Lithium-Ion Battery Charge Control (1 to 2 cells)
Monolithic IC MM1433

Outline

This IC is used to control charging of lithium-ion batteries. It is a one-chip charge control IC where the protection circuit incorporates constant-current/constant-voltage charge and precharge, overcharge timer, and battery temperature detection functions. It was developed by adding the above-described functions to the conventional MM1332 and MM1333.

Series Table

Temperature conditions A: Ta=−25~75°C, B: Ta=−20~70°C, C: Ta=0~50°C, D: Ta=0~40°C

	Package				Output voltage (V)	Output voltage temperature conditions	Full charge detection voltage (mV)	Over voltage detection voltage (v)	Remarks ∗
	SOP-8C, 8E	VSOP-8A, 8B	TSOP-16A	TSOP-24A					
MM1433				AV	4.100±0.030	C	18±5	4.35±0.05	1cell
				BV	8.400±0.060	C	12±5	8.70±0.10	2cell
				EV	4.200±0.030	C	18±5	4.35±0.05	1cell

Features

1. Charge voltage accuracy (Ta=0°C ~ +50°C)   ±30mV/cell
2. Current consumption   5mA typ.
3. Precharge function
4. Recharge function
5. Overcharge timer
6. Battery temperature detection function
7. Adaptor (primary side) abnormality detection function
8. LED driver (R, G pins)
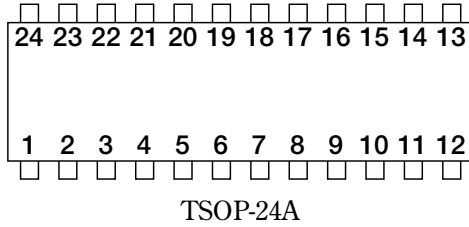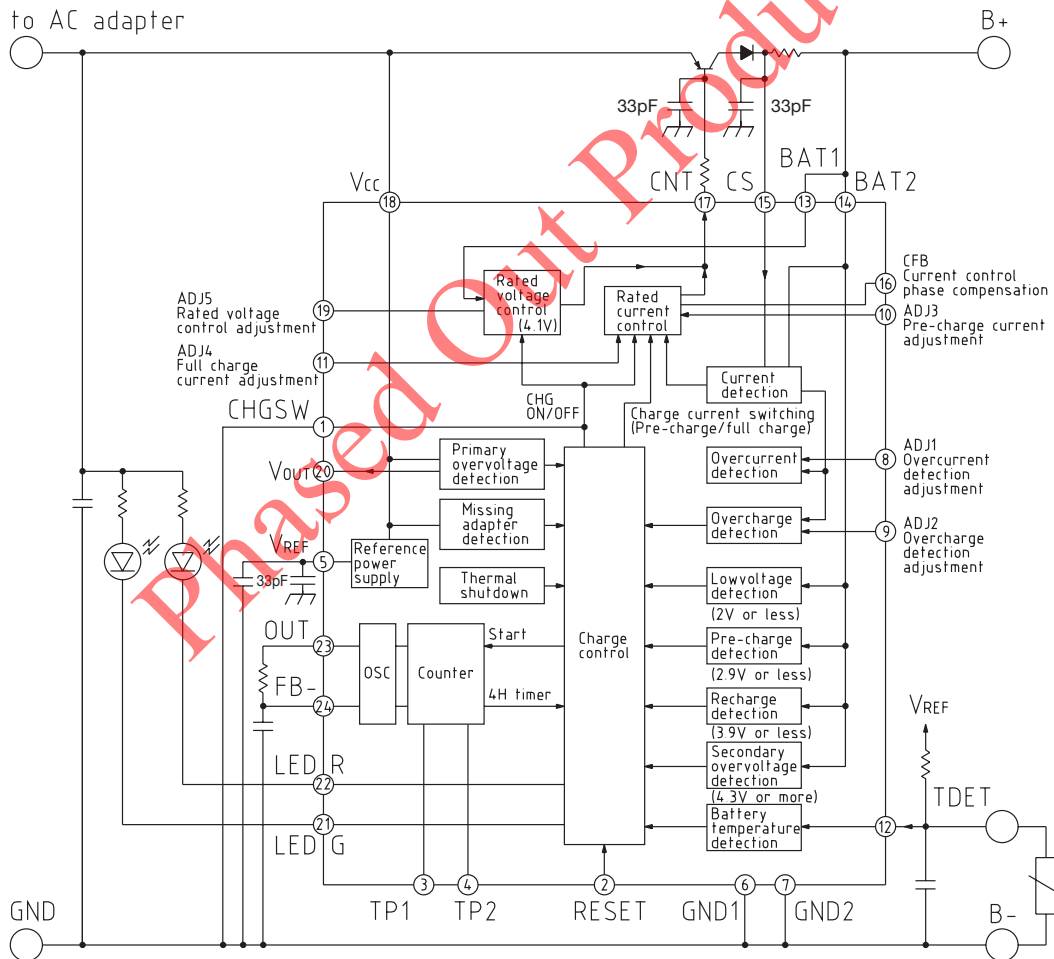9. Available for 1 to 2 cells

Package

TSOP-24A

Applications

For lithium-ion battery charge control

Pin Assignment

1	CHGSW	13	BAT1
2	RESET	14	BAT2
3	TP1	15	CS
4	TP2	16	CFB
5	VREF	17	CNT
6	GND1	18	V_{CC}
7	GND2	19	ADJ5
8	ADJ1	20	V_{OUT}
9	ADJ2	21	LED G
10	ADJ3	22	LED R
11	ADJ4	23	OSC OUT
12	TDET	24	OSC FB−

TSOP-24A

24 23 22 21 20 19 18 17 16 15 14 13

1 2 3 4 5 6 7 8 9 10 11 12

Block Diagram

Note: For lithium ion battery charging control (1-2 cells) For mobile telephones and other cases in which high frequency noise could be a problem, we recommend lowering impedance by adding 33pF capacitance between the VREF pin and GND, between the CS pin and GND, and between external PNP TR base and GND. Please make sure that the wiring on the pattern is kept as short as possible. When implementing noise countermeasures, be sure to consider the set as a whole.

Applicable circuits shown are typical examples provided for reference purposes. Mitsumi cannot assume responsibility for any problems arising out of the use of these circuits or for any infringement of third party patent and other right due to same.

Pin Description

Pin No.	Pin name	I/O	Functions
1	CHGSW	Input	Forced charging OFF pin L: Forced charging circuit ON (OFF for reset) H: Charging stop is forced
2	RESET	Input	Logic reset pin L: Forced charging circuit ON (start) H: Forced charging circuit OFF
3	TP1	Input/ Output	Test pin 1 Pre-charge timer test pin Inverts while counting (the middle stage of the several FF stages) and output to TP1, to permit monitoring. Also, TP1 output signal is inverted again inside the IC and inputs to the next stage FF. (Timer setting is done by binary counter.)
4	TP2	Input/ Output	Test pin 2 Full charge timer test pin Same structure as TP1
5	VREF	Output	Reference power supply output pin Outputs 1.2V typ. reference voltage. Used for temperature detection reference power supply and ADJ1 - ADJ4 adjustment.
6	GND1	Input	GND pin.
7	GND2	Input	GND pin.
8	ADJ1	Input	Overcurrent detection adjustment pin Set so that overcurrent detection does not function. Pin voltage is 1.16V typ. Overcurrent detection value can be varied by adjusting pin voltage with an external resistor, etc. Overcurrent detection is based on a comparison of ADJ1 pin voltage and a CS-BAT voltage drop of 12dB.
9	ADJ2	Input	Full charge detection adjustment pin Pin voltage is set at 103mV typ. Full charge detection value can be changed by adjusting pin voltage with an external resistor, etc. Full charge detection is done by comparing ADJ2 pin voltage and 12dB voltage drop value between CS and BAT.
10	ADJ3	Input	Pre-charge current adjustment pin Pin voltage is set at 120mV typ. Pre-charge current can be changed by adjusting pin voltage with an external resistor, etc. Pre-charge current control is done by comparing ADJ3 pin voltage and 12dB voltage drop value between CS and BAT.

