# RENESAS

# M61041FP

## 4-Battery Version, No Reset Pin

This product is currently under development, and its specifications, pin assignments, etc., are subject to change.

## Description

The M61041FP is an semiconductor IC device developed for smart battery packs. It incorporates all the analog circuitry required by smart batteries in a single chip. When used in conjunction with a microprocessor, it allows the implementation of a variety of functions, such as battery capacity detection, through the addition of minimal peripheral devices and is ideal for smart battery system (SBS) battery packs.

The M61041FP also has an on-chip overcurrent detect circuit so that the FET for controlling battery charging and discharging is protected regardless of the processing speed of the microprocessor.

The microprocessor can change the amplifier gain of the charge/discharge current detect circuit, so battery capacity detection accuracy is increased. In addition, the M61041FP incorporates a linear regulator that allows it to function as the power supply for the microprocessor, thereby simplifying power supply block design.

### Features

- On-chip high-gain op-amp for monitoring charge and discharge current.
- On-chip overcurrent detect circuit to protect FET.
- Charge/discharge FET can be controlled from microprocessor.
- Power-save function for reducing current consumption.
- 5.2 V operation to reduce microprocessor current consumption.
- High-voltage device (absolute maximum rating: 33 V).

### Application

- Smart battery system (SBS) battery packs

This product is currently under development, and its specifications, pin assignments, etc., are subject to change.
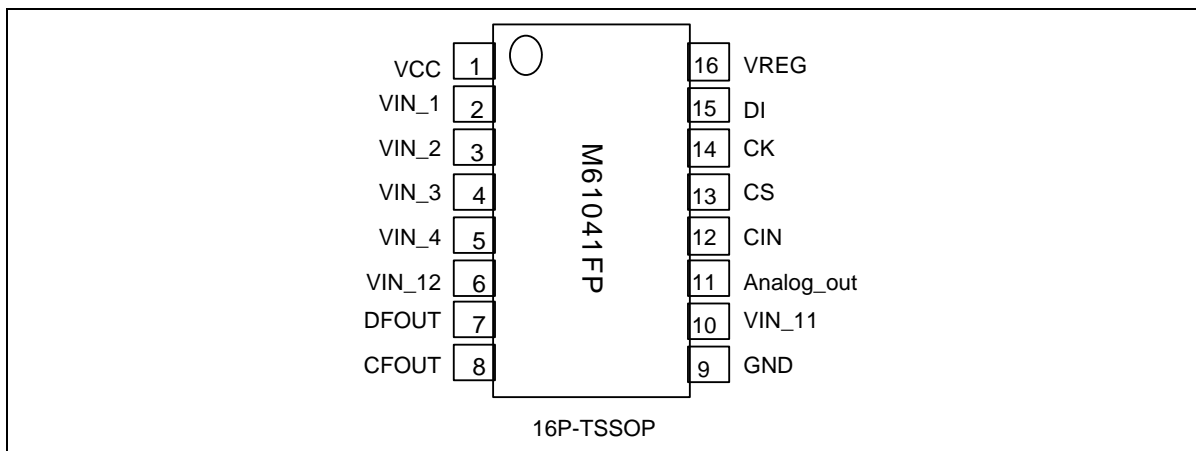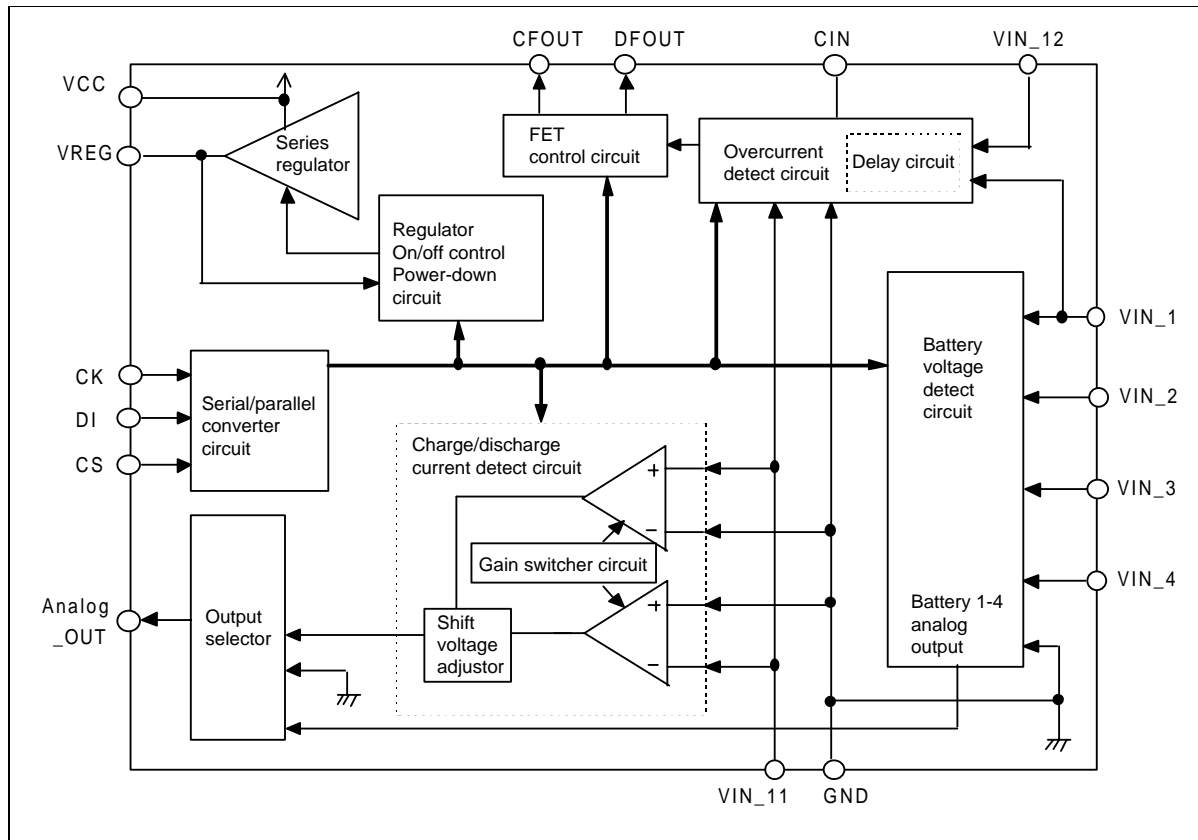


| Pin | Left | | Pin | Right |
|---|---|---|---|---|
| 1 | VCC | | 16 | VREG |
| 2 | VIN_1 | | 15 | DI |
| 3 | VIN_2 | | 14 | CK |
| 4 | VIN_3 | | 13 | CS |
| 5 | VIN_4 | | 12 | CIN |
| 6 | VIN_12 | | 11 | Analog_out |
| 7 | DFOUT | | 10 | VIN_11 |
| 8 | CFOUT | | 9 | GND |

M61041FP

16P-TSSOP

**Figure 1  Pin Connection Diagram (Top View)**

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**Figure 2  Block Diagram**

## Pin Function Description

**Table 1**

| Pin No. | Symbol | Function |
|---|---|---|
| 1 | Vcc | The chip's power supply pin. Power is supplied by the charger or the battery. |
| 2 | VIN_1 | Positive input pin for lithium ion battery 1. |
| 3 | VIN_2 | Negative input pin for lithium ion battery 1. Positive input pin for lithium ion battery 2. |
| 4 | VIN_3 | Negative input pin for lithium ion battery 2. Positive input pin for lithium ion battery 3. |
| 5 | VIN_4 | Negative input pin for lithium ion battery 3. Positive input pin for lithium ion battery 4. |
| 6 | VIN_12 | Charger connect monitor pin. Detects changes from power-down status. |
| 7 | DFOUT | Output pin for discharge FET on/off signals. Also turns off when overcurrent detected. |
| 8 | CFOUT | Output pin for charge FET on/off signals. |
| 9 | GND | Ground pin. Negative input pin for lithium ion battery 4. Connected to charge/discharge current sensor resistor. |
| 10 | VIN_11 | Charge/discharge current monitor pin. Connected to charge/discharge current sensor resistor. |
| 11 | Analog_OUT | Output pin for analog signals. |
| 12 | CIN | Capacity connection pin for setting overcurrent prevention delay time. |
| 13 | CS | When this pin is low level, data input is accepted and data can be stored in a 6-bit shift register. At the rising edge from low to high the value in the 6-bit shift register is latched. |
| 14 | CK | Shift clock input pin. At the rising edge to high the input signal from the DI pin is input to the 6-bit shift register. |
| 15 | DI | Shift data input pin. Serial data with a data length of 6 bits may be input via this pin. |
| 16 | Vreg | Power supply pin for microprocessor. Power can be shut off using a signal from the microprocessor. |

## Operation

The M61041FP is an semiconductor IC device developed for smart battery packs. It is ideal for smart battery system (SBS) battery packs that consist of four lithium ion batteries connected in series. A high-voltage device, it is suitable for use with a wide variety of charger systems.

It incorporates all the analog circuitry required by smart batteries in a single chip. When used in conjunction with a microprocessor, it allows the implementation of a variety of functions, such as battery capacity detection, through the addition of minimal peripheral devices. The functions of the M61041FP are described below.

1. Battery Voltage Detect Circuit

The M61041FP can output the voltage levels of the batteries connected in series via the Analog_out pin. An on-chip buffer amplifier monitors the pin voltages of the batteries. Offset voltage correction using adjustment by the microprocessor is also supported. The M61041FP is configured to detect the battery voltage using a microprocessor driven using a power supply voltage of 5.2 V.

2. Charge/Discharge Current Detect Circuit

SBS requires a function for monitoring the battery capacity. The M61041FP uses an on-chip amplifier to monitor battery capacity based on a drop in the voltage of an external sensor resistor. In this way, the charge/discharge current is converted into a voltage.

The voltage amplification ratio can be adjusted from the microprocessor. In addition, the current output shift voltage can be adjusted from the microprocessor, widening the allowable dynamic range of the A/D converter.

3. Overcurrent Detect Circuit

The M61041FP has an on-chip overcurrent detect circuit. If an excessive current flows from the lithium ion batteries, the discharge control FET is shut off after a set delay time, halting discharge. This makes the battery pack safer. The delay time can be set using an external capacitor. It is possible to determine the overcurrent detect status by monitoring the CIN pin. The overcurrent detect circuit provides protection regardless of the processing speed of the microprocessor.

4. Series Regulator

The M61041FP has an on-chip low-dropout series regulator. It can be used as the power supply for the microprocessor, thereby simplifying power supply block design.
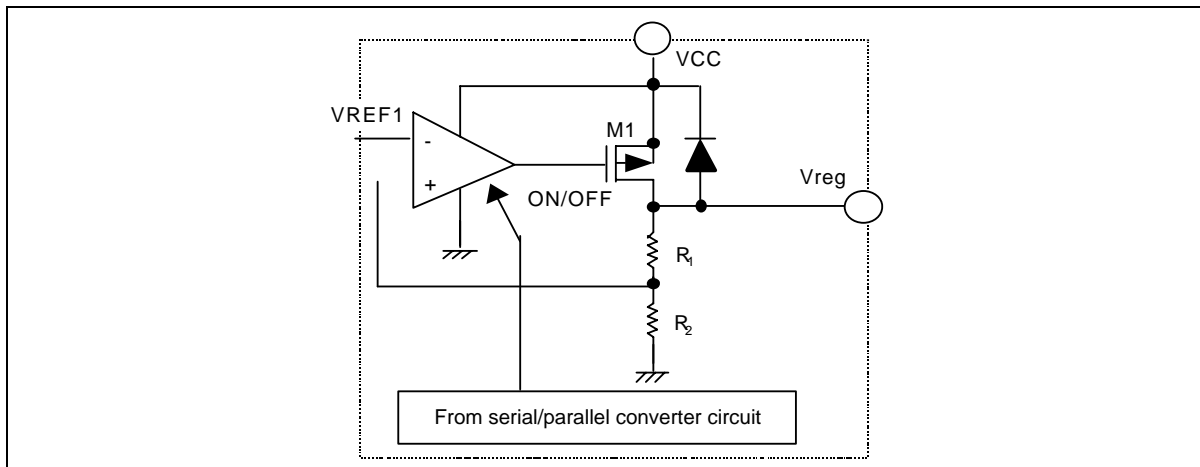


**Figure 3  Series Regulator**

5. Power-Save Function

The M61041FP is equipped with a power-save function.

When the battery voltage is being monitored a portion of the charge/discharge current monitor circuit automatically stops operating, and when the charge/discharge current is being monitored the battery voltage monitor circuit automatically stops operating. This helps prevent unnecessary power consumption. In addition, current consumption is further reduced by setting the analog output selector to ground potential output when in the standby mode.

