Starter IC with High-Efficiency Burst Function

MCZ5303

MCZ5305SG is an optional IC for LLC control IC to allow you to use a current resonance power supply in various applications. It is an IC that adds self-start function, burst function, and AC line monitoring function to an existing control IC.
MCZ5303SH is an IC made by removing the AC line monitoring function and the control logic from MCZ5305SG. It can be also used as start circuit part of general power supply control ICs.

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Shindengen Electric Manufacturing Co., Ltd.
Electronic Device Division

CAT.No. 1H0400-1E

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Caution	**Do not use the circuit beyond the rated input voltage and install a protection device on the input rail to prevent smoke/fire that may be caused from an abnormal condition.**
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1 Overview of Product

MCZ5303SG is a function IC in which the standby IC is removed from the conventional two-converter configuration to realize a one-converter configuration while keeping high efficiency. MCZ5303SH of SOP7J package is also in the lineup in case only start circuit is required.

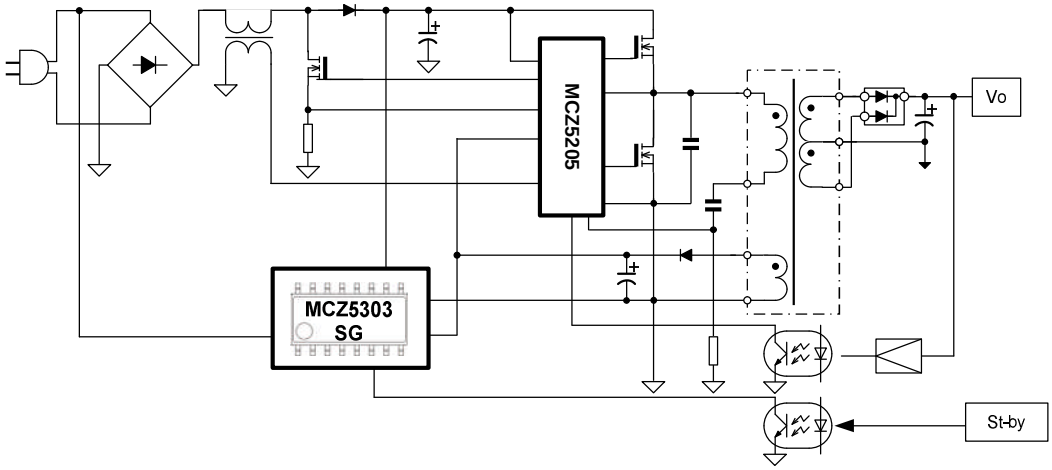
- SOP7J(MCZ5303SH), SOP16(MCZ5303SG) package
- 500V HV startup function
- Optimised burst mode control
- 35V supply withstanding
- 18.5V internal dropper
- Specialized burst sequence circuit for using LLC controllers like Shindengen MCZ5205 and MCZ5207 (MCZ5303SG only)
- Input main line sensing
- Thermal shutdown function eliminates external protective components

1.1 Features

- When using MCZ5303, the sub converter for Vcc supplying in existing 2 converter configuration (PFC&LLC + sub converter) is no longer required.
- Open load 0.1W consumption is possible in single LLC converter solution.
- Total component counts can be much reduced.

