Secondary-side Control for Energy-Saving AC Adaptor
Monolithic IC MM1548

Outline

This IC is a secondary-side control IC for AC adaptors with energy-saving mode. The energy-saving mode function operates when charging is completed or when a set is disconnected, thus greatly reducing power consumption in an AC adaptor.
When a set is connected, the IC automatically enters normal mode to start charging.
Compared to the conventional MM1529, this IC is smaller and has fewer external components.

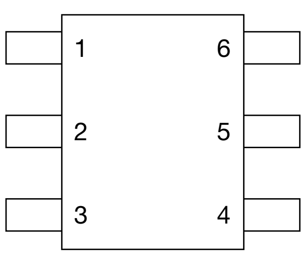
Features

1. Automatic switching between energy-saving mode and normal mode
2. Current consumption (energy-saving mode) 60μA
3. Current consumption (normal mode) 1.5mA
4. Controls the oscillator on the primary side using one photocoupler.
5. One photocoupler is used for constant-voltage/constant-current control and switching between energy-saving and normal modes.

Package

SOT-26A

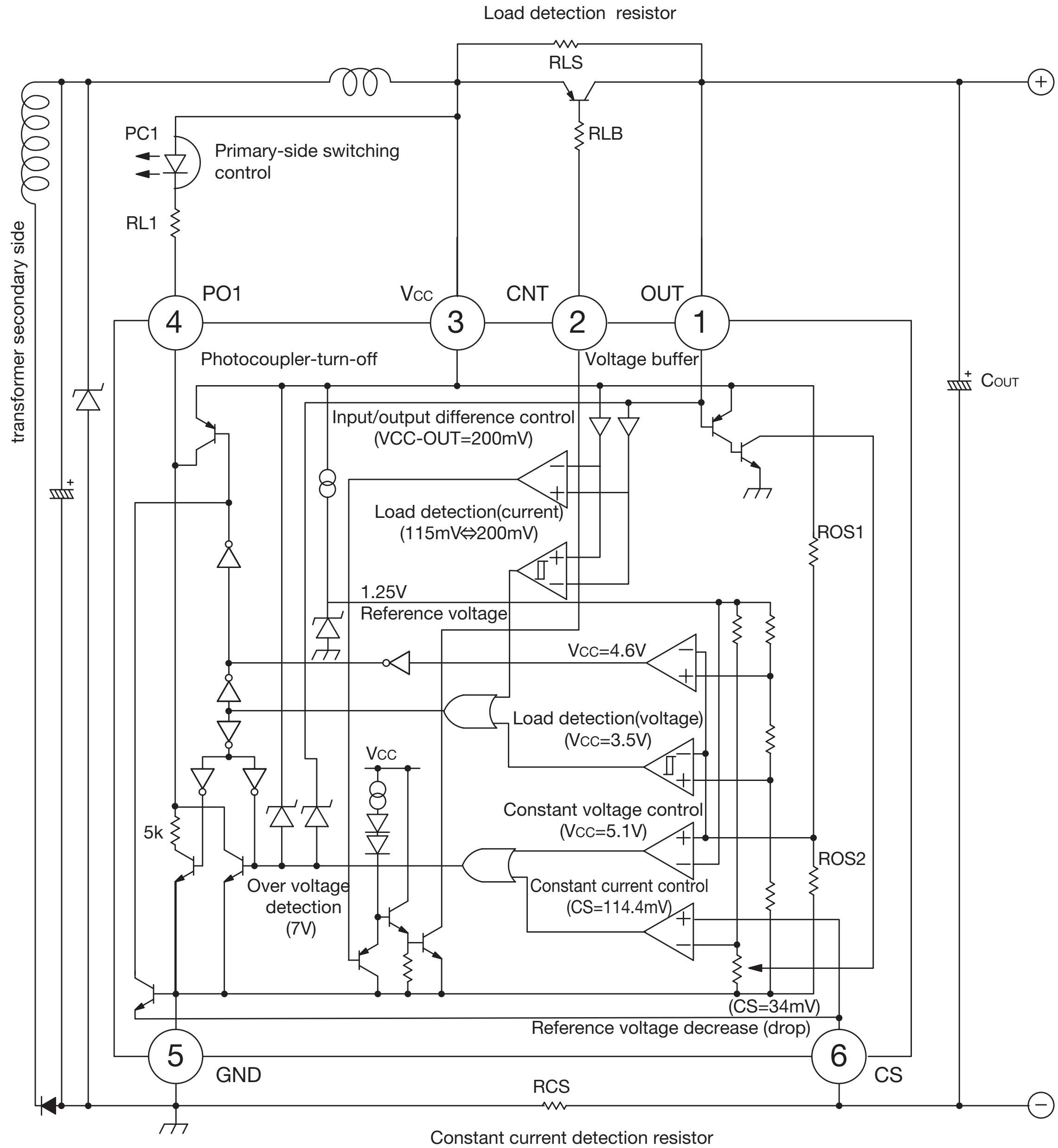
Pin Assignment



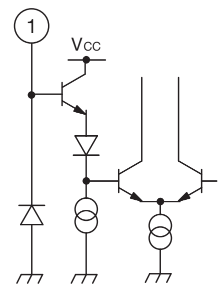
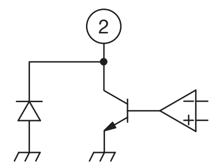
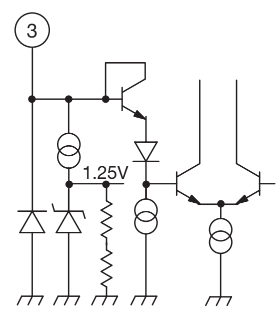
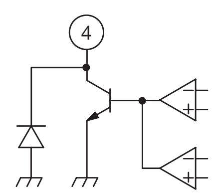
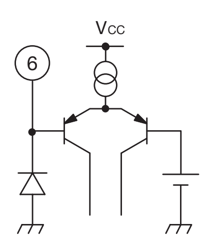
SOT-26A