**Transition to Power-Down Mode**

When the microprocessor determines that the battery voltage has dropped it sends a power-down instruction via the interface circuit. When it receives the instruction, the M61041FP's DFOUT pin switches to high voltage. In addition, the VIN_12 pin is pulled down to low level by an internal resistor. When the VIN_12 pin goes to low potential after reception of the power-down instruction, output from the series regulator stops, switching the M61041FP into power-down mode.

At this point the operation of the circuitry is completely halted. In this status CFOUT is high level and DFOUT is high level (external charge/discharge prohibited status). The maximum current consumption of the M61041FP is 1.0 µA in order to prevent any further drop in the battery voltage.

**Cancellation of Power-Down Mode**

If the battery pack is connected to a charger when the M61041FP is in the power-down mode (VIN_12 becomes high level), the series regulator immediately begins to operate. The power-down mode is canceled, and once again the M61041FP is ready to receive instructions from the microprocessor.
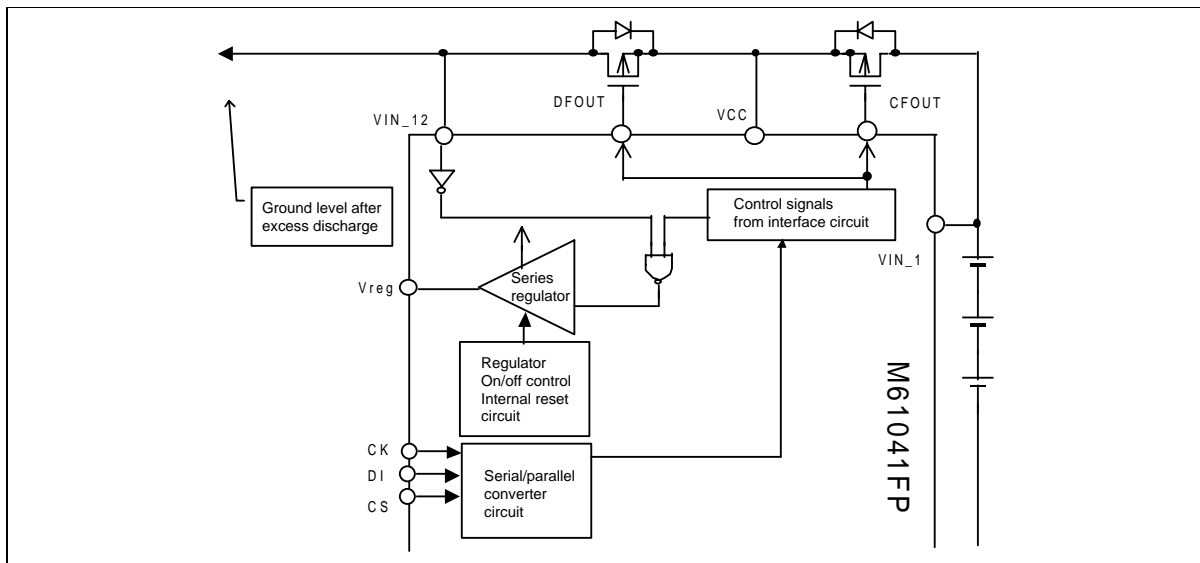


**Figure 4  Operation After Excess Discharge Detection**

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## Absolute Maximum Ratings

**Table 2**

| Item | Symbol | Rated Value | Unit | Conditions |
|---|---|---|---|---|
| Absolute maximum rating | Vabs | 33 | V | |
| Power supply voltage | Vcc | 30 | V | |
| Allowable loss | PD | 500 | mW | |
| Ambient operating temperature | Topr1 | -20 to +85 | °C | |
| Storage temperature | Tstg | -40 to +125 | °C | |
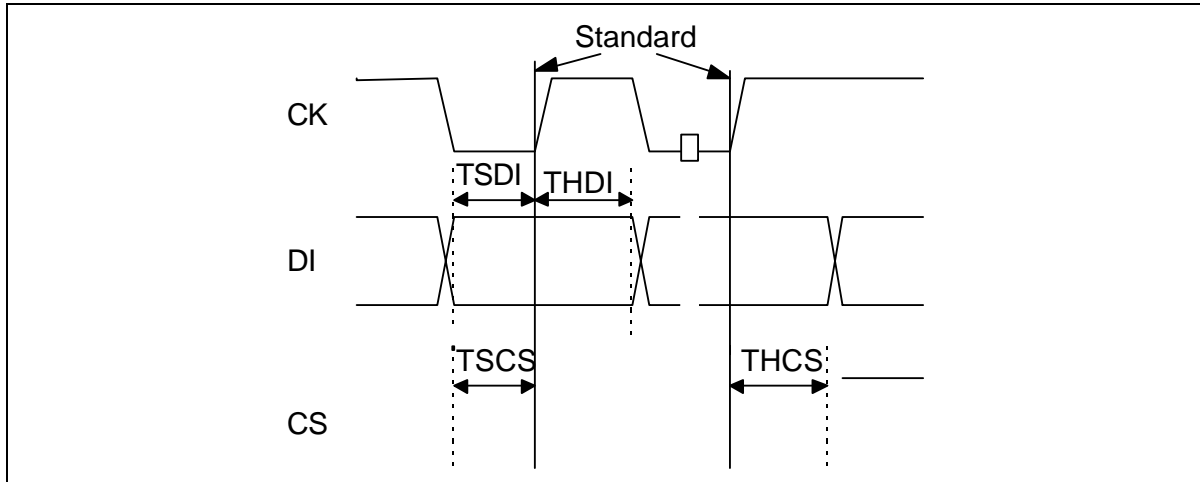


**Figure 5  Interface Block Timing Definitions**

## Electrical Characteristics

**Table 3**

(Ta = 25°C, Vcc = 14 V unless otherwise specified)

| Block | Item | Symbol | Rated Value | | | Unit | Circuit | Command | Conditions |
| | | | Min. | Typ. | Max. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| All | Power supply voltage | Vsup | — | — | 30 | V | 1 | — | |
| | Circuit current 1 | Isup1 | 60 | 150 | 215 | µA | 1 | 1 | During charge/discharge current monitoring |
| | Circuit current 2 | Isup2 | 55 | 140 | 200 | µA | 1 | 2 | During battery voltage monitoring |
| | Circuit current 3 | Isup3 | 25 | 80 | 115 | µA | 1 | 3 | During ground output (initial status) |
| | Circuit current (power-down mode) | Ipd | — | — | 0.5 | µA | 1 | 4 | All circuits halted, VIN_12 = GND |
| Regulator | Output voltage | Vreg | 5.075 | 5.2 | 5.325 | V | 2 | — | Vcc = 14V, Iout = 20mA |
| | Input stability | ΔVout10 | — | 60 | 100 | mV | 2 | — | Vcc = 6.2V to 24V, Iout = 20mA |
| | Load stability | ΔVout20 | — | 30 | 50 | mV | 2 | — | Vcc = 6.2V, Iout = 0.1mA to 20mA |
| | Input voltage (VCC pin) | VIN0 | 6.2 | — | 30 | V | 2 | — | |
| Overcurrent detect | Overcurrent prevention voltage 1 | Vd1 | 0.18 | 0.2 | 0.22 | V | 3 | 5 | |
| | Overcurrent prevention voltage 2 | Vd2 | Vcc/3×0.6 | Vcc/3 | Vcc/3×1.4 | V | 4 | 5 | Load short detected |
| | Overcurrent prevention delay time 1 | Tvd1 | 7 | 10 | 15 | ms | 3 | 5 | CICT = 0.01µF |
| | Overcurrent prevention delay time 2 | Tvd2 | 150 | 250 | 350 | µs | 4 | 5 | |
| Battery voltage detect | Input offset voltage 1 | Voff1 | 31 | 206 | 385 | mV | 5 | 6 | |
| | Voltage amplification ratio 1 | Gamp1 | 0.99 | 1.0 | 1.01 | — | 5 | 7 | |
| | Output source current capacity | Isource1 | 150 | — | — | µA | 6 | 8 | |
| | Output sink current capacity | Isink1 | 150 | — | — | µA | 6 | 9 | |
| | Maximum detect battery voltage | Vmo_max | 4.64 | — | — | V | 5 | — | (Vreg−Voff1)/Gamp1 |

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| Block | Item | Symbol | Rated Value | | | Unit | Circuit | Command | Conditions |
|---|---|---|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | | | | |
| Charge/ discharge current detect | Input offset voltage | Voff2 | 1.0 | 2.4 | 3.8 | V | 7 | 10* | Gain = 200 |
| | Voltage amplification ratio 21 | Gain21 | 38.4 | 40 | 41.6 | | 7 | 11* | |
| | Voltage amplification ratio 22 | Gain22 | 96 | 100 | 104 | | 7 | 12* | |
| | Voltage amplification ratio 23 | Gain23 | 192 | 200 | 208 | | 7 | 13* | |
| | Current output shift voltage 1 | Vios1 | 0.96 | 1.04 | 1.12 | V | 7 | 14* | |
| | Current output shift voltage 2 | Vios2 | 1.93 | 2.08 | 2.23 | V | 7 | 15* | |
| | Current output shift voltage 3 | Vios3 | 2.91 | 3.12 | 3.33 | V | 7 | 16* | |
| | Current output shift voltage 4 | Vios4 | 3.49 | 3.74 | 3.99 | V | 7 | 17* | |
| | Output source current capacity | Isource2 | 150 | — | — | μA | 8 | 18* | |
| | Output sink current capacity | Isink2 | 150 | — | — | μA | 8 | 18* | |
| Interface | DI input H voltage | VDIH | Vreg−0.5 | — | Vreg | V | 9 | — | |
| | DI input L voltage | VDIL | 0 | — | 0.5 | V | 9 | — | |
| | CS input H voltage | VCSH | Vreg−0.5 | — | Vreg | V | 9 | — | |
| | CS input L voltage | VCSL | 0 | — | 0.5 | V | 9 | — | |
| | CK input H voltage | VCKH | Vreg−0.5 | — | Vreg | V | 9 | — | |
| | CK input L voltage | VCKL | 0 | — | 0.5 | V | 9 | — | |
| | DI setup time | TSDI | 600 | — | — | ns | 9 | — | |
| | DI hold time | THDI | 600 | — | — | ns | 9 | — | |
| | CS setup time | TSCS | 600 | — | — | ns | 9 | — | |
| | CS hold time | THCS | 600 | — | — | ns | 9 | — | |

Refer to figures 1 to 9 for the circuits and to table 4 for the command sequences used for measurement.

* For the charge/discharge current detect block, different command sequences are used during charging and discharging.

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## Measurement Circuit Diagrams



