Application Note

LogiCoA™ Power Solutions

Analog-Digital Hybrid Control Innovating Switching Power Supply Design

Overview

The control of switching power supply circuits using digital controllers such as DSP (Digital Signal Processor), etc. (hereinafter referred to as "full digital control") has been put into practical use more than twenty years ago, but it has not become popular except in the fields of "switching power supplies with large power and high functionality" and "DC/DC converters requiring high-speed response". In particular, most commercially available switching power supplies in 300W range (small to medium power) are controlled by analog controllers.

This is because the high-speed, high-performance processors such as DSP consume a large amount of power and are expensive. Therefore, when a DSP is used in a switching power supply circuit with a small amount of power, the problems of "inefficiency" and "cost UP" become significant.

To solve this problem, ROHM proposes to apply the analog-digital hybrid control (LogiCoA™ Controls) to designs for switching power supplies, which bring out the advantages of analog control and digital control, and which can compensate for their disadvantages. We also hope to innovate our switching power supply designs by providing LogiCoA™ power supply solutions, centered on the "Microcontroller (MCU) ML62Q20xx Group for Power Supply Control Optimized for Analog-Digital Hybrid Control." Applying LogiCoA™ control enables you to design a switching power supply that has the same power dissipation as analog control, while also offering superior digital-specific functions.

※" LogiCoA™"is a trademark or registered trademark of ROHM Co,. Ltd.

[LogiCoA™ Power Solutions]

(1) MCU ML62Q20xx Groups for Power Supply Control Optimized for Analog-Digital Hybrid Control
(2) Operating system for power supply control microcontroller (multitask, real-time control, state transition control, communication function, etc. are implemented as standard)
(3) GUI for communications and its development tool
(4) Design references (Practical level control programs, circuit diagrams, and evaluation boards optimized for each power supply topology)
(5) Electronic components (power semiconductors, gate drivers, shunt resistors for current sensing, and etc.) for realizing compact, high efficiency switching power supplies

This document explains the switching power supply design using analog-digital hybrid control, a newly developed MCU for switching power supply control, and topology examples that can be controlled by this MCU.

Table of contents

1. Comparison of Switching Power Supply Control Methods

In order to clarify the features of "Analog-Digital Hybrid Control", the following sections compare "Analog Control" and "Full Digital Control" by referring to the synchronous Buck DCDC converter (hereafter Buck Converter) circuit.

(a)Analog control

Figure 1-1 shows an analog-controlled buck converter. The analog-controlled buck converter is controlled as shown below.

(1) The control signal "Vc" is generated by comparing the output voltage "Vo" and the reference voltage "Vref" of the switching power supply using the "analog compensator". When the output voltage is lower than "Vref", the control voltage "Vc" is raised. When the output voltage is higher than "Vref", the control signal "Vc" is lowered.

(2) Driving signal (ON duty) of the switching device "S1" is generated by comparing the control signal "Vc" with the ramp signal "Vramp" using "PWM comparators". When the control voltage "Vc" is high, ON duty is widened, and when the control voltage "Vc" is low, ON duty is narrowed.

(3) A circuit that generates the inverted signal of the switching device "S1" is used to generate the drive signal of the synchronous rectifier device "S2". For the drive signal of the synchronous rectifier circuit "S2", a dead time must be provided for the drive signal of the switching device "S1".

(4) The “analog compensating circuit” and the “analog PWM circuit” control the switching power supply so that the output voltage "Vo" is the same voltage as the reference voltage "Vref".

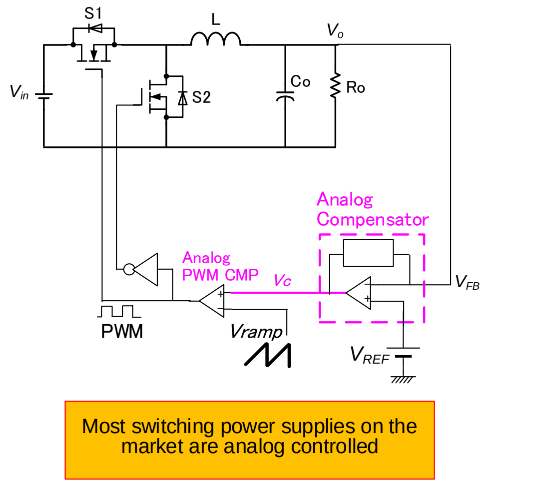

Figure 1-1. Analog Controlled Buck Converter

Switching power supplies with "analog control" can realize switching power supply control circuits with low power consumption and low cost. However, many fixed values such as the output voltage setting value, dead time setting value, and protection circuit setting value become fixed values, resulting in a circuit that is greatly affected by variations in parts. Therefore, in order to maintain the safety of the circuit, it is necessary to design with a large margin in the rating of the components to be used, so extra cost and volume are required.