1.2 Example of Circuit Configuration

MCZ5205SE(PFC/LLC combo IC) + MCZ5303SG



2 Block Diagram

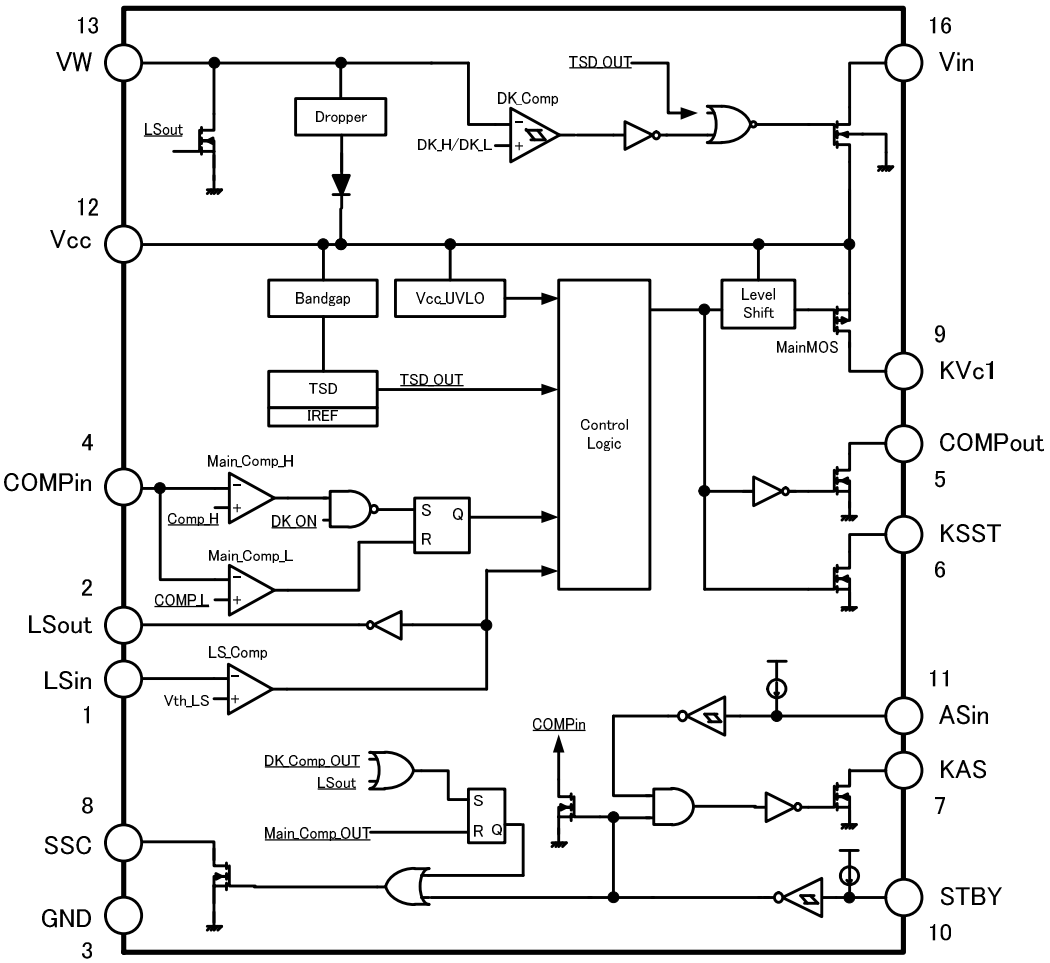


Figure 1. MCZ5303SG : SOP16

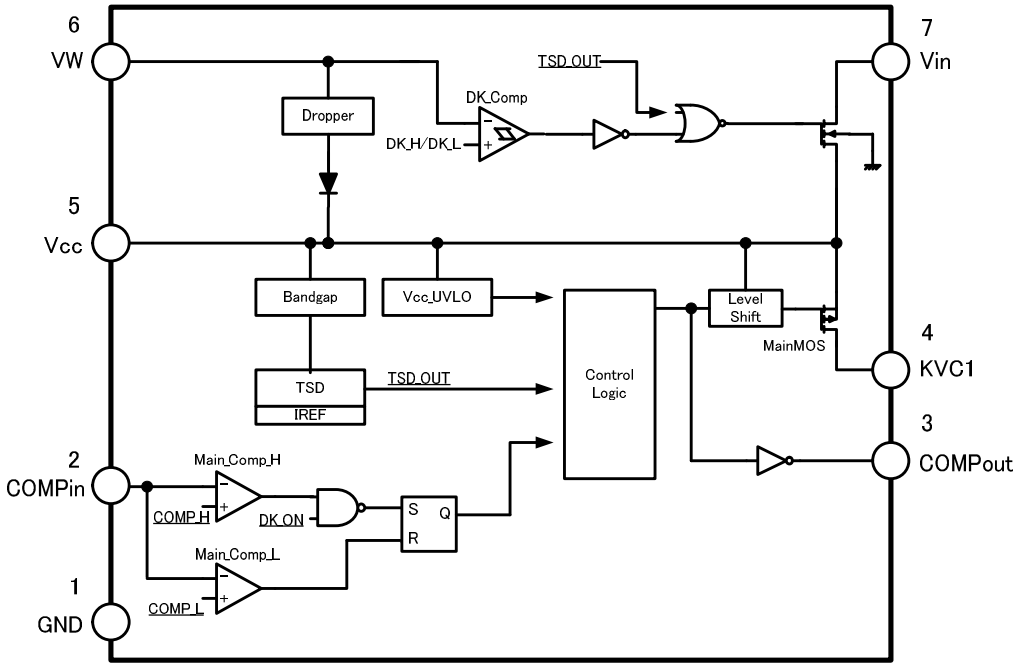


Figure 2. MCZ5303SH : SOP7J

3 Pin Assignment and Pin Function List

3.1 Pin Assignment Diagram

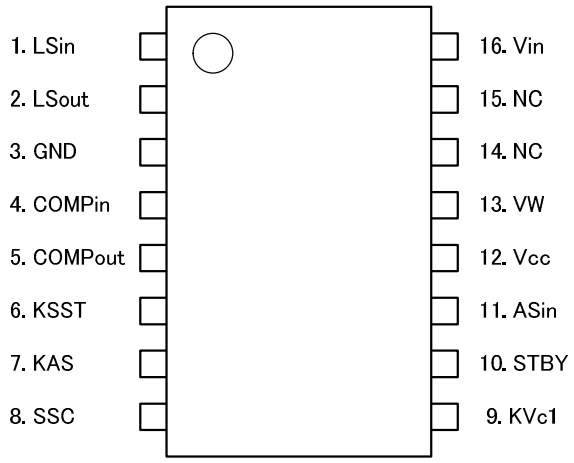


Figure 3. MCZ5303SG : SOP16

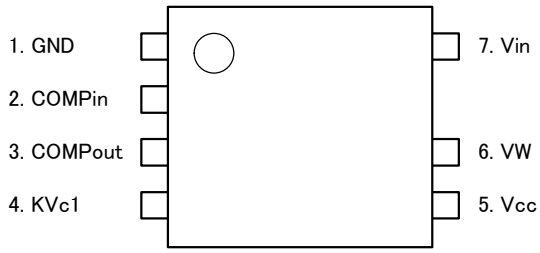


Figure 4. MCZ5303SH : SOP7J

3.2 Pin Function List

Symbol	Pin No.		Function
	SOP16	SOP7J	
LSin	1	-	Input main line sensing terminal: Input main line voltage sensing comparator input.
LSout	2	-	Input main line sensing terminal output: Input main line voltage sensing comparator output.
GND	3	1	GND terminal: GND connection terminal for IC.
COMPin	4	2	Burst control comparator input terminal: Terminal to control burst operation by detecting the voltage.
COMPout	5	3	Comparator output terminal for burst operation: Used to adjust the hysteresis of the burst control comparator.
KSST	6	-	Output terminal for SST reset: Terminal to reset the SST terminal by synchronizing with burst.
KAS	7	-	AS switching signal output terminal: Outputs switching signals of active standby mode. Becomes Lo in standby mode or active standby mode.
SSC	8	-	Soft start circuit switching terminal: Control terminal to switch the time constant of soft start at the time of burst operation.
KVc1	9	4	Vcc supply terminal: Supplies power to the control IC.
STBY	10	-	Standby mode switching terminal: Switches to burst mode. Burst mode with terminal open.
ASin	11	-	AS switching signal input terminal: Input terminal of active standby signals.
Vcc	12	5	Power supply terminal (start circuit output): A current is supplied from the Vin terminal at the time of start, and a voltage is supplied from the VW terminal after start.
VW	13	6	Vcc winding voltage input terminal: Terminal for voltage input from the Vcc winding. Has an 18.5V dropper.
NC	14,15	-	Unused terminal
Vin	16	7	Start circuit input terminal: A current is supplied from the Vin terminal to the Vcc terminal at the time of start, and the start circuit becomes off when Vw exceeds 19.5V.

Table 1. Pin Function List

4 MCZ5303SG

* Unless otherwise specified, values such as threshold values are represented in TYP. For details, refer to the characteristic specifications.

4-1. Introduction

MCZ5303SG(SOP16) had three control modes depending on the states of the STBY terminal and the ASin terminal. Here, they are defined as follows (with circuit configuration with MCZ5205 and MCZ5207).

1) Normal mode: Performs normal operation (symmetrical control) when the STBY terminal is shorted to GND and the ASin terminal is left opened.
2) Active Standby mode (AS mode) *: Performs continuous asymmetric LLC operation when the STBY and ASin terminal are both shorted to GND. When using MCZ5205, PFC is also forced to stop.
3) Burst mode: Performs burst oscillation control with the STBY terminal open. Accordingly, the mode becomes AS mode and the PFC is also stopped.

* The AS mode is an energy-saving mode in our LLC controller MCZ5205/5207.

The standby power is further reduced by applying AS mode in addition to burst mode.
The SST terminal is a function terminal of MCZ5205 or MCZ5207 that performs soft start and timer protection operation.

4-2. LSin Terminal (pin1) and LSout Terminal (pin2)

The LSin terminal is an input terminal of the hysteresis comparator for input main line sensing. It monitors the AC input voltage with voltage divider from AC and turns on/off the KVc1 terminal output according to the voltage. It also outputs the detection result to the LSout terminal.

LSin terminal input threshold voltage	Operation	LSout terminal output
1.05V or more	Oscillation start (KVc1 supply start)	Hi
0.75V or less	Oscillation stop (KVc1 supply stop)	Lo

KVc1 terminal: Refer to 4-8 KVc1 terminal.

Figure 5 is a connection example of the LSin terminal. Input lines are detected by connecting resistances R1 and R2 from the AC line to divide the resistance voltage and smoothing by C1. Figure 5 shows detection with half-wave rectification. Since the C1 capacity can be reduced by connecting diodes from both AC terminals for full-wave rectification, response at a higher speed can be obtained.
Voltage VLSin that is generated in LSin at the time of half-wave rectification can be obtained with an approximation of formula 3-1. Capacitor C1 sets the capacity so that the amplitude of the ripple does not exceed the hysteresis width. If the capacitor capacity is unnecessarily large, delay in start and stop becomes longer. In addition, since the operating point is affected when the amplitude of the ripple changes with the capacity of capacitor C1, check and adjust R1 or R2 in actual machine.
In the configuration example of Figure 5, settings are made as R1=4MΩ, R2=100kΩ, C1=2.2uF as reference constant examples in the case of 90Vrms to 264Vrms input specification. Actually, R1 should be divided into several pieces and installed in consideration of withstand voltage. When installing parts, place R2 and C1 just proximal to the IC terminal.

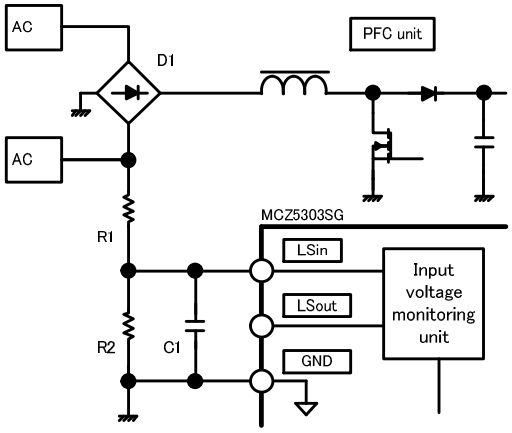


Figure 5. Typical line sensing circuit configuration (MCZ5303SG)

Voltage VLSin of the LSin terminal for AC input AC (rms) is,

$$VLSin = \frac{AC(\mathrm{rms})}{1.72} \times \frac{R2}{R1+R2} \quad [\mathrm{V}]$$

...Formula 4-1

Sensing resistor consumption Rloss is approximately as follows.

$$Rloss = \left(\frac{AC(\mathrm{rms})}{1.3}\right)^2 \div (R1+R2) \quad [\mathrm{W}]$$

...Formula 4-2

4-3. GND Terminal (pin3)

This is a GND terminal for IC.
Connect it with the control GND of the main control IC.

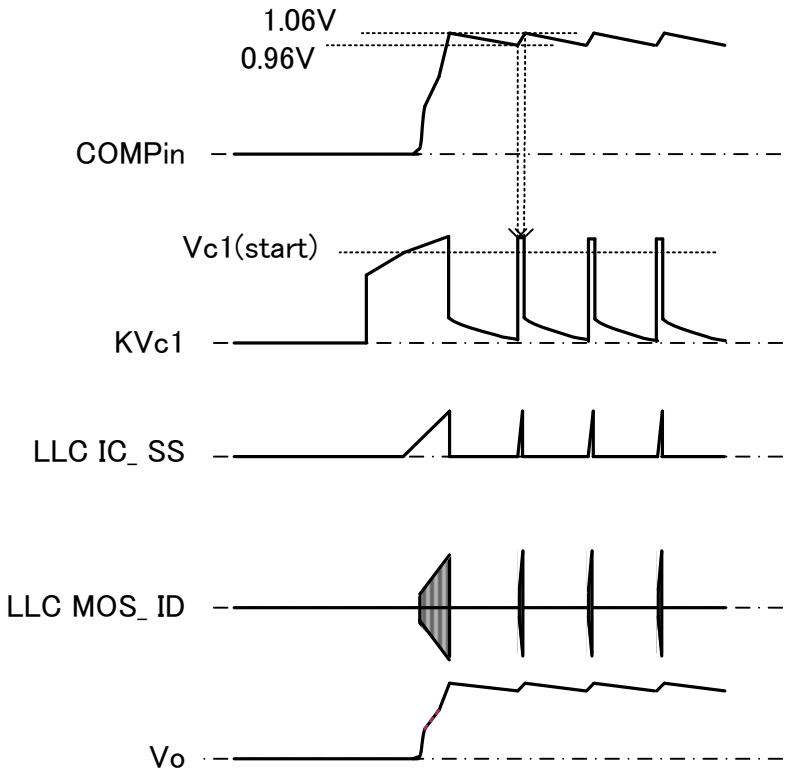
4-4. COMPin Terminal (pin4) and COMPout Terminal (pin5)

The COMPin terminal is a comparator input terminal for burst control.
To operate it in indirect control, detect the Vcc winding rectified voltage on the primary side with voltage divider and connect it to the COMPin terminal. Voltage supply to KVc1 is controlled according to the state of the COMPin terminal (in burst mode). Connect KVc1 to Vcc(Vc1 terminal of MCZ5205 and MCZ5207) of the LLC controller.
In normal mode, COMPin input becomes ineffective and the output voltage is continuously supplied to the KVc1 terminal.

In burst mode (STBY: Open)

COMPin terminal input threshold voltage	Operation	COMPout terminal
Upper limit of 1.06V	Converter operation stop (KVc1 supply stop)	Open
Lower limit of 0.96V	Converter operation start(KVc1 supply start)	Short (Lo)

The LLC controller repeats start and stop in burst duration as shown in Figure 6, set the voltage divider to be connected to the COMPin terminal in a way that KVc1 supply start voltage setting should be equal to the start voltage Vc1(start) of the LLC controller or more. In the case of MCZ5303SG, the COMPout terminal is open drain, and the burst duration can be adjusted by connecting a resistor between the COMPout and the COMPin terminal.



