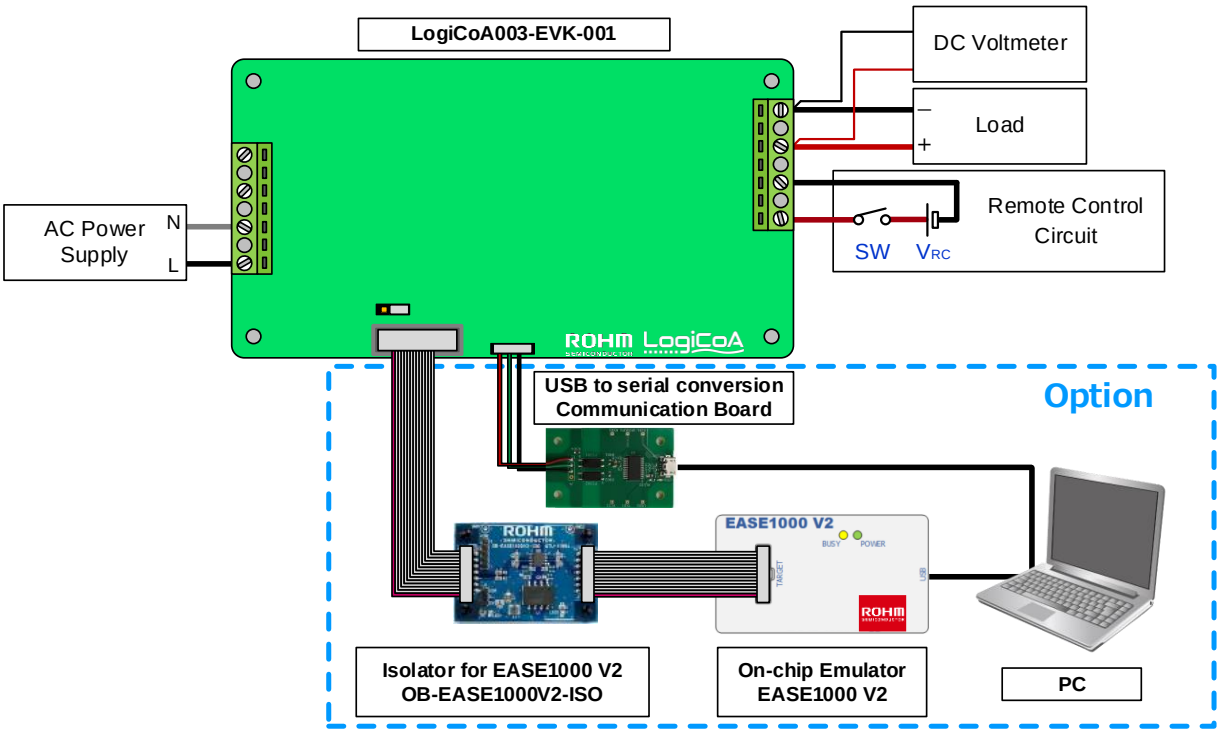

Figure 7. LogiCoA003-EVK-001 Connection Diagram

1. Required Equipment
   (1) AC power supply ($85V_{AC}$ to $264V_{AC}$, 120W or more)
   (2) Load (up to 4A)
   (3) DC voltmeter
   (4) Remote control circuit (external power supply V_{RC} 4.5V to 12.5V and switch)
   (5) Communication board equipped with serial conversion IC *(Note 1)*
   (6) On-chip emulator EASE1000 V2 *(Note 2)*
   (7) Isolator for EASE1000 V2 *(Note 2)*
   (8) Windows PC *(Note 1) (Note 2)*

2. Equipment Connections
   (1) Preset the AC power supply to $85V_{AC}$ to $264V_{AC}$ and turn off the power output.
   (2) Set the load to 4A or less and disable the load.
   (3) Preset the external power supply for the remote control circuit to 4.5V to 12.5V and turn off both the power output and the switch. *(Note 3)*
   (4) Connect the EVK, AC power supply, load, DC voltmeter, and remote control circuit as shown in Figure 7.
   (5) For communication control, connect the EVK, communication board and PC. *(Note 1)*
   (6) For debugging, connect the EVK, EASE1000 V2, EASE1000 V2 isolator and PC. *(Note 2)*
   (7) Turn on the output of the AC power supply.
   (8) Turn on the external power supply output and switch for the remote control circuit. *(Note 3)*
   (9) Make sure that the DC voltmeter display shows the output voltage of 24V. *(Note 3)*
   (10) Activates the load.

(Note 1) This is required when performing communication control for optional functions. It is not necessary if communication control is not performed.
(Note 2) This is required when performing debugging work on optional features. It is not necessary if you are not performing debugging work.
(Note 3) This is the initial setting. The output logic settings of the remote control and the output voltage can be changed by modifying the firmware or by using the communication GUI provided in Microsoft Excel.

8 Serial Communication

The LogiCoA003-EVK-001 allows to change power control parameters, to perform calibration, and to obtain log data via serial communication from an external Windows PC through a communication board that converts USB to serial communication. For details on serial communication and communication commands, please refer to Serial Communication of RMOS and GUI Developing Manual [7].

8.1 Monitoring and Calibration Functions

The LogiCoA003-EVK-001 provides a communication GUI using Microsoft Excel, allowing monitoring, calibration, and setting changes of the items shown in Table 8 and Figure 8. Calibration is performed on the relevant items at the time of shipment, with corrections made for each power supply. For more details, please refer to Serial Communication of RMOS and GUI Developing Manual [7].

Table 8. Monitoring/Calibration Functions in LogiCoA003-EVK-001 Communication GUI

No.	Item	Function
1	Input Voltage	Monitor
2	QR Flyback Input Voltage (BCM-PFC Output Voltage)	Monitor
3	QR Flyback Auxiliary Winding Output Voltage	Monitor
4	QR Flyback MOSFET Drain Current	Monitor
5	BCM-PFC/QR Flyback Power Supply	Monitor
6	QR Flyback Output Voltage	Calibration
7	QR Flyback Overcurrent Protection Detection Current	Calibration
8	BCM-PFC Startup Voltage	Calibration
9	BCM-PFC Stop Voltage	Calibration
10	QR Flyback MOSFET Drain Current	Calibration
11	Remote Control Enable Logic	Setting