Pin No.	Pin name	I/O	Functions
11	ADJ4	Input	Full charge current adjustment pin Pin voltage is set at 0.89mV typ. Full charge current can be changed by adjusting pin voltage with an external resistor, etc. Full charge current control is done by comparing ADJ4 pin voltage and 12dB voltage drop value between CS and BAT. When full charge current is controlled to rated current by an adapter, short ADJ4 pin and VREF pin so that rated current control does not function in the IC.
12	TDET	Input	Temperature detection input pin Apply potential resistance divided by external resistor and thermistor from reference voltage when using. Reset state will exist if TDET pin does not reach the specified potential.
13	BAT1	Input	Battery voltage input pins
14	BAT2	Input	Detect battery voltage and control charging.
15	CS	Input	Current detection pin Detects current by external resistor (between CS and BAT) voltage drop and controls charging current.
16	CFB	Input	Rated current control phase compensation pin Oscillation is improved by connecting an external capacitor (around 100pf) between CFB and CNT for phase compensation.
17	CNT	Output	Charging control output pin Controls external PNP-Tr base for rated current rated voltage charging.
18	V$_{CC}$	Input	Power supply input pin
19	ADJ5	Input	Rated voltage control adjustment pin Allows fine adjustment of rated voltage value. For example, rated voltage value rises by around 15mV (at 4.1V typ.) when ADJ5-GND is shorted.
20	V$_{OUT}$	Output	Overvoltage detection output pin For V$_{CC}$ overvoltage input: L For V$_{CC}$ recommended operating voltage: H
21	LED G	Output	LED C control output pin NPN-Tr open collector output. Refer to the flow chart for ON/OFF.
22	LED R	Output	LED R control output pin NPN-Tr open collector output. Refer to the flow chart for ON/OFF.
23	OSC OUT	Output	Oscillator output pin Timer setting time changes according to oscillation frequency. Oscillation frequency is determined by an external resistor (connected between OSC OUT and OSC FB) and capacitor (connected between OSC FB and GND). For example, the full charge timer setting is 4H for external resistor of 130kΩ and capacitor of 0.01μF.
24	OSC FB–	Input	Oscillator inverted input pin

Pin Description (Models listed MM1433E)

Pin No.	Pin name	Equivalent circuit diagram	Pin No.	Pin name	Equivalent circuit diagram	Pin No.	Pin name	Equivalent circuit diagram
1	CHGSW		10	ADJ3		17	CNT	
2	RESET		11	ADJ4		19	ADJ5	
3	TP1		12	TDET		20	V_{OUT}	
4	TP2		13	BAT1		21	LED G	
5	VREF		14	BAT2		22	LED R	
8	ADJ1		15	CS		23	OSC OUT	
9	ADJ2		16	CFB		24	OSC FB–	

Absolute Maximum Ratings (Ta=25°C)

Item	Symbol	Ratings	Unit
Storage temperature	T_{STG}	−40~+125	°C
Operating temperature	T_{OPR}	−20~+70	°C
Power supply voltage	V_{CC} max.	−0.3~+15	V
Allowable loss	Pd	250	mW

Recommended Operating Conditions

Item	Symbol	Ratings	Unit
Operating temperature	T_{OPR}	−20~+70	°C
Charging control operating voltage	V_{OPR}	2.7~5.9	V

Electrical Characteristics (Except where noted otherwise, Ta=25°C, Vcc=5V) Models listed MM1433E

Item	Symbol	Conditions	Measurement Pin	Min.	Typ.	Max.	Unit
Consumption current	I_{CC}		18		5.0	7.0	mA
Reference voltage	V_{REF}		5		1.207		V
ADP detection voltage L	V_{ADPL}	V_{CC} : H→L	20	2.35	2.45	2.55	V
ADP detection voltage L Hysteresis voltage width	V_{ADPLW}		20	50	100	150	mV
ADP detection voltage H	V_{ADPH}	V_{CC} : L→H	20	6.1	6.3	6.5	V
ADP detection voltage H Hysteresis voltage width	V_{ADPHW}		20	50	100	150	mV
Impedance for ADP detection output L	Z_{ADPL}		20		30		kΩ
BAT pin leak current	I_{BAT}		13, 14, 15			1	μA
BAT pin output voltage	V_{BAT}	Ta=0~+50°C	13	4.170	4.20	4.23	V
CNT pin output voltage	V_{CNT}	I_{CNT}=20mA	17			0.5	V
CHGSW pin input current	I_{SW}		1	40	60	80	μA
CHGSW pin input voltage H	V_{SWH}	CHGSW : OFF	1	0.6		1.20	V
CHGSW pin input voltage L	V_{SWL}	CHGSW : ON	1			0.25	V
RESET pin input current	I_{RE}		2	40	60	80	μA
RESET pin input voltage H	V_{REH}	Charging control circuit: OFF	2	0.6		1.20	V
RESET pin input voltage L	V_{REL}	Charging control circuit: ON	2			0.25	V
Current limit 1	V_{L1}	Quick charge	14, 15	0.20	0.22	0.24	V
Current limit 2	V_{L2}	Pre-charge	14, 15	21	26	31	mV
Full charge detection	V_F		14, 15	13	18	23	mV
Low voltage detection voltage	V_{LV}	V_{BAT} : L→H	13	1.90	2.00	2.10	V

Item	Symbol	Conditions	Measurement Pin	Min.	Typ.	Max.	Unit
Low voltage detection voltage Hysteresis voltage width	V_{LVW}		13	25	50	100	mV
Pre-charge detection voltage	V_P	$V_{BAT} : L{\to}H$	13	2.80	2.90	3.00	V
Pre-charge detection voltage Hysteresis voltage width	V_{PW}		13	25	50	100	mV
Re-charge detection voltage	V_R	$V_{BAT} : H{\to}L$	13	3.85	3.90	3.95	V
Overvoltage detection voltage	V_{OV}	$V_{BAT} : L{\to}H$	13	4.30	4.35	4.40	V
Battery temperature detection voltage H	V_{TH}	Low temperature 3°C ± 3°C detection	12	0.835	0.860	0.885	V
Battery temperature detection voltage L1	V_{TL1}	High temperature 43°C ± 3°C detection (charging start)	12	0.390	0.413	0.435	V
Battery temperature detection voltage L2	V_{TL2}	High temperature 50°C ± 3°C detection (during charging)	12	0.335	0.353	0.370	V
TDET input bias current	I_T		12		30	150	nA
LED R pin output voltage	V_{LEDR}	I_{LEDR}=10mA	22			0.4	V
LED G pin output voltage	V_{LEDG}	I_{LEDG}=10mA	21			0.4	V
Timer error time	$\triangle T$	Not including external deviation	21, 22	–10		10	%

Note 1: Current limits 1 and 2 and full charge detection are specified at current detection resistor voltage drop.

