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

## Outline

This IC is secondary control on AC adaptors that have energy-saving mode. The energy-saving mode function operates when charging is completed or when the set is unplugged, thus greatly reducing AC adaptor power consumption.
When a set is connected, normal mode automatically starts and charging starts.
Compared to the conventional MM1529, this IC is smaller and has fewer external components.

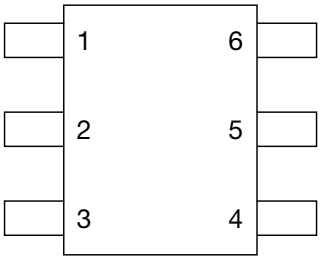
## Features

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. Uses one photocoupler to control oscillator primary side.
5. One photocoupler is used to control rated voltage and rated current and switching between energy-saving and normal modes.

## Package

SOT-26

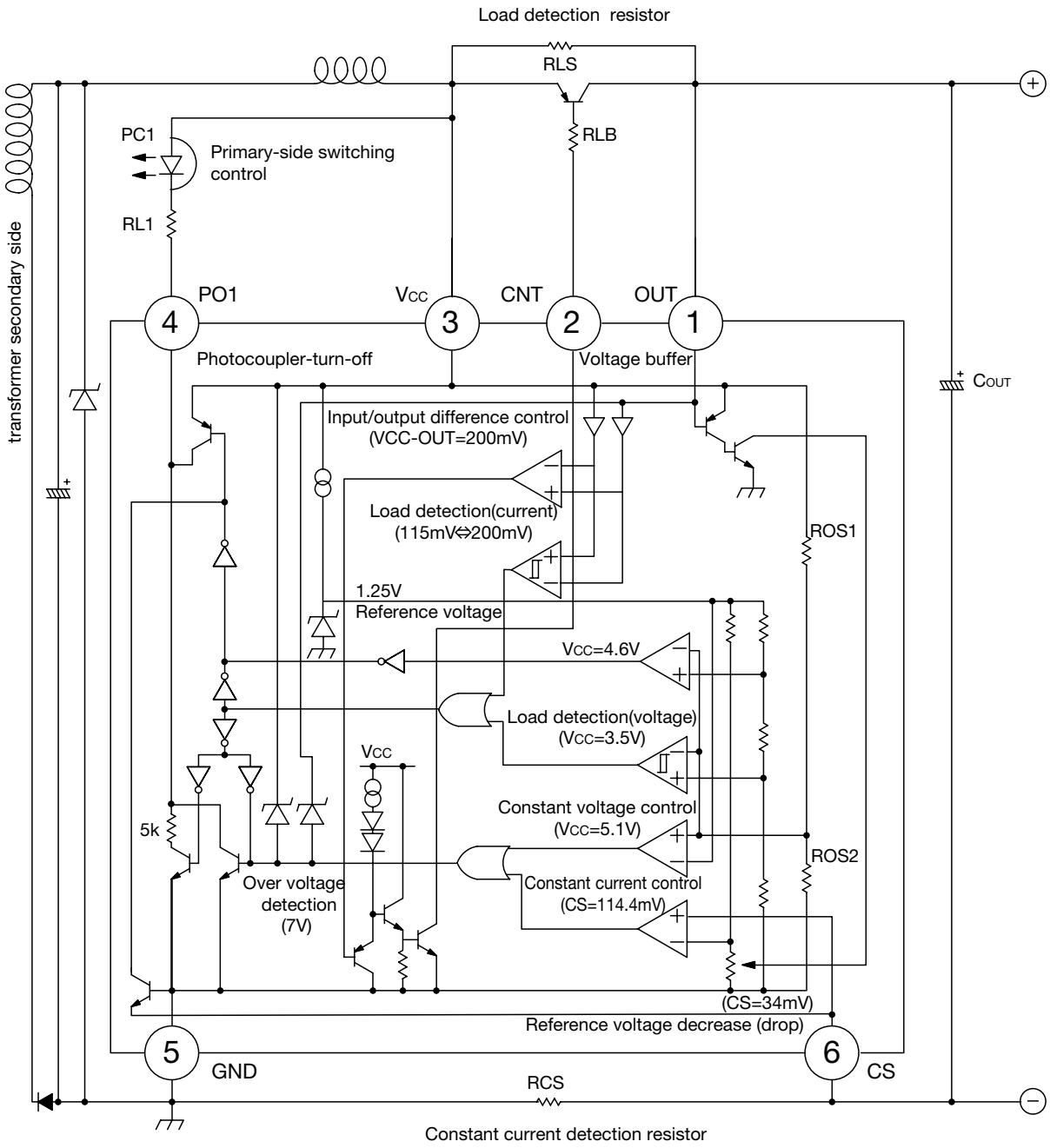
## Pin Assignment



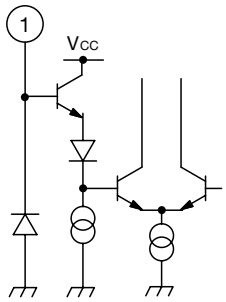
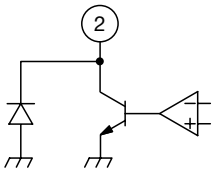
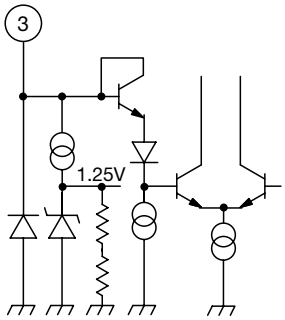
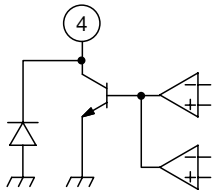
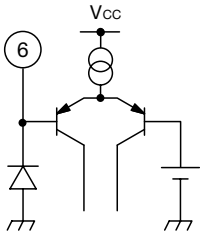

SOT-26

| | | | |
|---|---|---|---|
| 1 | OUT | 4 | PO1 |
| 2 | CNT | 5 | GND |
| 3 | Vcc | 6 | CS |

## Block Diagram



## Pin Description

| Pin No. | Pin Name | Function | Internal equivalent circuit |
|---|---|---|---|
| 1 | OUT | Output (+) pin.<br>Connect Registor for load detection between Vcc pin, and connect collector of PNP power transistor. |  |
| 2 | CNT | PNP power transistor control pin.<br>Connect base of PNP power transistor. |  |
| 3 | Vcc | (+) power supply pin.<br>This pin doubles load detection pin.<br>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.<br>Connect to cathode of diode. |  |
| 5 | GND | Ground pin of this IC. | |
| 6 | CS | Overcurrent detection pin.<br>This pin doubles as output- pin.<br>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

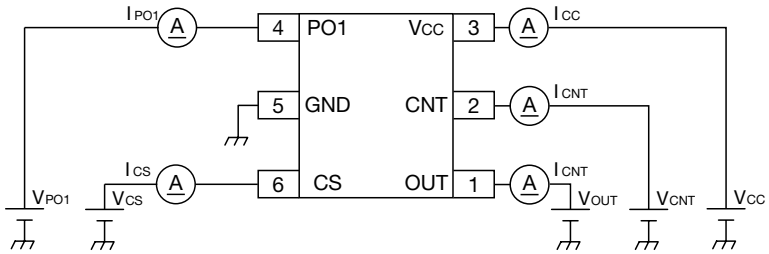
| Item | Symbol | Ratings | Unit |
|---|---|---|---|
| Operating temperature | $T_{OPR}$ | –30~+85 | °C |
| Supply voltage | $V_{OP}$ | +2.5~+12 | V |

## 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 Vcc 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

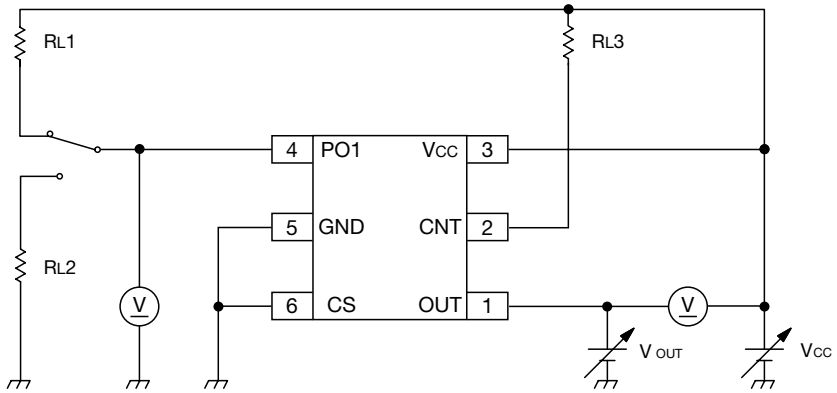
$I_{CC1}$, $I_{CC2}$, $I_{OUT}$, $I_{CS}$, $I_{PO1}$, $I_{PO2}$, $I_{PO3}$, $I_{PO4}$, $I_{CNT}$




| | VCC | VOUT | VCS | VPO1 | VCNT |
|---|---|---|---|---|---|
| $I_{CC1}$ | 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