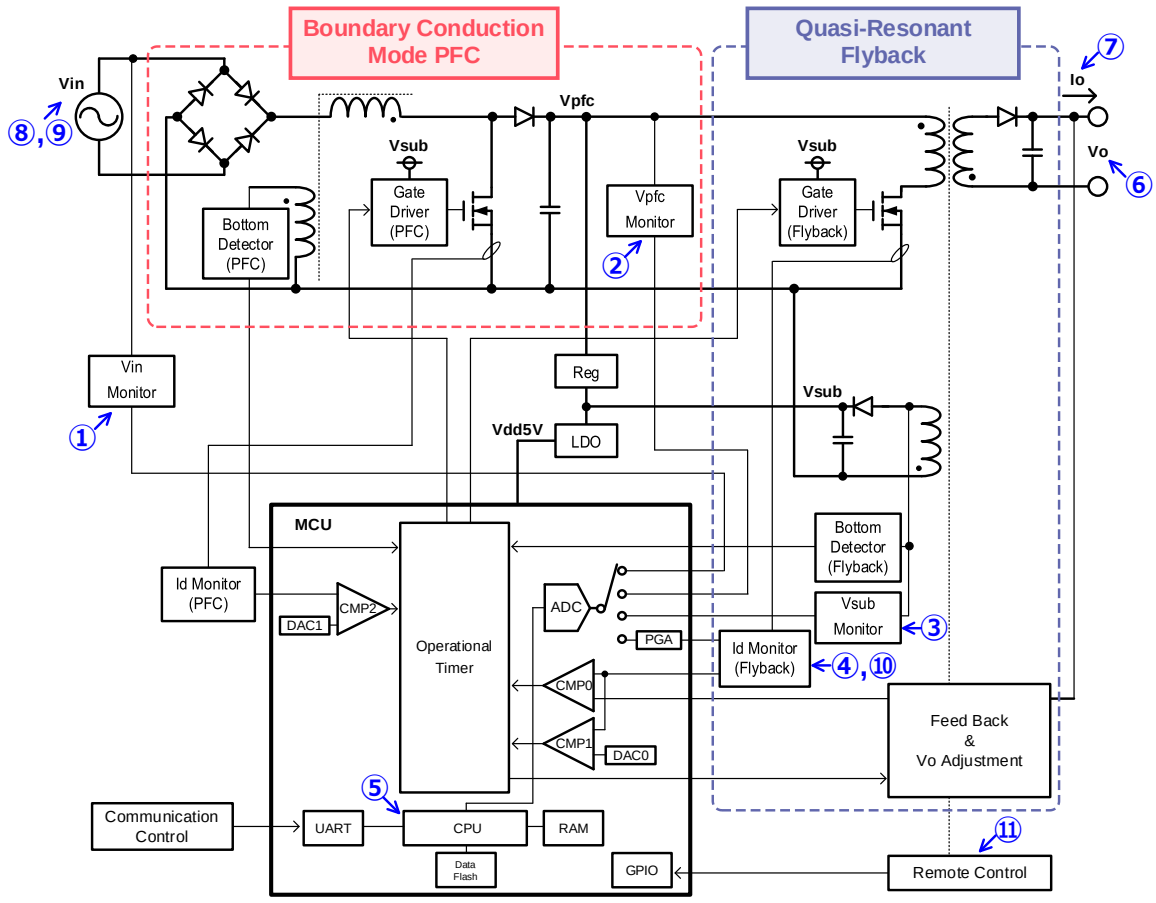

Figure 8. Monitoring/Calibration Functions in LogiCoA003-EVK-001 Communication GUI

8.2 Logging Function

The LogiCoA003-EVK-001 provides a communication GUI using Microsoft Excel, which allows users to obtain log data recorded by the microcontroller ML62Q2035 via GUI. The log data is a time-series record of the operating status, including various monitored voltages, power-on time, the number of abnormal operation detections, and other operating conditions. This data can be used to understand the status and to investigate the causes of some issues. The main items that can be obtained from the log data are listed below. For more details, please refer to Serial Communication of RMOS and GUI Developing Manual [7].

- Lifetime Log Data …Operation history from the time the power supply was manufactured to the present, microcontroller ON time, BCM-PFC/QR flyback operating time, maximum input voltage, number of abnormal operations detected, etc.
- Stop Log Data …State of the power supply just before it stopped, input voltage, PFC output voltage, auxiliary winding output voltage, shutdown operation code, etc.
- Operating Log Data …Maximum/minimum values of various monitored data during each unit period (3600 seconds). input voltage, PFC output voltage, auxiliary winding output voltage, number of abnormal operations detected, etc.

9 Program Development and Debugging Work

The LogiCoA003-EVK-001 is pre-installed with the firmware and can be evaluated independently. In addition, the following environment can be used to develop and to debug switching power supply control programs using RMOS.

① Integrated Development Environment LEXIDE-Ω
② RMOS project file (file to be read into LEXIDE-Ω and used)
③ Windows PC (Windows 10 64-bit version or Windows 11 64-bit version)
④ On-chip emulator EASE1000 V2
⑤ Isolator for EASE1000 V2 (OB-EASE1000V2-ISO)
⑥ Microsoft Excel 64-bit version (This is used to check the communication function and requires permission to use the macro function. Operation is confirmed on Office 365 MSO 32-bit, Microsoft 365 MSO 64-bit, and Office 365 MSO 64-bit)
⑦ Communication board equipped with serial conversion IC (FTDI FT232RL)

Integrated Development Environment LEXIDE-Ω is a developed software based on Eclipse, an open-source integrated development environment. The installers can be downloaded from our website.

RMOS project file is provided in a zip-compressed format and can be extracted to any folder in the HDD (SSD) drive of a Windows PC. Please refer to Operating System for Switching Power Control MCU "RMOS" [4] for more detail information about developing or debugging of switching power supply control program with RMOS.