Note 2: If the IC is damaged and control is no longer possible, its safety can not be guaranteed. Please protect with something other than this IC.

Note 3: Temperature detection is the setting value at B constant 3435 (10KC15-1608 made by Ishizuka Denshi).

Note 4: Use a capacitor with good temperature characteristics in the oscillator. Capacitor deviation will contribute to timer error.

Note 5: If the battery overdischarges, charge 1mA for 14 seconds, and if it does not switch to pre-charging during that interval, it means the IC has identified a battery abnormality.

OSC CR Setting Reference Materials

(1) OSCR CR-Oscillation Cycle T Examples

C \ R	75k	100k	120k	130k	150k	200k
0.0047µ	0.47ms	0.63ms	0.75ms	0.82ms	0.94ms	1.26ms
0.0082µ	0.83ms	1.10ms	1.32ms	1.43ms	1.65ms	2.20ms
0.01µ	1.03ms	1.37ms	1.63ms	1.77ms	2.04ms	2.73ms
0.015µ	1.48ms	1.98ms	2.38ms	2.58ms	2.97ms	3.95ms
0.022µ	2.16ms	2.87ms	3.44ms	3.73ms	4.30ms	5.76ms

(2) Timer Times

Item	Calculation formula	Examples of calculation (for C = 0.01µ, R = 230k)
Pre-charge timer	$T \times 2^{19}$	15min. 28s
Full charge timer	$T \times 2^{23}$	4h7min.
1mA charge time	$T \times 2^{13}$	14.5s
Full charge detection delay time	$T \times 2^{6}$	0.90s
Overcurrent detection delay time	$T \times 2^{8}$	0.45s
Overvoltage detection delay time	$T \times 2^{8}$	0.45s
Re-charge detection delay time	$T \times 2^{5}$	56.6ms
LED R blinking cycle	$T \times 2^{10}$	1.8s

Note: T: OSC oscillation cycle

Operation

1. Basic Functions
· Constant voltage/constant current control.
· Full charge status detection.

2. Protection Functions
· Protection when AC adapter or battery is abnormal.
· Protection from abnormal operation by monitoring battery temperature.
· Protection from abnormal operation by time limitation.

3. Warning Functions
· Constant lighting of green LED to show completion of normal charging
· Constant lighting of red LED to show normal charging operation
· Blinking of red LED showing charging disabled on detection of abnormality.
· Operation check of internal timer for time limitation

4. Forced Stop Function
· Forced stopping of charging by controlling RESET and CHGSW pins.

5. Charge Restart Functions
· Charge restart when battery voltage drop detection operates after full charge detection
· Charge restart by reconnecting after disconnecting AC adaptor
· Charge restart by reconnecting after removing batteries
· Charge restart by canceling forced stop operation

Description

1. Charging Operation
1.1 Start of Charging
· Charging is disabled at the start of charging in the following cases:
1) Battery is in overvoltage state, i.e., the battery voltage is higher than overcharge detection voltage (Vov). (Charging is prohibited after overvoltage delay time elapses.)
2) AC adapter or battery is not correctly connected.
3) RESET pin and CHGSW pin are 0.6 ~ 1.2V.

4) Pin 12 (TDET) is open.

· At the start of charging, charge waiting results in the following cases (initially prohibited, but charging starts when the voltage returns to the normal range):

1) AC adapter supply voltage is less than VADPL or higher than VADPH.

2) Pin 12 (TDET) voltage is outside the range from battery temperature detection voltage L1 (VTL1) to battery temperature detection voltage H (VTH). Even during charging or when fully charged, neither LED will light up and the timer will be reset if pin 12 (TDET) voltage is outside the temperature range. AC adapter abnormality detection, RESET and TDET will operate similarly.

· Except in the above cases, charging starts.

1.2 1mA Charging Operation

· When charging starts, if the battery's voltage is below the low voltage detection voltage (V_{LV}), the battery is charged using the 1mA charging current.

· If the battery is overdischarged, a time limit is provided by a 1mA charging timer in order to protect the battery if the battery voltage does not rise because of some problem. If battery voltage does not reach VLV within the time set by the 1mA charging timer, charging is prohibited.

· See "OSC CR Settings" on the data sheet for the 1mA charge timer setting.

1.3 Preparatory Charging Operation

· When battery voltage is higher than low voltage detection voltage (V_{LV}), the battery is charged by pre-charge current. The standard preparatory charging current is determined by dividing current limit 2 (V_{L2}) by the value of the external resistance (0.3-Ω recommended) between pins 14 and 15. This status is maintained until the battery's voltage rises and the voltage at pin 13 reaches the preparatory charging detection voltage (VP).

· However, if for some reason the battery does not reach the preparatory charge detection voltage (VP), the preparatory charge timer limits the time in this state in order to protect the battery. If the battery does not reach the preparatory charge detection voltage (VP) within the preparatory charge timer's setting, charging is disabled.

· See "OSC CR Settings" on the data sheet for the preparatory charge timer setting.

1.4 Full Charging Operation

· When the battery voltage rises and the voltage at pin 13 reaches the preparatory charge detection voltage (VP), charging starts using the full charging current. The standard full charging current is determined by dividing the current limit 1 (VL1) by the value of the external resistance (0.3-Ω recommended) between pins 14 and 15.

· As the battery voltage rises, operation switches from constant current charging to constant voltage charging when the voltage at pin 13 approaches the output voltage at the BAT pin (VBAT).

· After switching to constant voltage charging, the charging current is gradually reduced. When the charging current drops below the value determined by dividing the full-charge detection value by the external resistance (0.3-Ω recommended) between pins 14 and 15, charging continues for the value of the full-charge detection delay timer, then stops, and the open collector NPN transistor at pin 21 (LED G) turns ON.

· However, a time limit is provided by a full-charge timer in order to protect the battery if, due to some abnormality, battery voltage does not reach BAT pin output voltage (VBAT), or if charging current does not drop off after switching to constant voltage charging and full charge detection does not operate. After the full charge timer setting time has elapsed, charging will be prohibited in the above cases.

· See "OSC CR Settings" on the data sheet for the full-charge detection delay timer setting and full-charge timer setting

· If, at the start of charging, the battery is already at BAT pin voltage, charging is continued for the value of the full-charge detection delay timer and then stops, and the open collector NPN transistor at pin 21 (LED G) turns ON.

1.5 Recharging Operation
· On detection of a full charge and after the end of charging, the battery voltage starts to drop. Recharging starts when the voltage has dropped to the recharge detection voltage (There is no re-charging detection function for rank B.).