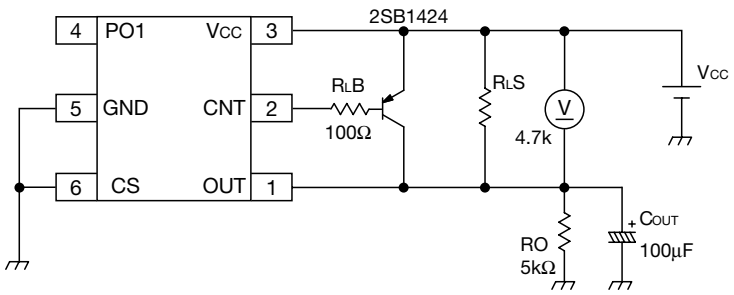
$\Delta V_{LSP1}$, $\Delta V_{LSP2}$, $\Delta V_{OL1}$, $\Delta V_{OL2}$




| | VCC | VOUT | VCS | VPO1 | VCNT |
|---|---|---|---|---|---|
| $\Delta V_{LSP1}$ | 4.9V | 4.9→4.6V | 0V | RL1=47kΩ | RL3=10kΩ |
| $\Delta V_{LSP1}$ | 4.9V | 4.6→4.9V | 0V | RL1=47kΩ | RL3=10kΩ |
| $V_{OL1}$ | 3.7→3.3V | VCC | 0V | RL1=10kΩ | OPEN |
| $V_{OL2}$ | 4.8→4.4V | VCC | 0V | RL2=47kΩ | OPEN |