During Ipd measurement: S1 = off, S2 = on
All other times: S1 = on, S2 = off
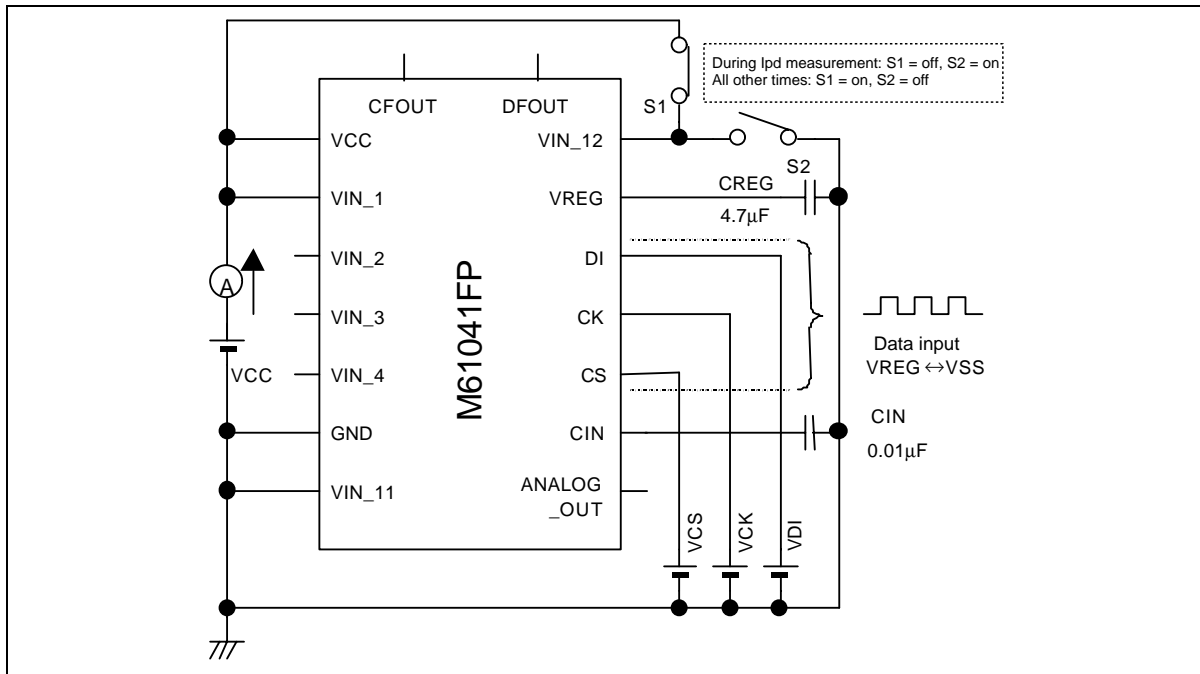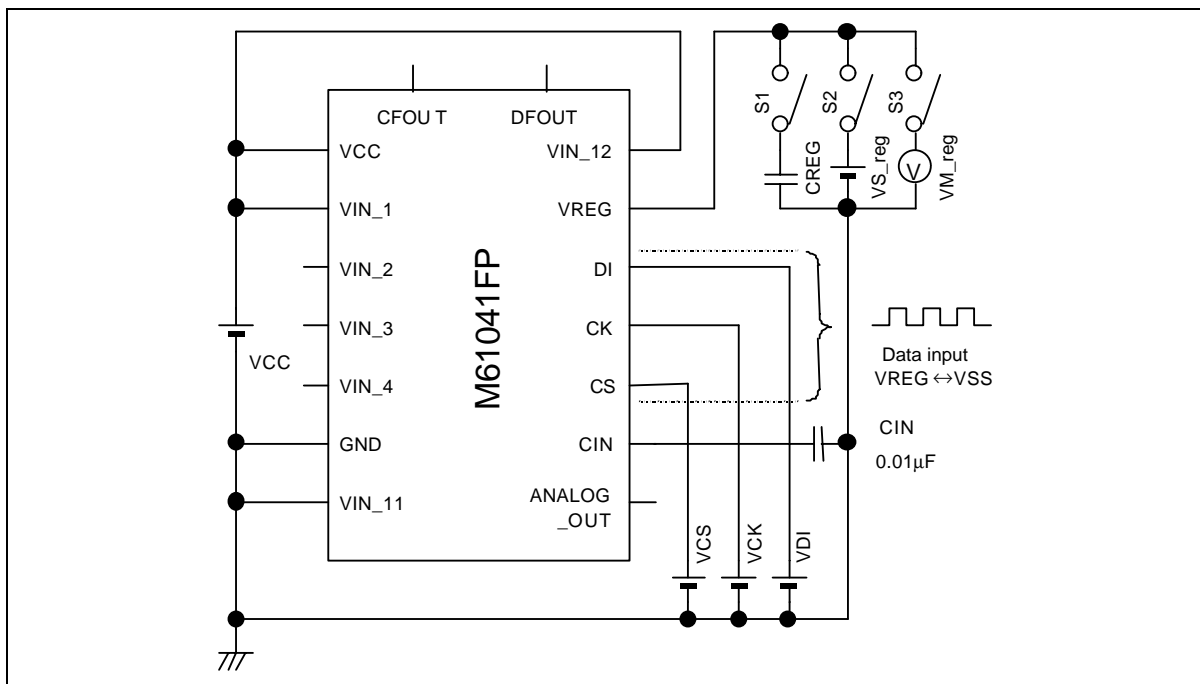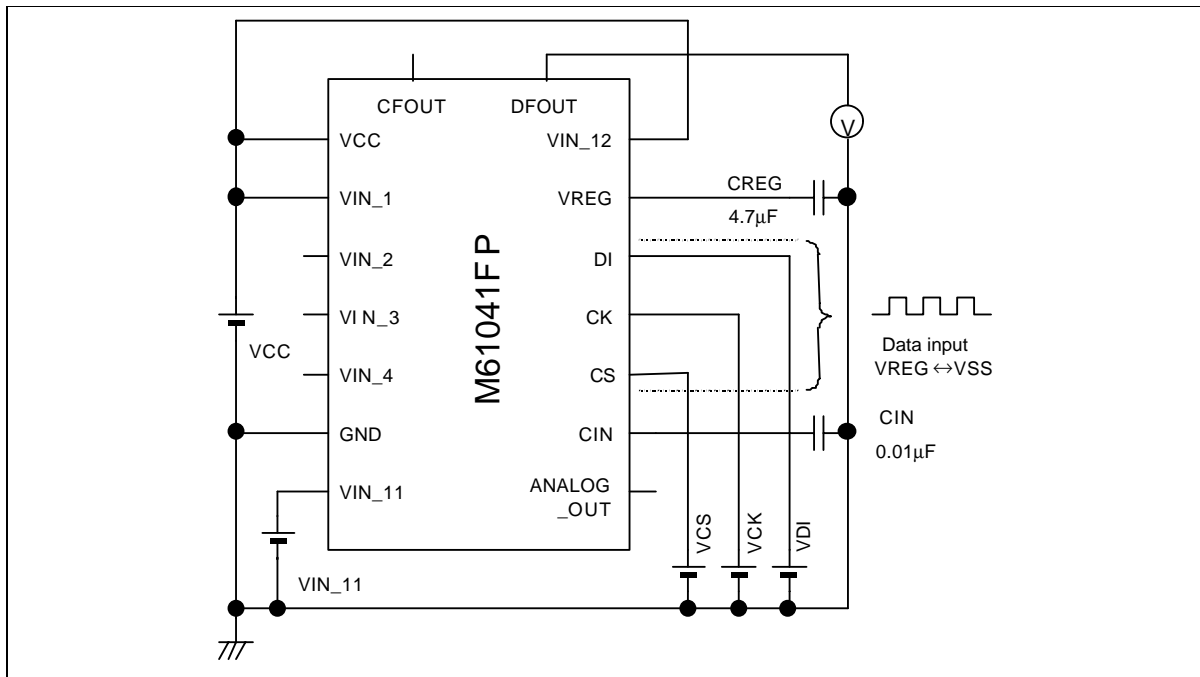
**Circuit 1**