10 Board Schematic

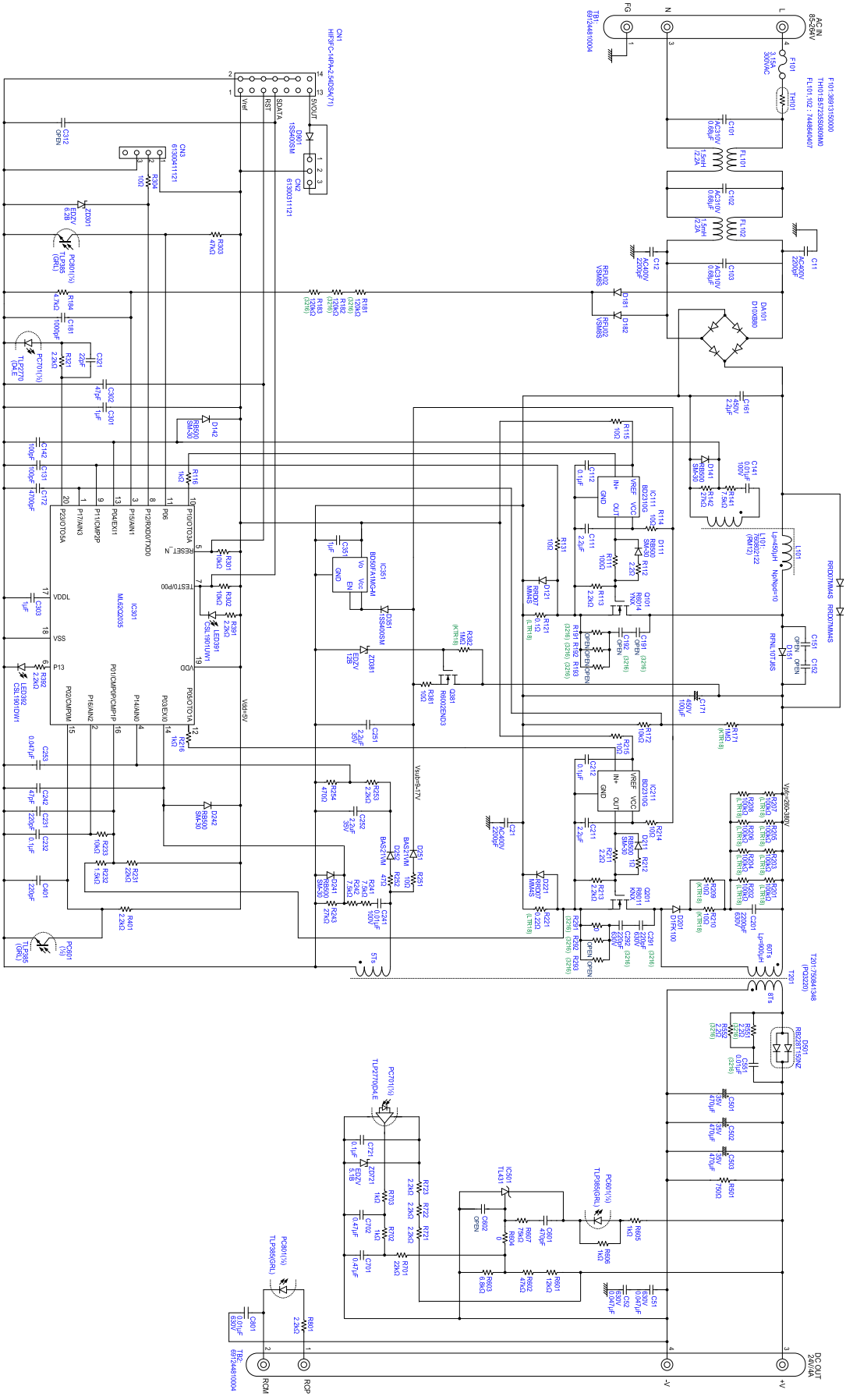

Figure 10. Board schematic

11 Board Information and Layout

The board information for LogiCoA003-EVK-001 is shown in Table 11.

Table 11. Board Information

Number of layers	Material	Board Dimension	Copper thickness
2	FR-4	170mm × 90mm × 1.6mmt	2oz(70μm)

Below are EVK Layouts.

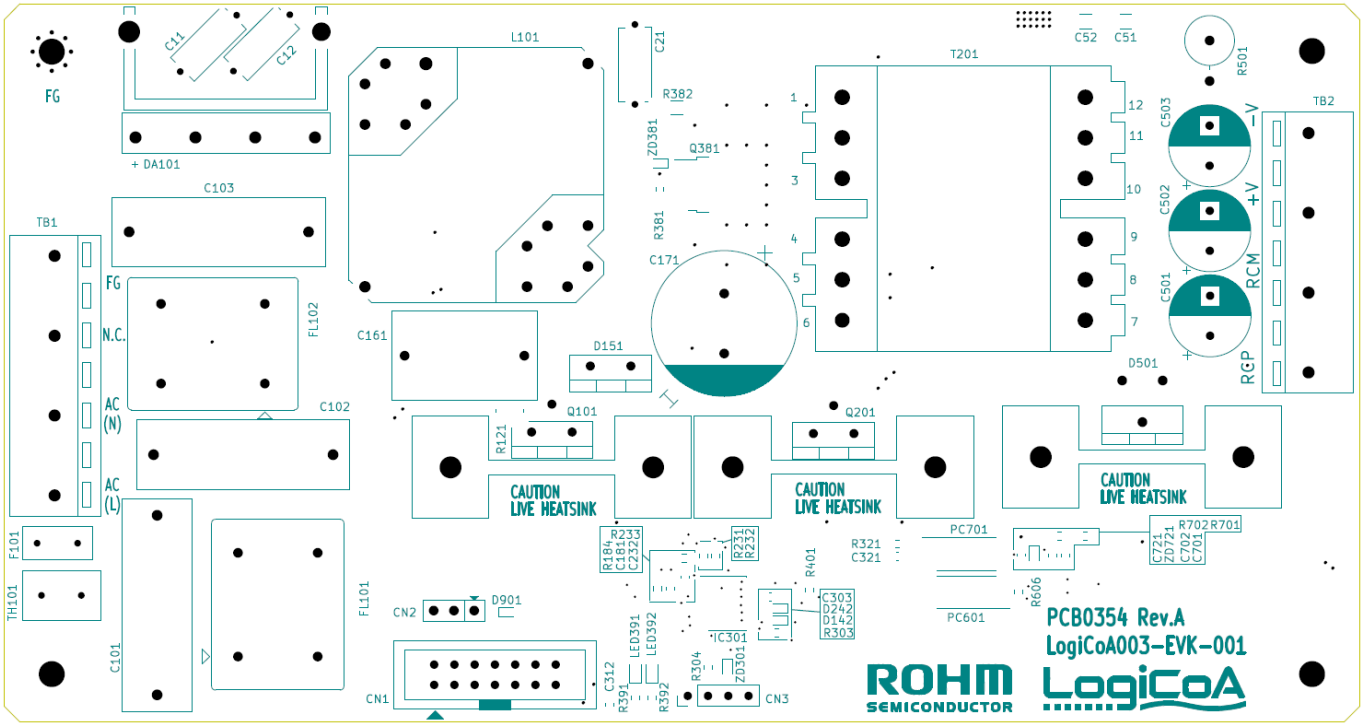

Figure 11-1. Top Silk Screen (Top View)