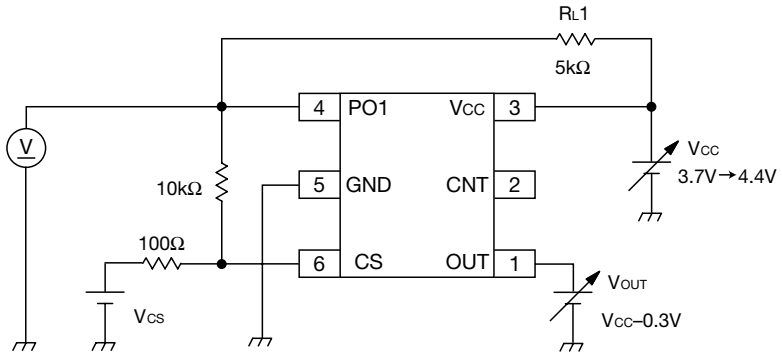
## Measuring Circuit 3

⊿VLS



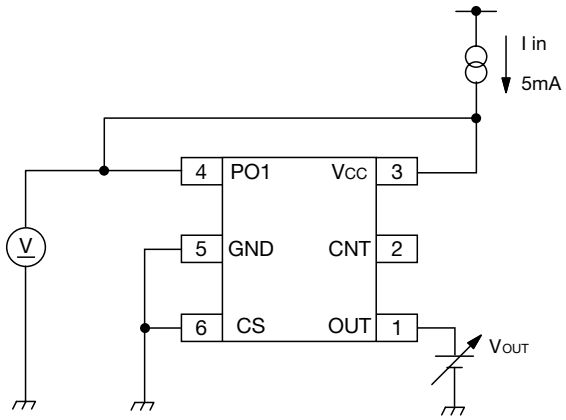

## Measuring Circuit 4

PSRR2



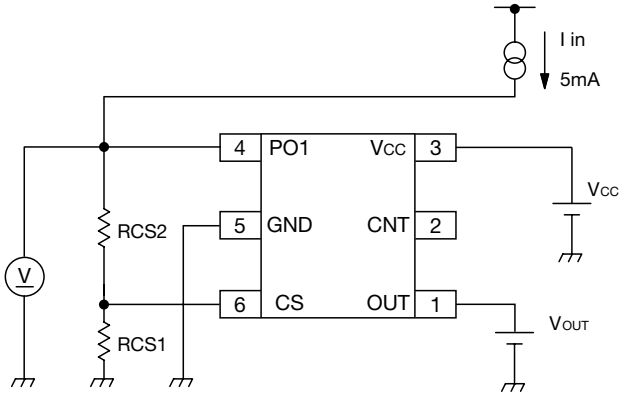

## Measuring Circuit 5

VO

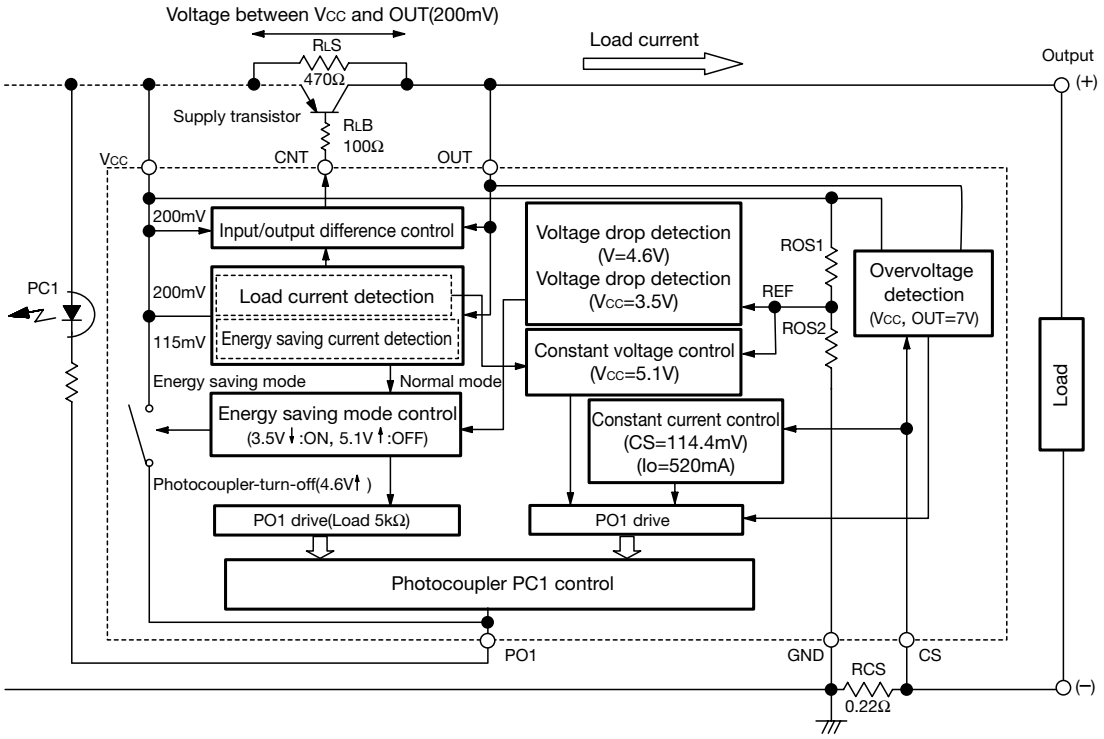



## Measuring Circuit 6

VCS1, VCS2



# 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 Vcc 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 Vcc and OUT exceeds $\Delta V_{LSP1}$ (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 ( $\Delta V_{LSP1}$) or decreasing ( $\Delta V_{LSP2}$).

( hysteresis: $\Delta V_{LSP1}$ = 200mV $\Leftrightarrow$ $\Delta V_{LSP2}$ = 115mV)