**Circuit 2**

**Circuit 3**
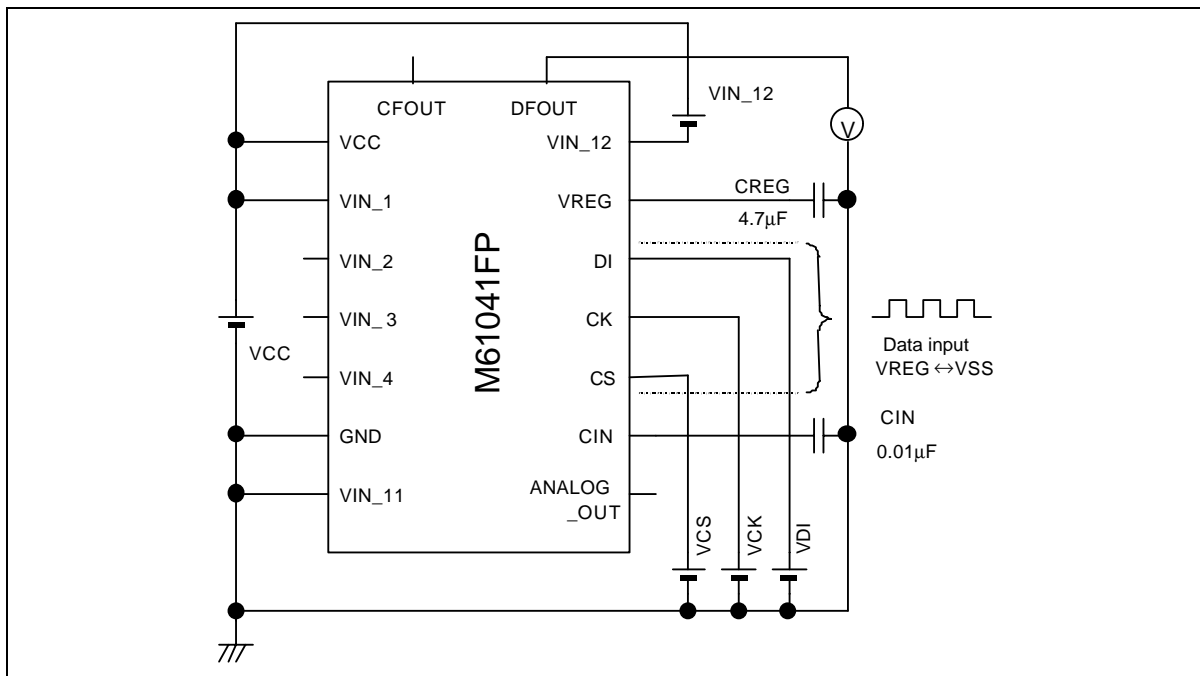


**Circuit 4**
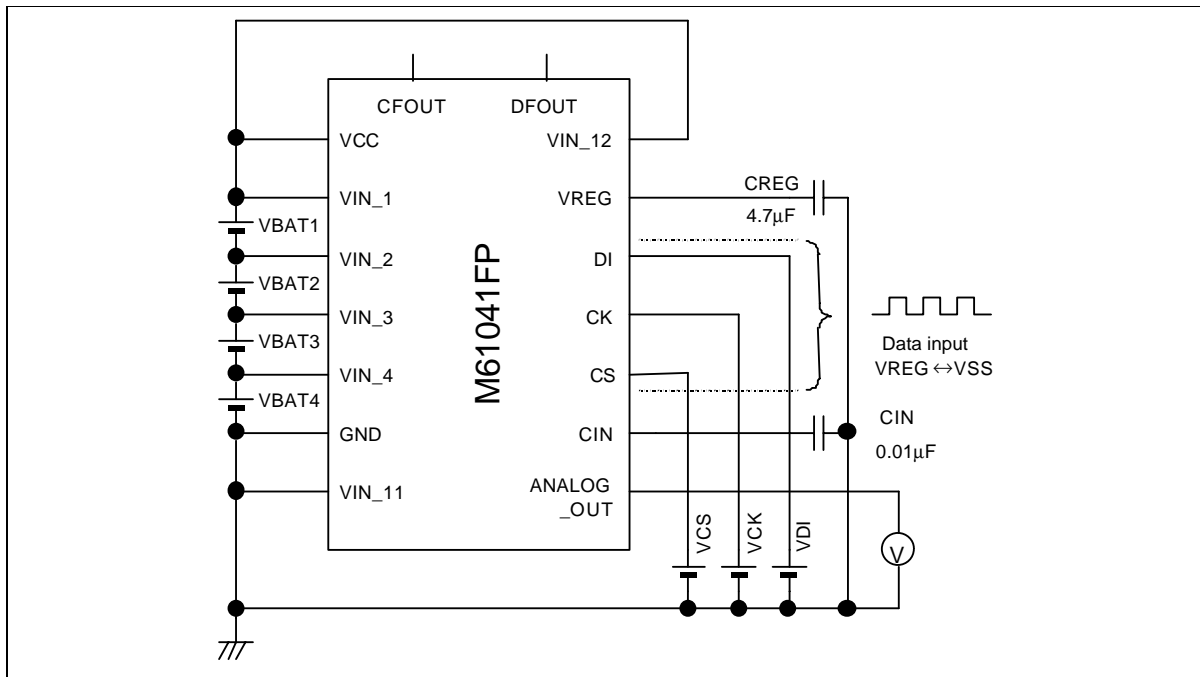
**Circuit 5**



**Circuit 6**

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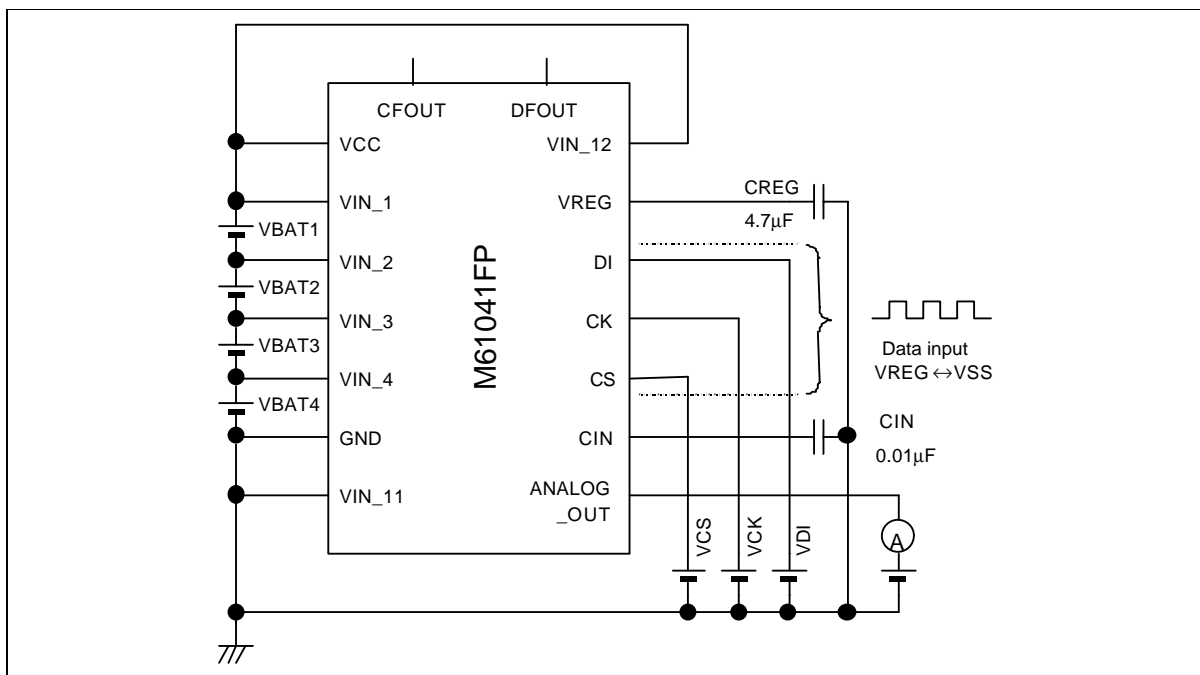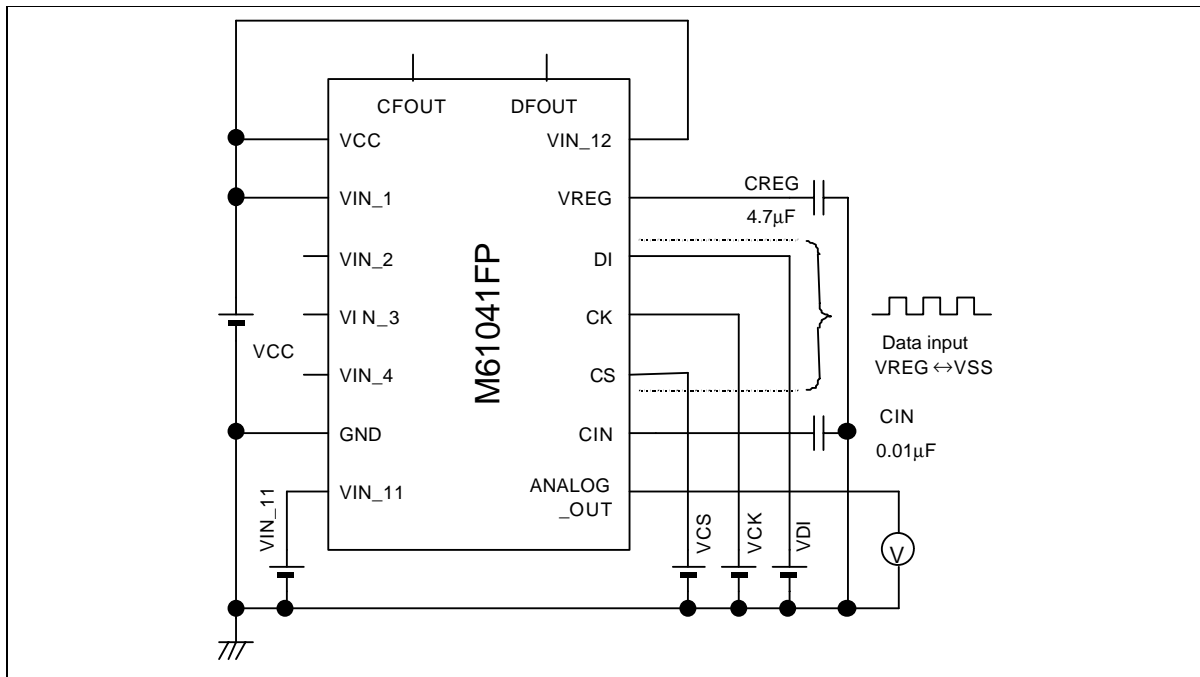
**Circuit 7**



**Circuit 8**

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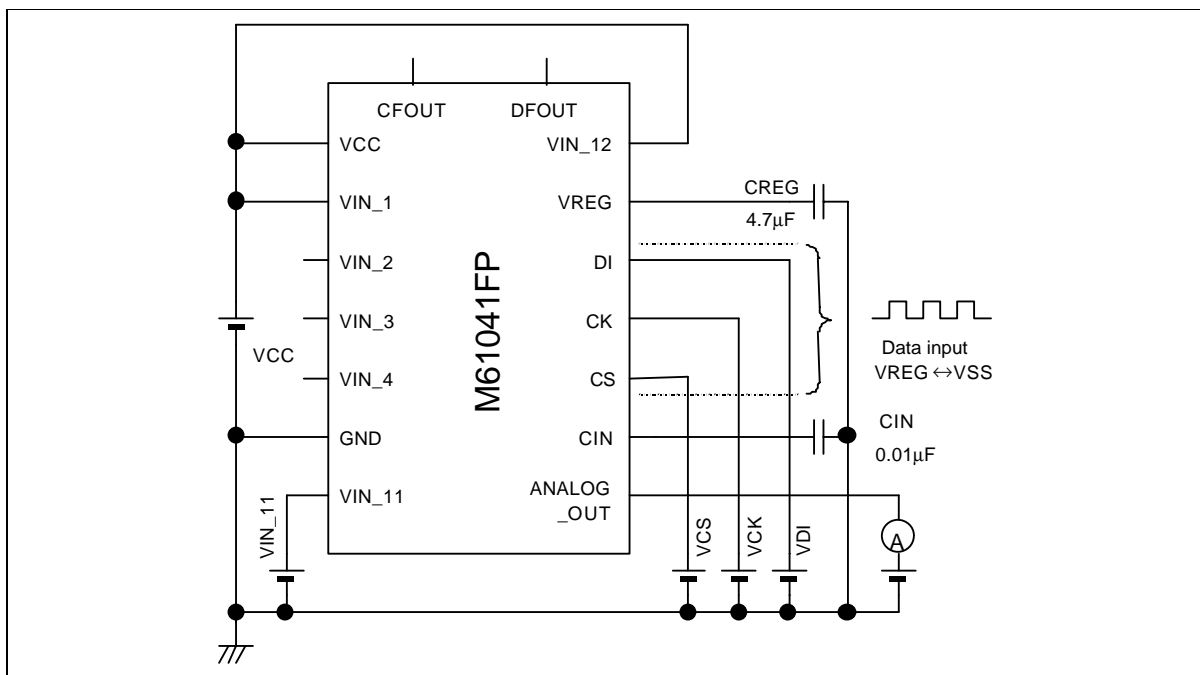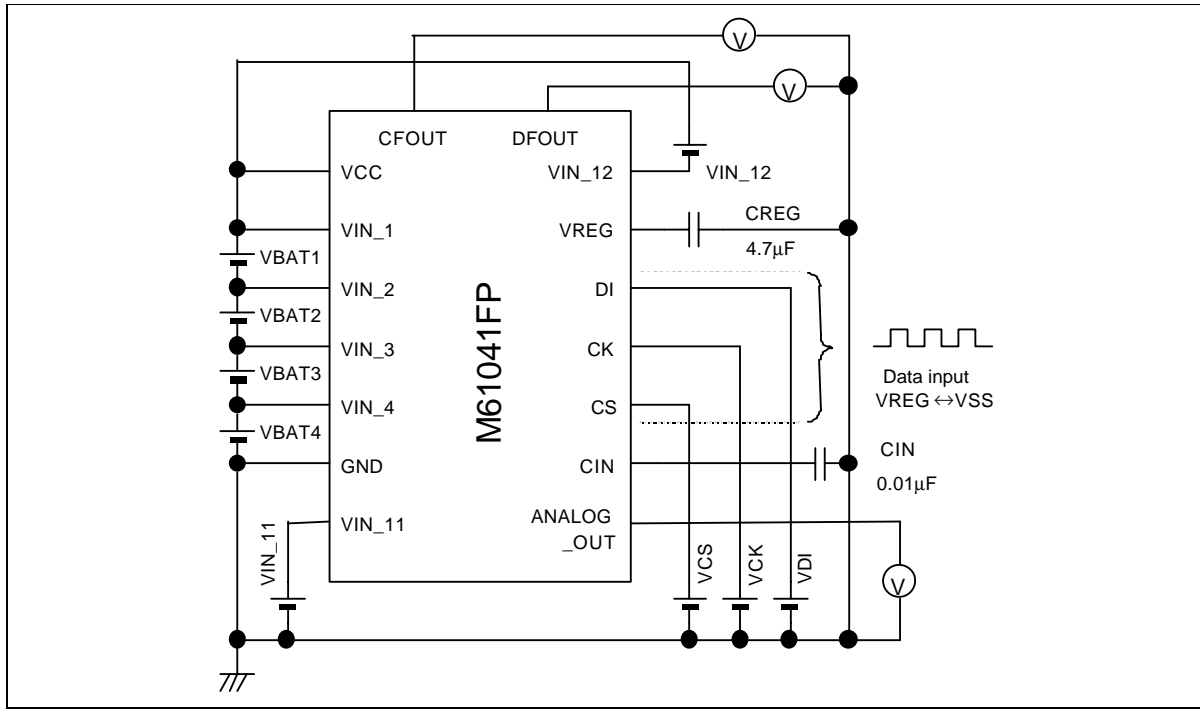
**Circuit 9**

**Table 4  Command Sequences Used for Measuring Rated Values**

| No | Command Sequence | VIN_11 Input |
|---|---|---|
| 1 | $(00)_8 \rightarrow (24)_8 \rightarrow (31)_8 \rightarrow (43)_8 \rightarrow (52)_8$ | 90mV |
| 2 | $(00)_8 \rightarrow (13)_8 \rightarrow (43)_8 \rightarrow (51)_8$ | 0mV |
| 3 | $(00)_8$ | 0mV |
| 4 | $(00)_8 \rightarrow (71)_8$ | 0mV |
| 5 | $(00)_8 \rightarrow (43)_8$ | 0mV |
| 6 | $(00)_8 \rightarrow (51)_8 \rightarrow (14)_8 \rightarrow (15)_8 \rightarrow (16)_8 \rightarrow (17)_8$ | 0mV |
| 7 | $(00)_8 \rightarrow (51)_8 \rightarrow (10)_8 \rightarrow (11)_8 \rightarrow (12)_8 \rightarrow (13)_8$ | 0mV |
| 8 | $(00)_8 \rightarrow (51)_8 \rightarrow (13)_8$ | 0mV |
| 9 | $(00)_8 \rightarrow (51)_8 \rightarrow (17)_8$ | 0mV |
| 10 | $(00)_8 \rightarrow (43)_8 \rightarrow (52)_8 \rightarrow (37)_8$ | 0mV |
| 11 | $(00)_8 \rightarrow (43)_8 \rightarrow (52)_8 \rightarrow (31)_8 \rightarrow (35)_8$ | 90mV |
| 12 | $(00)_8 \rightarrow (43)_8 \rightarrow (52)_8 \rightarrow (32)_8 \rightarrow (36)_8$ | 25mV |
| 13 | $(00)_8 \rightarrow (43)_8 \rightarrow (52)_8 \rightarrow (33)_8 \rightarrow (37)_8$ | 3mV |
| 14 | $(00)_8 \rightarrow (43)_8 \rightarrow (52)_8 \rightarrow (31)_8 \rightarrow (24)_8$ | 90mV |
| 15 | $(00)_8 \rightarrow (43)_8 \rightarrow (52)_8 \rightarrow (31)_8 \rightarrow (25)_8$ | 90mV |
| 16 | $(00)_8 \rightarrow (43)_8 \rightarrow (52)_8 \rightarrow (31)_8 \rightarrow (26)_8$ | 90mV |
| 17 | $(00)_8 \rightarrow (43)_8 \rightarrow (52)_8 \rightarrow (31)_8 \rightarrow (27)_8$ | 90mV |
| 18 | $(00)_8 \rightarrow (43)_8 \rightarrow (52)_8 \rightarrow (31)_8$ | 45mV |

Notes : 1.  Indications such as $(00)_8$ show the address and data, in that order, of the serial data from the microprocessor in octal notation.
2.  Numbers 10 to 17 are command sequences used during charging. For the commands used during discharging, substitute $(53)_8$ for $(52)_8$.
3.  During measurement, the voltage listed in table 4 should be input to VIN_11. When measuring during charging, the specified voltage should be input to VIN_11 as a negative voltage. The specified voltage should be input to VIN_11 as a positive voltage during discharging.

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## Description of Circuit Blocks

(1) Battery Voltage Detect Circuit

As shown in figure 6, the battery voltage detect circuit block of the M61041FP consists of switches, a buffer amplifier, a reference voltage circuit, and a logic circuit.