(b)Full digital control

Figure 1-2 shows a fully digitally controlled buck converter. The buck converter with full digital control is controlled as shown below.

(1) “DSP” uses “A/D converters” to acquire “Vo” of the switching power supply and compares it with “Vref” reference set in DSP.

(2) In response to the instruction from “DSP”, the “high-resolution timer (ex.256MHz)” generates ON duty for the switching device “S1”. Control is performed so that when the output voltage is lower than the reference value, ON duty is widened, and when the output voltage is higher than the reference value, ON duty is narrowed.

(3) In the same way, the “high-resolution timer” generates the driving signal of the synchronous rectifier device "S2" upon receiving the instruction from "DSP". The drive signal of the synchronous rectifier device "S2" is set to provide a dead-time for the drive signal of the switching device "S1".

(4) DSP calculation controls the switching power supply's output voltage "Vo" to the same voltage as the reference value "Vref". The switching power supply's output-voltage "Vo" can be changed by changing the reference "Vref" with the software.

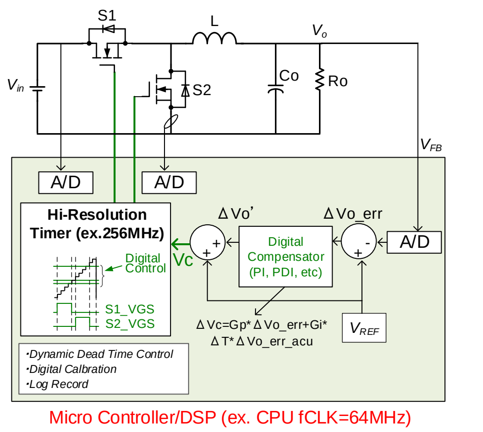

Figure 1-2. Full Digital Controlled Buck Converter

"Full digital control" switching power supplies can realize highly functional control circuits. For example, because many of the output voltage setting, dead time setting, and protection circuit setting values can be changed by software, variations in parts can be absorbed by software. Therefore, it is possible to make the optimum design for the rating of the components to be used (no large margin like analog control is required). Moreover, since the output voltage control is realized by DSP calculation, the response characteristic of the output voltage can be optimized, and high-speed response can be realized. Furthermore, it is possible to optimize the efficiency of the switching power supply because the control values such as dead time can be optimized dynamically. In addition, advanced functions such as communication function and log recording function can also be realized. However, there is a problem that the power consumption of the digital processor is large and the cost is high.

(c)Analog-digital hybrid control

Figure 1-3 shows an analog-digital hybrid control buck converter. The buck converter of analog-digital hybrid control is controlled as shown below.

(1) Similar to analog control, an "analog compensation circuit" is used to generate a control signal "Vc" by comparing the output voltage "Vo" of the switching power supply with the reference voltage "Vref". However, the reference voltage "Vref" is controlled by the "D/A converter" in the "MCU" unlike the analog control.

(2) By using the "PWM comparators" in the "MCU" to compare the control signal "Vc" with the ramp signal "Vramp", the drive signal (ON duty) of the switching device "S1" is generated. However, unlike the analog control, the period of the ramp signal "Vramp" is controlled by the "timer (ex.64MHz)" in the "MCU".

(3) Using the falling edge of “PWM comparator” as a trigger, the “timer” in the “MCU” starts to generate the driving signal of the synchronous rectifier device “S2”. The dead time is generated by the "timer" setting of the synchronous rectifier "S2", so the dead time can be changed by an instruction from "CPU".

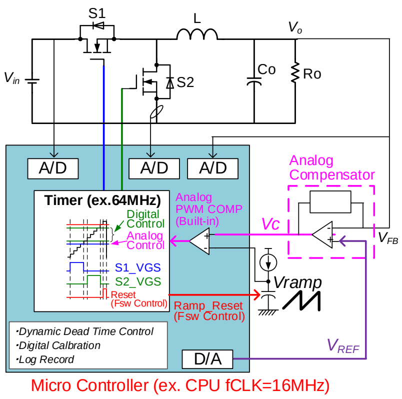

Figure 1-3. Analog-Digital Hybrid Controlled Buck Converter

(4) The “analog compensating circuit” and the “analog PWM circuit” control the switching power supply so that the output voltage "Vo" is the same voltage as the reference voltage "Vref". Since the reference voltage "Vref" is controlled by the "D/A converter" in the "MCU", the output voltage "Vo" can be changed by software.

