

Control for Lithium Ion Battery Charging (one cell) Monolithic IC MM1333

Outline

This IC was developed for use in charging lithium ion batteries. PNP power transistor or P-MOS FET is mounted externally to control charging. This IC is for use with a single cell only, and provides precise control of the charging voltage ; the charging current can be set through an external resistance. In addition to the functions of the MM1332, it incorporates a comparator for full-charge detection.

Series Table

Temperature conditions A: $T_a = -25\text{~}75^\circ\text{C}$, B: $T_a = -20\text{~}70^\circ\text{C}$, C: $T_a = 0\text{~}50^\circ\text{C}$,
D: $T_a = 0\text{~}40^\circ\text{C}$

	Package	Output voltage (V)	Output voltage temperature conditions	Full charge detection voltage (mV)	Over voltage detection voltage (v)	Remarks *
	VSOP-8A, 8B					
MM1333	DW	4.200 ± 0.050	D	20 ± 3		1cell
	HW	4.100 ± 0.050	D	31 ± 5		1cell
	JW	4.200 ± 0.050	D	31 ± 5		1cell

Note: In the case of rank D, the Co output voltage level changes to "L" when charging is turned ON. (The function is reversed in the case of ranks H and J).

Features

1. Output voltage 1 ($T_a=25^\circ\text{C}$)	$4.100\text{V}\pm 35\text{mV}$
2. Output voltage 2 ($T_a=0^\circ\text{C}\text{~}+40^\circ\text{C}$)	$4.100\text{V}\pm 50\text{mV}$
3. Constant-current output	Current limit Constant current value = current limit/external resistance
4. Low-voltage (LV) detection function	$2.00\text{V}\pm 100\text{mV}$
5. Full-charge detection function	Detection voltage $31\text{mV}\pm 5\text{mV}$

Package

VSOP-8A (MM1333□W)

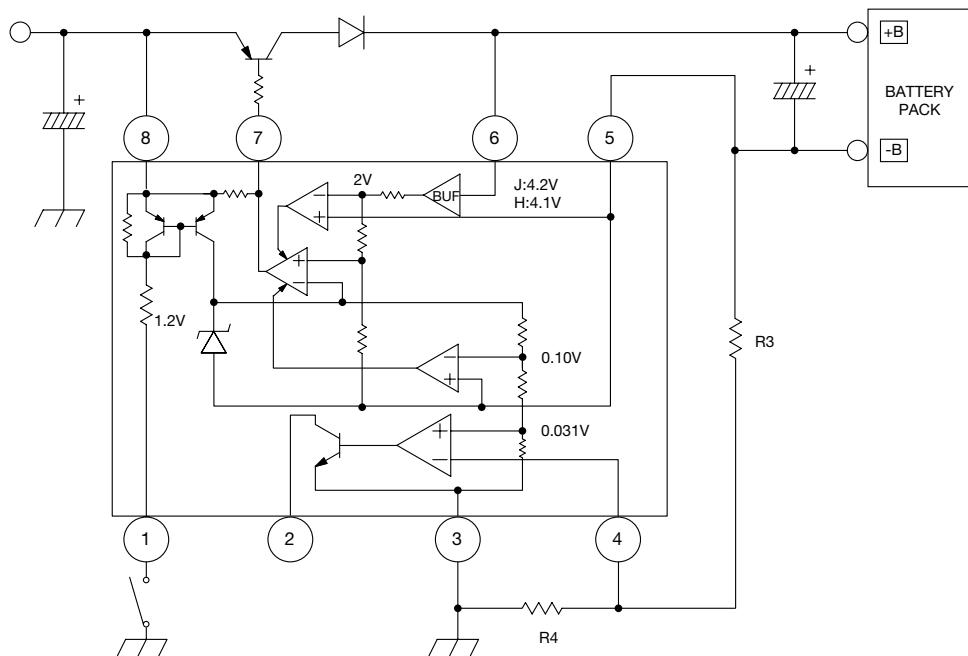
Note: Output (charge) voltage rank is inside the □.