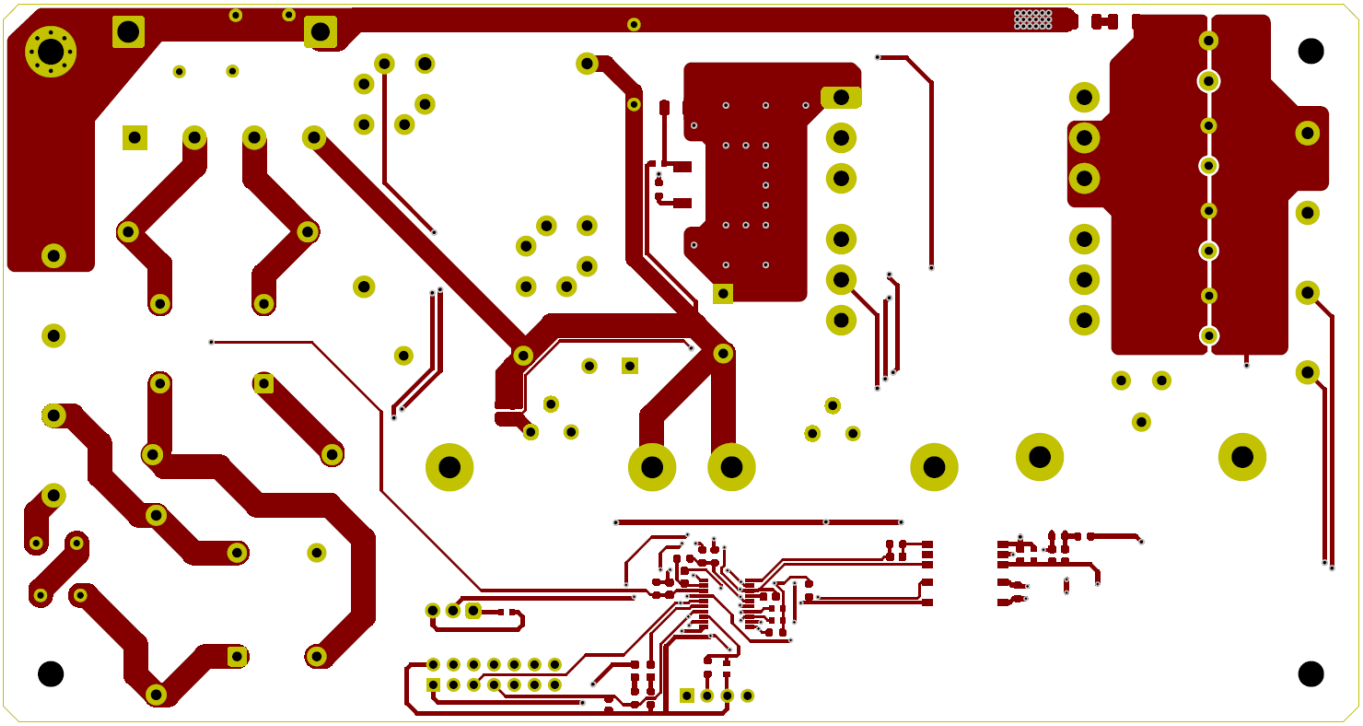

Figure 11-2. Top Layer (Top View)

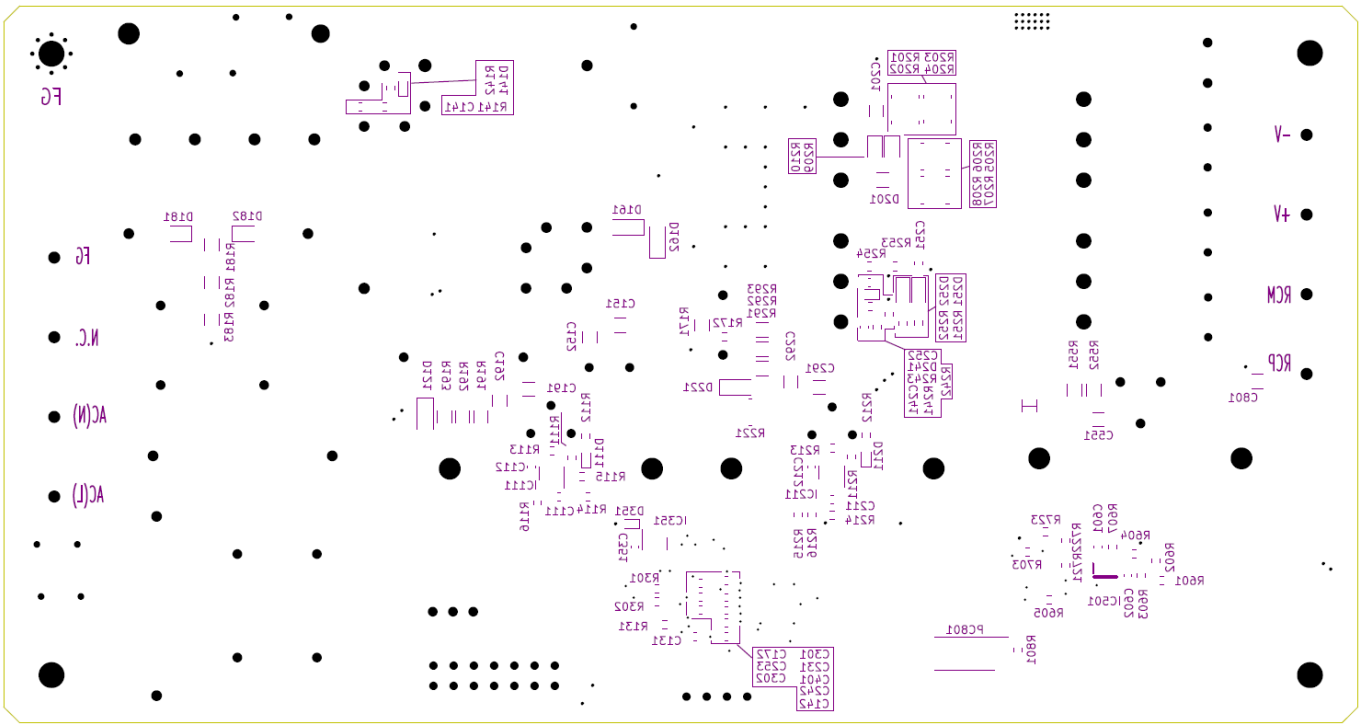

Figure 11-3. Bottom Silk Screen (Top View)

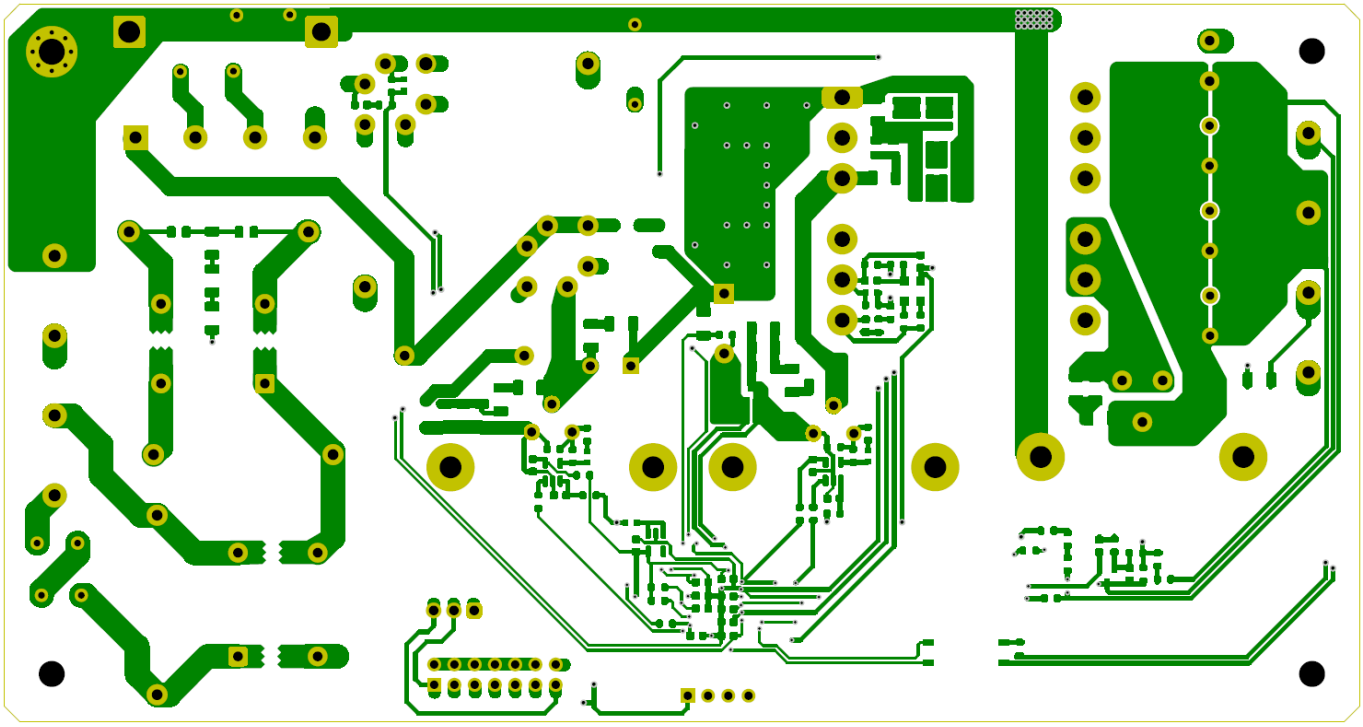

Figure 11-4. Bottom Layer (Top View)

12 Bill of Materials

The Bill of Materials for LogiCoA003-EVK-001 is shown in Table 12.