The use of an “analog compensator” for output voltage control eliminates the need for DSP in switching power supplies with “analog-digital hybrid control”, enabling the use of low-cost, low-power microcontrollers. The use of a microcontroller allows many parameters such as the output voltage setting value, dead time setting value, and protection circuit setting value to be changed by the software in the same way as the full digital control. Therefore, variations in parts can be absorbed by the software. So, as with full digital control, it is possible to make the optimum design for the rating of the component to be used (no large margin like analog control is required). It can also realize dynamic optimization such as dead time, and advanced functions such as communication function and log recording function.

Although the response characteristics of the output voltage are inferior to "full digital control" due to the use of an "analog compensator" for output voltage control, it is not a significant demerit as it can realize sufficient response characteristics as a general switching power supply device. Table 1-1 shows the features of each control.

Table 1-1. Comparison of features of switching power supply control circuit

Analog control	Full digital control	Analog-digital hybrid control
●Low power (ex. Icc=3 to 5mA) ●Analog compensator (output voltage setting is analog) ●Analogue PWM control (resolution = infinity) ●Fixed dead time control (difficult to optimize) ●Low added value	●Requires high-speed CPU/DSP (ex. fCLK=64 to 200MHz) ●Requires high-speed timer (ex. fCLK=256MHz) ●High Power (ex. Icc=100 to 150mA) ●Digital compensator (fast response) ●Digital PWM control (resolution = ex. 3.9ns) ●Dynamic dead time control (optimizes the whole area) ●High added value (communication functions, log records, etc.)	●Controllable in low-speed CPU (ex. fCLK=16MHz) ●Controllable by low-speed timer (ex. fCLK=64MHz) ●Low power (ex. Icc=3 to 10mA) ●Analog compensator (output voltage setting is digital) ●Analog-digital integrated PWM control (resolution = infinity, Timer controls on timing of SW devices) ●Dynamic dead-time control (fully optimized) ●High added value (communication functions, log records, etc.)

2. Features of Analog-Digital Hybrid Control Switching Power Supply with LogiCoA™ MCU

This section describes the features of a switching power supply designed using ML62Q20xx Groups (hereinafter referred to as LogiCoA™ MCU), which are microcontrollers optimized for analog-digital hybrid control, in Figure 2-1.

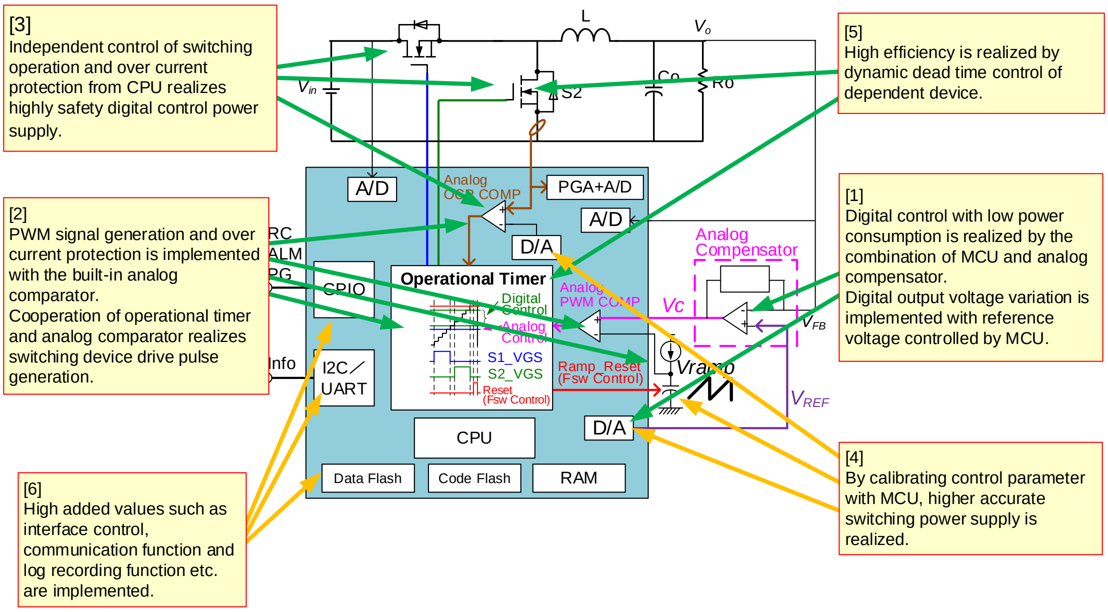

Figure 2-1. Features of an Analog-Digital Hybrid Control Power Supply with LogiCoA™ MCU