1	OUT	4	PO1
2	CNT	5	GND
3	V_{CC}	6	CS

Block Diagram



Pin Description

Pin No.	Pin Name	Function	Internal equivalent circuit
1	OUT	Output (+) pin. Connect Registor for load detection between Vcc pin, and connect collector of PNP power transistor.	
2	CNT	PNP power transistor control pin. Connect base of PNP power transistor.	
3	Vcc	(+) power supply pin. This pin doubles load detection pin. Connect load detection resistor between OUT pin, and connect emitter of PNP power transistor.	
4	PO1	Photo diode drive pin of photocoupler for constant-current and constant-voltage control. Connect to cathode of diode.	
5	GND	Ground pin.	
6	CS	Overcurrent detection pin. This pin doubles as output- pin. Connect Resistor for overcurrent detection between GND pin.	

Absolute Maximum Ratings (Ta=25°C)

Item	Symbol	Ratings	Unit
Storage temperature	T_{STG}	–40~+125	°C
Operating temperature	T_{OPR}	–30~+85	°C
Supply voltage	V_{CC} max.	–0.3~+18	V
Allowable loss	Pd	150 (alone)	mW

Recommended Operating Conditions

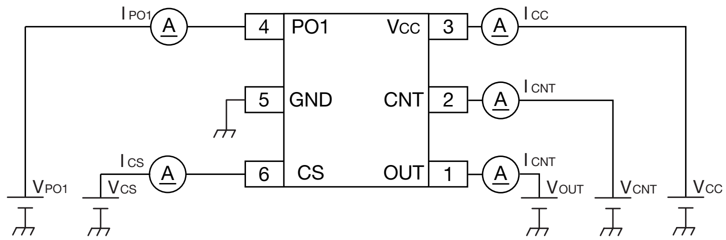
Item	Symbol	Ratings	Unit
Operating temperature	T_{OPR}	–30~+85	°C
Supply voltage	V_{OP}	+2.5~+12	V

Electrical Characteristics (unless otherwise specified, Ta=+25°C, Vcc=4.9V)

Item	Symbol	Test Conditions	Min.	Typ.	Max.	Unit.
Current consumption1(energy saving mode)	I_{CC1}	V_{CC}=4.4V, V_{OUT}=4.4V, V_{CS}=0V		60	110	µA
Current consumption2(normal mode)	I_{CC2}	V_{CC}=5.3V, V_{OUT}=5.0V, V_{CS}=0V		1.5	3.0	mA
Voltage control section						
Output inversion voltage	V_O	I_{IN}=5mA, V_{OUT}=V_{CC}–0.3V, V_{CS}=0V	4.99	5.10	5.21	V
OUT input sink current	I_{OUT}	V_{CC}=4.9V, V_{OUT}=4.9V, V_{CS}=0V		25	150	nA
PO1 output sink current 1	I_{PO1}	V_{CC}=5.3V, V_{OUT}=5.0V, V_{CS}=0V V_{PO1}=0.5V	5	17		mA
Constant current control						
Output inversion voltage 1 (Constant current control)	V_{CS1}	V_{CC}=4.9V, R_{CS1}=1kΩ, V_{OUT}=4.6V, R_{CS2}=40kΩ, I_{IN}=5mA	111.2	114.4	117.6	mV
Output inversion voltage 2 (Constant current control drop)	V_{CS2}	V_{CC}=2.0V, R_{CS1}=1kΩ, V_{OUT}=0V, R_{CS2}=40kΩ, I_{IN}=5mA	22	34		mV
CS input source current	I_{CS}	V_{CC}=4.9V, V_{OUT}=4.6V, V_{CS}=0.1V		5	100	nA
Power supply voltage rejection ratio	PSRR2	V_{CC}=3.7V→4.4V, V_{CS}=V_{CS1}–10mV, R_{L1}=5kΩ	60	70		dB
PO1 output sink current 2	I_{PO2}	V_{CC}=4.9V, V_{OUT}=4.6V, V_{CS}=0.2V, V_{PO1}=0.5V	5	17		mA
Input-output difference control						
Input-output difference control voltage	$\triangle V_{LS}$	V_{CC}=5.1V, R_{LS}=4.7kΩ, R_{LB}=100Ω, R_O=5kΩ	140	200	260	mV
CNT output sink current	I_{CNT}	V_{CC}=5.1V, V_{OUT}=4.8V, V_{CS}=0V, V_{CNT}=0.8V	5	30		mA
Load detection						
Load detection voltage	$\triangle V_{LSP1}$	V_{CC}=4.9V, R_{L1}=47kΩ, V_{OUT}=4.9V→L, V_{CS}=0V	170	200	230	mV
Energy saving detection voltage (load detection release voltage)	$\triangle V_{LSP2}$	V_{CC}=4.9V, R_{L1}=47kΩ, V_{OUT}=L→4.9V, V_{CS}=0V	85	115	145	mV
3.5V undervoltage detection	V_{OL1}	V_{CC}=H→L, R_{L1}=10kΩ, V_{OUT}=V_{CC}, V_{CS}=0V	3.4	3.5	3.6	V
3.5V undervoltage detection hysteresis	V_{OL1H}	V_{CC}=L→H, R_{L1}=10kΩ, V_{OUT}=V_{CC}, V_{CS}=0V		350		mV
4.6V undervoltage detection	V_{OL2}	V_{CC}=H→L, R_{L1}=47kΩ, V_{OUT}=V_{CC}, V_{CS}=0V	4.47	4.60	4.73	V
PO1 output sink current 3	I_{PO3}	V_{CC}=4.9V, V_{OUT}=4.6V, V_{CS}=0V, V_{PO2}=1.0V	100	200	400	µA
PO1 output source current	I_{PO4}	V_{CC}=4.9V, V_{OUT}=4.9V, V_{CS}=0V, V_{PO2}=4.6V	1.0	5.0		mA
Constant current mode selection						
2pin(CNT pin) disable voltage	V_{CNTO}	V_{CC}=H→L, V_{CNT}=0.8V, V_{OUT}=V_{CC}–0.3V, V_{CS}=0V, I_{CNT} < 1mA		2.4		V
Constant current mode selection threshold (between V_{CC} and OUT)	V_{CSS}	V_{CC}=4.9V, R_{CS1}=1kΩ, V_{OUT}=4.6V, R_{CS2}=20kΩ, I_{IN}=5mA, V_{CS} < V_{CS} min.		0.6		V