2 Other Protective Functions
  2.1 Forced Charge Disabling Function
· By setting pin 1 (CHGSW) or pin 2 (RESET) level HIGH (0.6V - 1.2V), charging is disabled. Normally, ground these pins.
· Pin 1 (CHGSW): Charging ON/OFF only; timer continues to work. Used to temporarily prohibit charging.
· Pin 2 (RESET): Resets timer simultaneously with charging ON/OFF.
· Disablement using pin 2 takes precedence over pin 1.
· Pin 1 and Pin 2 are connected to Pin 5 (reference power supply output: VREF) via an internal resistor. This reference power supply does not have sync capability, so high level should not exceed Pin 5 voltage (VREF).
  2.2 Temperature Monitoring Function
· A potential created by splitting the voltage at pin 5 (VREF) using external resistor and thermistor is monitored at pin 12 (TDET). Charging is disabled if, at the start of charging, the temperature is not within the range of 3°C to 43°C, or between 3°C and 50°C during charging.
· If a thermistor is not used, a resistor can be connected for charging operation, but temperature protection will not operate.   Note: Battery OPEN detection assumes that the battery pack thermistor is removable. If the thermistor is not used, a battery OPEN detection circuit is required.
· Pin 5 (VREF) is approximately 1.207V ± 2% and output source current is approximately 180mA.
· Confirmation of charging prohibited status
  If charging is prohibited during charging due to the timers reaching time up, the open collector NPN transistor inside Pin 22 (LED R) will repeat ON/OFF. This can be verified by connecting Pin 22 (LED R) via a resistor (pull-up connection) to an LED, which will blink.
  2.3 Hysteresis and Delay Times
· To protect the circuit from malfunction due to noise, etc., hysteresis characteristics are applied to the ADP detection voltage, low-voltage detection voltage, and preparatory charge detection voltage.
· Also, a constant delay time is applied to full-charge detection, over-voltage detection, and recharge detection operations.
· The respective delay times are set by the internal timers. See the "OSC CR Settings" on the data sheet for the timer settings.

3. Checking Charging Operation
· During pre-charging and full charge operations, the open collector NPN transistor inside Pin 22 (LED R) is constantly ON. Pre-charging and full charge can be verified by connecting Pin 22 (LED R) via a resistor (pull-up connection) to a red LED, which will be constantly lit.
· During 1mA charging operation, the open collector NPN transistor inside Pin 22 (LED R) repeats ON/OFF. When operation switches from 1mA charging to pre-charging, the open collector NPN transistor inside Pin 22 (LED R) stays ON constantly. Switching from 1mA charging to pre-charging can be verified by connecting Pin 22 (LED R) via a resistor (pull-up connection) to a red LED, which will be constantly lit.
· If charging is prohibited during charging due to the timer reaching time up, the open collector NPN transistor inside Pin 22 (LED R) will repeat ON/OFF. This can be verified by connecting Pin 22 (LED R) via a resistor (pull-up connection) to an LED, which will blink.
· Pre-charging timer operation can be verified by Pin 3 (TP1) high/low switching.
  The TP1 pin signal inverts at the 10th stage of the pre-charge timer binary counter (total 19 stages) and

outputs on the TP pin. Referring to the data sheet "OSC CR setting reference materials," when T = 1.77ms, a waveform with cycle of approximately 1.8s is output.

· Full charge timer operation can be verified by Pin 4 (TP2) high/low switching.

The TP2 pin signal inverts at the 12th stage of the full charge timer binary counter (total 23 stages) and outputs on the TP pin. Referring to the data sheet "OSC CR setting reference materials," when T = 1.77ms, a waveform with cycle of approximately 7.2s is output.

· The blinking period of the LED connected to pin 22 is determined by the internal timer. See the "OSC CR Settings" on the data sheet for the timer settings.

4. Checking the End of Charging

· For full charge detection, after the full charge delay time elapses, the open collector NPN transistor inside Pin 22 (LED R) goes OFF, and the open collector NPN transistor inside Pin 21 (LED G) goes ON. This can be verified by a pull-up connection of Pin 22 (LED R) to a red LED and of Pin 21 (LED G) to a green LED via resistors. The red LED should be out and the green LED should be lit.

5. Checking Disabling of Charging

· In the case of the following cases in which charging is disabled, the open collector NPN transistors at pin 21 (LED G) and pin 22 (LED R) remain OFF. The LEDs connected to pins 21 and 22 will not turn on.

1) When the battery is not connected correctly.

2) When the AC adapter is not connected correctly, or the voltage output by the AC adapter is less than VADPL or higher than VADPH.

· If charging is disabled because the charger is faulty, the voltage at pin 20 (Vout) switches from HIGH level (pin 18 voltage to 0.5[v] max.) to LOW level (0.5[V] max.). You can check if the charger is faulty by monitoring this voltage.

3) When battery temperature is outside the charging start temperature range.

6. Recharging from Full Charge

· Once charging ends as a result of the full-charge detection operation and the battery voltage drops as a result of it being used and simply by its own natural discharge, recharging starts when the recharge detection delay timer times out after the voltage drops to the recharge detection voltage.

· See the "OSC CR Settings" on the data sheet for the recharge detection delay time.

· There is no re-charging detection function for rank B.

7. Recovery from Charge-Disabled State

· The following conditions apply before recovery can be implemented from the charge-disabled state:

1) Disconnect and then reconnect the charger.

2) Disconnect and then reconnect the battery.

3) Set pin 2 (RESET) to the HIGH RESET pin input voltage, then return it to the LOW RESET pin input voltage.

8. Other States

· If power is supplied to MM1433 when a battery is not connected, the red LED may immediately start blinking (red LED blinking cycle is higher than the setting value). This is because voltage that is not within the temperature abnormality range detected by Pin 12 (TDET pin) is impressed, and Pins 13 and 14 (BAT 1, 2) oscillate while they are open. In IC operating state, the oscillation occurs because BAT pin impedance is high due to constant voltage control. The oscillation causes charging operation to go ON/OFF repeatedly, and the red LED blinks at BAT oscillation frequency. On this IC, it is assumed that battery connection check will be done using the thermistor inside the battery pack. If a thermistor is not used, the IC RESET pin will go ON/OFF according to whether a battery is present or not.

Measuring Circuit
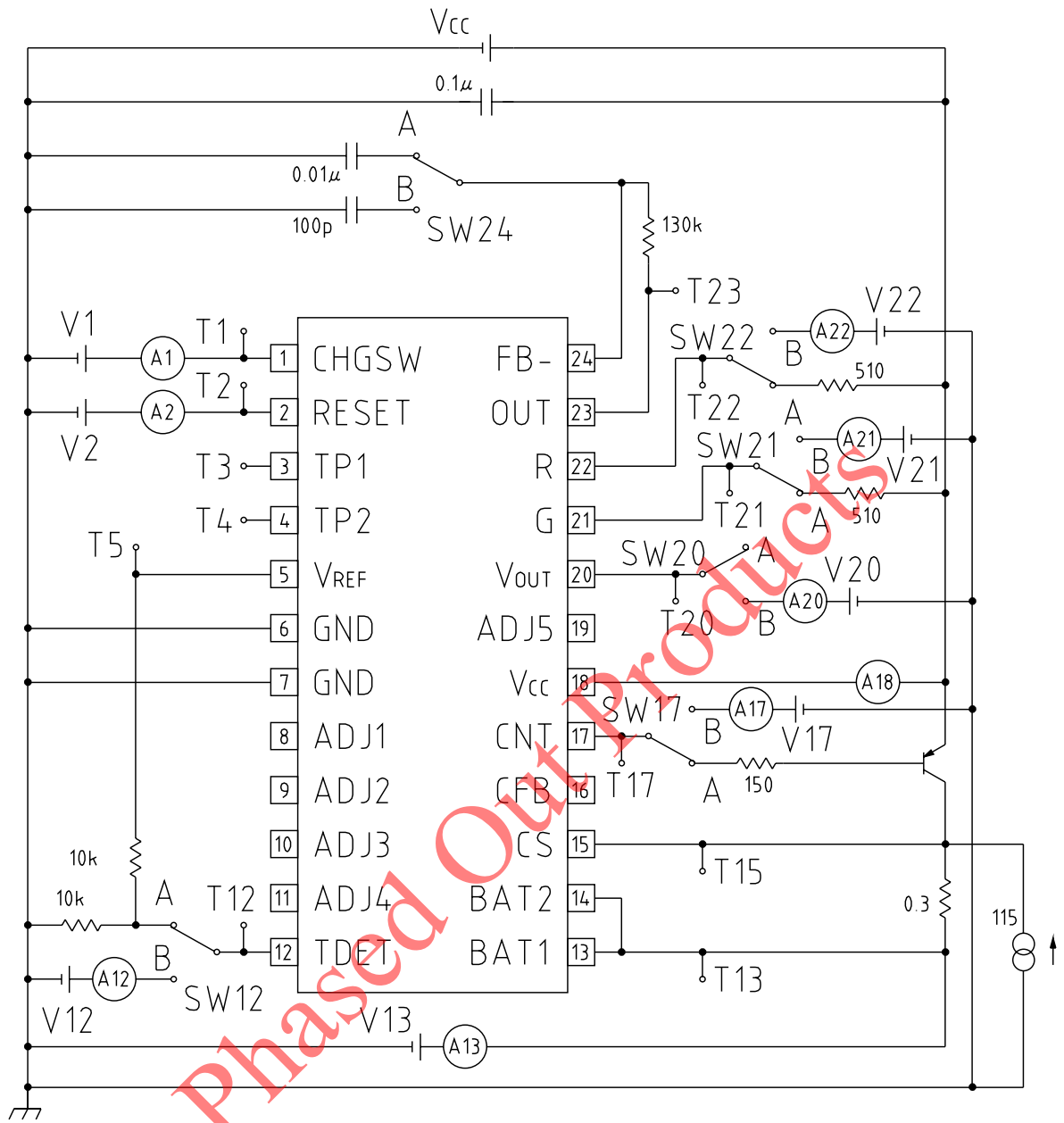
Measurement Procedures