(1) Digital control and digital output voltage setting using an analog compensator and low-power microcontroller

The control circuit of switching power supply is configured using an analog compensator for output voltage control and with LogiCoA™ MCU (CPU clock; 16MHz, timer clock; 64MHz). Since high power consumption devices such as DSP are not used, the power consumption of the control circuit can be reduced.

The output voltage control is performed by an analog compensator and the reference voltage V_{REF} applied to the analog compensator is generated by LogiCoA™ MCU D/A converter. Therefore, the output voltage setting of the switching power supply can be controlled by LogiCoA™ MCU.

(2) Cooperation of built-in analog comparator and operational timer realizes switching device drive pulse generation and overcurrent protection

LogiCoA™ MCU includes operational timers (10 outputs, controlling up to 10 power devices) optimized to generate gate drive signals for power devices, analog comparators (3 channels) those can be used for PWM signal generation and overcurrent protection circuit, and D/A converters (2 channels) those can be used as a reference voltage signal. The operational timer is configured to allow free setting of "inter-timer coordination operation," "timer-comparator coordination operation," "timer-external inter-signal coordination operation," and "phase tracking operation," allowing control of various power supply circuit topologies (Buck, Boost, Buck-Boost, forward, bridges, PWM flyback, quasi resonant flyback, boundary current mode PFC, and interleaved PFC, etc).

For PWM control signal, configure the built-in analog comparator in LogiCoA™ MCU to operate as a PWM comparator. PWM signal is generated by inputting a triangle wave to PWM comparator similar to analog control. The triangle wave can be generated using an operational timer to control the on-timing (switching frequency) of the switching device from LogiCoA™ MCU. In addition, since the ON duty (pulse width of PWM signal) of the switching device is determined by analog control, the resolution of the switching pulse becomes infinite (in full digital control, the switching pulse has a finite resolution because it is determined by the resolution of the timer). Moreover, the maximum duty limit of the switching device can also be controlled from LogiCoA™ MCU.

For overcurrent protection, an analog comparator built-in LogiCoA™ MCU is set to operate as an overcurrent protection comparator. By connecting a D/A converter built-in the MCU to the overcurrent protection comparator, the overcurrent protection setting can be controlled from the MCU.

(3) Switching operation and overcurrent protection independent from CPU realize highly safe digitally controlled power supply

As operational timers, comparators, and D/A converters and so on in the LogiCoA™ MCU continue to operate independently of CPU after they are set once even if CPU is stopped, protective operations such as overcurrent protection continue to operate, making it possible to create a highly safe digitally controlled power supply.

In analog-digital hybrid control, the output voltage control is controlled by an analog compensator. Therefore, even if CPU is stopped, the output voltage immediately before CPU is stopped is output.

(4) Calibration of control parameters improves the accuracy of switching power supplies

LogiCoA™ MCU controls various control parameters of the switching power supply with a microcontroller so that the change in characteristics due to "component variation" can be corrected by software.

[Control parameter example]

・Switching frequency	・・・	Controlled by the cycle setting of the operational timer
・Max. duty limit of switching device	・・・	Controlled by the pulse width setting of the operational timer
・Dead time of dependent device	・・・	Controlled by setting Rise point of the operational timer
・Start/stop voltage	・・・	Controlled by acquiring input-voltage with A/D converters
・Preset output voltage	・・・	Controlled the reference voltage to the analog compensator by D/A converters.
・Overcurrent protection setting	・・・	Controlling the reference voltage to the comparator with D/A converters

(5) Dynamic dead time control of the dependent device realizes high efficiency of the switching power supply

The operational timer of LogiCoA™ MCU has a function to detect the falling edge of the switching device and start counting operation of the timer. This makes it possible to control the operation timing of the dependent device (synchronous rectifier device, switching device for resonance, etc.). It also has a function to control the timing from the start of the timer counter until the timer output turns to the high level, so the dead time can be controlled. In addition, the microcontroller monitors the input voltage, the current of the switching device, the output voltage, etc., and can dynamically optimize the dead time for the state of the power supply, thus maximizing the efficiency of the power supply circuit.