Measuring Circuit 1

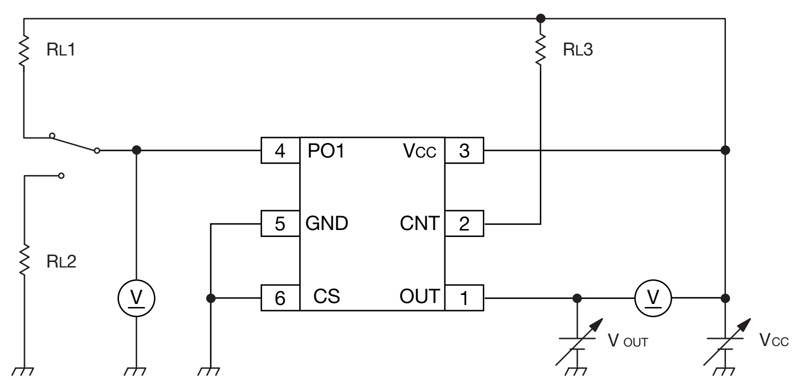
I_{CC1}, I_{CC2}, I_{OUT}, I_{CS}, I_{PO1}, I_{PO2}, I_{PO3}, I_{PO4}, I_{CNT}



	V_{CC}	V_{OUT}	V_{CS}	V_{PO1}	V_{CNT}
I_{CC1}	4.4V	4.4V	0.0V	OPEN	OPEN
I_{CC2}	5.3V	5.0V	0.0V	OPEN	OPEN
I_{OUT}	4.9V	4.9V	0.0V	OPEN	OPEN
I_{CS}	4.9V	4.9V	0.1V	OPEN	OPEN
I_{PO1}	5.3V	5.0V	0.0V	0.5V	OPEN
I_{PO2}	4.9V	4.6V	0.2V	0.5V	OPEN
I_{PO3}	4.9V	4.6V	0.0V	1.0V	OPEN
I_{PO4}	4.9V	4.9V	0.0V	4.6V	OPEN
I_{CNT}	5.1V	4.8V	0.0V	OPEN	0.8V

Measuring Circuit 2

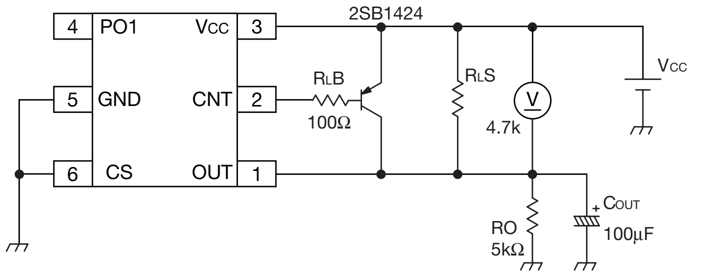
⊿V_{LSP1}, ⊿V_{LSP2}, ⊿V_{OL1}, ⊿V_{OL2}



	V_{CC}	V_{OUT}	V_{CS}	V_{PO1}	V_{CNT}
⊿V_{LSP1}	4.9V	4.9→4.6V	0V	R_{L1}=47kΩ	R_{L3}=10kΩ
⊿V_{LSP1}	4.9V	4.6→4.9V	0V	R_{L1}=47kΩ	R_{L3}=10kΩ
V_{OL1}	3.7→3.3V	V_{CC}	0V	R_{L1}=10kΩ	OPEN
V_{OL2}	4.8→4.4V	V_{CC}	0V	R_{L2}=47kΩ	OPEN