When the voltage to be detected is selected, based on serial data from the microprocessor, the appropriate switch connections are determined by the logic circuit. The voltages Vbat1, Vbat2, Vbat3, and Vbat4 from the batteries connected to the M61041FP, multiplied by Gamp1 (1.0), are output from the Analog_out pin. It is also possible to output an offset voltage.

In the power-save mode all the switches are turned off, so the current consumption of this circuit block is zero.

Note :  The settling time of this circuit block after voltage changes is about 50 μs.
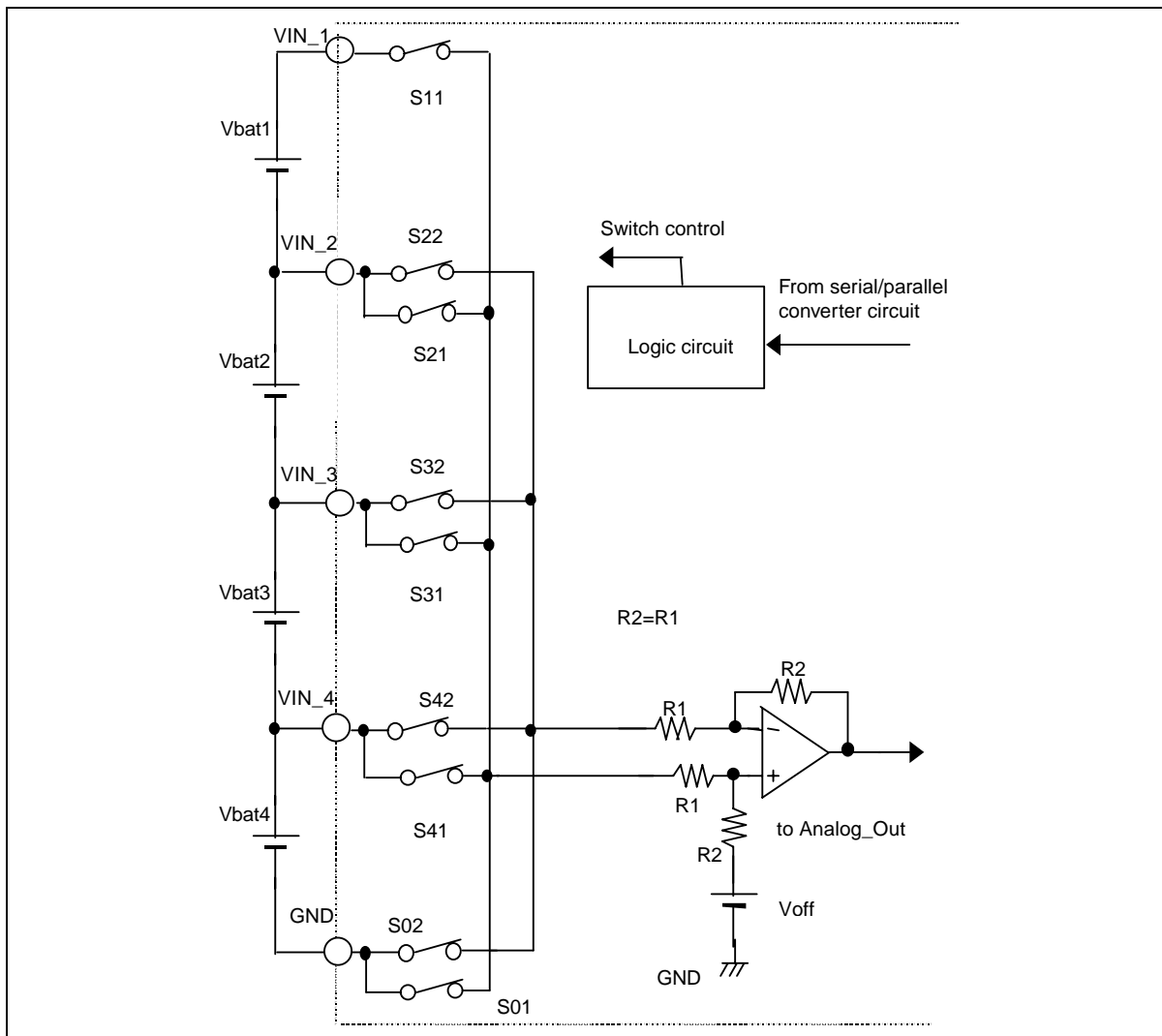


**Figure 6  Battery Voltage Detect Circuit**

Battery Voltage Monitoring Method

To select battery voltage detection, serial data $(51)_8$ is sent from reset status $(00)_8$. The V1 battery voltage (Vin1) is output from the analog output pin by sending $(10)_8$. Next, $(14)_8$ is sent to switch the analog output pin from the V1 battery voltage to the V1 offset voltage (Voff1). The actual voltage (Vbat1) can be obtained by the microprocessor by calculating Vbat1 = (Vin1 – Voff1) / Gamp. The same method can be used for Vbat2 to Vbat4 in order to monitor the battery voltage with a high degree of accuracy.

(2) Charge/Discharge Current Detect Block

As shown in figure 7, the charge/discharge current detect block of the M61041FP consists of a preamplifier current output shift voltage adjustment circuit, a buffer amplifier, and dividing resistors.

The voltage difference indicated by the sensor resistor is amplified to the ground reference voltage by the preamplifier. The gain can be switched using serial signals from the microprocessor. The output is impedance converted by the buffer amplifier.

It is also possible to switch the current detect shift voltage using the microprocessor.
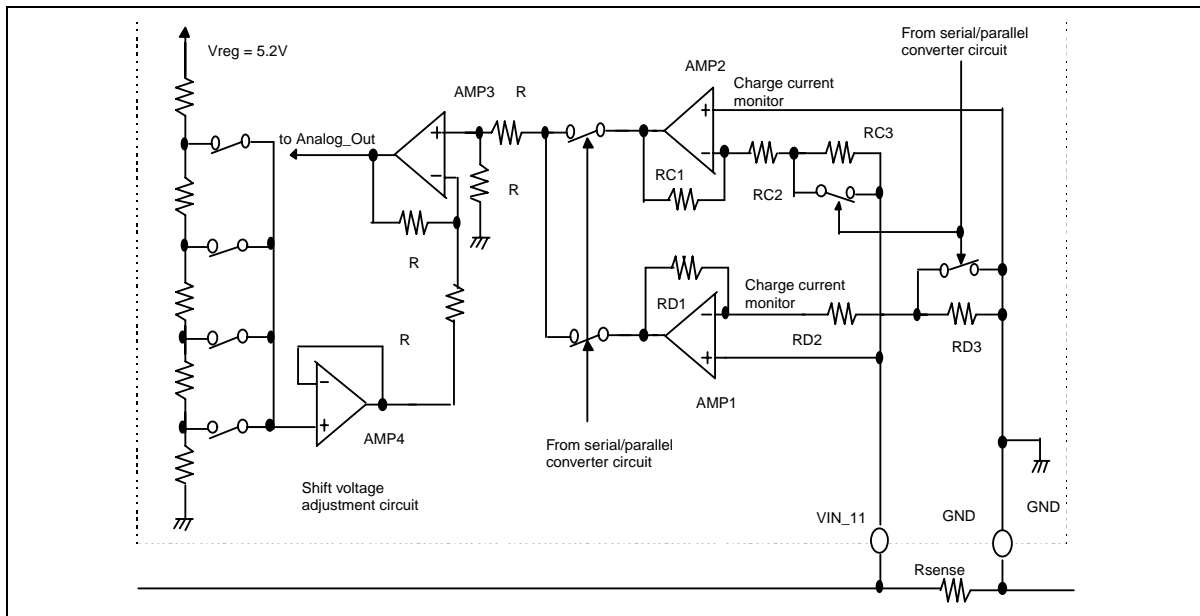


**Figure 7  Charge/Discharge Current Detect Block**

Figure 8 illustrates the circuit block's operation during discharge current detection. The discharge current flows into Rsense, and any voltage drop that occurs is applied to the positive terminal of the amplifier (AMP1). The amplifier's gain can be increased by an instruction from the microprocessor, making it possible to monitor even minute discharge currents with high accuracy.

To allow monitoring of the charge current, the voltage generated by VIN_11 is inverted and amplified before being output. The other aspects use the same operating principle as that described above.
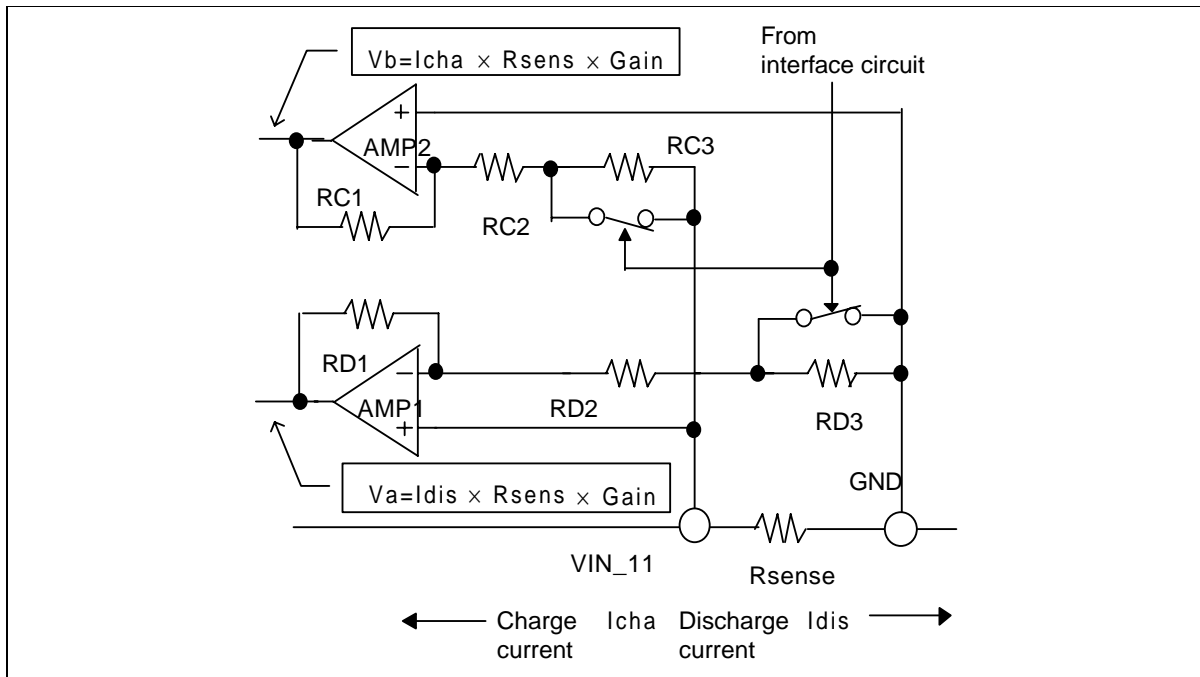
**Figure 8  Charge/Discharge Current Detect Explanation Diagram**

(3) Overcurrent Detect Circuit Block

As shown in figure 9, the overcurrent detect circuit block of the M61041FP consists of a comparator, a reference voltage circuit, and a delay circuit.

The detection voltage can be adjusted by trimming, making possible highly accurate voltage detection in conjunction with a sensor resistor. In addition, it is possible to determine when the M61041FP is in overcurrent detect status by monitoring the CIN pin using the microprocessor.