LLC IC_SS: Soft start signal of LLC part

Figure 6. Burst operation sequence drawing (MCZ5303SG)

4-5. KSST Terminal (pin6)

KSST is a terminal to send halt trigger to convert controller and has open drain output. In MCZ5205/5207 case, it is connected to the SST (soft start) terminal of the LLC controller. The KSST terminal is controlled by the COMPin terminal at the time of burst operation and operates in synchronization with the burst duration. In normal mode, it is always open.
Unnecessary oscillation is restrained by performing reset operation of soft start at the time of burst operation and in every burst duration to reduce the standby power.

In burst mode (STBY: Open)

COMPin terminal input threshold voltage	Operation	KSST terminal output
1.06V or more	Oscillation stop (KVc1 supply stop)	Lo (reset SST)
0.96V or less	Oscillation start (KVc1 supply start)	Open

SS: Soft start of LLC controller

4-6. KAS Terminal (pin7), ASin Terminal (pin11) and STBY Terminal (pin10)

The KSST terminal voltage is controlled in response to COMPin terminal voltage and changes its status of high and low according to the burst duration. The KAS terminal enters sink operation (Lo) in burst mode and is set to AS mode (asynchronous control) during burst operation. With ASin terminal input, it can be set to AS mode during light load operation in continuous mode.
The STBY terminal is a terminal to switch between normal mode and burst mode. When the STBY terminal is open, the mode becomes burst mode with COMPin terminal detection.

STBY terminal input	ASin terminal input	Operation	KAS terminal output
Short (Lo)	Short (Lo)	Continuous mode/symmetrical mode	Open
Short (Lo)	Open	Continuous mode/AS mode	Short (Lo)
Open	–	Burst mode/AS mode	Short (Lo)

4-7. SSC Terminal (pin8)

The SSC terminal is a circuit to switch the time constant of soft start. Output is open drain, and the terminal is in sink (Lo) state in static operation and in open state in burst operation.
Figure 7 is an example of connection with the LLC controller. The soft start time constant circuit of the SST terminal is switched with SSC terminal control. Since SSC is Lo and Css2 is shorted in normal operation, the soft start time is decided by Css1. When in burst mode, the SSC terminal becomes open. Therefore, in the time constant circuit with series connection of Css1 and Css2 and parallel connection of Css2 and Rss2, the start time is set shorter than in normal mode. However, the time of soft start operation in the beginning of start is the soft start time of normal mode (Css1) even if the mode is standby mode.

STBY terminal input	Operation	SSC terminal output
Short (Lo)	Normal mode (Css1)	Open
Open	Burst & AS mode (Cssi + Css2/Rss configuration)	Short (Lo)

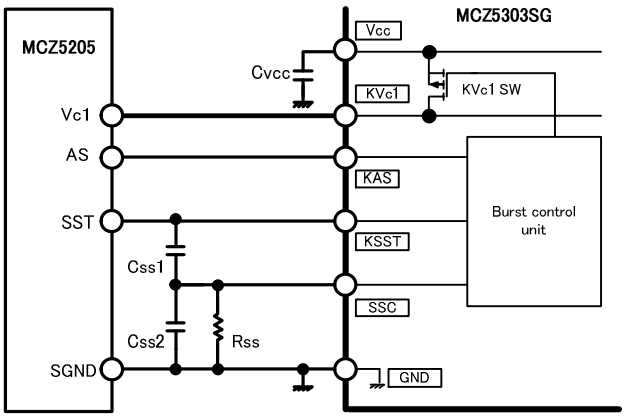


Figure 7. Connection diagram with LLC controller (MCZ5303SG)

4-8. KVc1 Terminal (pin9)

The KVc1 terminal is a terminal for Vcc supply to the control IC. In burst operation, it makes the LLC perform burst operation by repeating start and stop of supply from the KVc1 terminal to reduce wasteful IC power consumption in the oscillation stop period.

In burst mode (STBY: Open)

COMPin terminal input threshold voltage	Operation	KVc1 SW
Set with 1.06V	Oscillation stop (KVc1 supply stop)	ON --> OFF
Reset with 0.96V	Oscillation start (KVc1 supply start)	OFF --> ON

KVc1 SW: See Figure 8.

4-9. Vcc Terminal (pin12)

The Vcc terminal receives a current supplied from the Vin at the time of start and from the Vw terminal after start. The UVLO threshold value of Vcc is 7V, and output of KVc1 is turned off when the value is below the threshold.
For the Cvcc capacitor, select a capacity of 220uF or below with which the power supply can be started.

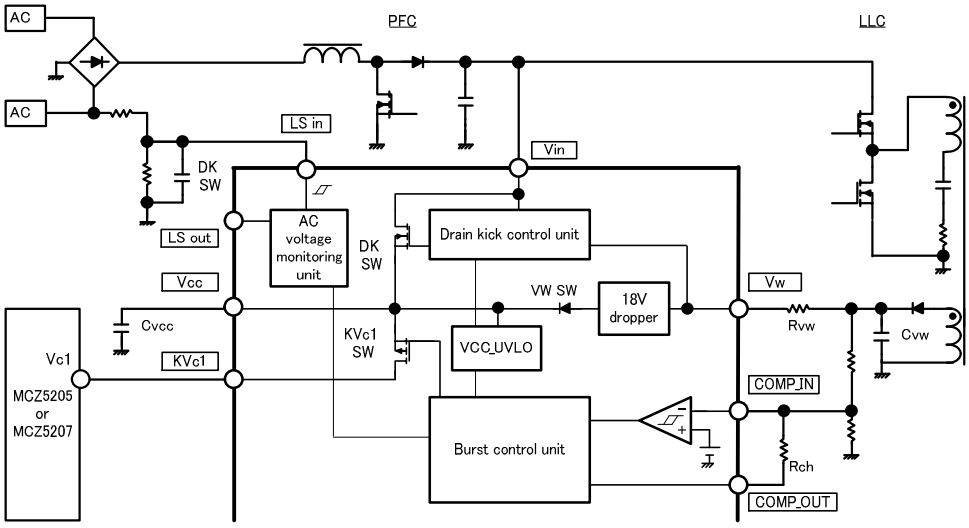


Figure 8. Connection diagram of Vcc system (MCZ5303SG)

4-10. Vw Terminal (pin13)

The Vw terminal inputs voltage in which output from the Vcc winding is rectified. The maximum input voltage of the Vw terminal is 35V. It is connected from the Vw terminal to the Vcc terminal with an 18.5V dropper circuit and a Vw switch.
When oscillation of the LLC is started and the Vw terminal voltage is increased to (Vcc+1V) or more at the time of start, the start circuit stops. When the Vw terminal voltage decreases to 7.5V or below, the start circuit starts operation.
Since the maximum allowable current of the Vw terminal is 200mA, the current should be limited with resistance, etc., in consideration of charging to Cvcc when the KVc1 SW is on.

VW terminal input threshold voltage	Operation
(Vcc+1V) or more	Start circuit stop
7.5V or less	Start circuit operation start

4-11. Vin Terminal (pin16)

The Vin terminal is a terminal to supply a current from the rectified high voltage part to Vcc at the time of power supply start and consists of a high withstand voltage switch and a constant current circuit. The supply current is 14.5mA with Vin=100VDC. When Vcc is 1V, it is reduced to 2.7mA.
Operation of the high withstand voltage switch is controlled by the above-mentioned VW terminal. When the high withstand voltage switch is turned on at the time of start, charging to the Vcc terminal capacitor is started and continued until the Vcc terminal voltage is clamped to 17V. The high withstand voltage switch is turned off when the LLC converter oscillates and the voltage of the Vw terminal becomes Vcc+1V or more with supply from the primary Vcc winding.
Figure 9 is a start/stop sequence drawing in burst mode.

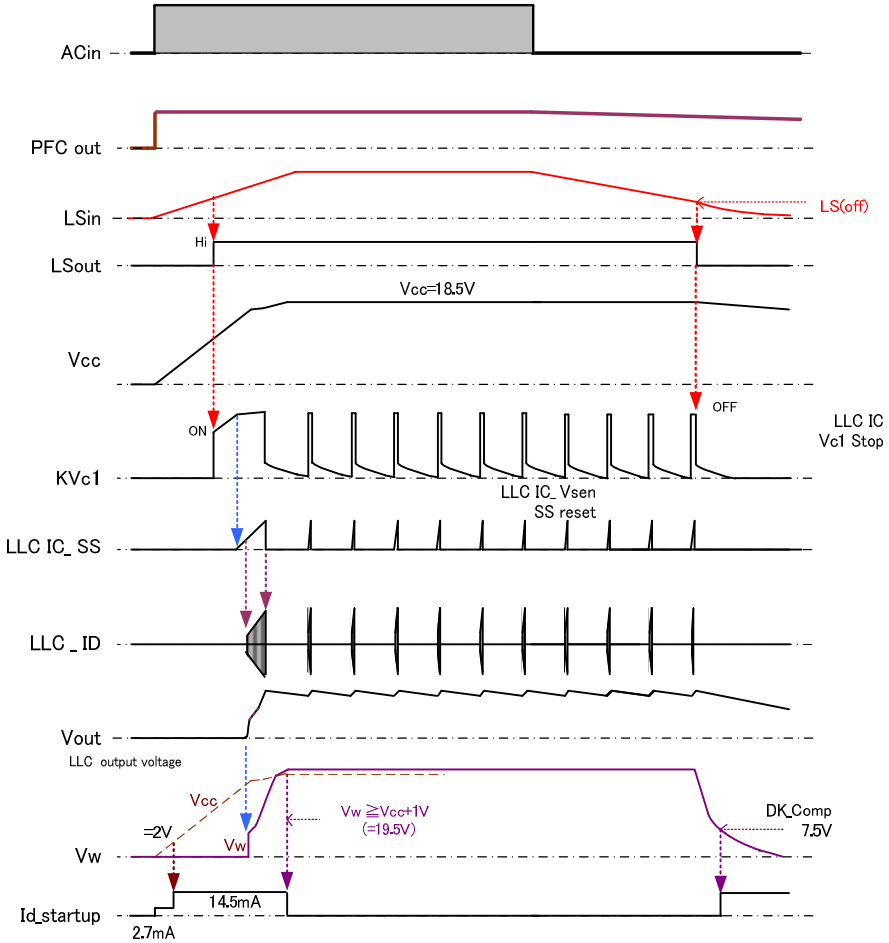


Figure 9. Start/stop sequence drawing in burst mode (MCZ5303SG)

5 MCZ5303SH

* Unless otherwise specified, values such as threshold values are represented in TYP. For details, refer to the characteristic specifications.