(Except where noted otherwise, Ta = 25°C, Vcc=5V, V1=V2=0V, V13=4.2V, SW12, 17, 20, 22, 24:A, I15=0mA Timers are not in time up state.)
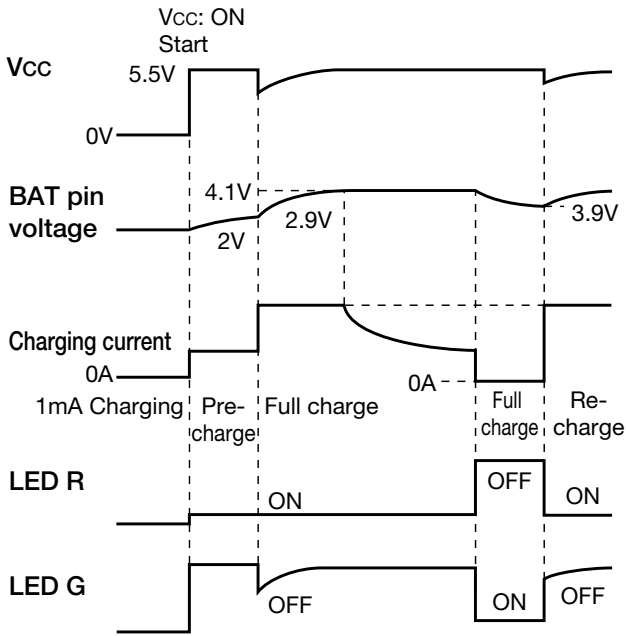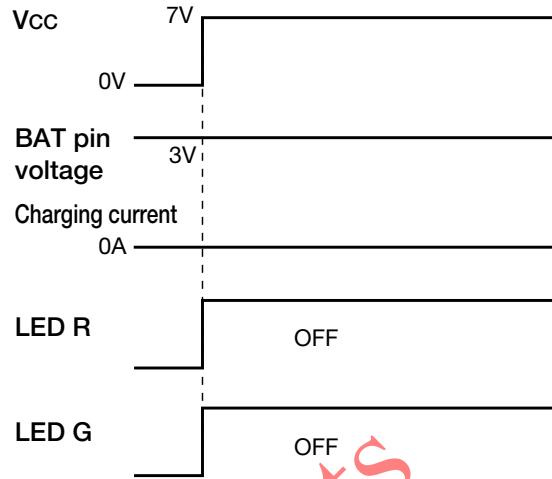
Item	Measurement Procedures
Consumption current	V1 = 1.2V. Measure A18 current value I_{CC}.
Reference voltage	Measure T5 potential V_{REF}.
ADP detection voltage L	Gradually lower Vcc from 5V; V_{CC} – potential is V_{ADPL} when T20 potential drops below 0.5V.
ADP detection voltage L Hysteresis voltage width	Gradually lower Vcc – from 2V. V_{CC} – potential is V_{ADPL2} when T20 potential goes over V_{CC} – 0.5V. $V_{ADPLW} = V_{ADLP2} – V_{ADPL}$
ADP detection voltage H	Gradually increase Vcc from 5V. Vcc potential is V_{ADPH} when T20 potential drops below 0.5V.
ADP detection voltage H Hysteresis voltage width	Gradually lower Vcc from 7V. Vcc potential is V_{ADPH2} when T20 potential goes over V_{CC} – 0.5V. $V_{ADPHW} = V_{ADPH} – V_{ADPH2}$
Impedance for ADP Ldetection output	V_{CC} = 7V, SW20: B, V20 – 0.5V, impedance between T20-GND is Z_{ADPL}.
BAT pin leak current	V_{CC} = 0V, SW17: B, V17 = 0V. Measure A13 current value I_{BAT}.
BAT pin output voltage	Gradually lower V13 from 3.5V. T13 potential is V_{BAT} when T15 – T13 potential difference falls to less than 20mV.
CNT pin output voltage	V13 = 3.5V, SW17: B. Gradually raise V17 from 0V. T17 potential is V_{CNT} when A17 current value 20mA.
CHGSW pin input current	Measure A1 current value I_{SW}.
CHGSW pin input voltage H	V13 = 3.5V. Raise V1 from 0V to 1.2V. CHGSW: ON when A13 is more than
CHGSW pin input voltage L	500mA. CHGSW: OFF when A13 is less than 1mA. Measure V_{SW}.
RESET pin input current	Measure A2 current value I_{RE}.
RESET pin input voltage H	V13 = 3.5V. Raise V2 from 0V to 1.2V. Charging control circuit: ON when A13 is more
RESET pin input voltage L	than 500mA. Charging control circuit: OFF when A13 is less than 1mA. Measure V_{RE}.
Current limit 1	V13 = 3.5V. T15-T13 potential difference is V_{L1}.
Current limit 2	V13 = 3.5V. T15-T13 potential difference is V_{L2}.
Full charge detection	SW24: B, I15 = 100mA. Gradually reduce I15 current value after reset. T15 – T13 potential difference is V_F when T21 potential goes under 0.5V.
Low voltage detection voltage	Gradually raise V13 from 0V. T13 potential is V_{LV} when A13 current value goes over 50mA.
Low voltage detection voltage Hysteresis voltage width	Gradually lower V13 from 2.5V. T13 potential is V_{LV2} when A13 current value goes over 10mA. $V_{LVW} = V_{LV} – V_{LV2}$
Pre-charge detection voltage	Gradually raise V13 from 2.5V. T13 potential is V_P when A13 current value goes over 500mA.
Pre-charge detection voltage Hysteresis voltage width	Gradually lower V13 from 3.5V. T13 potential is V_{P2} when A13 current value goes under 150mA. $V_{PW} = V_P = V_{P2}$
Re-charge detection voltage	Wait about 1s at V13 = 4.2V; in full charge detection state, gradually lower V13 potential to lower T21 potential to under 0.5V. T13 potential is V_R when T21 potential is more than V_{CC} – 0.5V.
Overvoltage detection voltage	Gradually raise V13 from 4V. T13 potential is V_{OV} when T22 potential starts to repeat HI/LOW.
Battery temperature detection voltage H	V13 = 3.5V, SW12: B. Gradually raise V12 from 0.6V. T12 potential is V_{TH} when A13 current value goes under 1mA.
Battery temperature detection voltage L1	V13 = 3.5V, SW12: B. Gradually raise V12 from 0V. T12 potential is V_{TL1} when A13 current value goes over 500mA.
Battery temperature detection voltage L2	V13 = 3.5V, SW12: B. Gradually raise V12 from 0.6V. T12 potential is V_{TL2} when A13 current value goes over 1mA.
TDET input bias current	SW12: B, V12 = 0V. Measure A12 current value IT.
LED R pin output voltage	V13 = 3.5V, SW22: B. Gradually raise V22 from 0V. T22 potential is V_{LEDR} when A22 current value is 10mA.
LED G pin output voltage	Wait about 1s at V13 = 4.27V; in full charge detection state, make T21 potential 0.5V or less. Next at SW21: B, gradually raise V21 from 0V. T21 potential is V_{LEDG} when A21 current value is 10mA.