Table 12. Bill of Materials

Qty	Reference Designator	Parts Number	Manufacturer	Value	Description [Unit:Inch(mm)]
IC					
2	IC111, IC211	BD2310G	ROHM	-	Lowside Gate Driver, SSOP5
1	IC301	ML62Q2035	ROHM	-	Micro Controller, TSSOP-20
1	IC351	BD50FA1MG-M	ROHM	-	LDO, SSOP5
1	IC501	TL431BIDBZT	Texas Instruments	-	Shunt Regulator, SOT23-3
Resistor					
1	R111	MCR03SEQPF1000	ROHM	100Ω	150V, 0.125W, ±1%, 0603(1608)
2	R112, R211	MCR03SEQPJ2R2	ROHM	2.2Ω	150V, 0.125W, ±5%, 0603(1608)
11	R113, R213, R253, R321, R391, R392, R401, R721, R722, R723, R801	MCR03SEQPF2201	ROHM	2.2kΩ	150V, 0.125W, ±1%, 0603(1608)
8	R114, R115, R131, R214, R215, R251, R304, R381	MCR03SEQPF10R0	ROHM	10Ω	150V, 0.125W, ±1%, 0603(1608)
6	R116, R216, R605, R606, R702, R703	MCR03SEQPF1001	ROHM	1kΩ	150V, 0.125W, ±1%, 0603(1608)
1	R121	LTR18EZPFLR100	ROHM	0.1Ω	1.5W, ±1%, 0612(1632)
3	R141, R241, R242	MCR03SEQPF7501	ROHM	7.5kΩ	150V, 0.125W, ±1%, 0603(1608)
2	R142, R243	MCR03SEQPF2702	ROHM	27kΩ	150V, 0.125W, ±1%, 0603(1608)
2	R171, R382	KTR18EZPF1004	ROHM	1MΩ	500V, 0.25W, ±1%, 1206(3216)
4	R172, R233, R301, R302	MCR03SEQPF1002	ROHM	10kΩ	150V, 0.125W, ±1%, 0603(1608)
3	R181, R182, R183	MCR18SEQPJ124	ROHM	120kΩ	200V, 0.4W, ±5%, 1206(3216)
1	R184	MCR03SEQPF4701	ROHM	4.7kΩ	150V, 0.125W, ±1%, 0603(1608)
0	R191	Not Mount			
0	R192	Not Mount			
0	R193	Not Mount			
8	R201, R202, R203, R204, R205, R206, R207, R208	LTR18EZPF1003	ROHM	100kΩ	200V, 0.75W, ±1%, 0612(1632)
2	R209, R210	KTR18EZPF10R0	ROHM	10Ω	500V, 0.25W, ±1%, 1206(3216)
1	R212	MCR03SEQPJ1R0	ROHM	1Ω	150V, 0.125W, ±5%, 0603(1608)
1	R221	LTR18EZPFLR220	ROHM	0.22Ω	1.5W, ±1%, 0612(1632)
2	R231, R701	MCR03SEQPF2202	ROHM	22kΩ	150V, 0.125W, ±1%, 0603(1608)
1	R232	MCR03SEQPF1501	ROHM	1.5kΩ	150V, 0.125W, ±1%, 0603(1608)
1	R252	MCR03SEQPF47R0	ROHM	47Ω	150V, 0.125W, ±1%, 0603(1608)
1	R254	MCR03SEQPF4700	ROHM	470Ω	150V, 0.125W, ±1%, 0603(1608)
1	R291	MCR18SEQPJ000	ROHM	0Ω	200V, 0.4W, 1206(3216)
0	R292	Not Mount			
0	R293	Not Mount			
2	R303, R602	MCR03SEQPF4702	ROHM	47kΩ	150V, 0.125W, ±1%, 0603(1608)
1	R501	MOS3C751	KOA	750Ω	700V, 3W, Lead Resistor
2	R551, R552	MCR18SEQPFL2R20	ROHM	2.2Ω	200V, 0.4W, ±1%, 1206(3216)
1	R601	MCR03SEQPF1202	ROHM	12kΩ	150V, 0.125W, ±1%, 0603(1608)
1	R603	MCR03SEQPF6801	ROHM	6.8kΩ	150V, 0.125W, ±1%, 0603(1608)
1	R604	MCR03SEQPJ000	ROHM	0Ω	150V, 0.125W, 0603(1608)
1	R607	MCR03SEQPF7502	ROHM	75kΩ	150V, 0.125W, ±1%, 0603(1608)
Capacitor					
3	C11, C12, C21	DE1E3RA222MJ4BH01F	Murata	2200pF	AC400V, E, ±20%, Ceramic Capacitors
2	C51, C52	GCJ31CR7LV473KW01K	Murata	0.047µF	630V, X7R, ±10%, 1206(3216)
3	C101, C102, C103	890334026020	Wurth Elektronik	0.68µF	AC310V, ±10%, Film Capacitors
4	C111, C211, C251, C252	GRM188R6YA225KA12D	Murata	2.2µF	35V, X5R, ±10%, 0603(1608)
4	C112, C212, C232, C721	GCJ188R71H104KA12D	Murata	0.1µF	50V, X7R, ±10%, 0603(1608)
2	C131, C142	GCM1885C2A101JA16D	Murata	100pF	100V, C0G, ±5%, 0603(1608)
2	C141, C241	GRM188R72A103KA01J	Murata	0.01µF	100V, X7R, ±10%, 0603(1608)
0	C151	Not Mount			
0	C152	Not Mount			
1	C161	ECW-FD2W225K	Panasonic	2.2µF	450V, ±10%, Film Capacitors
1	C171	860241480001	Wurth Elektronik	100µF	450V, ±20%, Aluminum Electrolytic
1	C172	GRM1885C1H472JA01D	Murata	4700pF	50V, C0G, ±5%, 0603(1608)
1	C181	GRM1885C1H102JA01D	Murata	1000pF	50V, C0G, ±5%, 0603(1608)
0	C191	Not Mount			
0	C192	Not Mount			
1	C201	GRM31A7U2J222JW31D	Murata	2200pF	630V, U2J, ±5%, 1206(3216)
2	C231, C401	CGA3E2C0G1H221J080AA	TDK	220pF	50V, C0G, ±5%, 0603(1608)
2	C242, C302	GCM1885C2A470JA16J	Murata	47pF	100V, C0G, ±5%, 0603(1608)
1	C253	GCM188R71H473KA55D	Murata	0.047µF	50V, X7R, ±10%, 0603(1608)
2	C291, C292	GRM31A5C2J221JW01D	Murata	220pF	630V, C0G, ±5%,1206(3216)
3	C301, C303, C351	GRT188R61H105KE13D	Murata	1µF	50V, X5R, ±10%, 0603(1608)
0	C312	Not Mount			
1	C321	GCM1885C2A220JA16D	Murata	22pF	100V, C0G, ±5%, 0603(1608)
3	C501, C502, C503	860080575017	Wurth Elektronik	470µF	35V, ±20%, Aluminum Electrolytic
2	C551, C801	GRM31C5C2J103FWA3L	Murata	0.01µF	630V, C0G, ±1%,1206(3216)
1	C601	GCM1885C1H471JA16D	Murata	470pF	50V, C0G, ±5%, 0603(1608)
0	C602	Not Mount			
2	C701, C702	GRM188R71E474MA12D	Murata	0.47µF	25V, X7R, ±20%, 0603(1608)
Diode					
1	DA101	D10XB80	Shindengen	-	800V, 10A, Bridge Rectifiers
6	D111, D141, D142, D211, D241, D242	RB500SM-30	ROHM	-	30V, 0.1A, EMD2
4	D121, D161, D162, D221	RRD07MM4S	ROHM	-	400V, 0.7A, PMDU
1	D151	RFNL10TJ6S	ROHM	-	600V, 10A, TO-220ACFP
2	D181, D182	RFU02VSM8S	ROHM	-	800V, 0.2A, TUMD2SM
1	D201	D1FK100	Shindengen	-	1000V, 1A, DO-214AC
2	D251, D252	BAS21VM	ROHM	-	200V, 0.2A, UMD2
2	D351, D901	1SS400SM	ROHM	-	80V, 0.1A, EMD2
1	D501	RB228T150NZ	ROHM	-	150V, 30A, TO-220FN (3PIN)
1	ZD301	EDZV6.2B	ROHM	-	6.2V, 150mW, EMD2
1	ZD381	EDZV12B	ROHM	-	12V, 150mW, EMD2
1	ZD721	EDZV5.1B	ROHM	-	5.1V, 150mW, EMD2