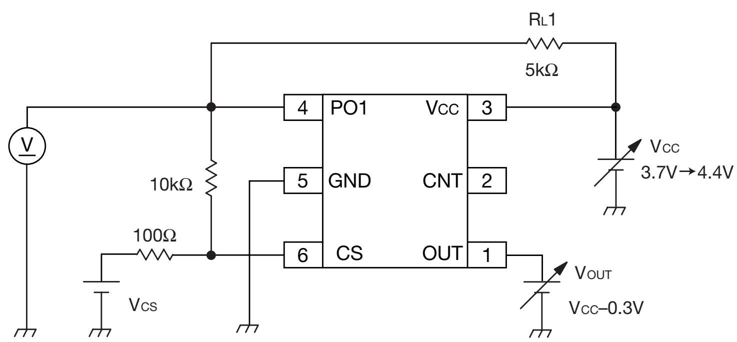
Measuring Circuit 3

⊿V_{LS}



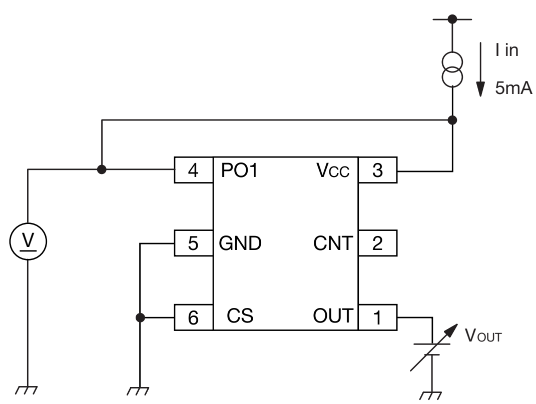
Measuring Circuit 4

PSRR2



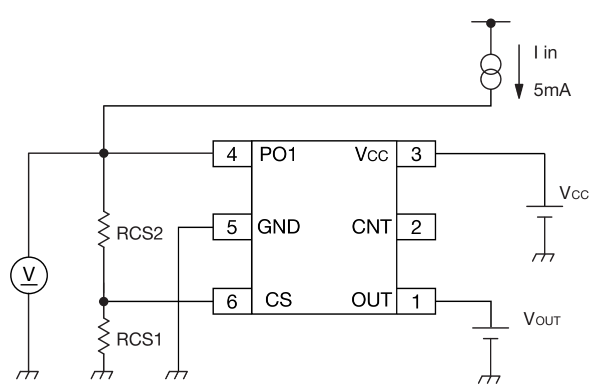
Measuring Circuit 5

V_O

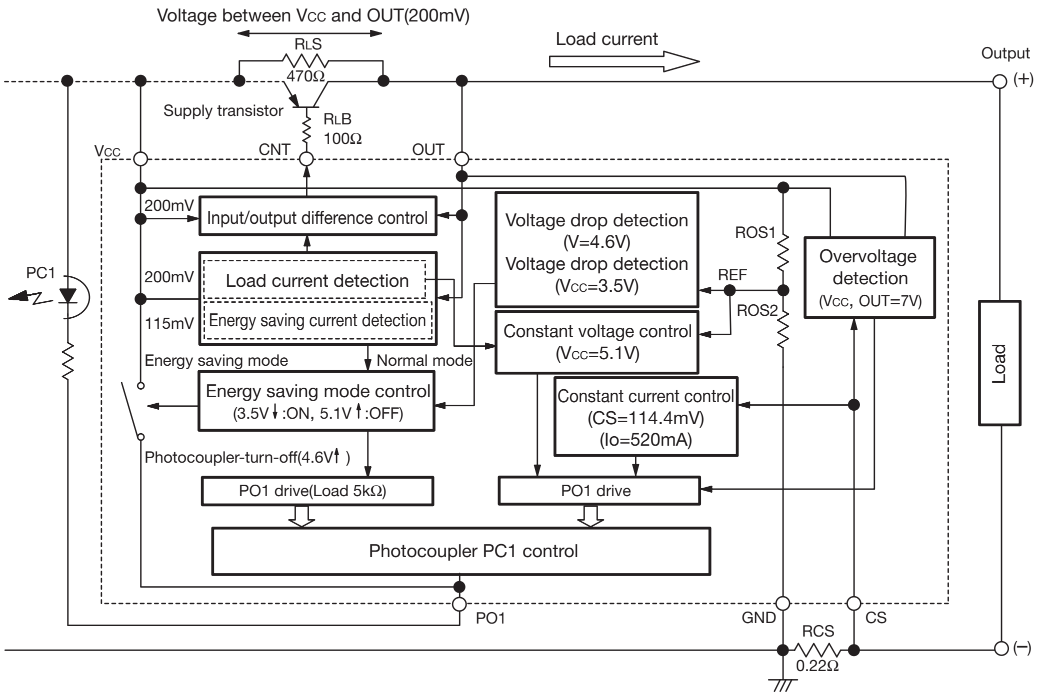


Measuring Circuit 6

V_{CS1}, V_{CS2}



Operation



1. Operation of Blocks

1.1 Input/output difference control

In the normal mode that a load current is detected and the system supplies the load current through the Supply Transistor (PNP type), MM1548 controls CNT current flowing into the base of Supply Transistor to keep the differential voltage between V_{CC} and OUT (Vce of Supply Transistor) at 200mV.

1.2 Load current detection and Energy saving current detection

When load current increases in energy saving mode and the differential voltage between V_{CC} and OUT exceeds ΔV_{LSP1} (200mV), MM1548 changes to the normal mode, PO1 switches from open to low mode, and the photocoupler PC1turns on. As a result, the system switches primary-side switching operation to normal mode from disabled.