When the differential voltage between Vcc and OUT falls to $\Delta V_{LSP2}$ (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 Vcc 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 Vcc 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

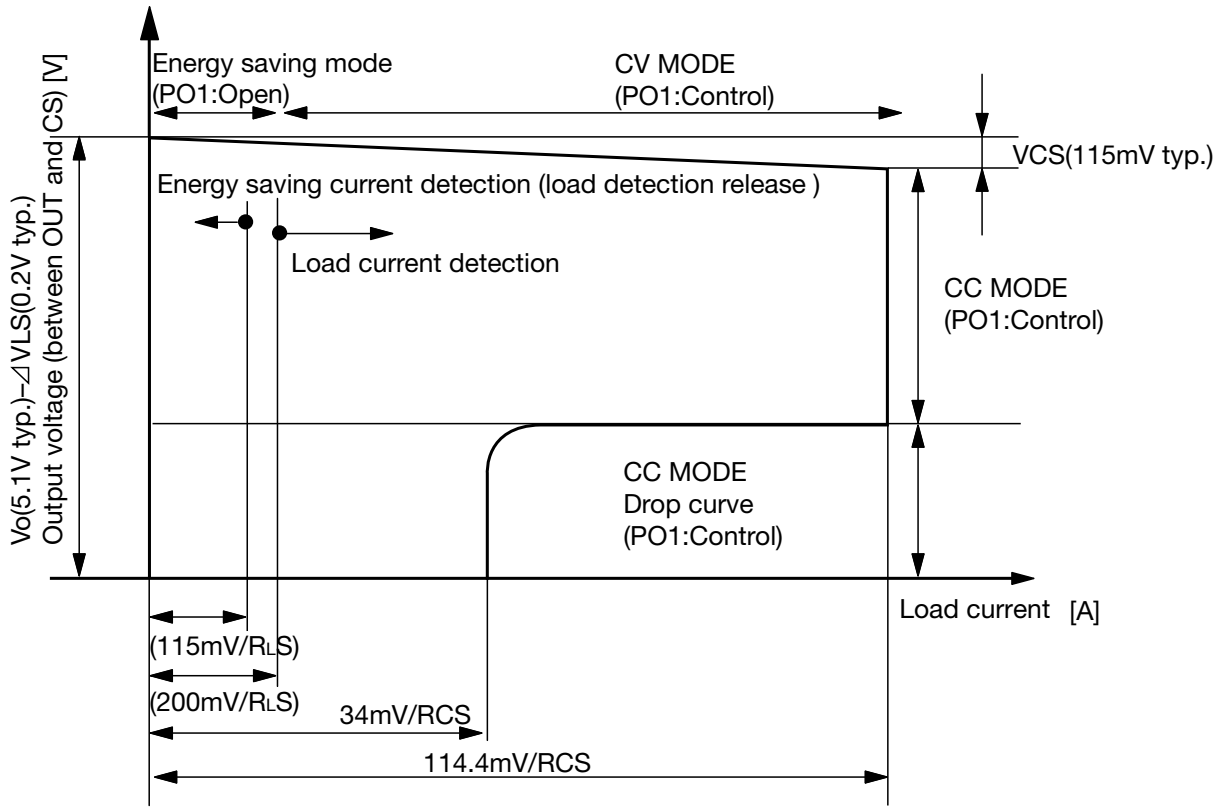
When MM1548 is in normal mode and isn't in constant current mode, it is in CV(constant voltage) mode, and PO1 current is controlled that Vcc voltage keeps 5.1V (equal to internal 1.25V: REF voltage).