5-1. Introduction

MCZ5303SH is an IC that is a SOP7J package with the input main line sensing function and the burst sequence circuit removed from MCZ5303SG. It is optimum when you use MCZ5207 as a main control IC to use the burst function of MCZ5207 itself or need only a start circuit.

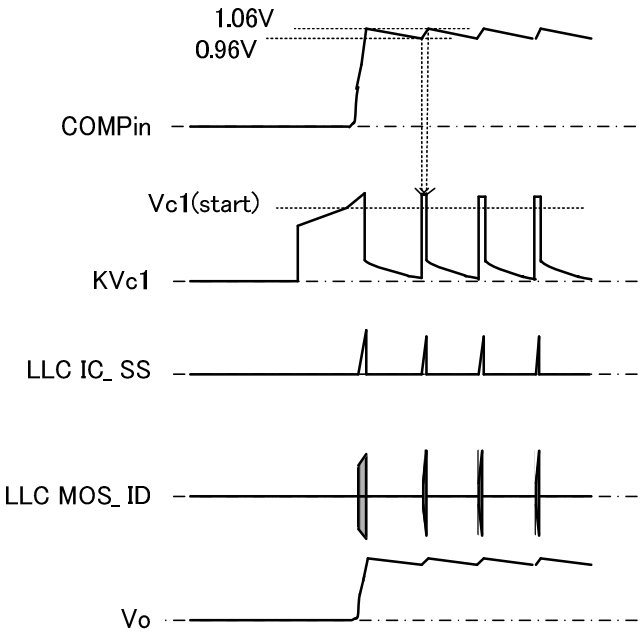
5-2. GND Terminal (pin1)

This is a GND terminal for IC.
Connect it with the control GND of the main control IC.

5-3. COMPin Terminal (pin2) and COMPout Terminal (pin3)

The COMPin terminal is a comparator input terminal for burst control. Supply to the main control IC can be turned on/off with input signals of COMPin.
To operate in primary side control, voltage divider shall be connected to COMPin terminal from Vcc self bias winding rectified DC voltage. Voltage supply to KVc1 is controlled according to the state of the COMPin terminal. Connect KVc1 to Vcc (Vc1 terminal of MCZ5205 and MCZ5207) of the LLC controller. Since the LLC controller repeats start and stop in every burst duration as shown in Figure 10, Vcc sensing voltage is applied to COMPin terminal through voltage divider to adjust burst duration, notice that KVc1 supplying voltage should be more than Vc1(start) of the LLC controller. (For the circuit configuration, see Figure 11.)
The COMPout terminal has a logic with reverse polarity of that of MCZ5303SG and the output circuit configuration is also different (Lo/Hi output).
It can used to control the soft start terminal of the main control IC, etc.

COMPin terminal input threshold voltage	Operation	COMPout terminal
Upper limit of 1.06V	Converter operation stop (KVc1 supply stop)	Lo
Lower limit of 0.96V	Converter operation start (KVc1 supply start)	Hi



LLC IC_SS: Soft start signal of LLC part

Figure 10. Burst operation sequence drawing (MCZ5303SH)

5-4. KVc1 Terminal (pin4)

The KVc1 terminal is a terminal for Vcc supply to the main control IC. In burst control, it makes LLC perform burst operation by repeating start and stop of supply from the KVc1 terminal to reduce wasteful IC power consumption in the oscillation stop period.
In addition, it can be also used as an on/off control switch of the main control IC with use of COMPin terminal, instead of use for burst.

In burst mode

COMPin terminal input threshold voltage	Operation	KVc1 SW
Set with 1.06V	Oscillation stop (KVc1 supply stop)	ON --> OFF
Reset with 0.96V	Oscillation start (KVc1 supply start)	OFF --> ON

KVc1 SW: See Figure 11.

5-5. Vcc Terminal (pin12)

The Vcc terminal receives a current supplied from the Vin at the time of start and from the Vw terminal after start. The UVLO threshold value of Vcc is 7V, and output of KVc1 is turned off when the value is below the threshold.
For the Cvcc capacitor, select a capacity of 220uF or below with which the power supply can be started.

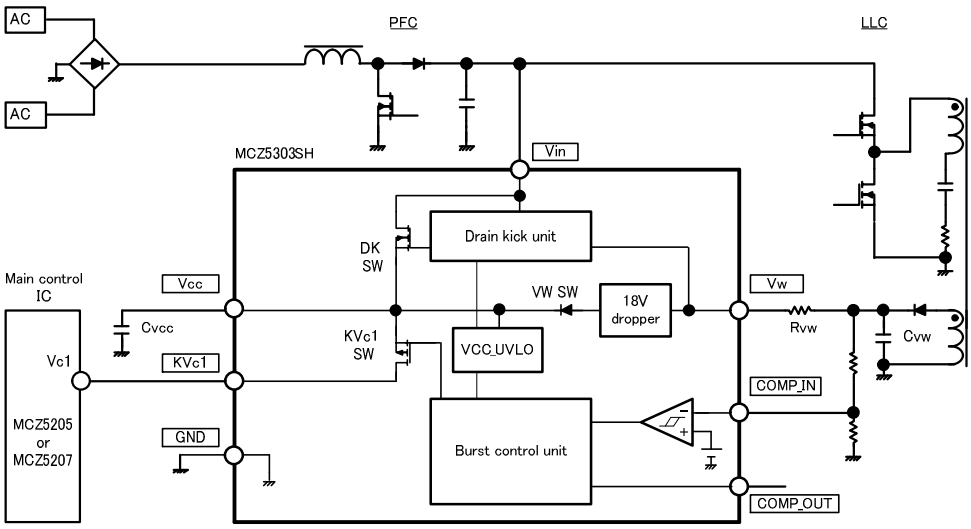


Figure 11. Connection diagram of Vcc system (MCZ5303SH)

5-6. Vw Terminal (pin6)

The Vw terminal inputs voltage in which output from the Vcc winding is rectified. The maximum input voltage of the Vw terminal is 35V. It is connected from the Vw terminal to the Vcc terminal with an 18.5V dropper circuit and a Vw switch.
When oscillation of the LLC is started and the VW terminal voltage is increased to (Vcc+1V) or more at the time of start, the start circuit stops. When the Vw terminal voltage decreases to 7.5V or below, the start circuit starts operation.
Since the maximum allowable current of the Vw terminal is 200mA, the current should be limited with resistance, etc., in consideration of charging to Cvcc when the KVc1 SW is on.

VW terminal input threshold voltage	Operation
(Vcc+1V) or more	Start circuit stop
7.5V or less	Start circuit operation start

5-7. Vin Terminal (pin7)

The Vin terminal is a terminal to supply a current from the rectified high voltage part to Vcc at the time of power supply start and consists of a high withstand voltage switch and a constant current circuit. The supply current is 14.5mA with Vin=100VDC. When Vcc is 1V, it is reduced to 2.7mA.
Operation of the high withstand voltage switch is controlled by the above-mentioned VW terminal. When the high withstand voltage switch is turned on at the time of start, charging to the Vcc terminal capacitor is started and continued until the Vcc terminal voltage is clamped to 17V. The high withstand voltage switch is turned off when the LLC converter oscillates and the voltage of the Vw terminal becomes Vcc+1V or more with supply from the primary Vcc winding.
Figure 12 is a start/stop sequence drawing when COMPin is Lo.