Timing Chart

■ Charging performed normally

Vcc

Vcc: ON
Start

5.5V

0V

BAT pin
voltage

4.1V

2V

2.9V

3.9V

Charging current

0A

0A

1mA Charging | Pre-charge | Full charge | Full charge | Re-charge

LED R

ON

OFF

ON

LED G

OFF

ON

OFF

■ Adapter abnormality

Vcc

7V

0V

BAT pin
voltage

3V

Charging current

0A

LED R

OFF

LED G

OFF

■ Power supply setting error (temperature detection pin open)

Vcc

5.5V

0V

BAT pin
voltage

3V

Charging current

0A

LED R

OFF

LED G

OFF

■ Battery overcharge

Vcc

5.5V

0V

BAT pin
voltage

4.35V

Charging current

0A

Abnormality detection at BA
pin overvoltage for 0.5s or more

LED R

ON/OFF 0.57Hz

LED G

OFF

■ Battery overdischarge

Vcc 5.5V / 0V

BAT pin voltage 2V or less / 0V — No battery voltage reset

14s

Charging current 0A — 1mA charging

LED R — ON/OFF 0.57Hz

LED G — OFF
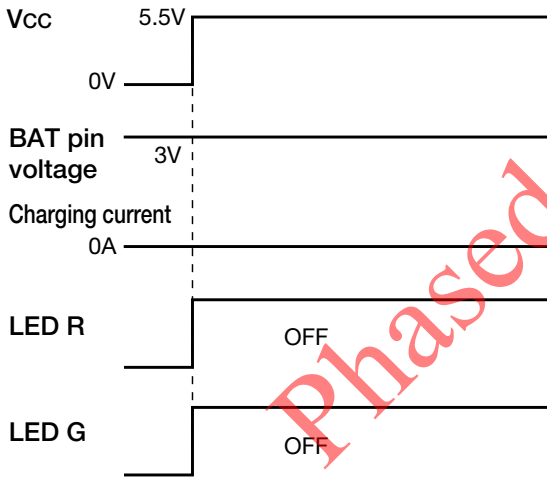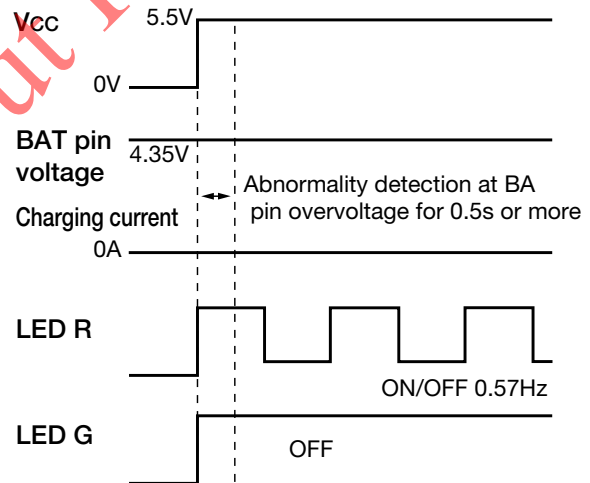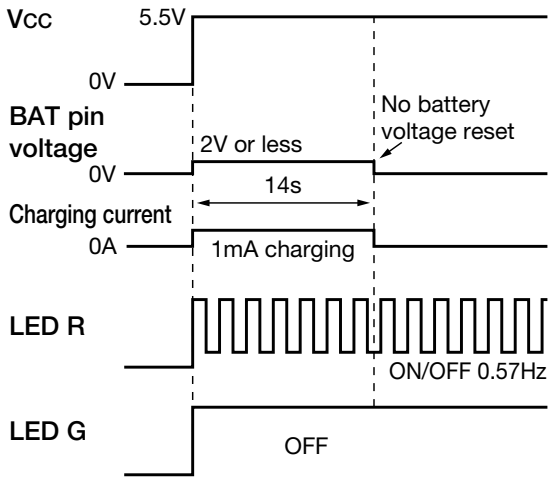
■ Overcurrent detection

Overcurrent detection does not function
A Lank

■ Pre-charge time up

Vcc 5.5V / 0V

BAT pin voltage — Battery voltage 2V or less / Battery voltage 2.9V or less

15min.