The M61041FP is also equipped with a simplified load detect circuit. Based on the status of the Vin12 pin it is possible to provide protection with a shorter delay time than when using overcurrent detection.
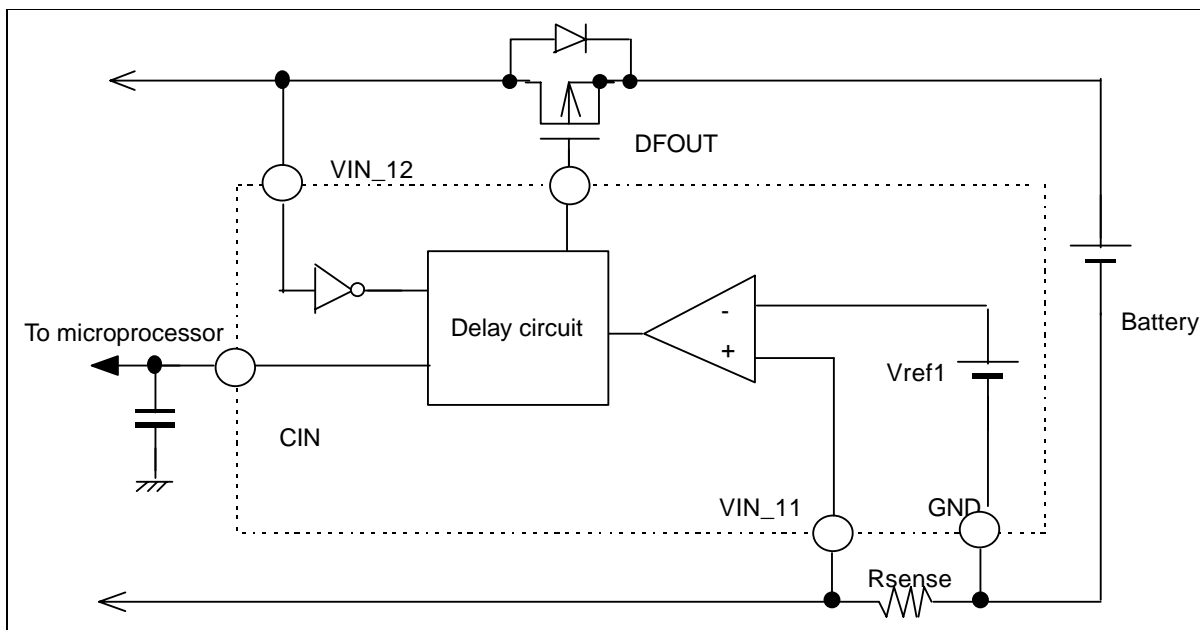


**Figure 9  Overcurrent Detect Circuit Block**

(4) Series Regulator

The series regulator circuit is shown in figure 10. A Pch MOS transistor is used as the output control transistor. The output voltage is adjusted by the M61041FP internally, so no external devices, such as resistors, are required.

Note : Due to the structure of the control transistor a parasite diode is formed between VCC and Vreg. This means that the M61041FP can be destroyed by reverse current if the Vreg potential exceeds VCC. Consequently, Vreg should be limited to VCC + 0.3 V or less.
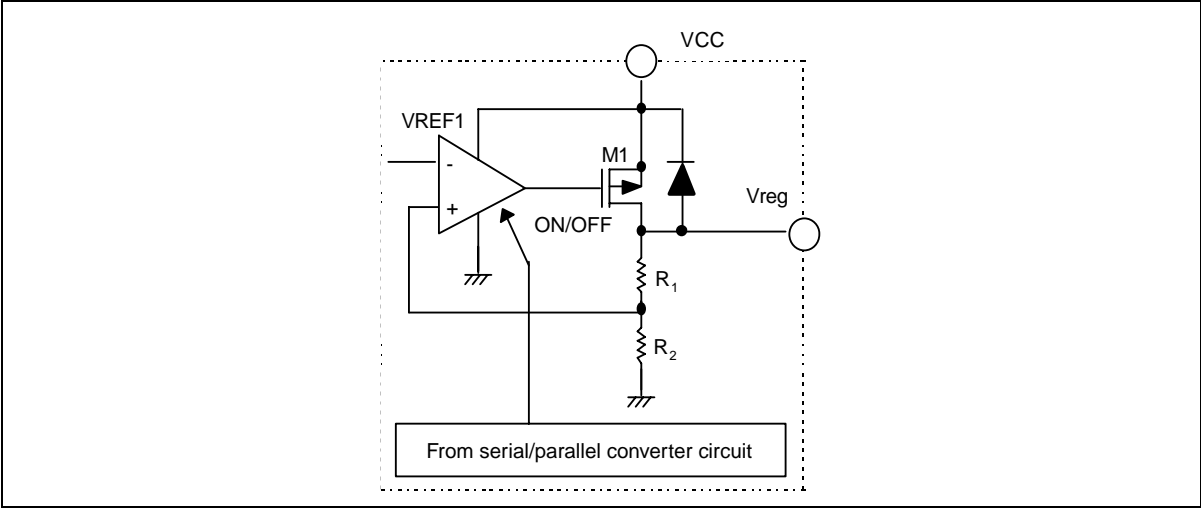


**Figure 10  Series Regulator**

**Digital Data Format**
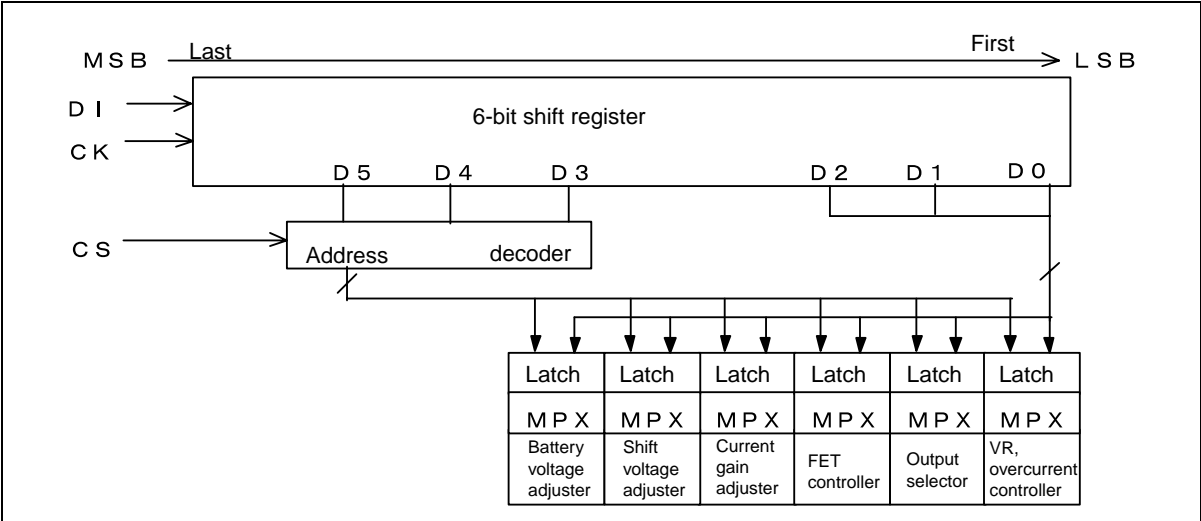


**Figure 11  Serial/Parallel Converter Circuit Block Diagram**

**Data Timing Diagram (Model)**
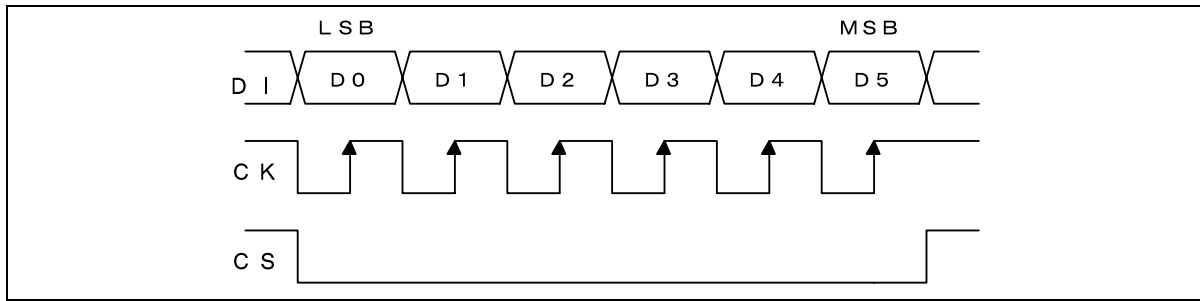


**Figure 12  Serial/Parallel Converter Circuit Timing Chart**

**Data Content**

**Table 5**

| Setting Data | Address | | | Data | | | Content |
|---|---|---|---|---|---|---|---|
| | **D5** | **D4** | **D3** | **D2** | **D1** | **D0** | |
| Reset | 0 | 0 | 0 | — | — | — | |
| Battery voltage selector | 0 | 0 | 1 | — | — | — | See table 8 |
| Current output shift voltage adjuster | 0 | 1 | 0 | — | — | — | See table 9 |
| Current monitor gain adjuster | 0 | 1 | 1 | — | — | — | See table 10 |
| FET controller | 1 | 0 | 0 | — | — | — | See table 11 |
| Output selector | 1 | 0 | 1 | — | — | — | See table 12 |
| Regulator Overcurrent detection controller | 1 | 1 | 1 | — | — | — | See table 13 |

**Data Content**

**Table 6  Battery Voltage Selector**

| D5 to D3 | D2 | D1 | D0 | Output Voltage | Note |
|---|---|---|---|---|---|
| 001 | 0 | 0 | 0 | V1 voltage | Selected after reset |
| 001 | 0 | 0 | 1 | V2 voltage | |
| 001 | 0 | 1 | 0 | V3 voltage | |
| 001 | 0 | 1 | 1 | V4 voltage | |
| 001 | 1 | 0 | 0 | V1 offset voltage | |
| 001 | 1 | 0 | 1 | V2 offset voltage | |
| 001 | 1 | 1 | 0 | V3 offset voltage | |
| 001 | 1 | 1 | 1 | V4 offset voltage | |

• V1 voltage is selected after reset.

**Table 7  Current Output Shift Voltage Adjuster**

| D5 to D3 | D2 | D1 | D0 | Current Output Shift Voltage Value | Note |
|---|---|---|---|---|---|
| 010 | 0 | 0 | 0 | 0 V (no shift voltage) | Selected after reset |
| 010 | 0 | 0 | 1 | 0 V (no shift voltage) | |
| 010 | 0 | 1 | 0 | 0 V (no shift voltage) | |
| 010 | 0 | 1 | 1 | 0 V (no shift voltage) | |
| 010 | 1 | 0 | 0 | 1V | Vreg/25×5 |
| 010 | 1 | 0 | 1 | 2V | Vreg/25×10 |
| 010 | 1 | 1 | 0 | 3V | Vreg/25×15 |
| 010 | 1 | 1 | 1 | 3.6V | Vreg/25×18 |

• No current output shift voltage after reset.

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## Timing Charts

### Charging Sequence



Note: A fixed-voltage charger is used.
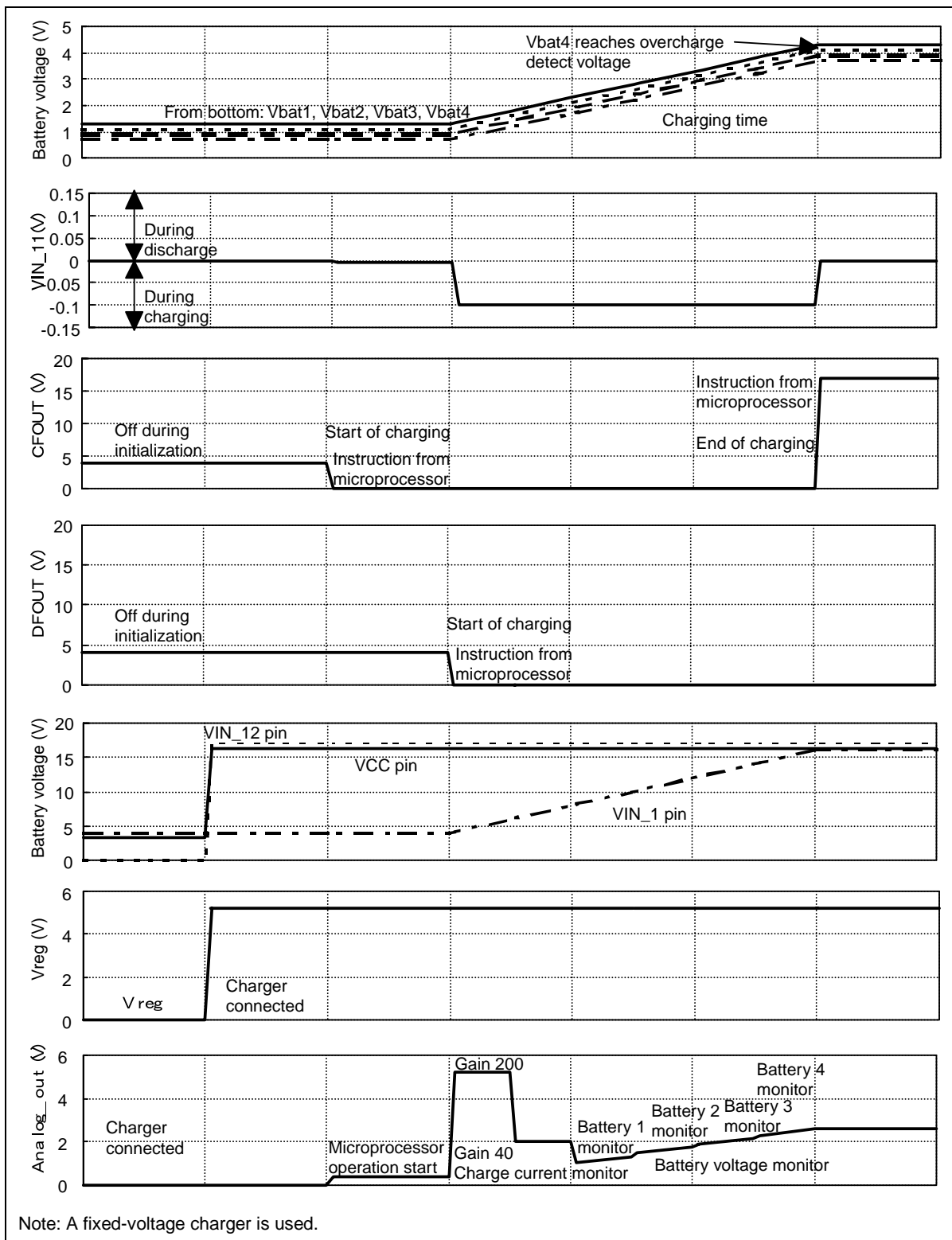
**Figure 13  Charging Sequence**