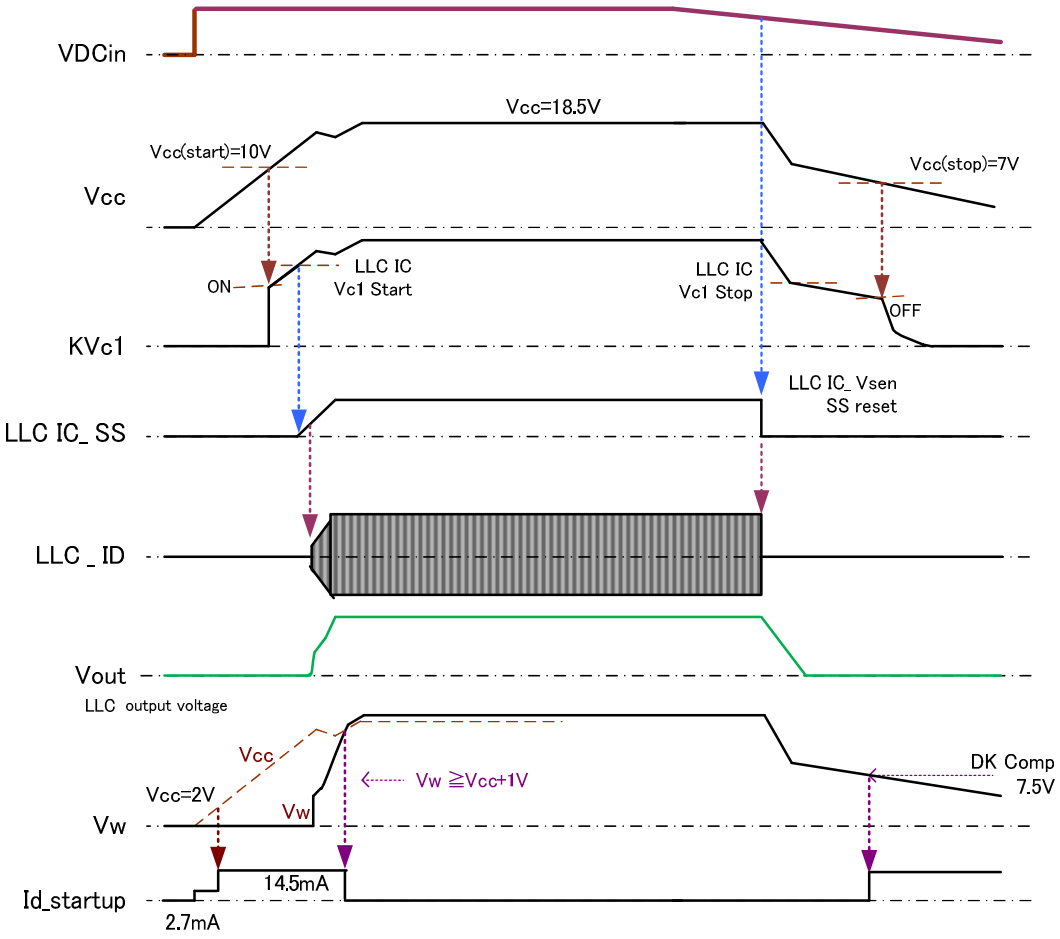
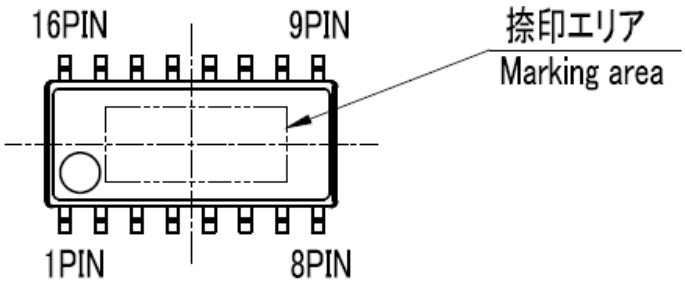
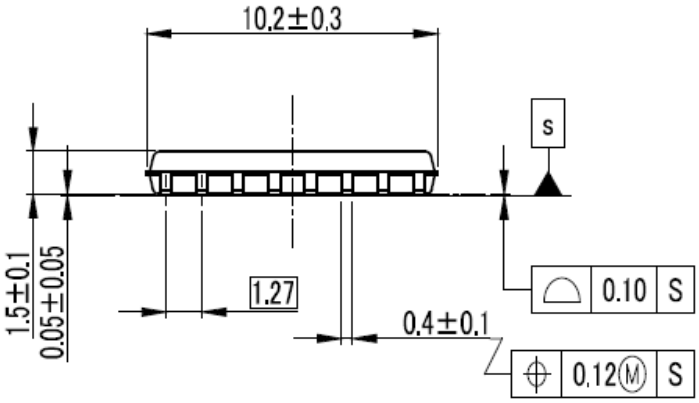


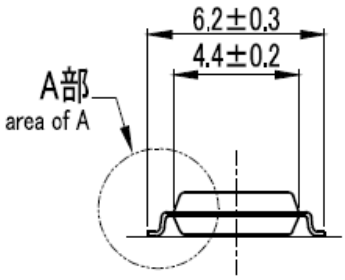
Figure 12. Start/stop sequence drawing in burst mode (MCZ5303SH)

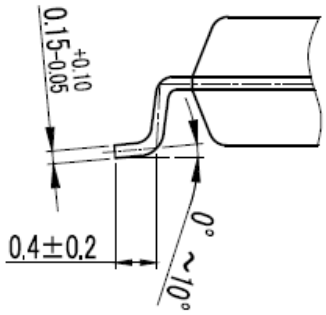
6 Package Dimensions (For Formal Dimensions, Refer to Delivery Specifications)

6.1 SOP16 (MCZ5303SG)









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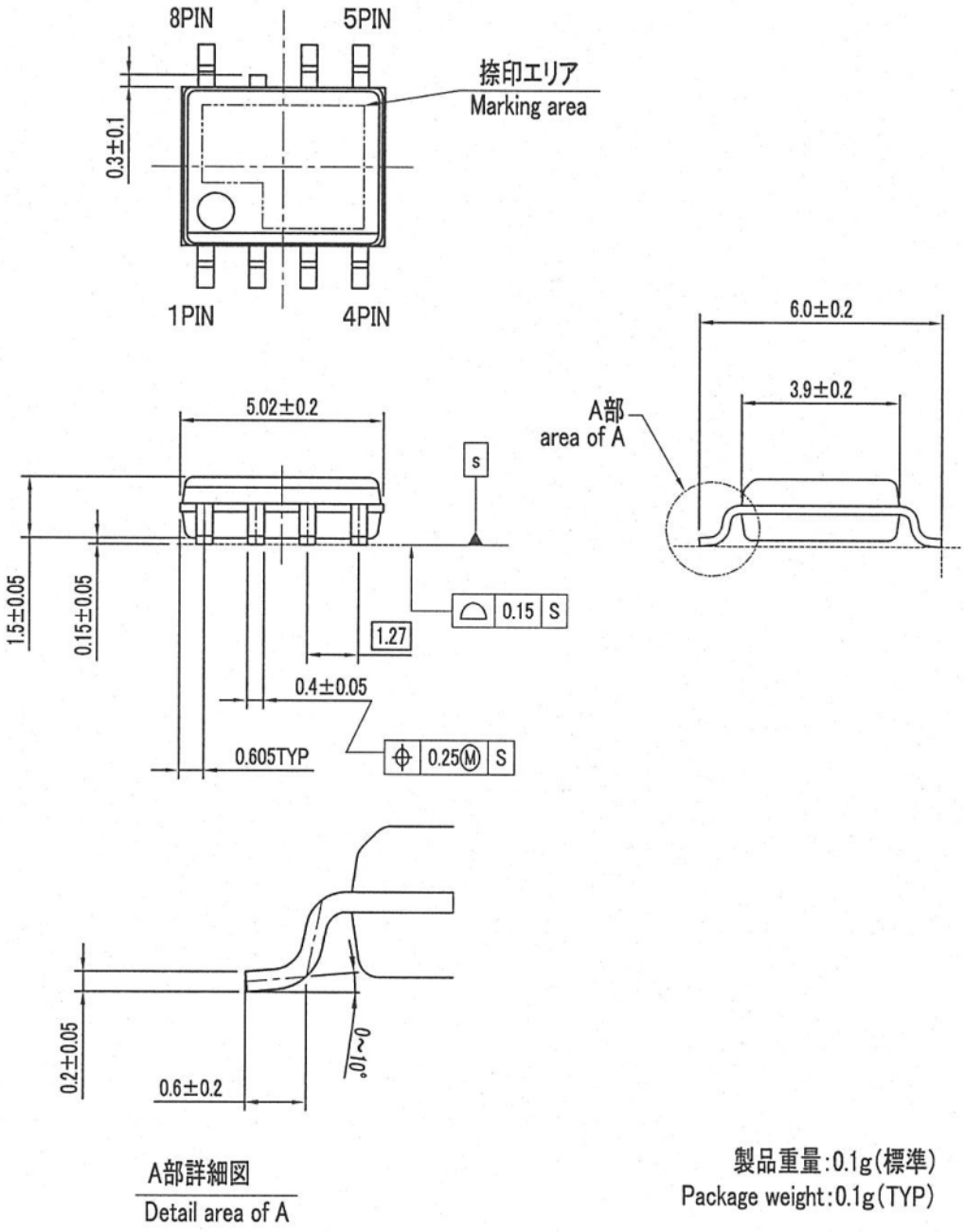
Detail area of A

6.2 SOP7J (MCZ5303SH)



7 Application Example

7.1 Main Components

<Control IC>
PFC+LLC Control ID: MCZ5205SE
Control IC for Start-up and STBY: MCZ5303SG

<Main Switch>
MOSFET for PFC: F11F60C3M（CoolMOS）
MOSFET for LLC: P6B52HP2（Hi-Pot MOS）

7.2 Power Supply Specifications

Line input voltage:	90Vrms to 264Vrms (50Hz ,60Hz)
Output in static operation:	Vo=24V Io(typ)=3.0A Io(max)=3.5A
	Vo=12V Io(typ)=1.0A Io(max)=2.0A
	Vo=5V Io=100mA Stabilization output by 5V dropper circuit
Output in standby state:	Vo=5V Io=0mA to 100mA Stabilization output by 5V dropper circuit
Standby electrical power:	50mW (100Vrms with no load)
Efficiency:	89.1% (100Vrms) 91.9% (230Vrms) Load: 24V/3.0A, 12V/1A
Power factor:	0.983PF (100Vrms) 0.955PF (230Vrms) Load: 24V/3.0A, 12V/1A
Burst control method:	Output ripple voltage With lower limit (6V) detection

7.3 About Control IC

MCZ5205SE (IC with PFC+LLC controller mixed)
The control IC is an IC with PFC and LLC integrated. It is a package of SOP22 with high functionality.

The main features are as follows.

<PFC controller part>
- Boundary-mode PFC controller
- Overcurrent detection threshold value 0.5V, detection resistance loss is reduced
- With on width (voltage) control, input line detection is not necessary
- Equipped with various protection functions
  - Feedback open/short protection
  - Overvoltage oscillation stop protection (OVP)
  - Thermal shutdown (common to LLC part)
  - Equipped with an output voltage increase protection function for light load

<LLC controller part>
- Vicinity of the gate is simplified with optimization of drive capability
- MOSFET is driven directly by a 600V high withstand voltage gate driver
- Efficiency of light load is significantly increased with an active standby function installed
- Equipped with various protection functions
  - Overcurrent protection (OCP)
  - di/dt protection
  - Timer latch
  - Insufficient voltage protection
  - Thermal shutdown (common to PFC part)

MCZ5303SG (self-start circuit + burst control function IC)

The standby converter is removed from the conventional configuration of converter dedicated to standby + main converter to realize one converter configuration while maintaining high efficiency.

The main features are as follows.