The switching voltage has following hysteresis if load current is increasing (ΔV_{LSP1}) or decreasing (ΔV_{LSP2}).

(hysteresis: ΔV_{LSP1} = 200mV ⇔ ΔV_{LSP2} = 115mV)

When the differential voltage between V_{CC} and OUT falls to ΔV_{LSP2} (115mV), MM1548 changes to the energy saving mode, and the photocoupler-turn-off circuit switches compulsory photocoupler current to zero under the condition that load current is decreasing in normal mode and Vcc = 4.6V or more.

1.3 Voltage drop detection

When V_{CC} voltage falls to 4.6V in the energy saving mode, MM1548 stops the photocoupler-turn-off circuit operation to save consumption current of MM1548.

When V_{CC} voltage falls to 3.5V in the energy saving mode, MM1548 changes to the normal mode.

As a result, Out voltage (output of secondary side) swings intermittent between 4.9V and 3.5V.

1.4 Constant current control

When load current is increasing in the normal mode, and the differential voltage between CS and GND exceeds V_{CS1} (114.4mV typ.), PO1 switches from open to low mode, and the photocoupler PC1 turns on. As a result, MM1548 changes to the CC(constant current) mode, and the load current is controlled that CS voltage keeps V_{CS1}.

1.5 Constant voltage control

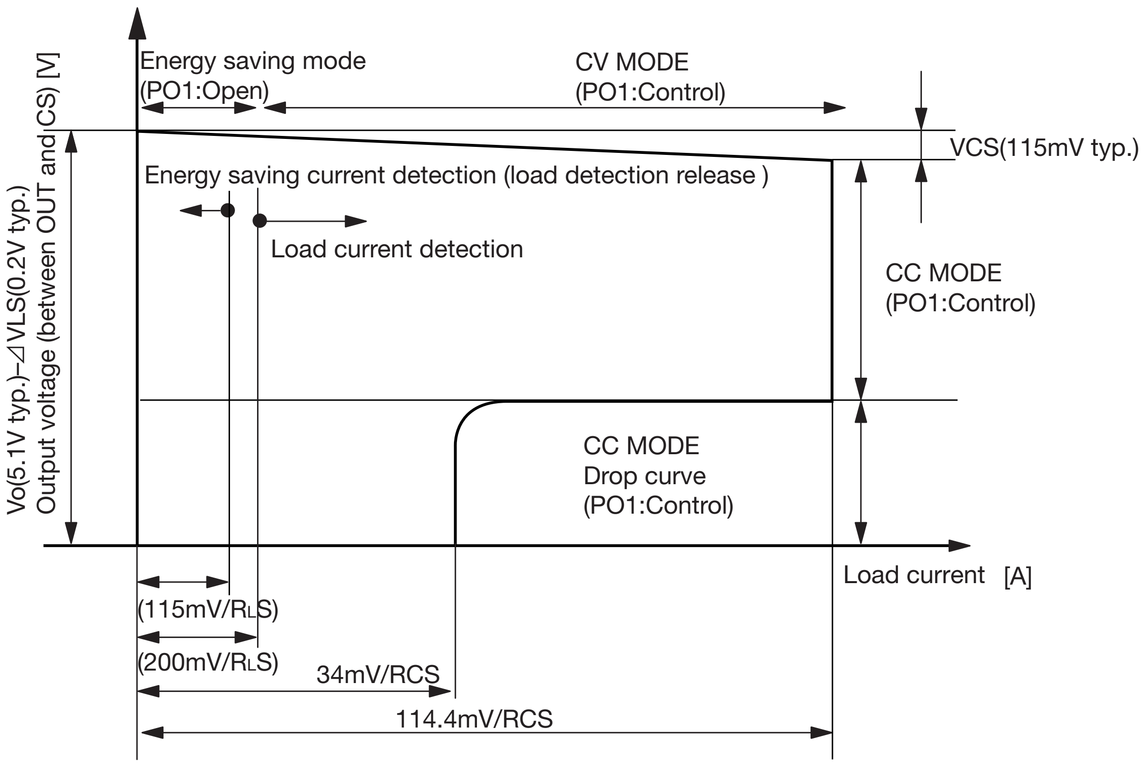
When MM1548 is in normal mode and isn't in constant current mode, it is in CV(constant voltage) mode, and PO1 current is controlled that V_{CC} voltage keeps 5.1V (equal to internal 1.25V: REF voltage).

1.6 Overvoltage detection

When V_{CC} voltage or OUT voltage exceeds 7V (overvoltage), overvoltage detection circuit turn on.
As a result, PO1 sink current is controlled to turn on the photocoupler PC1, and system is protected from overvoltage.
This circuit also detects negative voltage applied CS pin, and when it is detected, PO1 current is turned off for overvoltage protection.

2. Design principles for each mode

AC adaptor output is controlled by following 4 mode under usage with MM1548.
Switching of each control mode is explained as follow.



2.1 for Output voltage

In MM1548 series, the output voltage can't be adjusted by external resistor, because referential voltage terminal (REF pin) for adjustment is build in the chip.
Instead of voltage adjustment, you can chose output voltage by select the rank of MM1548 series.
Output voltage is lower 0.2V (equal to in-out differential control voltage) than 5.1V (equal to the value set by ROS1 and ROS2).