Qty	Reference Designator	Parts Number	Manufacturer	Value	Description [Unit:Inch(mm)]
Optocoupler					
2	PC601, PC801	TLP385(GRL	Toshiba	-	Optocoupler, 5000V, SO6L-4pin
1	PC701	TLP2770(D4,E	Toshiba	-	Optocoupler, 5000V, 20Mbps, SO6L-4pin
Transistor					
1	Q101	R6014YNX	ROHM	-	600V, 9A, TO-220FM
1	Q201	R8011KNX	ROHM	-	800V, 11A, TO-220FM
1	Q381	R6002END3	ROHM	-	600V, 2A, TO-252
Inductor					
2	FL101, FL102	7448640407	Wurth Elektronik	1.5mH	250V_{AC}, 2.2A, Common Mode Chokes
1	L101	760802122	Wurth Elektronik	450µH	10:1, PFC Choke
Transformer					
1	T201	750841348	Wurth Elektronik	900µH	Custom specification, See Figure-12.
Others					
2	TB1, TB2	691244810004	Wurth Elektronik	-	300V, 16A, 4pole, Terminal Blocks
1	F101	36913150000	Littlefuse	-	3.15A, 300V_{AC}, Fuse
3	HS1, HS2, HS4	HSEB20254-035H-01	Same Sky	-	Heat Sink for Q101, Q201 and D501
1	HS5	HSS-B20-053H-01	Same Sky	-	Heat Sink for DA101
1	JS1	60900213421	Wurth Elektronik	-	Jumper Socket for MCU Power SW
1	LED391	CSL1901UW1	ROHM	-	Red LED, 0603(1608)
1	LED392	CSL1901DW1	ROHM	-	Orange LED, 0603(1608)
1	CN1	HIF3FC-14PA-2.54DSA(71)	Hirose Electric	-	Pin Header 14pin, Connector for Debugging
1	CN2	61300311121	Wurth Elektronik	-	Pin Header 3pin, MCU Power-supply Switch
1	CN3	61300411121	Wurth Elektronik	-	Pin Header 4pin, Communication Connector
1	TH101	B57235S0809M0	TDK	8Ω	3.5A, Thermistor

ELECTRICAL SPECIFICATIONS @ 25° C unless otherwise noted:

PARAMETER		TEST CONDITIONS	VALUE
D.C. RESISTANCE	1-3	@20ºC	0.63 ohms max.
D.C. RESISTANCE	5-6	@20ºC	0.19 ohms max.
D.C. RESISTANCE	8-9	tie(8+9, 10+11), @20ºC	0.03 ohms max.
INDUCTANCE	1-3	10kHz, 100mV, Ls	900µH ±10%
SATURATION CURRENT	1-3	20% rolloff from initial	2.5A
LEAKAGE INDUCTANCE	1-3	tie(5+6+8+9+10+11),100kHz, 100mV, Ls	40uH max.
DIELECTRIC	1-11	tie(3+5,10+11), 3750VAC, 1 second	3000VAC, 1 minute
TURNS RATIO		(1-3):(11-8), tie(8+9,10+11)	7.5:1
TURNS RATIO		(1-3):(5-6)	12:1