1.6 Overvoltage detection

When Vcc 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.

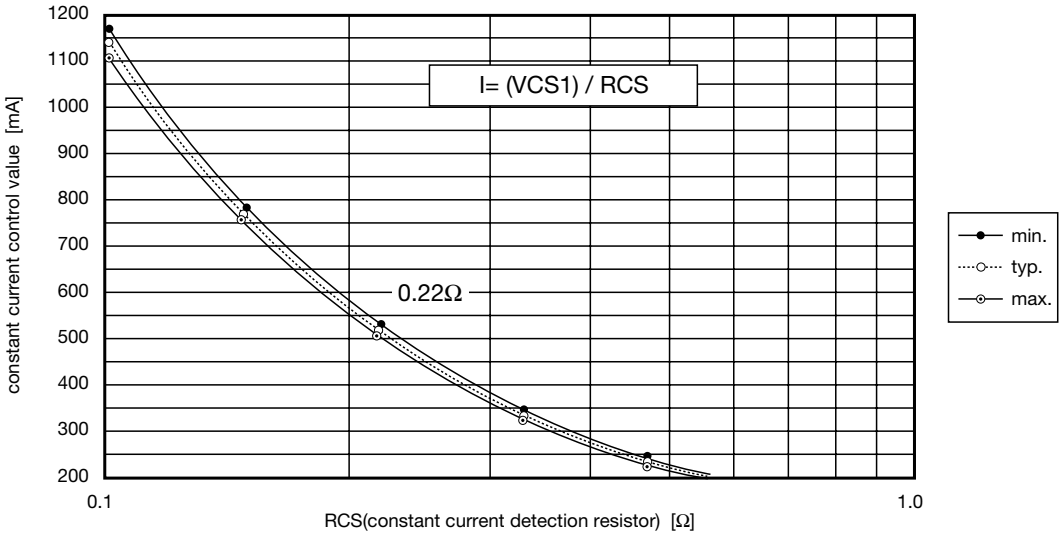
On the design, constant current operation changes when [load current] > 520[mA] in the case of 0.22Ω use.

[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 (RLS adjust method)

Load detection current and energy saving detection current is set by RLS as load detection resistor.