- Equipped with a drain kick (lossless start circuit)
- Input power of 50mW or less at the time of no load can be realized with a high-efficiency burst control circuit
- Equipped with an input main line sensing circuit

7.4 Circuit Block Diagram

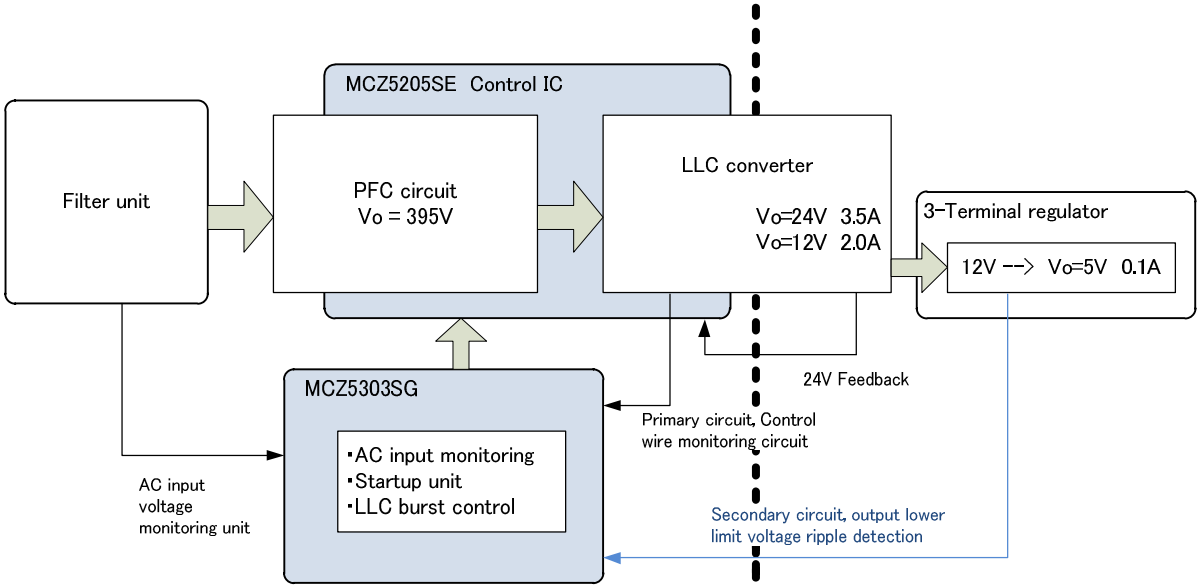


Figure -1

The main control IC MCZ5205SE controls PFC and LLC, and MCZ5303SG detects AC input and controls the start circuit and burst.
LLC outputs 24V and 12V as secondary output and performs feedback control with 24V.
At the time of standby, control is performed with ripple detection of 12V output, and standby power is supplied with 5V regulator output.

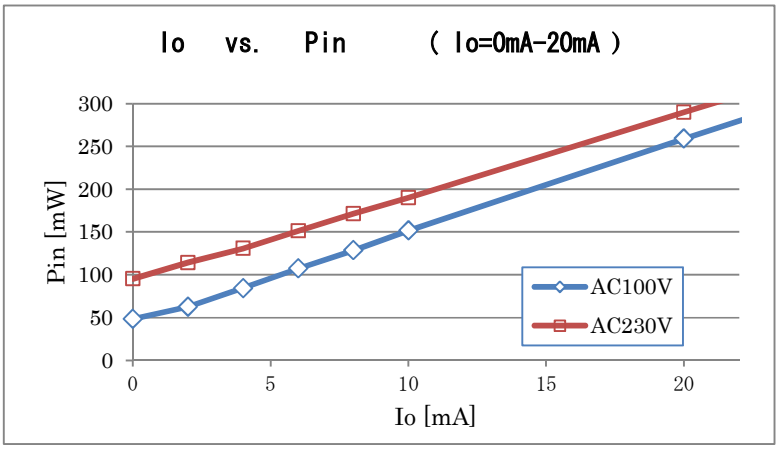
In this circuit example, the load range that can be handled is expanded by detecting the lower limit of the secondary output voltage at the time of standby. When the load is constant at the time of standby, the number of part items can be reduced by deleting the output ripple lower limit detection circuit to control only with detection of the primary side control.

7.5 Standby (Burst) Operation

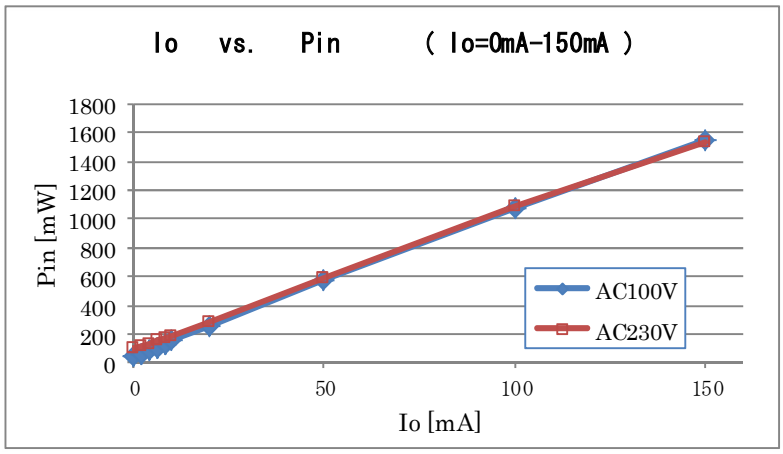
PFC is in stop state at the time of standby, and LLC performs burst oscillation with asymmetrical control. This allows low input power to be realized in wide input.
Graph 1 and 2 are those of input power at the time of standby operation. The measurement conditions are input voltage of 100Vrms and 230Vrms, and output is 5V, 0 to 150mA. Graph 1 is an enlarged graph with output current up to 20mA, and Graph 2 with up to 150mA. The input power with 100Vrms and no load is 48mW.

Input power at the time of standby operation

24V system, 12V system output: No load
Input AC voltage: YOKOGAWA WT210 integration mode



Graph 1



Graph 2

Figures 1 to 10 are burst waveforms when the load is changed from 0 to 100mA in 100Vrms and 230Vrms. The displayed waveforms are LCC switching current waveform, Vc1 voltage waveform of MCZ5205SE, and 12V output voltage waveform from the top.
The Vc1 voltage, which is the power supply of the main control IC MCZ5205SE is turned on/off in every burst duration, and start is repeated with soft start in every cycle. When the load increases and the ripple lower limit of 12V output reaches 6V, LCC is restarted and oscillates. When output voltage increases with oscillation start, oscillation is stopped. Burst operation is performed by repeating this operation. The upper limit is detected indirectly with the output voltage of the Vcc winding on the primary side and controlled. With no load, Figures 1 and 6 are in a state when the output does not reach the ripple lower limit 6V. In this case, the oscillation period and the stop period depend on voltage ripple detection of the Vcc winding output on the primary side.

At the timing of oscillation stop, the soft start circuit (SST terminal of MCZ5205SE) is also reset by the KSST terminal.

Burst operation waveform

Input AC voltage: 100Vrms, 230Vrms
Output: 5V system (via dropper) Io=0 to 100mA, no load for 24V system and 12V system output

Top: LLC switching current (high side MOSFET)	0.5A/div
Middle: KVc1 voltage (Vc1 voltage of MCZ5205SE)	5V/div
Bottom: 12V output voltage (dropper input side)	2V/div

[100Vrms] 200mSec/div **[230Vrms]** 200mSec/div

Figure 1 **Io=0mA** Cycle: 1.28Sec

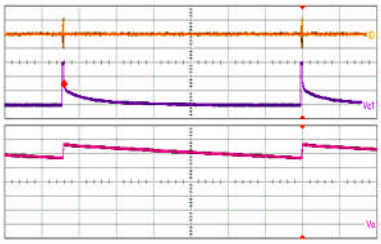


Figure 6 **Io=0mA** Cycle: 928mSec

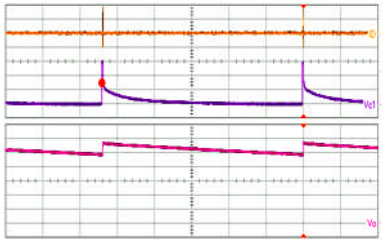


Figure 2 **Io=6mA** Cycle: 617mSec

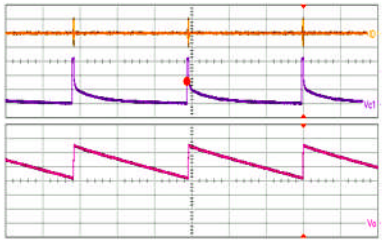


Figure 7 **Io=6mA** Cycle: 594mSec

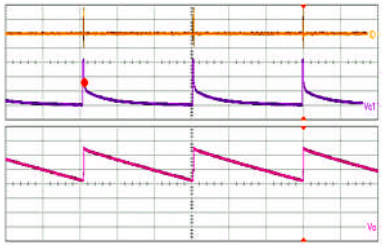


Figure 3 **Io=10mA** Cycle: 389mS

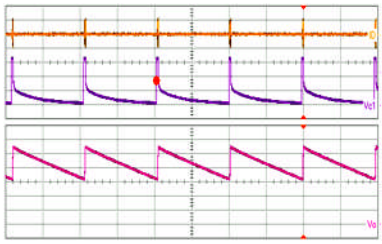


Figure 8 **Io=10mA** Cycle: 366mS

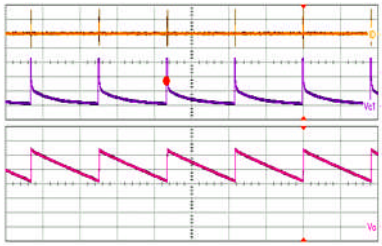


Figure 4 **Io=50mA** Cycle: 85mS

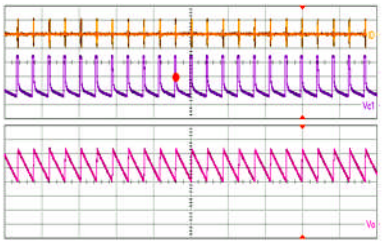


Figure 9 **Io=50mA** Cycle: 74mS

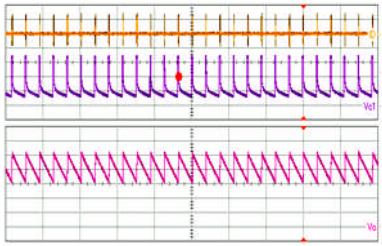


Figure 5 **Io=100mA** Cycle: 45mS

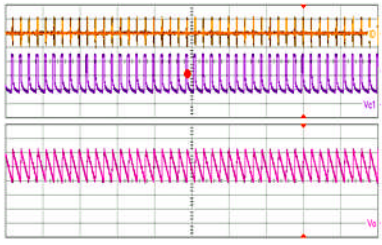
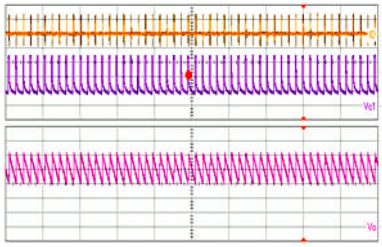