[Formula]

Output voltage

= Vo – ⊿VLS

= {1+(ROS1/ ROS2)} ×1.25 – ⊿VLS (Vo = 5.1V)

= {1+(2460k/800k)} ×1.25 – 0.2 (⊿VLS = 0.2V)

= 4.9V

2.2 for Constant current detection (RCS adjust method)

Constant current value is set by RCS value as load detection resistor.

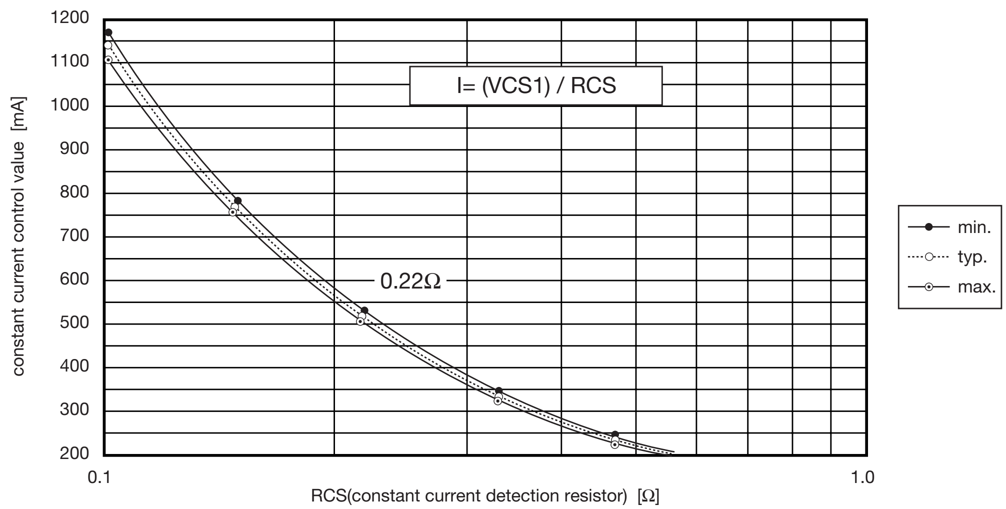
On the design, constant current operation changes when [load current] > 520[mA] in the case of 0.22Ω use.

[Formula]

[Constant current control] = V_{CS1} / RCS ((V_{CS1} = 114.4mV)

[Drop curve] = V_{CS2} / RCS (V_{CS2} = 34mV)

RCS(constant current detection resistor) - constant current control value



2.3 Description of load detection and energy saving detection (R_{LS} adjust method)

Load detection current and energy saving detection current is set by R_{LS} as load detection resistor.

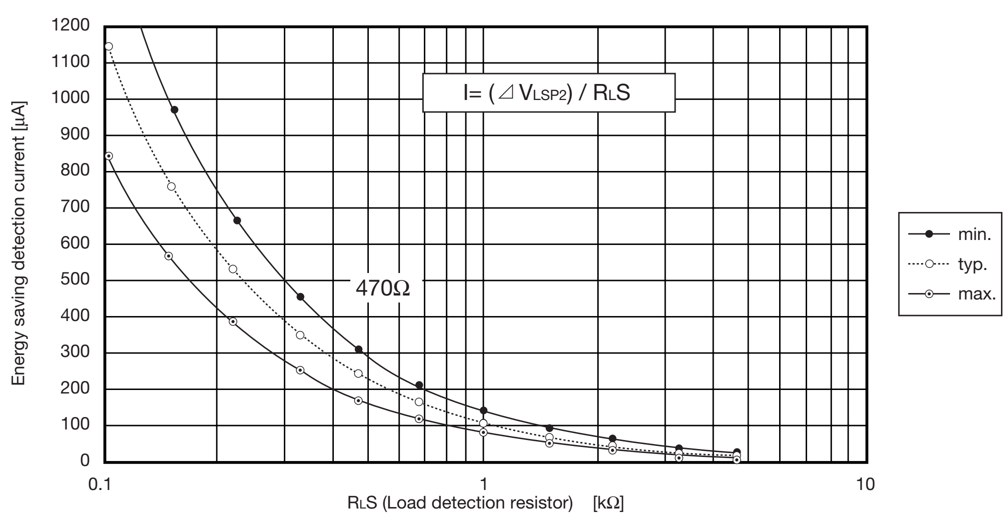
On the design, each current changes when [current flows through R_{LS}] > 240µA, in the case of 470Ω use.

[Formula]

[Load detection current] = (⊿V_{LSP1} / R_{LS}) (⊿V_{LSP1} = 200mV)

[Energy saving detection current] = (⊿V_{LSP2} / R_{LS}) (⊿V_{LSP2} = 115mV)

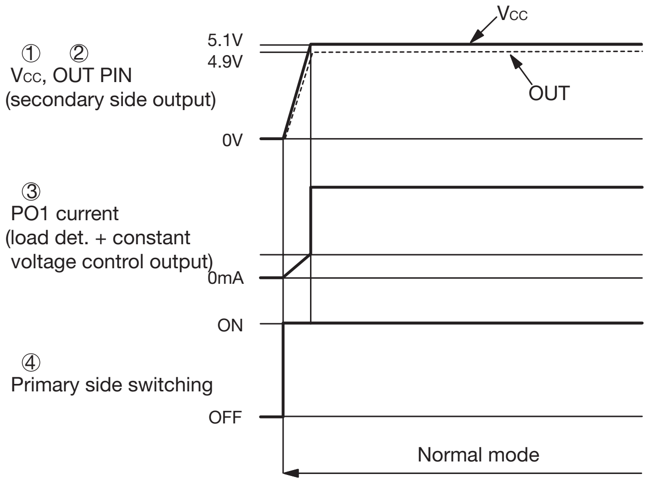
R_{LS} (Load detection resistor) - Energy saving detection current