(6) High-value-added features such as interface control, communication functions, and log functions

LogiCoA™ MCU is a low-power microcontroller, but it has enough performances to realize high value-added functions such as interface control, communication functions, and log recording functions. In addition, an operating system for switching power supply control "RMOS" that realizes multitasking and real-time control is available for LogiCoA™ MCU. The communication and logging functions can be realized as standard functions of the operating system.

3. Outline of LogiCoA™ MCU

Table 3-1 outlines LogiCoA™ MCU. This microcontroller has the following functions to control the analog-digital hybrid control power supply.

(1) Multi-function timer (operational timer) optimized for switching power supply control
- 6 timers (OTM0 to OTM5), 10 outputs are implemented, and up to 10 MOSFET can be controlled (2 outputs for OTM0,OTM1,OTM4,OTM5 and 1 output for OTM2,OTM3)
- Compatible with various topologies by inter-timer cooperation, inter-timer-comparator cooperation (logical product, trigger start/stop) and external signal cooperation function
- Capture function and 1/2 phase tracking function enable to control interleave operation of boundary current mode PFC without CPU control

(2) Built-in Analog comparator × 3ch
- Analog PWM control (voltage-mode, peak current-mode control) and overcurrent protective operation control (pulse by pulse operation) are supported by the function of stopping timer output by comparator output, the timer counter start/stop function, and the logical product output function with timer output.
- D/A converters can be connected inside the microcontroller.

(3) Programmable gain amplifier (amplifies the voltage signal up to 32 times and acquires A/D converters)
- Capable of acquiring current detection signals, etc. with low loss

(4) Serial communication, data flash, multiplication/division
- Supports recording of power supply operation status log and various calculations

Table 3-1. Main Specifications of LogiCoA™ MCU

		ML62Q2033/5	ML62Q2043/5
CPU		16bit RISC CPU Core(nX-U16/100), Max. 16MHz operation	
Memory		Code Flash:16KB or 32KB Data Flash: 4KB (erase units: 128B) RAM: 2KB	
Comparator		3ch (clock-asynchronous operation), response-time: Max 100ns	
Timer		16bit timer with PWM/Capture × 6 counters, 10-outputs Max. 64MHz operation (resolution 15.625ns)	
A/D converters		12bit SA-ADC:5ch	
D/A converters		8bit, 2ch	
Programmable gain amplifier		1ch, gain setting: 4 levels. (×4/×8/×16/×32)	
Serial I/F (Communication)		I^2C×1, UART×2	
I/O Port		I: 1, I/O: 15	I: 1, I/O: 19
External interrupt		4	
Other		Multiplier/Divider, Thermal Sensor, Power ON Reset	
Clock	Low	Internal RC Oscillator: 32.768kHz±1.5%*	
	High	PLL: 64MHz±1.5%*, CPU: 16 MHz to 125 kHz±1.5%* PWM/Capture: 64MHz to 500kHz±1.5%*	
Supply Current (CPU)		Stop: 80μA, Halt: 90μA, Active: 3.3mA@16MHz	
Operating voltage		4.5V to 5.5V	
Operating temperature		Ta=-40°C to +105°C (Tj=115°C) (Absolute max. rating: Tjmax=125°C)	
Package		TSSOP20	WQFN24

*:Ta=-20°C to +85°C

4. Topologies Controllable with LogiCoA™ MCU

The following is a sample circuit topology that can be controlled by LogiCoA™ MCU. Since a reference board is provided for each topology, this manual provides an overview of the control. (The reference board documentation describes the details of the circuits and software.)

(1) Full-bridge synchronous rectifier converter

Figure 4-1 shows a full-bridge converter with LogiCoA™ MCU control. The operation of this circuit is outlined below.

・Voltage-mode PWM

Generates a triangle wave in OTO0A of the microcontroller (output of the operational timer OTM0). A PWM control signal is generated by inputting a signal from an analog compensator and a triangular wave to the comparator CMP0 built-in the microcontroller.

・Switching device control

Set OTO1A and OTO1B (output of the operational timer OTM1) to operate at the complementary output of duty50% and the frequency of 1/2 of OTM0 (the frequency of 1/2 of the triangle wave signal). In addition, by setting to output the logical product of CMP0 output (PWM signal), PWM signal is distributed to OTO1A and OTO1B.