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**Discharge Sequence**
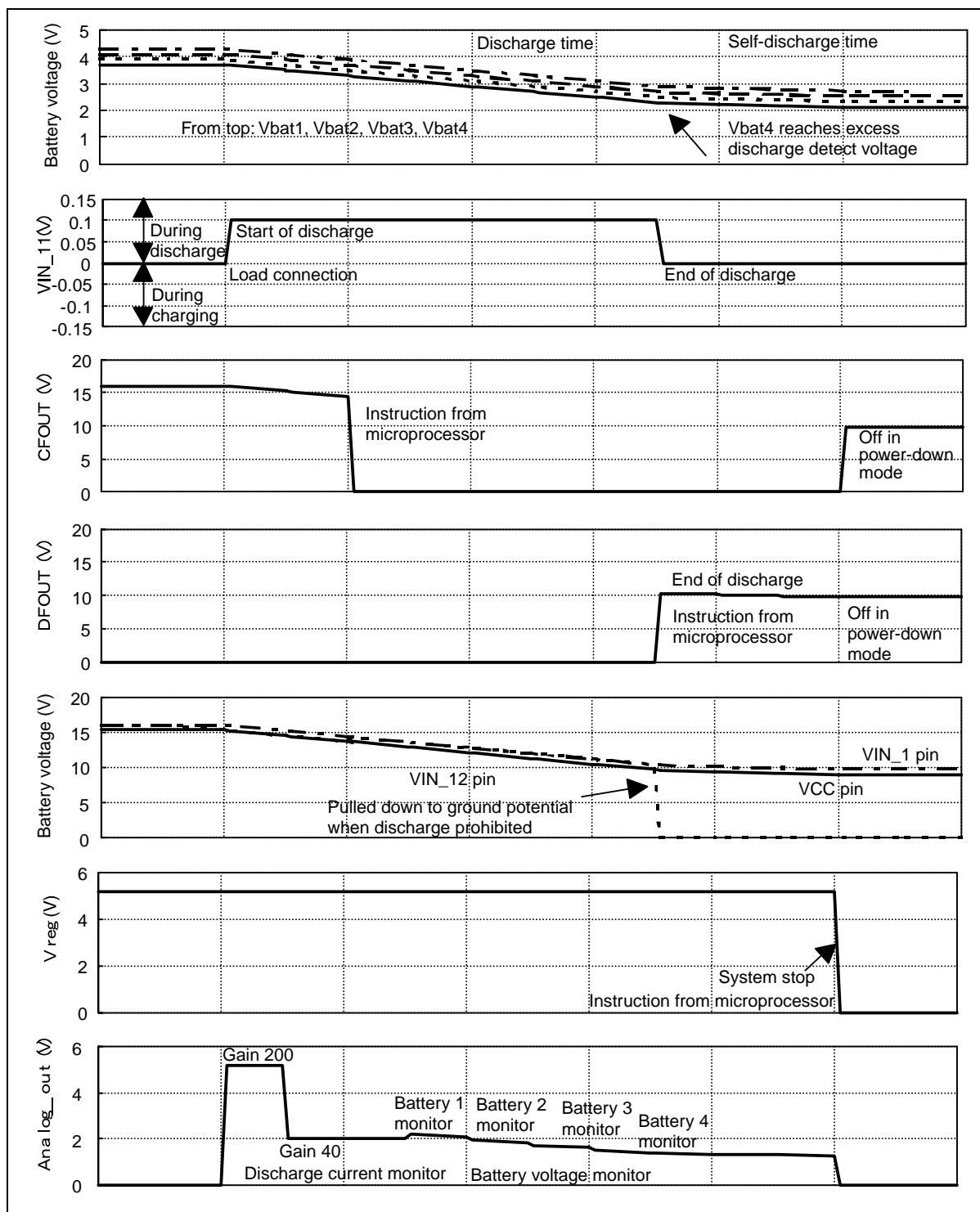


**Figure 14  Discharge Sequence**

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**Overcurrent Sequence**
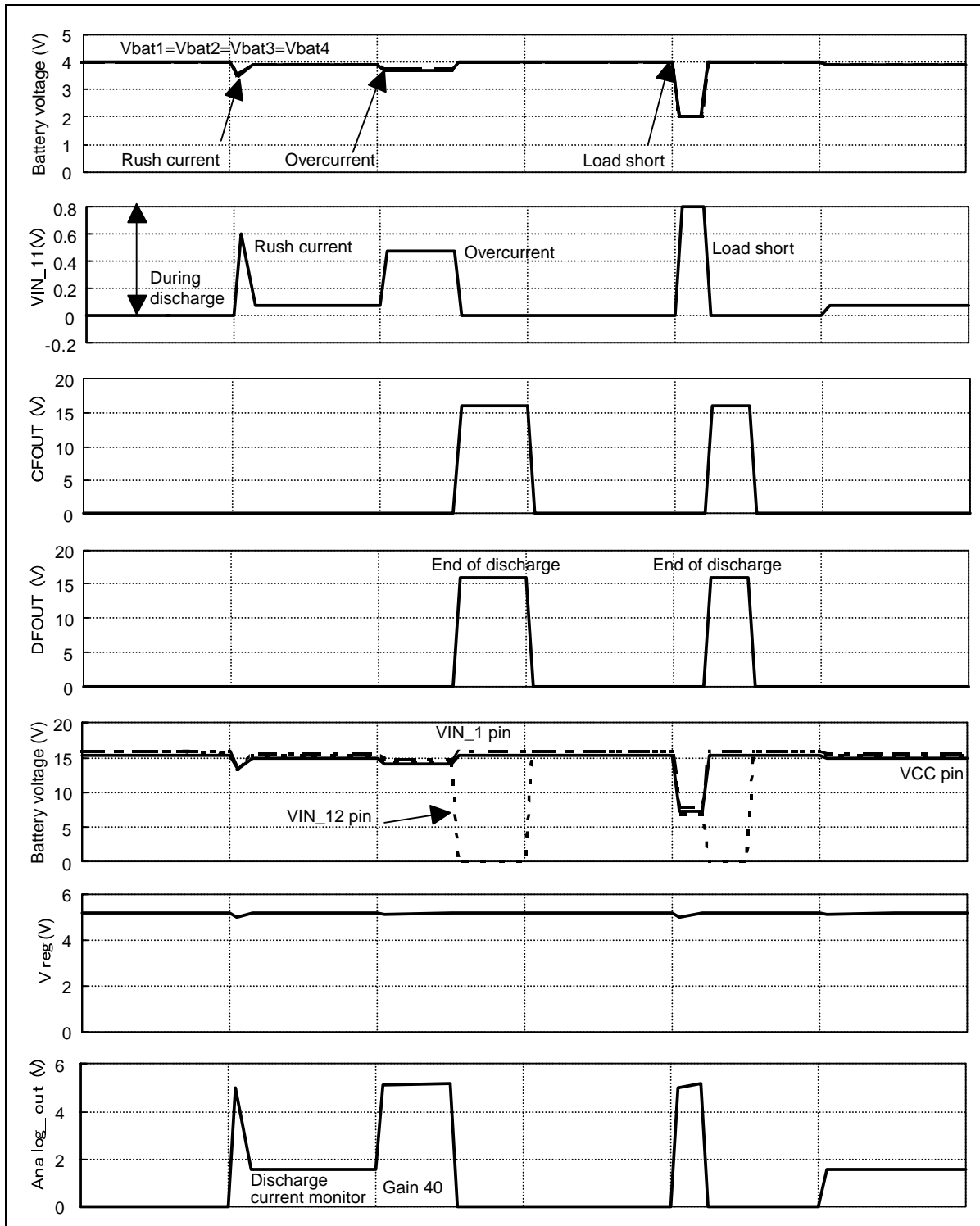


**Figure 15  Overcurrent Sequence**

## Principal Item Characteristics

Overall

Current Consumption (ISUP1)-Power Supply Voltage (VCC) Characteristics Temp.=25℃

Current Consumption (ISUP1)-Temperature (Ta) Characteristics Vcc=14V

Current Consumption (ISUP2)-Power Supply Voltage (VCC) Characteristics Temp.=25℃

Current Consumption (ISUP3)-Temperature (Ta) Characteristics Vcc=14V

Current Consumption (IPS)-Power Supply Voltage (VCC) Characteristics Temp.=25℃

Current Consumption (IPS)-Temperature (Ta) Characteristics Vcc=14V

Current Consumption (IPD)-Power Supply Voltage (VCC) Characteristics Temp.=25℃

Current Consumption (IPD)-Temperature (Ta) Characteristics Vcc=14V

Regulator Block

Regulator Output Voltage (VREG)-Power Supply Voltage (VCC) Characteristics Temp.=100°C

Regulator Output Voltage (VREG)-Temperature (Ta) Characteristics Vcc=30V

Regulator Output Voltage (VREG)-Power Supply Voltage (VCC) Characteristics Temp.=25°C

Regulator Output Voltage (VREG)-Temperature (Ta) Characteristics Vcc=14V

Regulator Output Voltage (VREG)-Power Supply Voltage (VCC) Characteristics Temp.=-25°C

Regulator Output Voltage (VREG)-Temperature (Ta) Characteristics Vcc=6V

Regulator Output Voltage (VREG)-Output Current (IREG) Characteristics Temp.=25°C

Regulator Output Voltage (VREG)-Output Current (IREG) Characteristics Vcc=14V

Overcurrent Detect Block

Overcurrent 1 Detect Voltage (VIOV1)-Temperature (Ta) Characteristics $_{VCC=14V}$
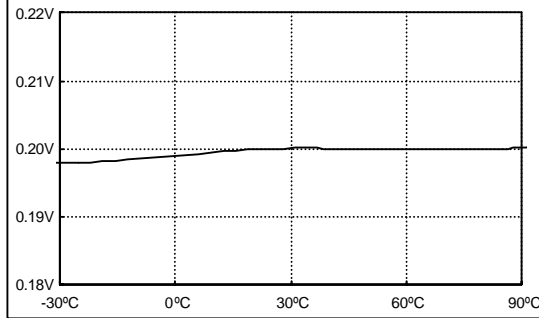
Overcurrent 1 Detect Delay Time (TIOV1)-Temperature (Ta) Characteristics $_{VCC=14V}$
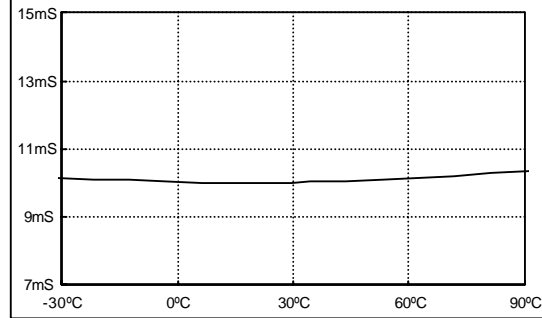
Overcurrent 2 Detect Voltage (VCC/VIOV2)-Temperature (Ta) Characteristics $_{VCC=14V}$
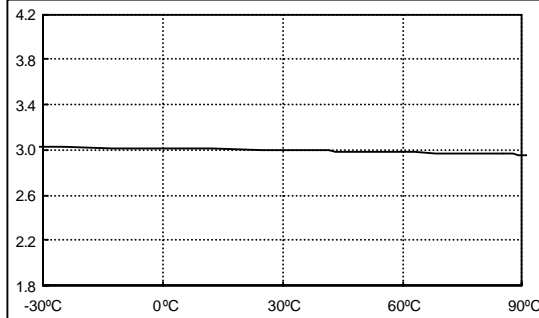
Overcurrent 2 Detect Delay Time (TIOV2)-Temperature (Ta) Characteristics $_{VCC=14V}$
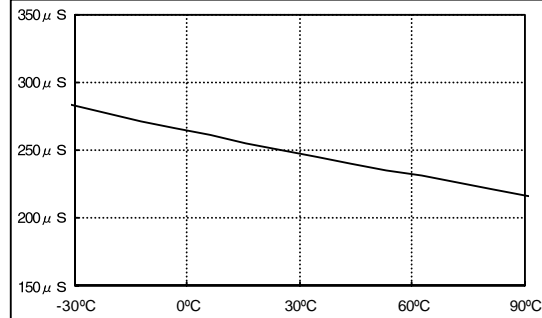
Overcurrent Hold Detect Voltage (VCC-VIOVX)-Temperature (Ta) Characteristics $_{VCC=14V}$
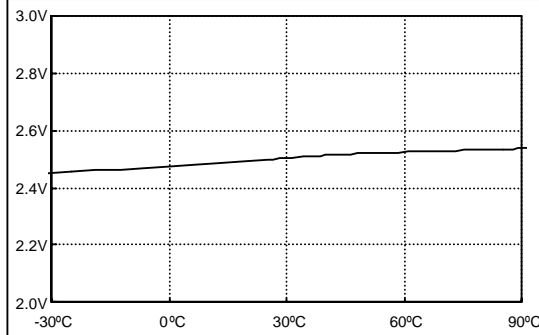
Overcurrent 1 Detect Delay Time (TIOV1)-Capacitance (CICT) Characteristics $_{VCC=14V}$
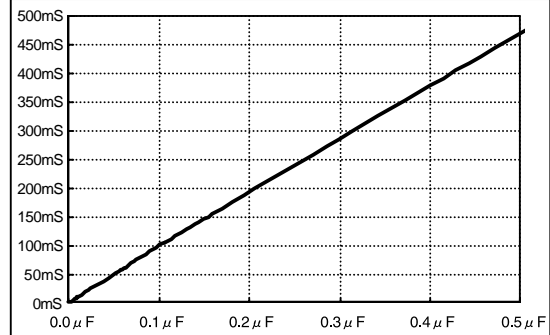
## Battery Voltage Detect Block