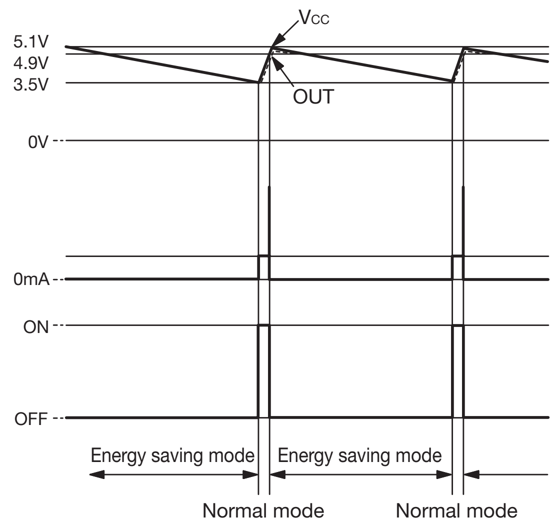
Timing Chart

Constant voltage control

Normal mode [Io>115mV / RLS]

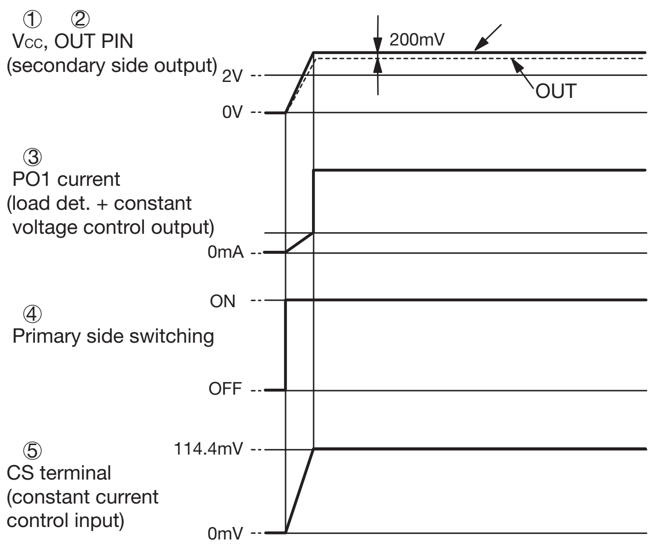


Energy saving mode [Io<115mV / RLS]

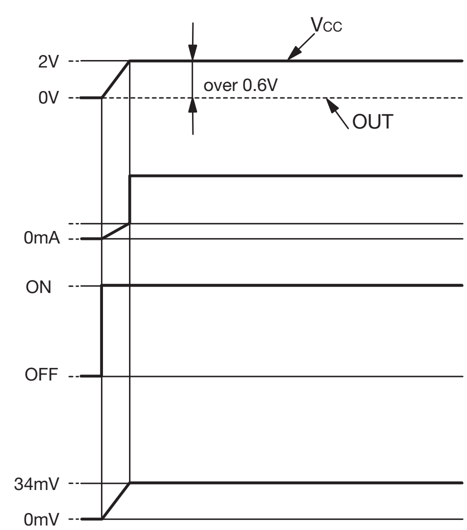


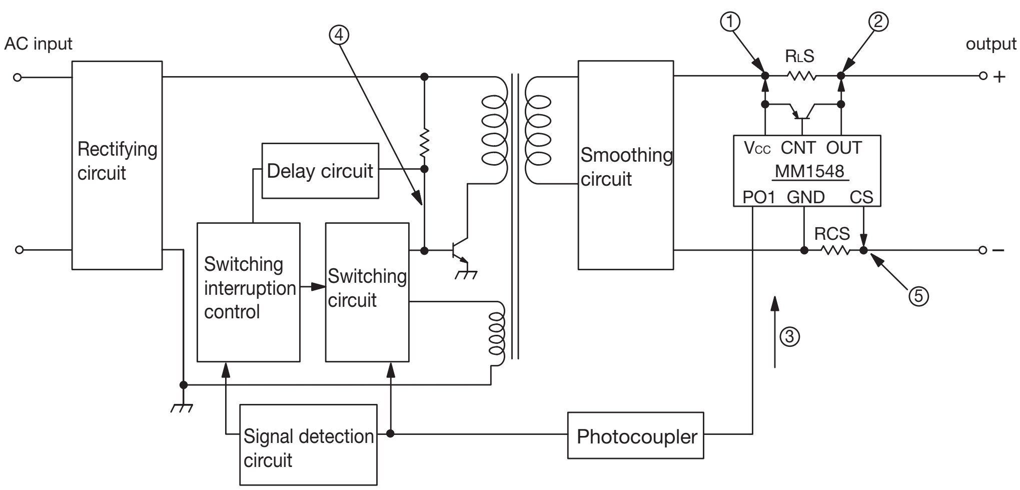
Constant current control

Normal control [Vcc>2.0V]