Applications

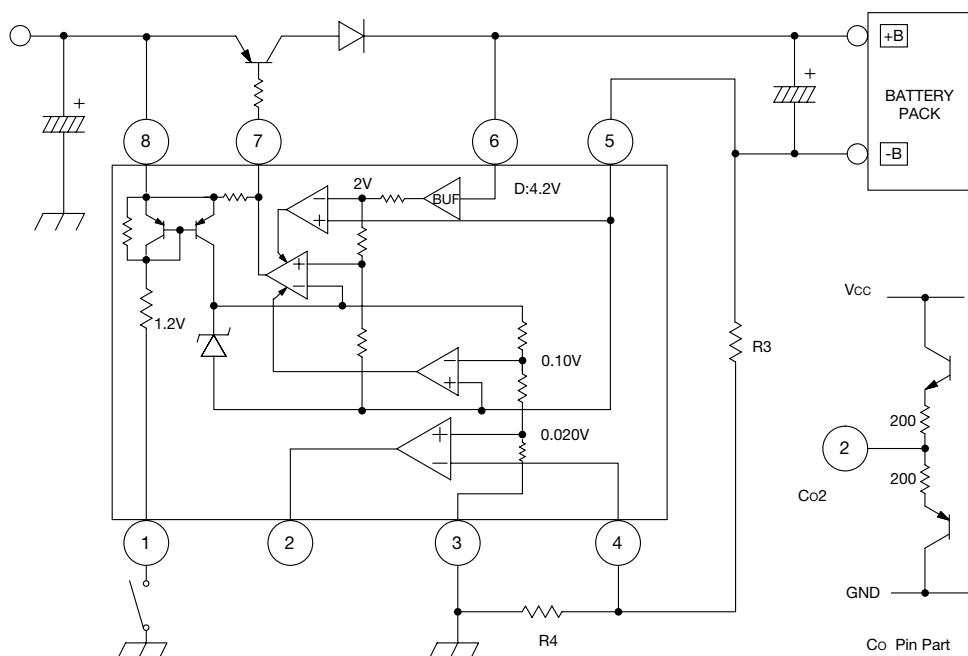
1. Lithium ion battery chargers

Block Diagram

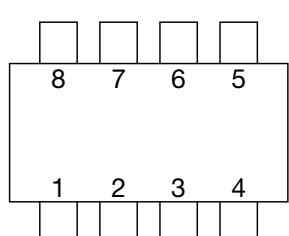
MM1333J, H



MM1333D



Pin Assignment



SOP-8C
SOP-8E
VSOP-8A

1	SW
2	CO
3	GND
4	CS2
5	CS1
6	CEL
7	EXT
8	Vcc

Pin Description

Values given are standard

Pin no.	Pin name	Input/output	Function
1	SW	Input	Input pin for on/off control SW=Vcc : off, SW=GND : on Pulled up to Vcc, so turned off when open
2	CO	output	Full-charge signal output pin While charging : Open collector output NPN transistor is off At full charge : Open collector output NPN transistor is on
3	GND	Input	GROUND pin
4	CS2	Input	Full charge detection pin The current is detected through the voltage drop across an external resistance, to control the full-charge signal. The ratio of the charge current set by CS1 and the current at full-charge signal output is $(V_{IC}) / (0.1 \text{ V} \times R4 / (R3+R4))$
5	CS1	Input	Current detection pin The current is detected through the voltage drop across an external resistance, to maintain a constant current. The current value can be set using $0.1 \text{ V} / (R3+R4)$.
6	CEL	Input	Battery voltage input pin The battery voltage is detected and used to maintain the voltage at the prescribed value. A low-voltage detection circuit is also present, and charging is forbidden when the battery voltage is less than 2V.
7	EXT	Output	Constant-voltage circuit output pin The base of an external PNP transistor or gate of a P-MOS FET is controlled in constant-voltage charging.
8	Vcc	Input	Power supply input pin

Absolute Maximum Ratings (Ta=25°C)

Item	Symbol	Ratings	Units
Storage temperature	T _{STG}	-40~+125	°C
Operating temperature	T _{OPR}	-20~+70	°C
Power supply voltage	V _{cc} max.	-0.3~+13	V
Output voltage	V _o max.	-0.3~V _{cc}	V
SW input voltage	V _{sw}	-0.3~V _{cc} +0.3	V
Allowable loss	P _d	300	mW

Recommended Operating Conditions

Item	Symbol	Ratings	Units
Operating temperature	T _{OPR}	-20~+70	°C
Operating voltage	V _{OPR}	+5~+12	V