Battery Voltage Input Offset Voltage (VOFF1)-Temperature (Ta) Characteristics $V_{REG}$=5.2V
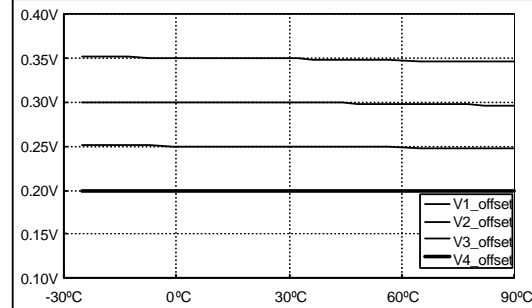


Battery Voltage Amplification Ratio 1 (Gamp1)-Temperature (Ta) Characteristics $V_{REG}$=5.2V
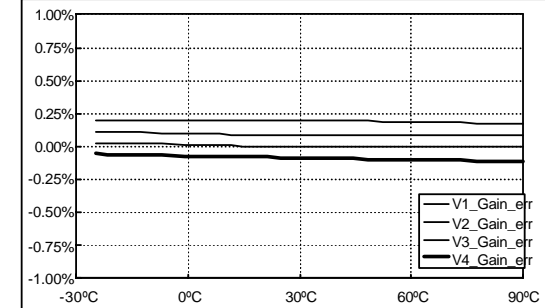


## Discharge XXXXX

Battery Voltage Input Offset Voltage (VOFF2)-Temperature (Ta) Characteristics $V_{REG}$=5.2V
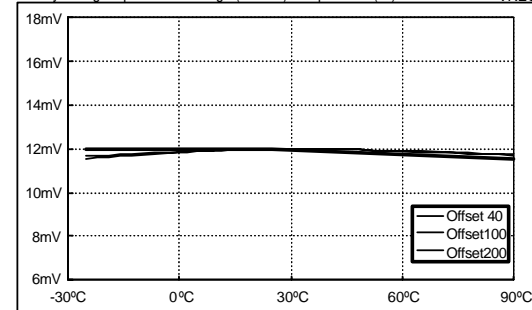


Discharge Current Input Offset Voltage (VOFF2)-Temperature (Ta) Characteristics $V_{REG}$=5.2V
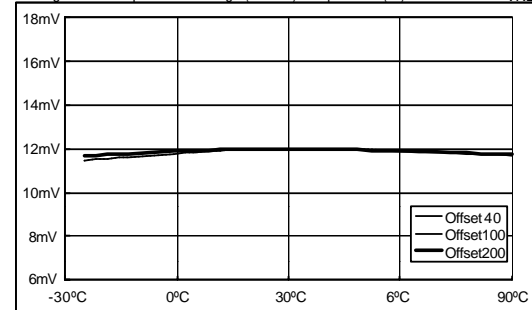


Battery Voltage Amplification Ratio (Gamp2)-Temperature (Ta) Characteristics $V_{REG}$=5.2V
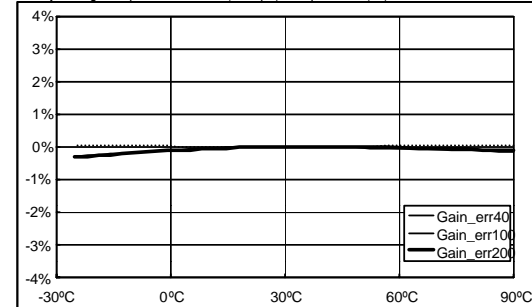


Discharge Current Amplification Ratio (Gamp2)-Temperature (Ta) Characteristics $V_{REG}$=5.2V
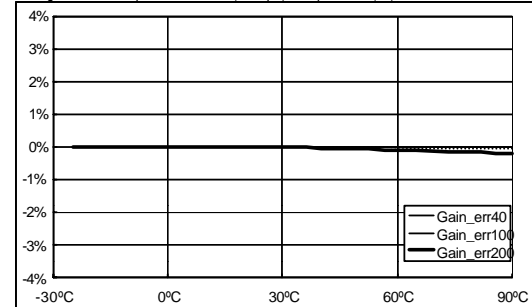
## Sample Application Circuit
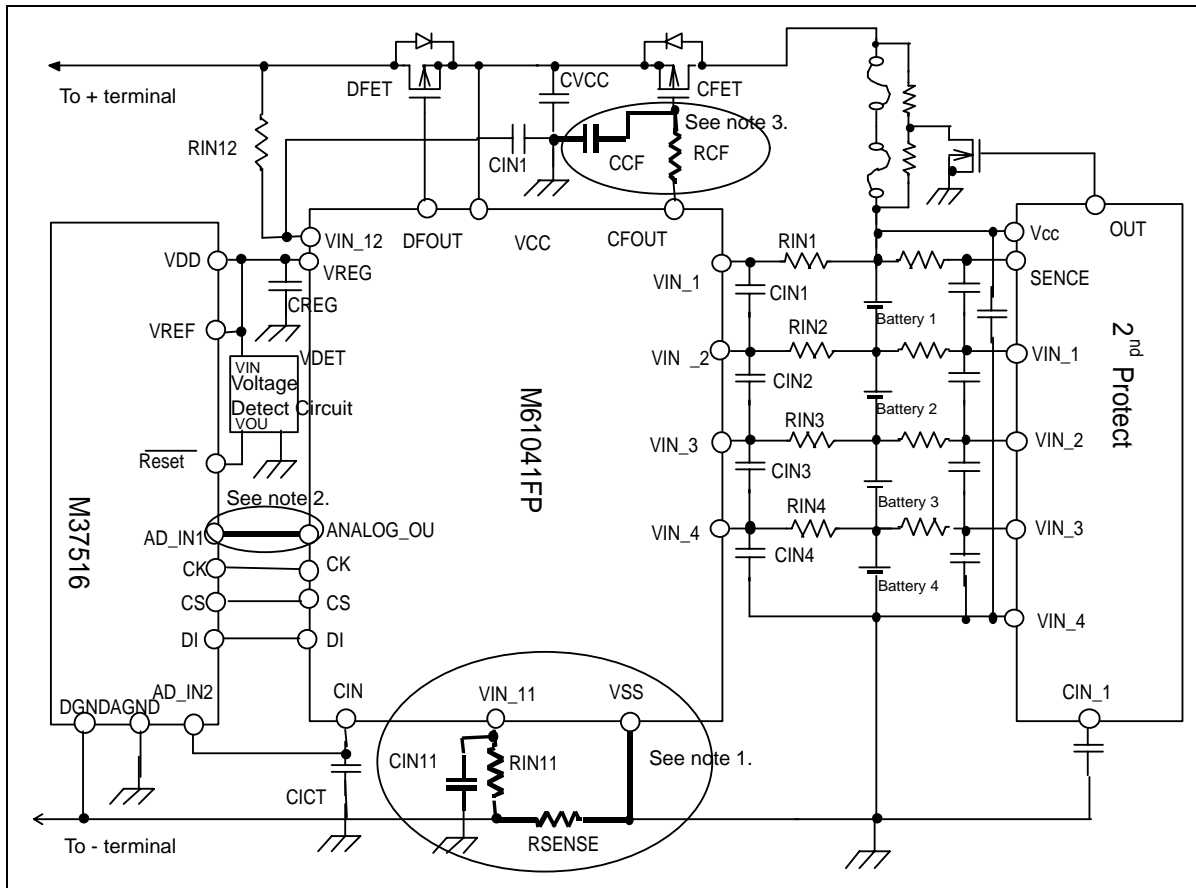


**Figure 16  Sample Application Circuit**

**Notes on Circuit Board Design**

1. The current sensor resistor (RSENSE) should be located adjacent to the VSS and VIN_11 pins of the M61041FP. In addition, no circuitry other than that recommended above should be added between the M61041FP and RSENSE. Any extraneous current flow in this channel could result in errors when measuring the charge and discharge currents.

2. The load capacitance of the ANALOG_OUT pin, including parasite capacitance, should be no more than 10 pF. If a capacitor of more than 10 pF is connected, the output from ANALOG_OUT may begin to oscillate.

3. Power supply fluctuations during overcurrent detection and when connected to a charger may cause the M61041FP to reset. It is possible to prevent incorrect operation by connecting a CR filter to the control signal of the charge control FET.

**Table 12  External Device Constants**

| Device | Symbol | Purpose | Recommended Value | Min. | Max. | Notes |
|---|---|---|---|---|---|---|
| Pch MOSFET | DFET | Discharge control | — | — | — | — |
| Pch MOSFET | CFET | Charge control | — | — | — | — |
| Resistor | RIN1 | ESD countermeasure | 10Ω | — | 1kΩ | 1) Values differ among RIN2 to RIN4. |
| Capacitor | CIN1 | Power supply fluctuation countermeasure | 0.22μF | — | 1.0μF | |
| Resistor | RIN2 | ESD countermeasure | 1kΩ | — | 1MΩ | — |
| Capacitor | CIN2 | Power supply fluctuation countermeasure | 0.22μF | — | 1.0μF | |
| Resistor | RIN3 | ESD countermeasure | 1kΩ | — | 1MΩ | 2) RIN2 and CIN2 should be set to the same value. |
| Capacitor | CIN3 | Power supply fluctuation countermeasure | 0.22μF | — | 1.0μF | |
| Resistor | RIN4 | ESD countermeasure | 1kΩ | — | 1MΩ | 2) RIN2 and CIN2 should be set to the same value. |
| Capacitor | CIN4 | Power supply fluctuation countermeasure | 0.22μF | — | 1.0μF | |
| Resistor | RIN11 | Power supply fluctuation countermeasure | 100Ω | — | 200Ω | 3) The upper value for confirmation of overcurrent operation should be adjusted as necessary. |
| Capacitor | CIN11 | Power supply fluctuation countermeasure | 0.1μF | — | 1.0μF | |
| Resistor | RIN12 | Charger reverse connection countermeasure | 10kΩ | 300Ω | 100kΩ | 3) The upper value for confirmation of overcurrent operation should be adjusted as necessary. |
| Capacitor | CIN12 | Power supply fluctuation countermeasure | 0.01μF | — | 0.1μF | |
| Capacitor | CVCC | Power supply fluctuation countermeasure | 0.22μF | — | — | — |
| Sensor resistor | RSENSE | Charge/discharge current monitoring | 20mΩ | — | — | — |
| Capacitor | CICT | Delay time setting | 0.01μF | — | 0.47μF | — |
| Capacitor | CREG | Output voltage fluctuation countermeasure | 4.7μF | 0.47μF | — | — |
| Resistor | RCF | Power supply fluctuation countermeasure | 1kΩ | 500Ω | — | 3) The upper value for confirmation of overcurrent operation should be adjusted as necessary. |
| Capacitor | CCF | Power supply fluctuation countermeasure | 0.1μF | 0.047μF | — | |

Note: When designing applications, due consideration should be given to safety.

RENESAS

## Package Dimensions

| 16P2X |
| --- |

Note :   Please contact Renesas Technology Corporation for further details.

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