Figure 10 **Io=100mA** Cycle: 39mS



Oscillation period enlarged waveform at the time of burst

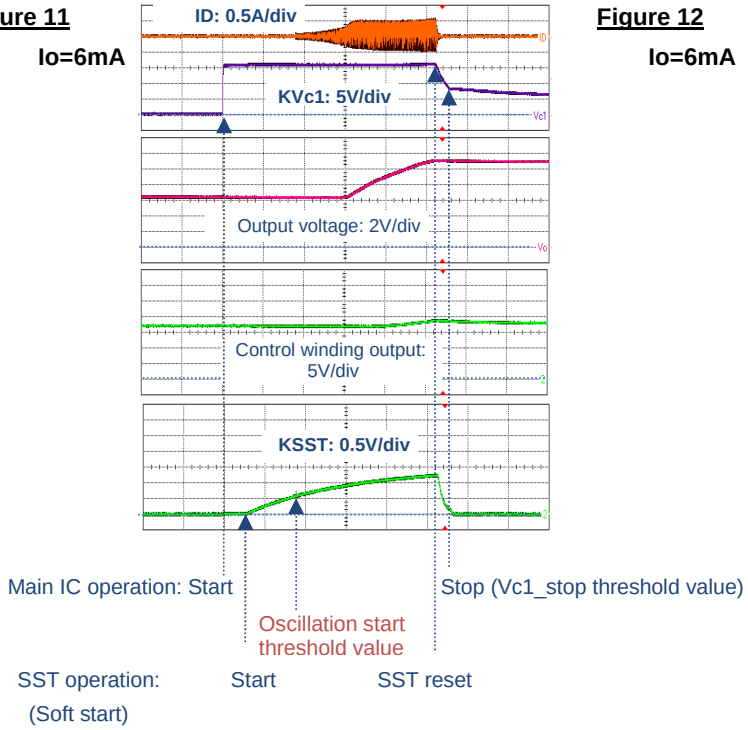
Input AC voltage: **100Vrms, 230Vrms**
Output: 5V system (via dropper) Io=6mA, no load for 24V system and 12V system output

1 : LLC switching current (high side MOSFET)	0.5A/div
2 : KVc1 voltage (Vc1 voltage of MCZ5205SE)	5V/div
3 : 12V output voltage (5V dropper input side)	2V/div
4 : Vcc winding output voltage	5V/div
5 : KSST voltage (SST of MCZ5205SE)	0.5V/div

The voltage generated in KSST is generated by charging by MCZ5205SE function.

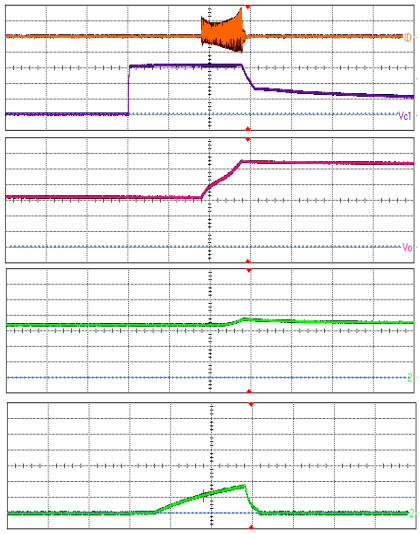
[100Vrms] 2mSec/div

Figure 11
Io=6mA



[230Vrms] 2mSec/div

Figure 12
Io=6mA



In standby mode, soft start time is switched by the SSC terminal of MCZ5303.
At the time of start and in static operation, the switch in the SSC terminal is on. The capacity of the SST terminal is 4.7uF and the soft start time is prolonged. In STBY mode, the switch in the SSC terminal is off and the parallel circuits of C307 and R314, and C214 are in serial connection. This reduces the SST terminal capacity, which shortens the soft start time. The constants of C307 and R311 are adjusted to stably oscillate in the required input range and to decrease the power at the time of standby (Figure 2).

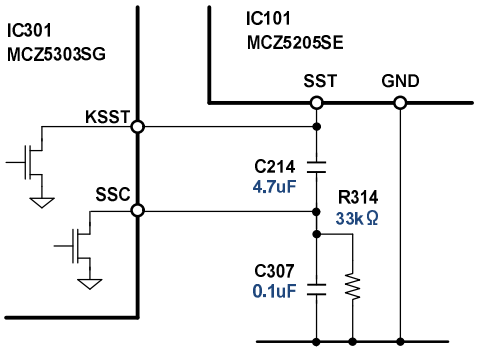


Figure -2

7.6 Start/Stop/Mode Sequential Operation

Operation waveform at the time of start

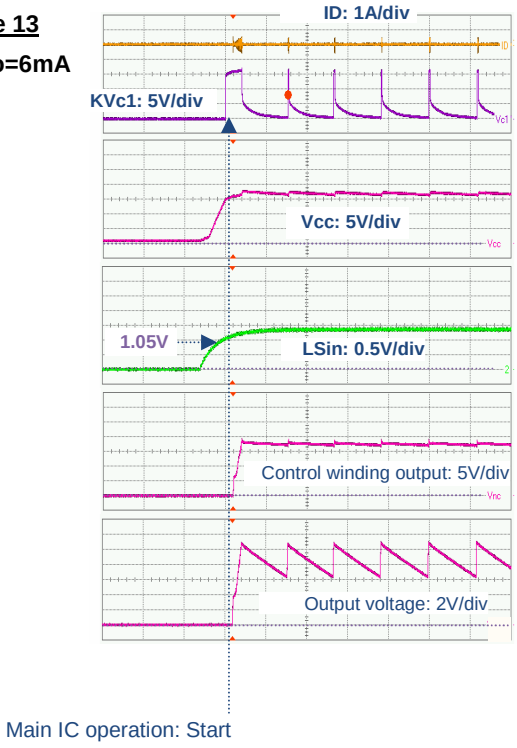
Figures 13 and 12 shows start waveforms. AC is input and the Vcc terminal capacitor C306 is charged from the Vin terminal. At the same time, voltages proportional to R301 to R304, partial voltage in R205, and AC voltage smoothed by C301 are applied to the LSin terminal, which is a terminal for input main line sensing. When this terminal voltage reaches 1.05V, oscillation is started by starting supply from Vcc to KVc1 and Vc1 of MCZ5205SE. As the condition of oscillation start, when Vcc is 10V (UVLO) or more, and the LSin terminal becomes 1.05V or more, output is made to KVc1. In 100Vrms input, the LLC controller is started with detection of LSin, however, with 230Vrms, it is started when Vcc reaches UVLO because LSin is started earlier than Vcc.

Input AC voltage: 100Vrms, 230Vrms
Output: 5V system (via dropper) Io=6mA, no load for 24V system and 12V system output

1: LLC switching current (high side MOSFET)	1A/div
2: KVc1 voltage (Vc1 voltage of MCZ5205SE)	5V/div
3: Vcc	5V/div
4: LSin	0.5V/div
5: Vcc winding output voltage	5V/div
6: 12V output voltage (5V dropper input side)	2V/div

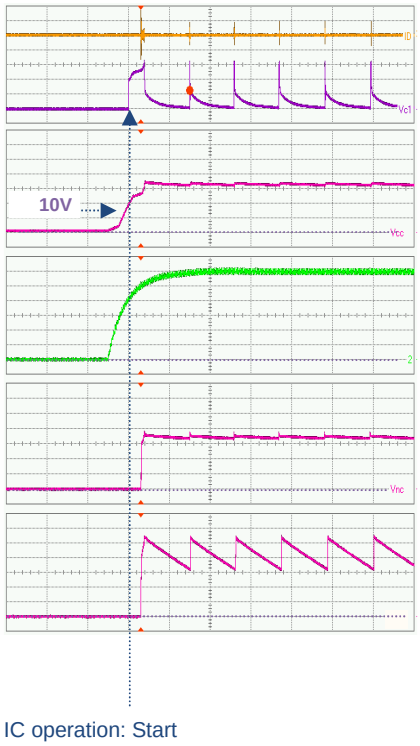
[100Vrms] 500mSec/div

Figure 13
Io=6mA



[230Vrms] 500mSec/div

Figure 14
Io=6mA



Operation waveform at the time of stop

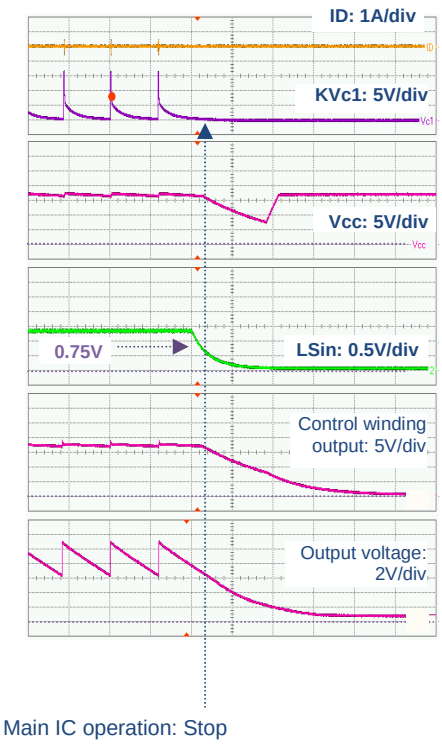
Figures 15 and 16 shows waveforms at the time of stop. When input main voltage is disconnected, the voltage of the LSin terminal decreases. When the LSin terminal voltage becomes 0.75V or below, output to KVc1 is stopped and MCZ5025SE stops operation.
The Vcc voltage once decreases after oscillation stop. Since main bulk voltage still remains in input smoothing capacitor C106, the start circuit operates again when the Vw terminal voltage decreases to 7.5V, and the voltage increases again. After that, it decreases with decrease of the input smoothing capacitor voltage.