・Synchronous rectifier device control

Set OTO2A (output of the operational timer OTM2) to start with respect to the falling edge of OTO1A, and set OTO3A (output of the operational timer OTM3) to start with respect to the falling edge of OTO1B. By setting the count value from the start of OTO2A and OTO3A until the H level is output, the dead time from turn off of switching device to turn on of synchronous rectification device is controlled.

OTM4 is set to operate synchronously with OTM1 (signal for controlling turn on of switching device), and OTO2A is turned off by OTM40 (internal output of operational timer), and OTO3A is turned off by OTM41. The dead time from turn off of synchronous device to turn on of switching device is controlled by setting OTM40 and the count-value at which OTM41 outputs an off-signal.

・Output voltage setting

Set OTO5A (output of the operational timer OTM5) to a frequency sufficiently high than the output filters of the full-bridge converter. Insert OTO5A output to the reference of the analog compensator on the secondary side via an isolating device such as a photocoupler. Output voltage setpoint can be controlled by setting duty of OTO5A.

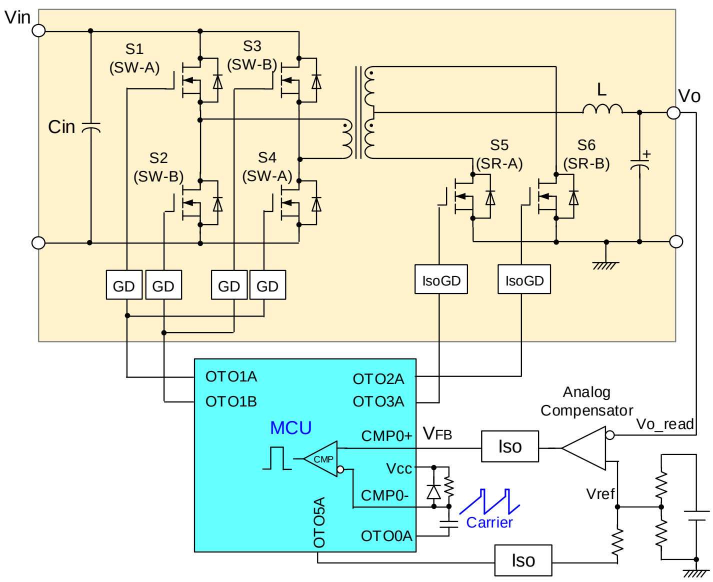

Figure 4-1. LogiCoA™ MCU Controlled Full-Bridge Converter

(2) Boundary current mode interleaved PFC

Figure 4-2 shows the boundary current mode interleaved PFC converter circuit controlled by LogiCoA™ MCU. Interleaved operation uses the phase tracking function, which is one of the functions of the operational timer of LogiCoA™ MCU. The operation of this circuit is outlined below.

・Switching device S1 control (Boundary current control)

To control the on-time of the switching device S1, set the time (count-value of the timer) during which OTO0A (output of the operational timer OTM0) outputs H-level. OTO0A restarts when a EXTRG0 (external trigger input pin) is input.

When OTO0A starts, S1 is activated and L1 is energized, increasing the current. When the time OTO0A is outputting H-level reaches to the value set before, S1 is turned off. This releases L1 excitation energy. This reduces the current.

When L1 current reaches zero, EXTRG0 is signaled. When EXTRG0 is signaled, OTO0A restarts and S1 turns on again (boundary current mode operation).

・Switching device S2 control (Boundary current control and interleaved control)

Set OTO1A so that S2 (switching device) on time is the same as S1 on time. Also, set OTO1A to restart when a signal is input from both OTM2 and EXTRG1. OTM2 is set so that OTO0A cycle is captured in the microcontroller and the signal is outputted at 1/2 the captured cycle.

By this setting, OTO1A restarts at the timing when S1 phase reaches 180° and the timing when L2 current reaches zero. Interleave control can be performed.

・Power factor control, output voltage control

CPU sets the on-time of S1 and S2 switching operations so that the output voltage Vo becomes the target voltage. At this time, change the set value of S1 and S2 on-time at the timing when the input voltage Vac (AC voltage) is zero-crossing, and do not change the set value during one cycle of the input voltage. This operation enables control to be performed so that the power factor is ≈ 1.