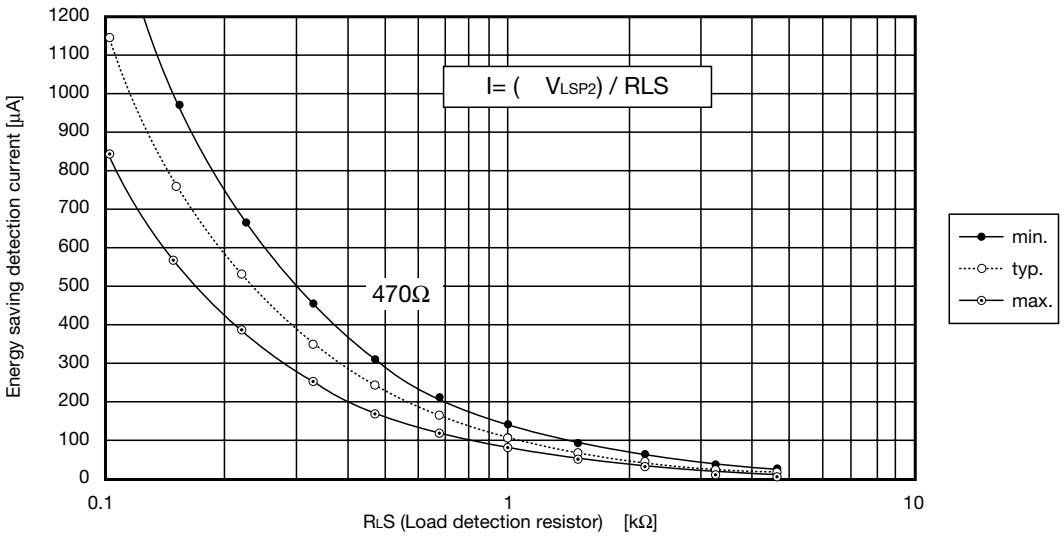
On the design, each current changes when [current flows through RLS] > 240μA, in the case of 470Ω use.

[Formula]

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

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

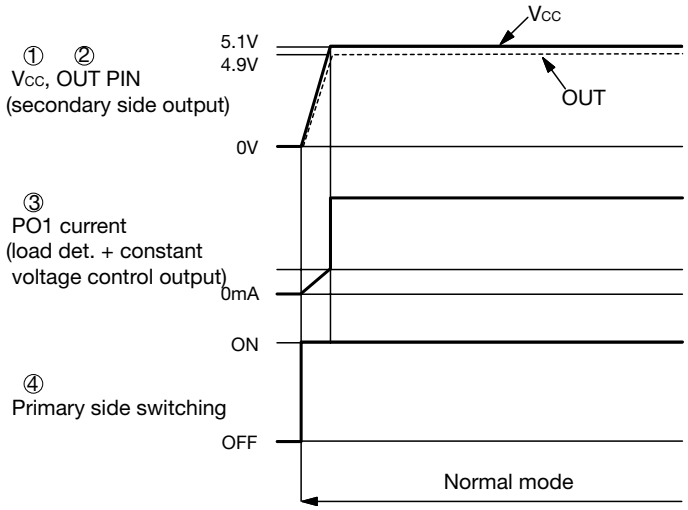
RLS (Load detection resistor) - Energy saving detection current