Drop control [Vcc<2.0V]

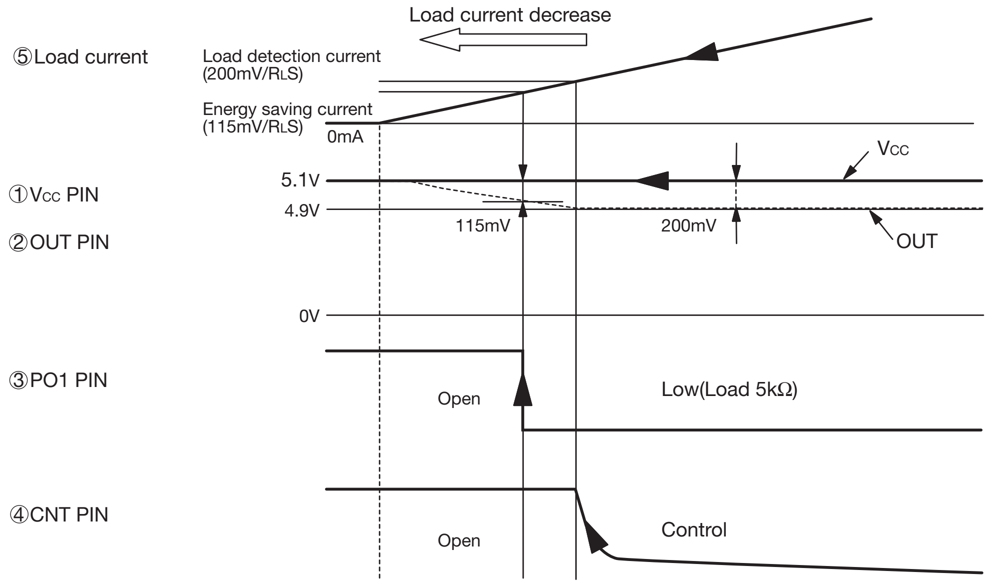




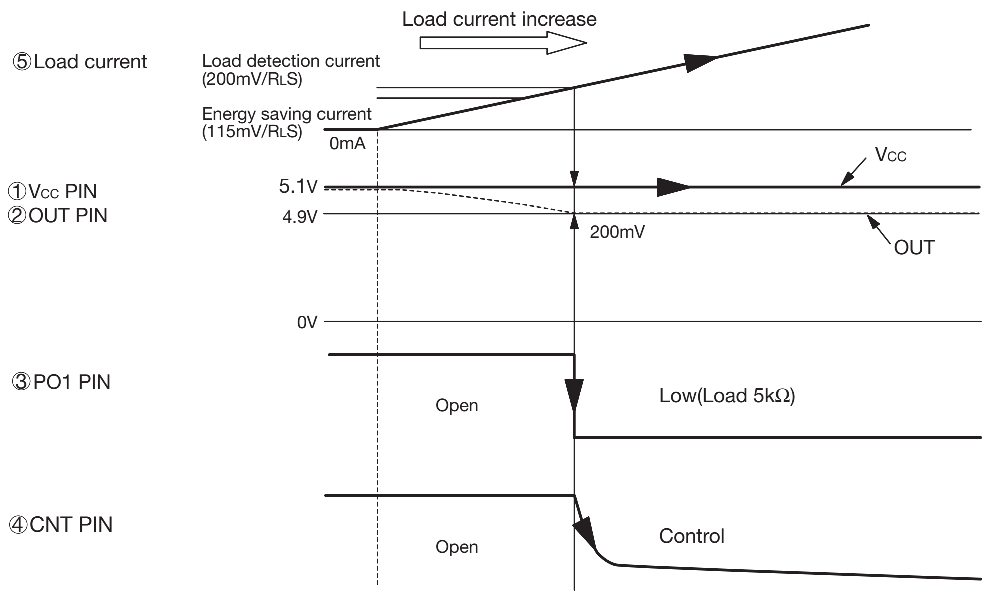
Timing Chart

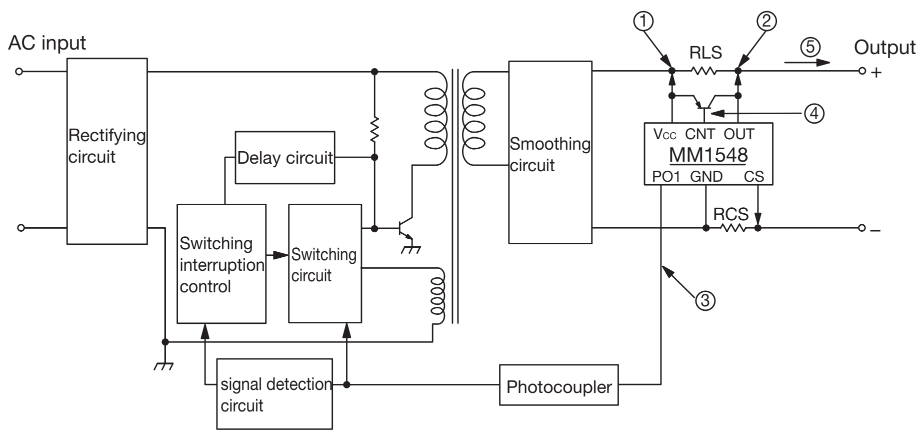
Load / Energy-saving detection

Load current decrease



Load current increase





Application Circuit