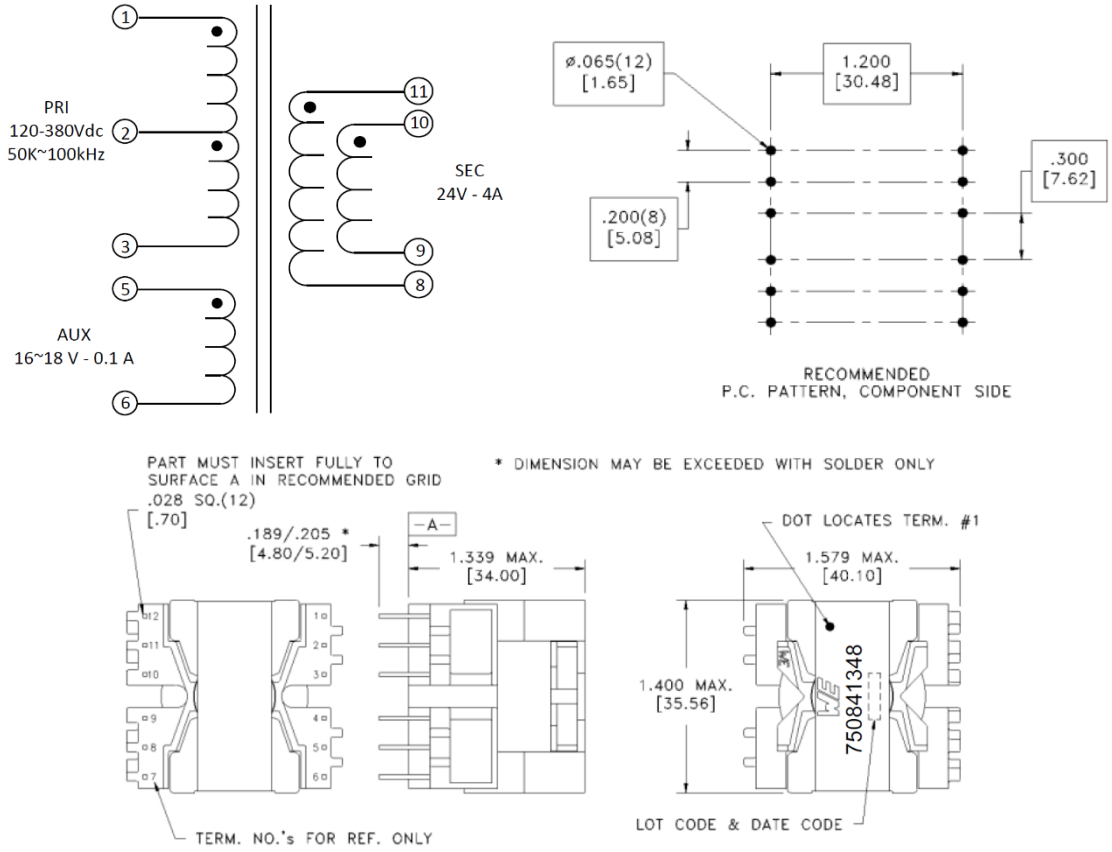

Figure 12. Specification of Transformer T201

(Wurth Elektronik 750841348)

13 Reference Application Data

Load Regulation

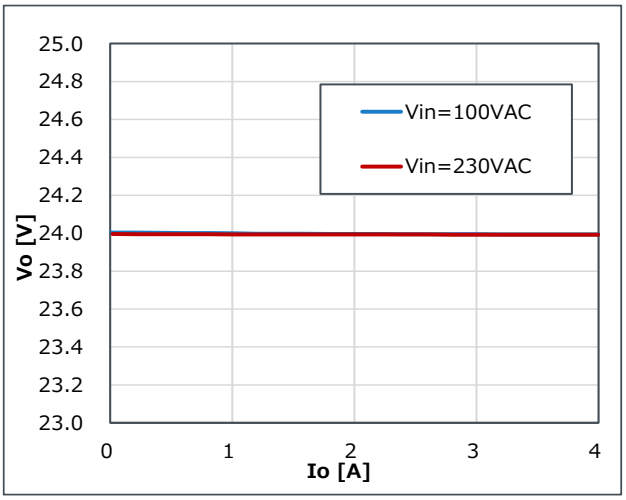

Figure 13-1. Load Regulation

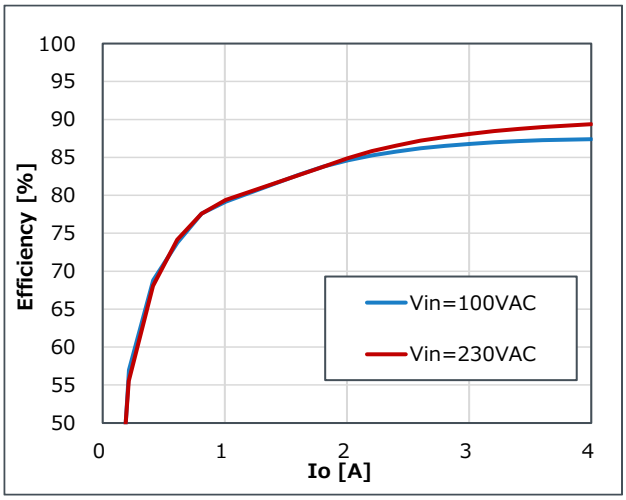

Figure 13-2. Efficiency vs Io

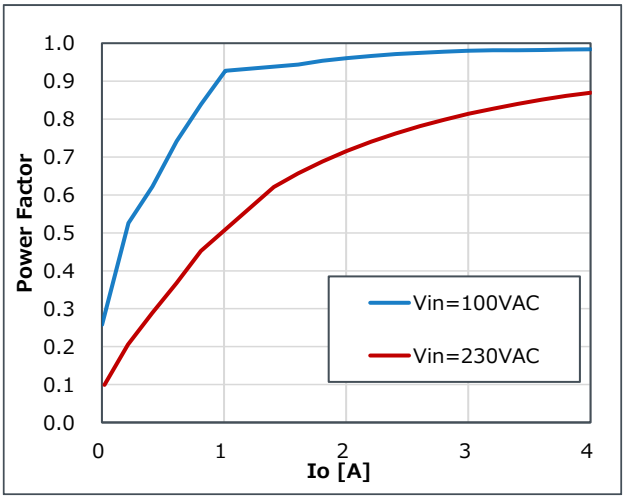

Figure 13-3. PF vs Io

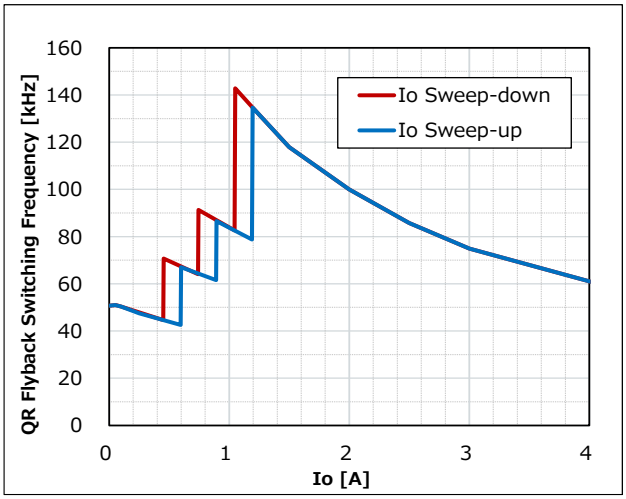

Figure 13-4. QR Flyback switching frequency vs Io (Vin=100V_{AC})