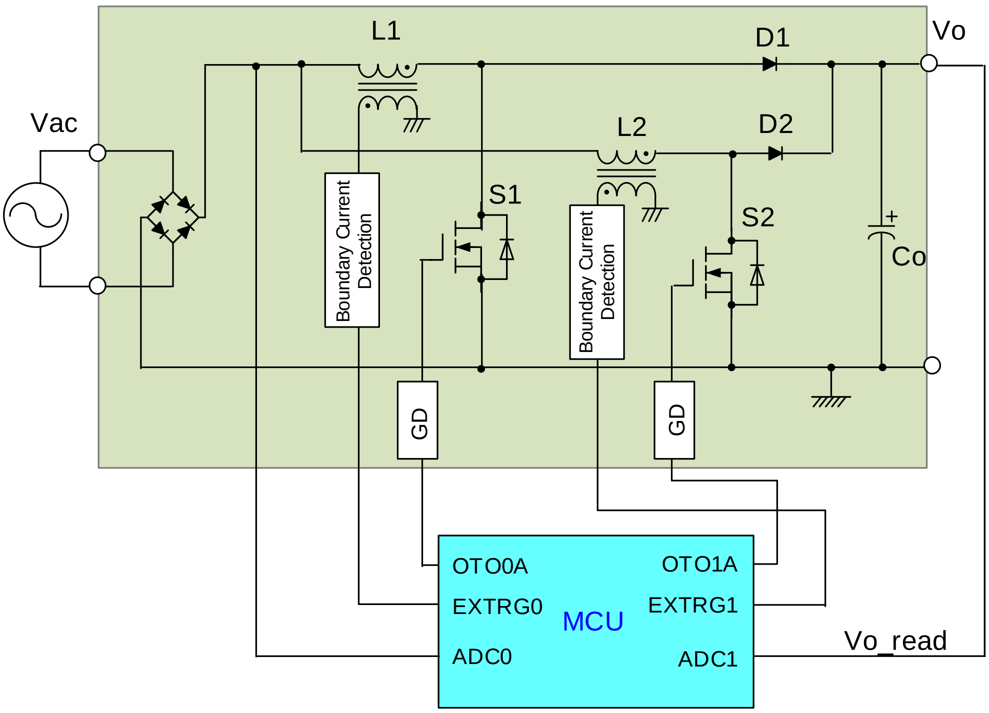

Figure 4-2. LogiCoA^{TM} MCU Controlled Boundary Current Mode Interleaved PFC

(3) Boundary current mode PFC + Quasi resonant flyback converter

In LogiCoA™ MCU, two converters can be controlled simultaneously by using the power control microcontroller operating system "RMOS"(Real time Micro Operating System").

For example, a boundary current mode PFC converter circuit and a quasi resonant flyback converter circuit in Figure 4-3 can be controlled by a single LogiCoA™ MCU. The operation of this circuit is outlined below.

The operation of the boundary current mode PFC is the same as that of the switching device S1 in the boundary current mode interleaved PFC described above. The operation of the quasi resonant flyback converter section is described below.

・Peak current mode PWM

OTO2A of the microcontroller (output of the operational timer OTM2) drives the switching device S2.

OTO2A is set to be turned off by CMP0 signal and restarted by EXTRG2 signal. The signal from the analog compensator and the signal of the current detecting resistor of S2 are inputted to the comparator CMP0 built-in the microcontroller.

When OTO2A starts, S2 turns on. The current flowing through S2 (excitation current of the transformer primary) is increased. When the signal voltage of the current sense resistor of S2 matches the signal voltage of the analog compensator, CMP0 operates and turns off OTO2A(S2) (peak current mode control).

・Quasi resonant operation

When S2 turns off, the transformer's excitation energy is released as current to the secondary side. When the transformer's excitation energy becomes zero, EXTRG2 is signaled. When EXTRG2 receives a signal, OTO2A restarts and S2 is activated again (quasi resonant operation).

・Output voltage setting

Set OTO5A (output of the operational timer OTM5) to a sufficiently higher frequency than the output filters of the quasi resonant flyback converter. Insert OTO5A output to the reference of the analog compensator on the secondary side via an isolating device such as a photocoupler. Output-voltage setpoint can be controlled by setting duty of OTO5A.