Charging current 0A — Charging at about 12% of full charge

LED R — ON / ON/OFF 0.57Hz

LED G — OFF

■ Full charge time up

Vcc 5.5V / 0V

BAT pin voltage — Battery voltage 2.9V or more / No full charge detection

4H

Charging current 0A — Full charge

LED R — ON / ON/OFF 0.57Hz

LED G — OFF
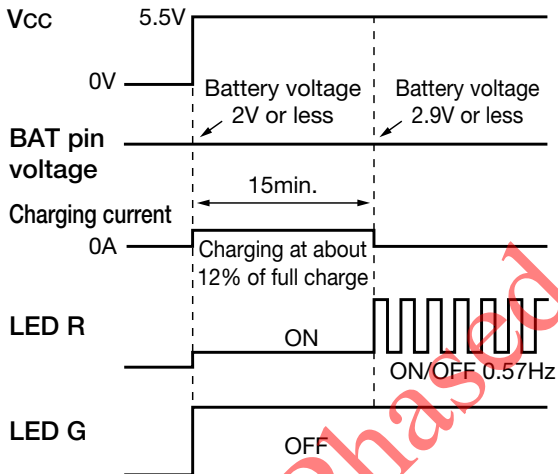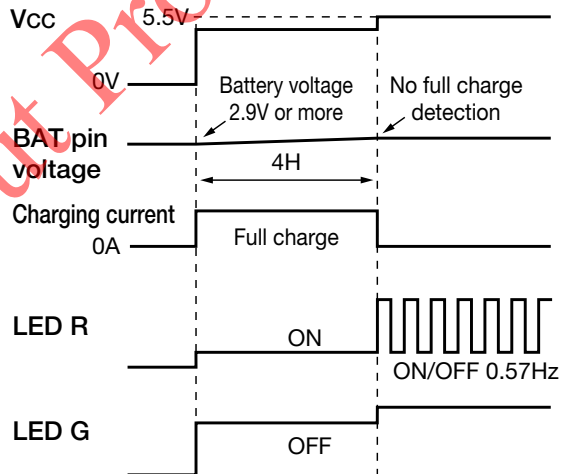
■ Battery full charge
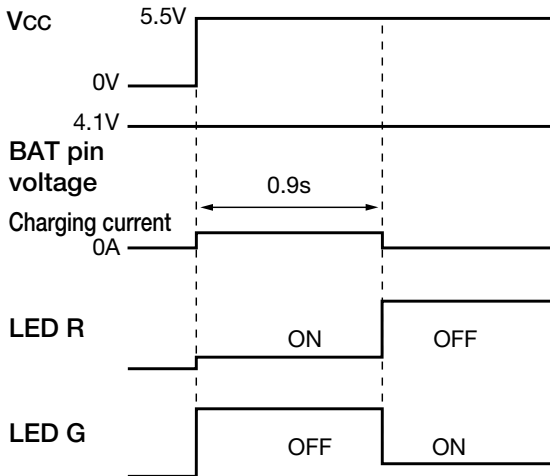
■ Re-charge detection
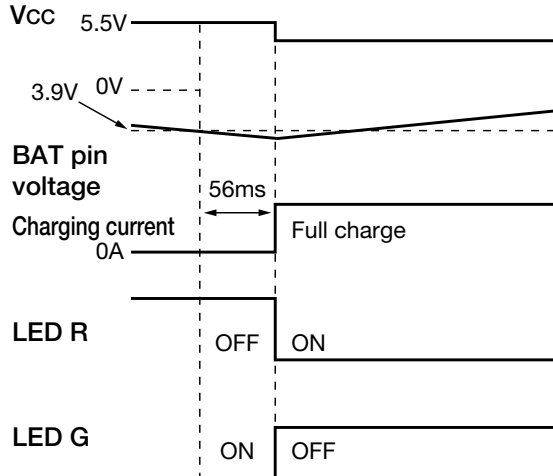
Application Circuit

Portable equipment
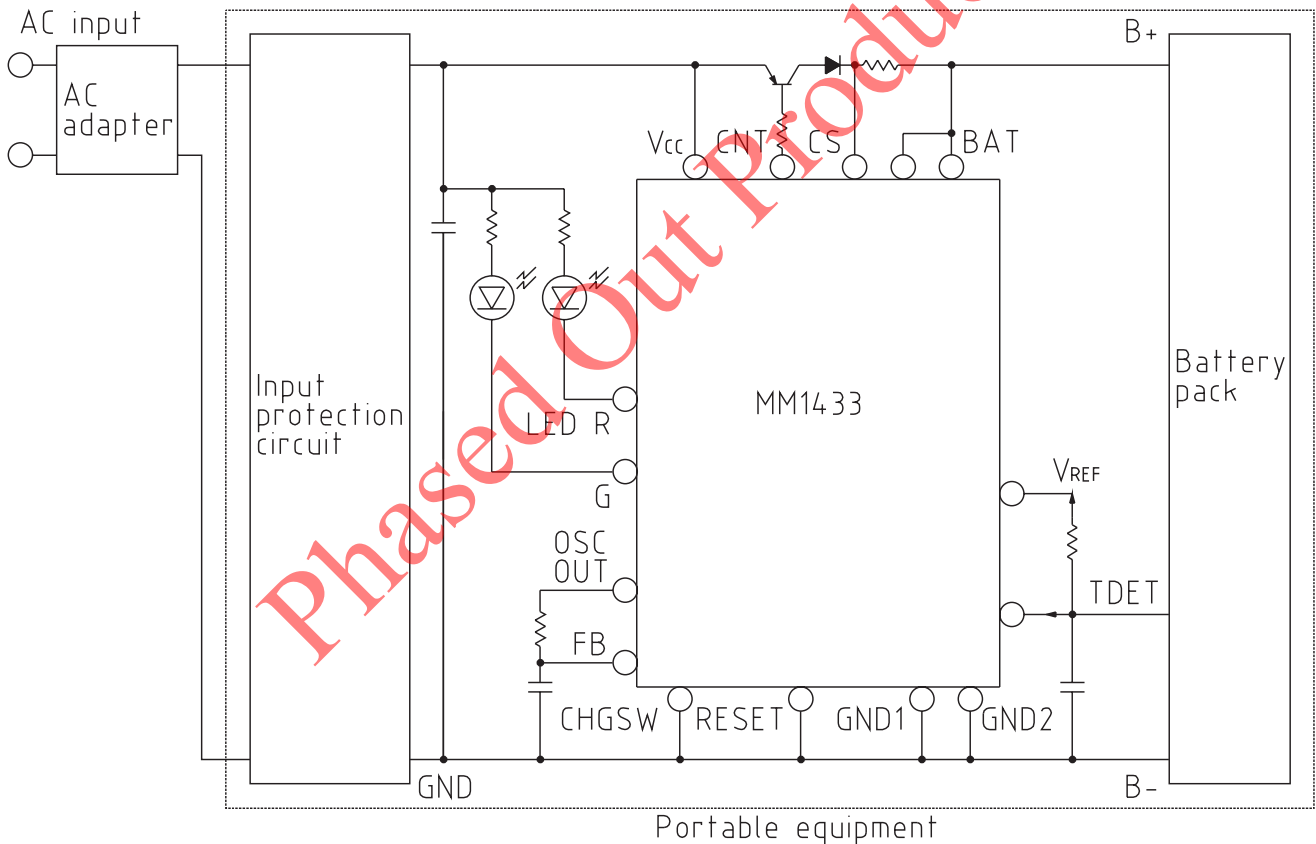
Note 1: This can be controlled even if a P-MOS FET is used in place of the external PNP-Tr. If you are using a
P-MOS FET, insert a resistance of several thousand ohms between the source and gate.

Note 2: Applicable circuits shown are typical examples provided for reference purposes. Mitsumi cannot
assume responsibility for any problems arising out of the use of these circuits or for any infringement
of third party patent and other right due to same.