Input AC voltage: 100Vrms, 230Vrms
Output: 5V (via dropper) Io=6mA, no load for 24V and 12V output

1: LLC switching current (high side MOSFET)	1A/div
2: KVc1 voltage (Vc1 voltage of MCZ5205SE)	5V/div
3: Vcc	5V/div
4: LSin	0.5V/div
5: Vcc winding output voltage	5V/div
6: 12V output voltage (5V dropper input side)	2V/div

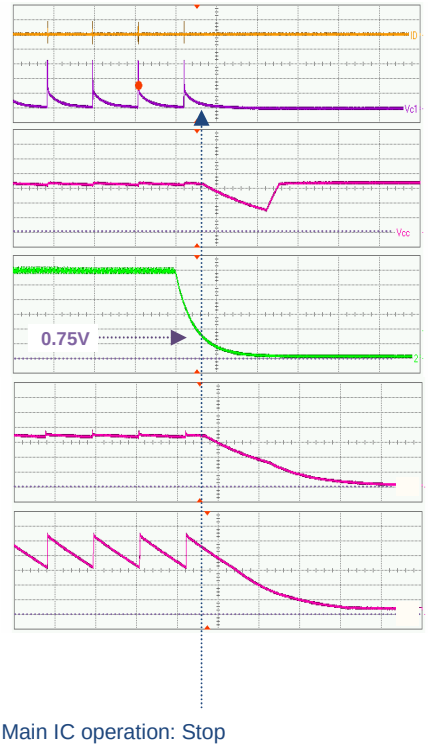
[100Vrms] 500mSec/div

Figure 15
Io=6mA



[230Vrms] 500mSec/div

Figure 16
Io=6mA



Operation waveform at the time of mode switching

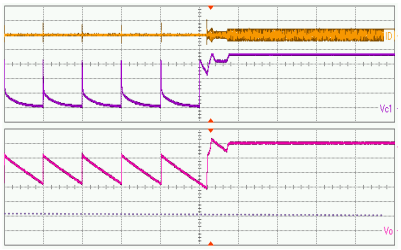
Figures 17 and 18 are operation waveforms when standby mode is switched to normal oscillation mode. In addition, figures 17 and 18 are waveforms when normal oscillation mode is switched to standby mode. Burst operation is cancelled when standby mode is switched to normal mode. With operation of PFC, the LLC operation is switched from asymmetrical control to symmetrical control.

Input AC voltage: 100Vrms, 230Vrms
Output: 5V (via dropper) Io=6mA, no load for 24V and 12V output

Top: LLC switching current (high side MOSFET)	0.5A/div
Middle: KVc1 voltage (Vc1 voltage of MCZ5205SE)	5V/div
Bottom: 12V output voltage (dropper input side)	2V/div

[100Vrms] 500mSec/div

Figure 17
From STBY to ON



[230Vrms] 500mSec/div

Figure 18
From STBY to ON

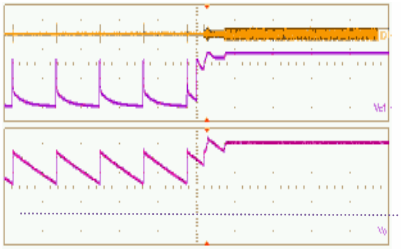


Figure 19
From STBY to ON

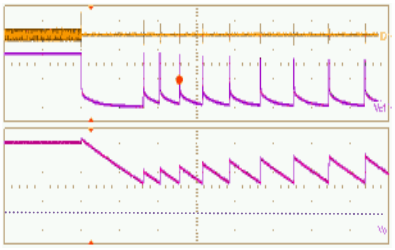
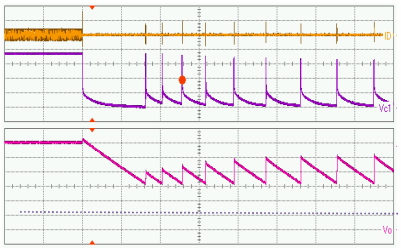


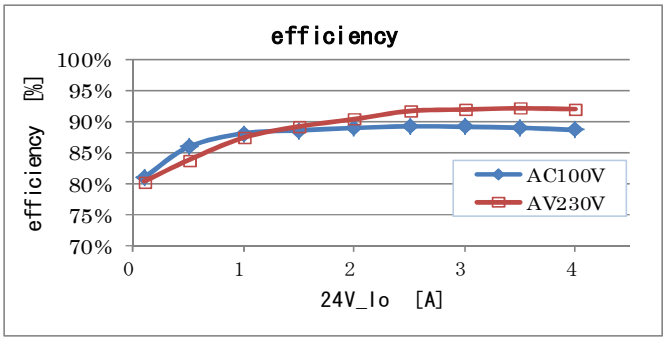
Figure 20
From STBY to ON



7.7 Static Operation

AC-DC efficiency vs output power characteristics

Measurement condition
Input: 100Vrms, 230VAV
Output: 24V system Io=0.1A to 4A, 12V system Io=1.0A fixed, 5V system no load



Graph 1

Temperature increase of main part T

Measurement condition
Input: 100Vrms, 230Vrms
Output: 24V system Io=3.0A, 12V system Io=1.0A fixed, 5V system no load

Unit: °C

Input voltage	D101	L111		T201		Q111	Q201
	B.D	PFC core	PFC line surface	LLC core	LLC line surface	PFC MOS	LLC MOS
100Vrms	43.9	30.4	35.2	25.6	26.4	34	22.7
230Vrms	21.9	19.5	21.9	24.8	25.8	32.2	22.5

Operation waveform at the time of max load

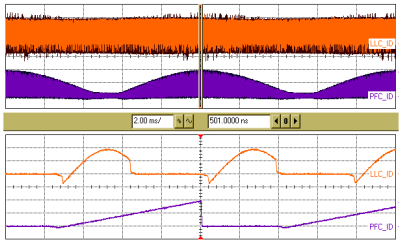
Input AC voltage: 100Vrms, 230Vrms
Output: 24V system Io=3.5V, 12V system Io=1.0A

Top: LLC switching current (high side MOSFET)	0.5A/div
Bottom: PFC switching current	0.2A/div

[100Vrms] Upper row: 2mSec/div
Enlarged lower row: 2uSec/div

Figure 21

Max load

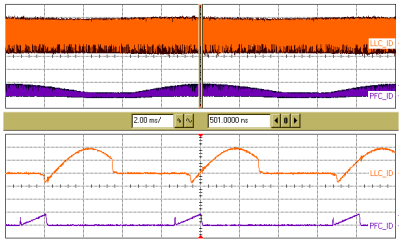


Frequency around peak
LLC 124kHz
PFC 86kHz

[230Vrms] Upper row: 2mSec/div
Enlarged lower row: 2uSec/div

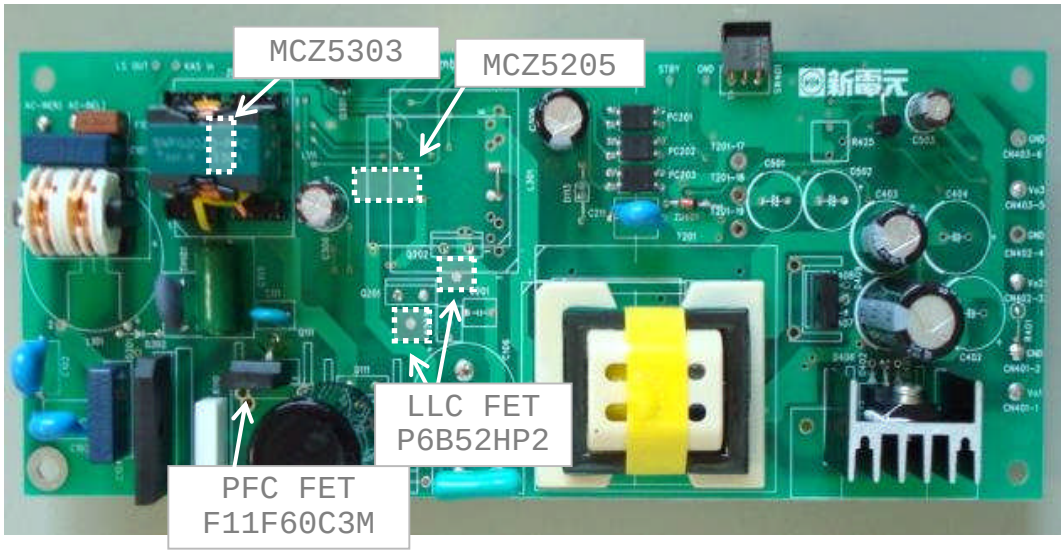
Figure 22

Max load



LLC 124kHz
PFC 133kHz

7.8 Figure of Actual PSU



: Installed on the back side of the substrate

7.9 Circuit Diagram