Line Regulation

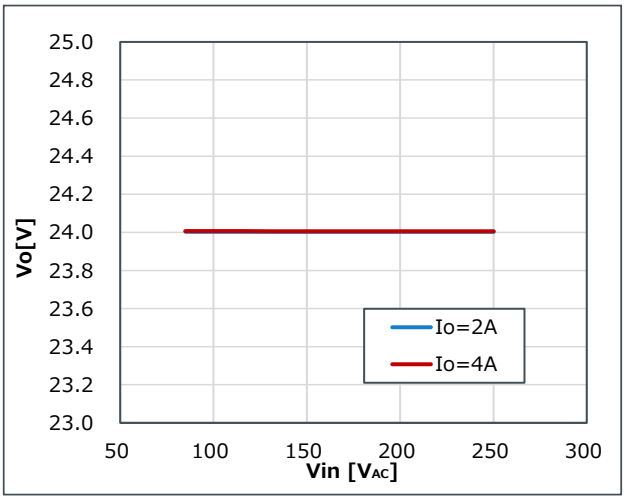

Figure 13-5. Line Regulation

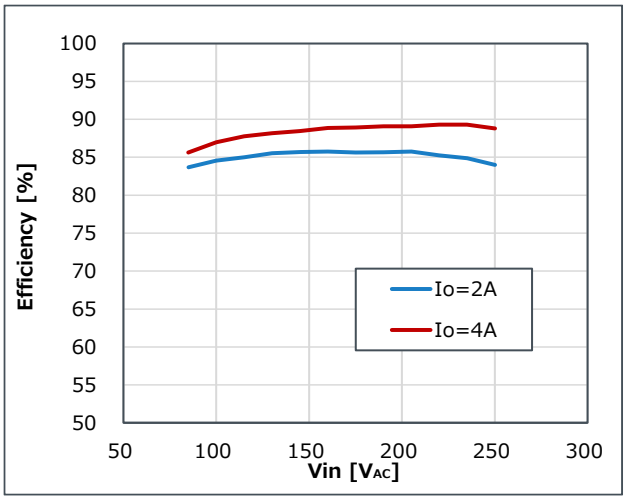

Figure 13-6. Efficiency vs Vin

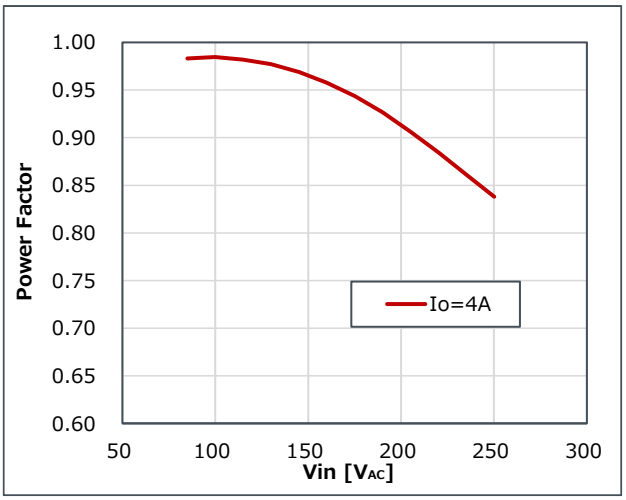

Figure 13-7. PF vs Vin

Operation Waveform

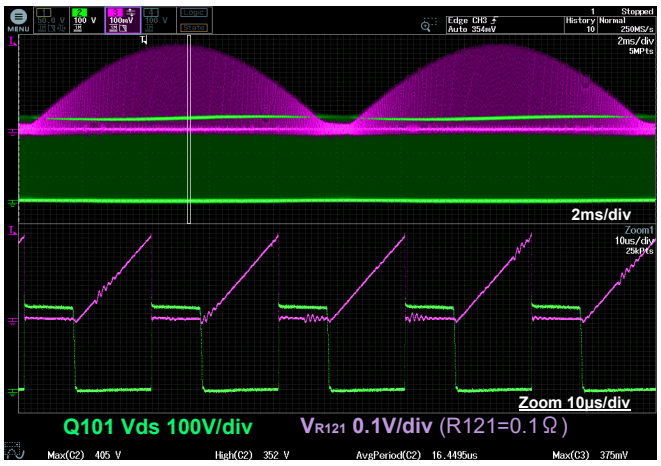

Figure 13-8. Operating Waveform of PFC Output MOSFET Q101 (Vin=100V_{AC}、Io=4A)

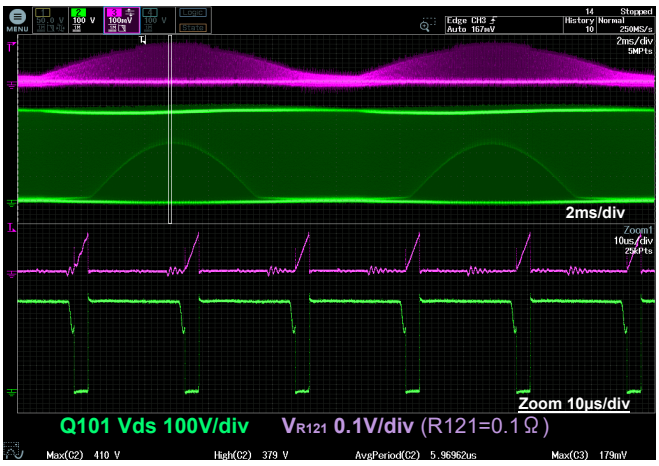

Figure 13-9. Operating Waveform of PFC Output MOSFET Q101 (Vin=230V_{AC}、Io=4A)

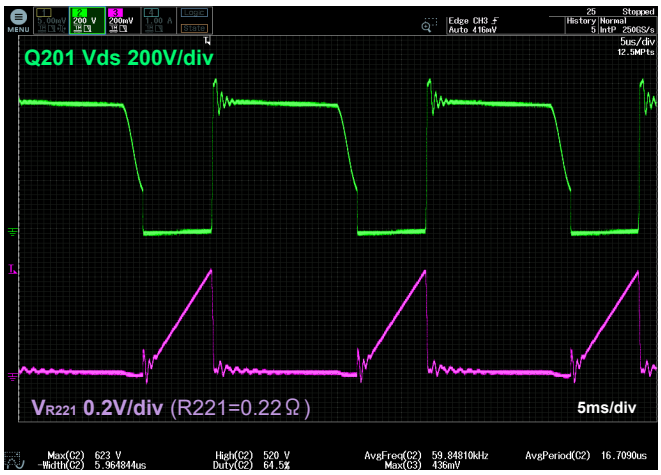

Figure 13-10. Operating Waveform of QR Flyback Output MOSFET Q201 (Vin=100V_{AC}、Io=4A)

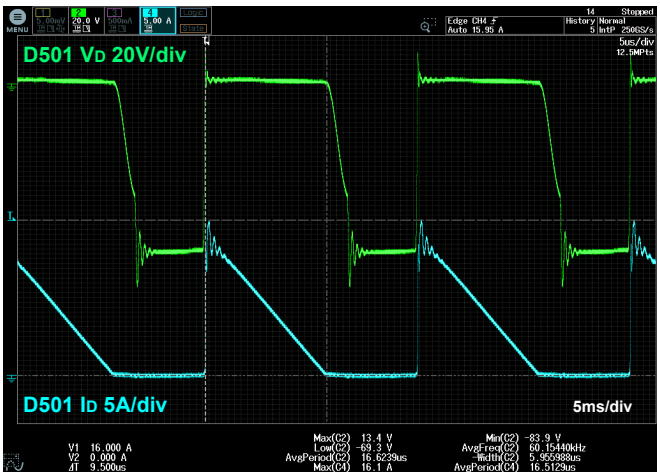

Figure 13-11. Operating Waveform of QR Flyback Rectifier Diode D501 (Vin=100V_{AC}、Io=4A)

14 Reference Documentations

[1] 66AN145E, Analog-Digital Hybrid Control Innovating Switching Power Supply Design

[2] FEDL62Q2045-03, ML62Q2033/2035/2043/2045 Datasheet

[3] FEUL62Q2045-02, ML62Q2033/2035/2043/2045 User's Manual

[4] 67AN099E, Operating System for Switching Power Control MCU "RMOS"

[5] 67AN039E, BCM-PFC and QR Flyback Converter with Analog-Digital Hybrid Control Operation Manual

[6] FEBLEASE1000V2ISO-01, OB-EASE1000-V2-ISO User's Manual

[7] 67AN103E, Serial Communication of RMOS and GUI Developing Manual

Revision history

Date	Revision Number	Description
31. Mar. 2025	001	New Release

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