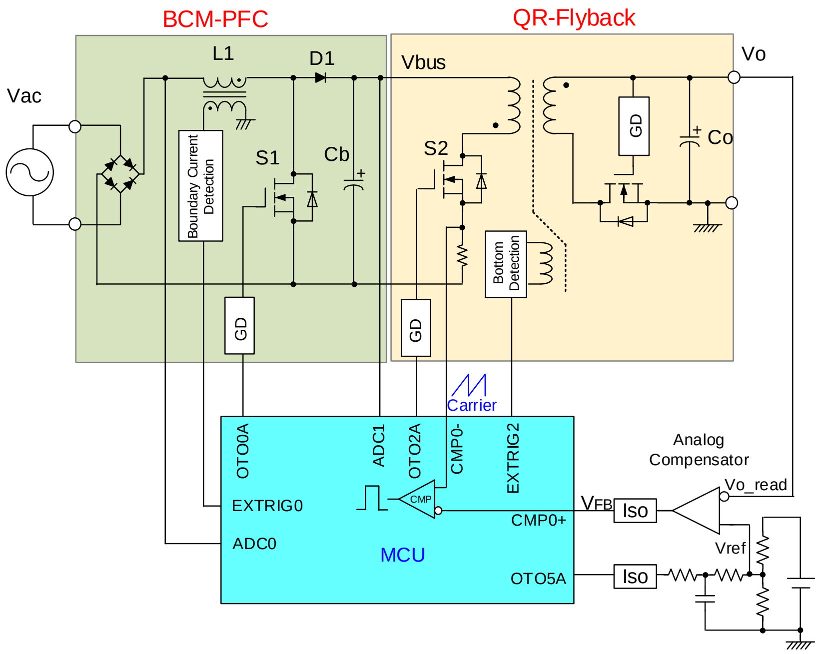

Figure 4-3. LogiCoA™ MCU Controlled Boundary Current Mode PFC and Quasi Resonant Flyback Converter

5. Related Documentation

Provides a list of documentation related to LogiCoA^{TM} Power Solutions.

[1] 66UG090E, Rev.001, Synchronous Buck DCDC Converter Evaluation Board LogiCoA001-EVK-001

[2] 66AN147E, Rev.001 Operating system for switching power control MCU "RMOS"

[3] 66AN149E, Rev.001, Serial communication of RMOS and GUI developing manual

[4] 66AN153E, Rev.001, Analog-Digital Hybrid Control Power Supply Synchronous Buck DCDC Converter Operating Instructions

Revision history

Date	Revision Number	Description
20. May. 2024	001	Initial release.

Notice

1) The information contained in this document is intended to introduce ROHM Group (hereafter referred to asROHM) products. When using ROHM products, please verify the latest specifications or datasheets before use.

2) ROHM products are designed and manufactured for use in general electronic equipment and applications (such as Audio Visual equipment, Office Automation equipment, telecommunication equipment, home appliances, amusement devices, etc.) or specified in the datasheets. Therefore, please contact the ROHM sales representative before using ROHM products in equipment or devices requiring extremely high reliability and whose failure or malfunction may cause danger or injury to human life or body or other serious damage (such as medical equipment, transportation, traffic, aircraft, spacecraft, nuclear power controllers, fuel control, automotive equipment including car accessories, etc. hereafter referred to as Specific Applications). Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses, or losses incurred by you or third parties arising from the use of ROHM Products for Specific Applications.

3) Electronic components, including semiconductors, can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against physical injury, and damage to any property, which a failure or malfunction of products may cause.

4) The information contained in this document, including application circuit examples and their constants, is intended to explain the standard operation and usage of ROHM products, and is not intended to guarantee, either explicitly or implicitly, the operation of the product in the actual equipment it will be used. As a result, you are solely responsible for it, and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses, or losses incurred by you or third parties arising from the use of such information.

5) When exporting ROHM products or technologies described in this document to other countries, you must abide by the procedures and provisions stipulated in all applicable export laws and regulations, such as the Foreign Exchange and Foreign Trade Act and the US Export Administration Regulations, and follow the necessary procedures in accordance with these provisions.

6) The technical information and data described in this document, including typical application circuits, are examples only and are not intended to guarantee to be free from infringement of third parties intellectual property or other rights. ROHM does not grant any license, express or implied, to implement, use, or exploit any intellectual property or other rights owned or controlled by ROHM or any third parties with respect to the information contained herein.

7) No part of this document may be reprinted or reproduced in any form by any means without the prior written consent of ROHM.

8) All information contained in this document is current as of the date of publication and subject to change without notice. Before purchasing or using ROHM products, please confirm the latest information with the ROHM sales representative.

9) ROHM does not warrant that the information contained herein is error-free. ROHM shall not be in any way responsible or liable for any damages, expenses, or losses incurred by you or third parties resulting from errors contained in this document.

ROHM SEMICONDUCTOR

Thank you for your accessing to ROHM product informations.
More detail product informations and catalogs are available, please contact us.

ROHM Customer Support System

https://www.rohm.com/contactus