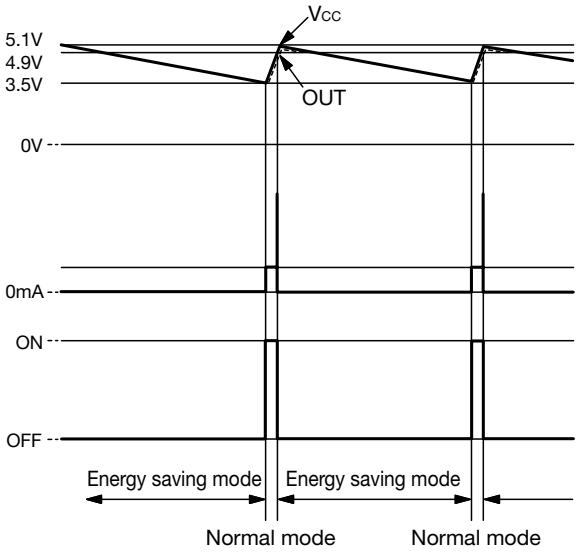
# Timing Chart

## Constant voltage control

### Normal mode [Io>115mV / RLS]

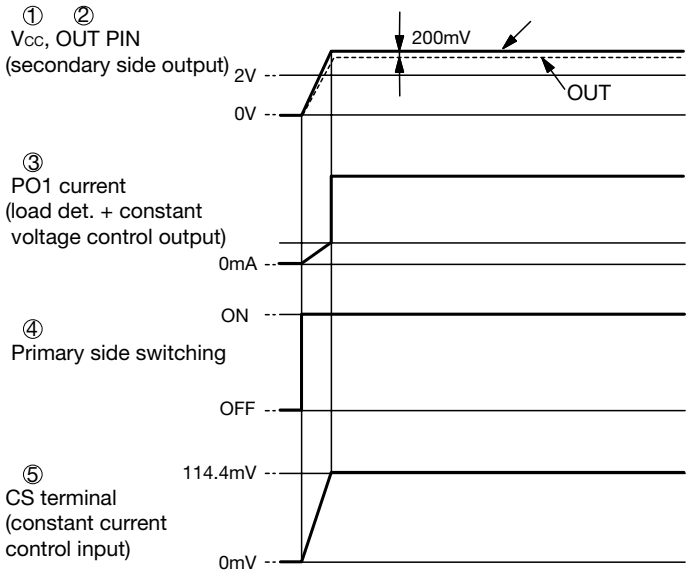



### Energy saving mode [Io<115mV / RLS]

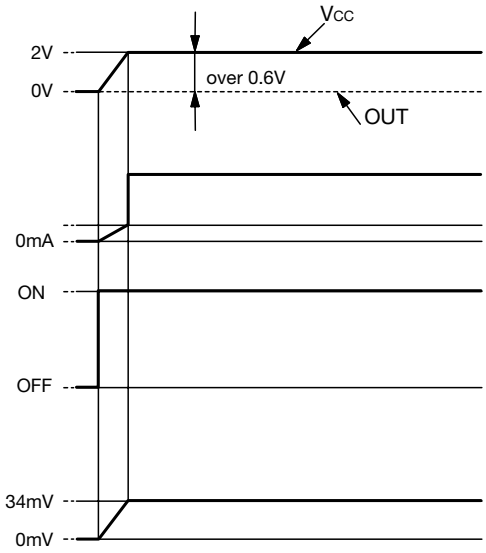


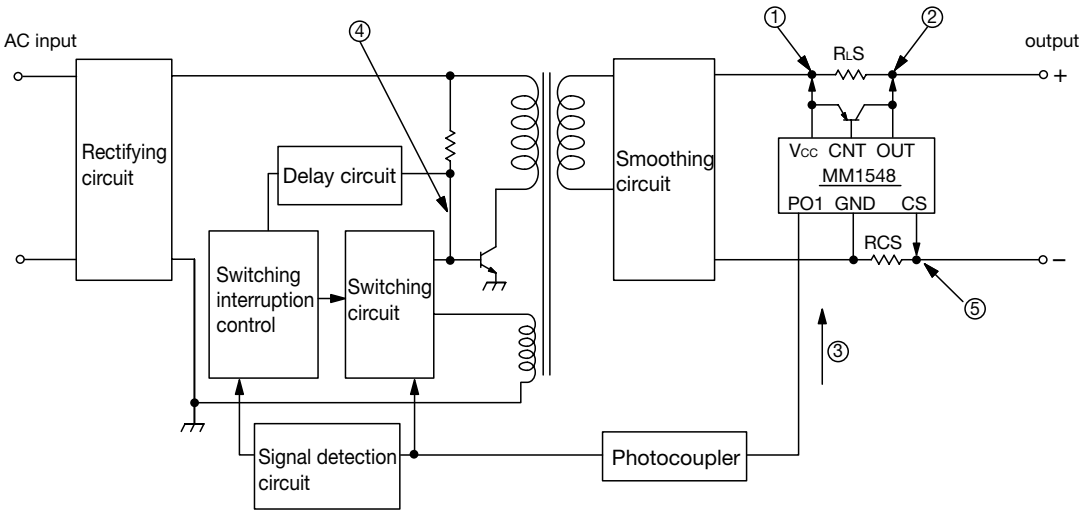