Flow Chart (Models listed MM1433A)

```
                          ┌──────────┐
                          │  Start   │                              LED display
                          └──────────┘
                               │
                          ╱ Adapter ╲      No
                        ╱  trouble    ╲ ──────────┐
                        ╲ 2.5V<Vcc<6.3V╱          │              Not lit up
                          ╲         ╱              │
                            │ Yes        Abnormal charging prohibited
                               │
                          ╱  Check  ╲     No
                        ╱ batteries  ╲ ────────────┤
                          ╲         ╱              │
                            │ Yes                  │
                               │                   │
                          ╱  Check   ╲    No        │
                        ╱ temperature ╲ ───────────┤
                        ╲   3~43°C    ╱             │
                          ╲         ╱              │
                            │ Yes                  │
                   ┌──────────────────┐           │
                   │ Charge 1mA 14s   │           │
                   │ when VBAT<2.0V   │           │
                   └──────────────────┘           │
                            │                      │
                          ╱  Check   ╲    No        │
                        ╱  voltage    ╲ ───────────┤
                        ╲2.0V<VBAT<4.35V╱          │
                          ╲          ╱             │
                            │ Yes                  │
                          ╱  Check   ╲    No        │
                        ╱  voltage    ╲ ──────────────────────────┐
                        ╲ VBAT>2.9V   ╱            │              │
                          ╲         ╱              │              │
                            │ Yes                  │              │
          ┌────────────────┴──────────┐    ┌────────────────────┴───┐
    ┌───────────┐                      │    │   ┌──────────────┐
    │  4H timer │                      │    │   │ 15min. timer │   Red lit up
    │   start   │                      │    │   │    start     │
    └───────────┘                      │    │   └──────────────┘
          │                            │    │          │
    ┌───────────┐                      │    │   ┌──────────────┐
    │Quick charging│                   │    │   │ Pre-charging │
    └───────────┘                      │    │   └──────────────┘
          │                            │    │          │
    No  ╱  Check   ╲                   │    │   Yes  ╱ Time out ╲
  ┌───╱ temperature ╲                  │    └──────╲          ╱
  │   ╲   3~50°C    ╱                  │            ╲        ╱
  │     ╲         ╱                    │              │ No
  │       │ Yes                        │        ╱  Check   ╲   No
  │       │                            │      ╱  voltage    ╲ ─────┐
  │       │                            │      ╲ VBAT>2.9V   ╱      │
  │     ╱  Check   ╲     No             │        ╲         ╱       │
  │   ╱  voltage    ╲ ────────┐        │          │ Yes            │
  │   ╲ VBAT<4.35V  ╱         │        │                           │
  │     ╲         ╱          │        │                           │
  │       │ Yes              │        │                           │
  │   ╱ Time out ╲    Yes     │        │                           │
  │ ╲          ╱ ────────────┤        │                           │
  │   ╲      ╱               │        │                           │
  │     │ No                 │        │                           │
  │   ╱  Check   ╲           │        │                           │
  └─╱  overcharge ╲    No     │        │                           │
    ╲ IBAT<60mA   ╱          │        │                           │
      ╲         ╱            │        │                           │
        │ Yes                │        │                           │
  ┌──────────────┐           │        │                           │
  │  Charging    │           │        │                Green lit up │
  │  complete    │           │        │                           │
  └──────────────┘           │        │                           │
        │                    │        │                           │
  No  ╱  Check   ╲           │        │                           │
  ┌─╱  voltage    ╲          │        │                           │
  │ ╲ VBAT<3.9V   ╱          │        │                           │
  │   ╲         ╱            │        │                           │
  │     │ Yes                │        │                           │
  │                    Abnormal charging prohibited   Red blinking │
```
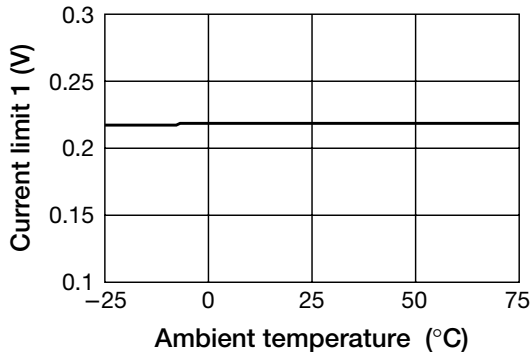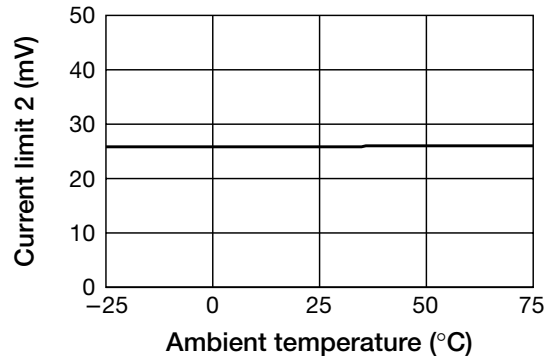
*When charging is prohibited,
disconnect the power supply,
remove the batteries,
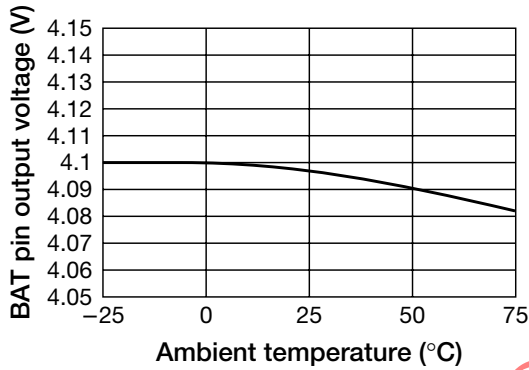or use reset to start again.

Characteristics

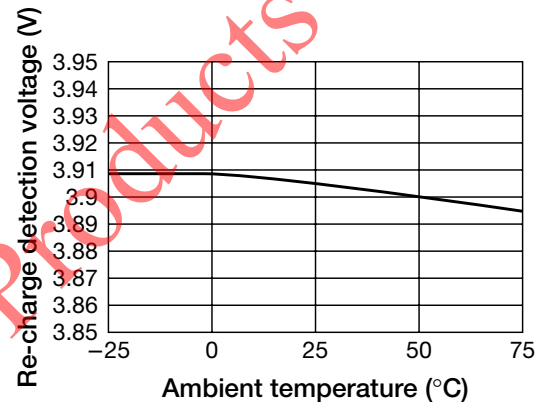### ■ Current limit 1 vs Ambient temperature

■ Current limit 2 vs Ambient temperature
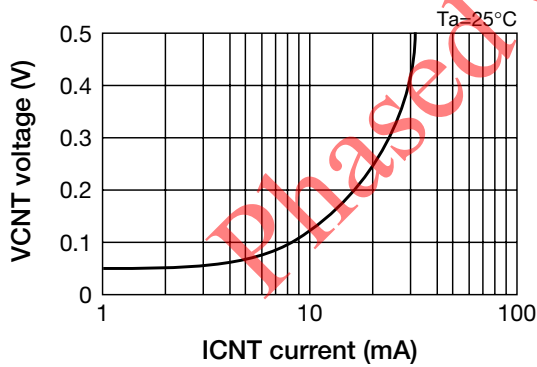

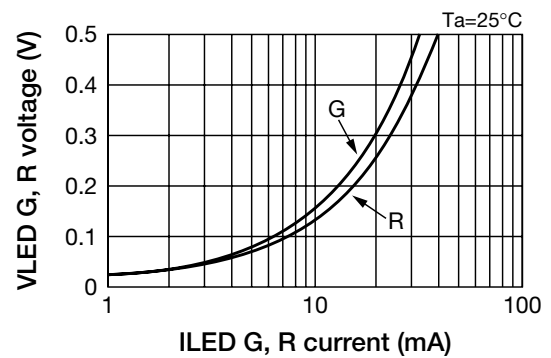### ■ BAT pin output voltage vs Ambient temperature

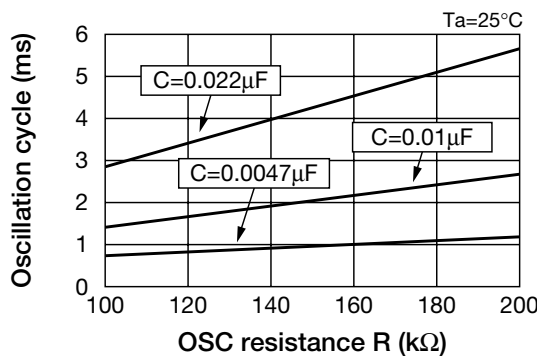### ■ Re-charge detection voltage vs Ambient temperature

■ VCNT voltage vs ICNT current

■ VLED G, R voltage vs ILED G, R current

■ OSC oscillation cycle vs CR

■ BAT pin reverse current vs BAT pin voltage