## Constant current control

### Normal control [VCC>2.0V]




### Drop control [VCC<2.0V]

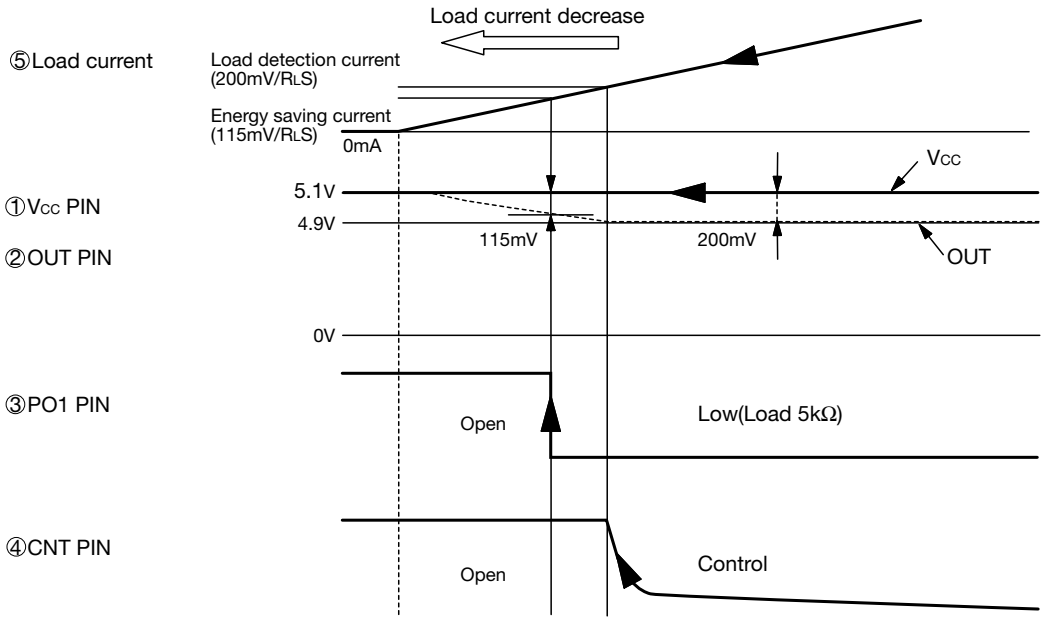


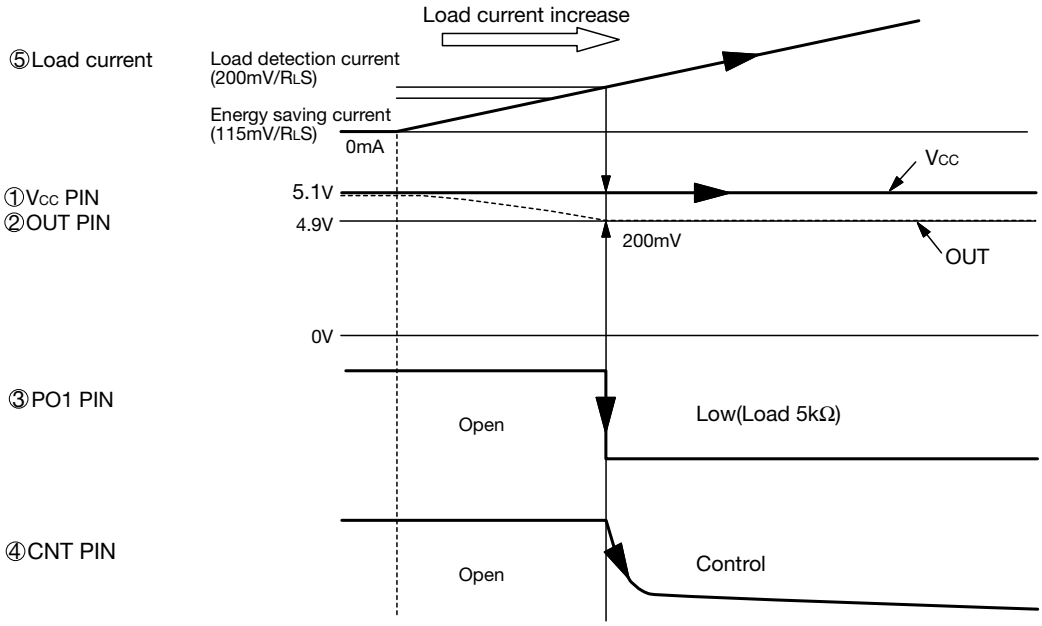
# Timing Chart

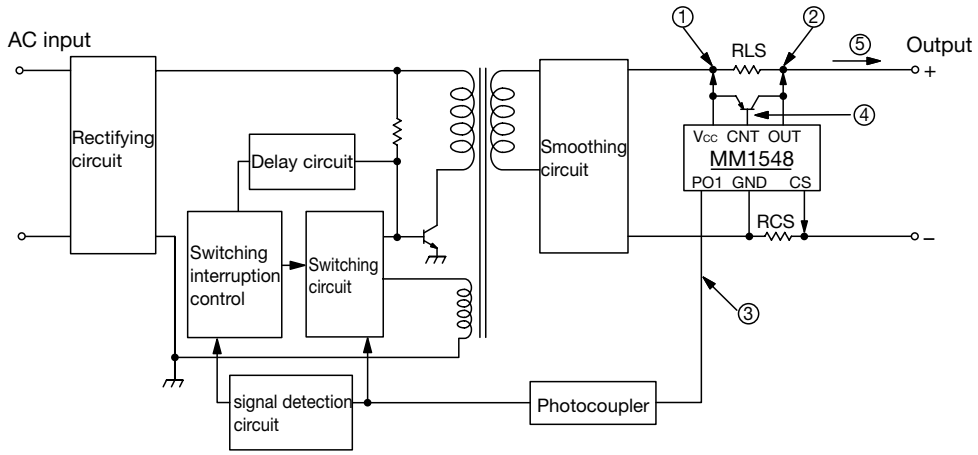
## Load / Energy-saving detection

### Load current decrease




### Load current increase



## Application Circuit