Electrical Characteristics

(Except where noted otherwise, Ta=25°C, Vcc=5V, SW2, 4, 6, 7 : A) Models listed MM1333

Item	Symbol	Measurement conditions	Min.	Typ.	Max.	Units
Consumption current 1	Icc1	VSW=0V (Charge : ON)	300	400	400	µA
Consumption current 2	Icc2	VSW=0V (Charge : ON)	1.1	1.6	1.6	mA
Consumption current 3	Icc3	VSW=Vcc (Charge : OFF)	2	4	4	µA
Output voltage 1	Vo1	Ta=25°C	4.065	4.100	4.135	V
Output voltage 2	Vo2	Ta=0~+40°C	4.050	4.100	4.150	V
Output voltage temperature drift	ΔVo	Ta=-20~+70°C		±0.25		$\frac{\text{mV}}{\text{°C}}$
Current limit	VCL		90	100	110	mV
CEL-CS leakage current	ICEL				1	µA
SW input current	IsW			20		µA
SW input voltage	VL	Charge : ON	-0.3		2.0	V
	VH	Charge : OFF	Vcc-1.0		Vcc+0.3	V
Low-voltage detection voltage	Lv		1.90	2.00	2.10	V
EXT pin input voltage	Is		10	20		mA
EXT pin output voltage	VEXT	No load	0.3		Vcc-0.3	V
Full-charge detection voltage	VIC		26	31	36	mV
Full-charge detection output L	VCOL	ISINK=0.3mA		0.2	0.4	V
Full-charge detection output leakage current	Ico				1	µA

Measurement Method

(Except where noted otherwise, Ta=25°C, Vcc=5V, SW2 : A, SW4 : A, SW6 : A, SW7 : A)

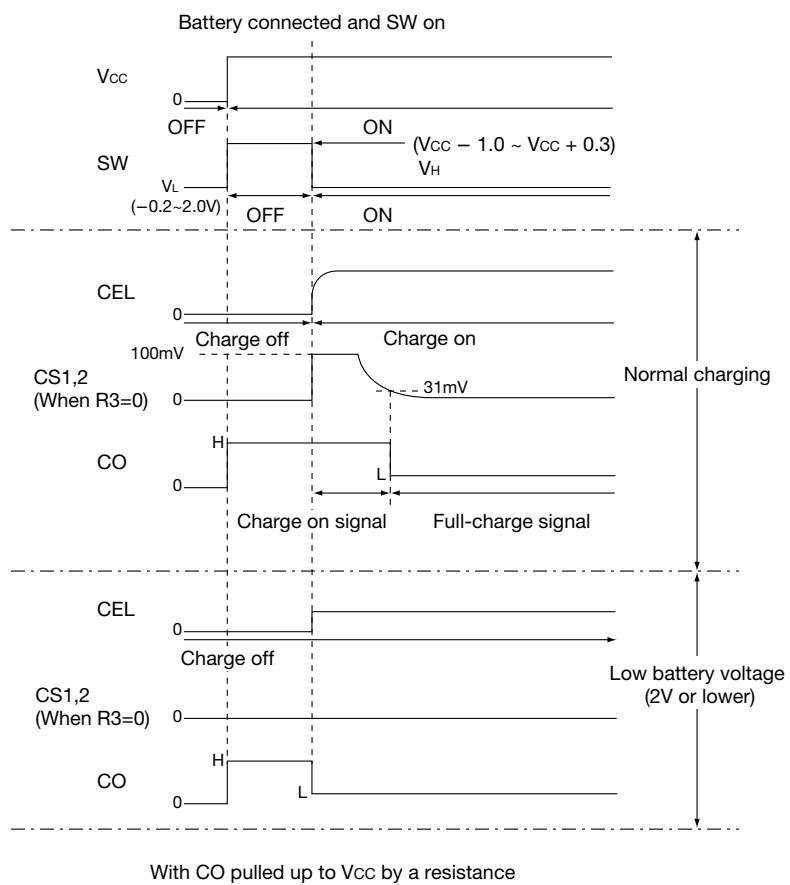
Item	Measurement Method
Consumption current 1	Set V1=0 V, SW4=B, V4=50mV, V6=4.5V ; switch SW6 from A to B and again to A ; then measure the A8 current Icc1.
Consumption current 2	Set V1=0V, SW4=B, V4=50mV, V6=4.5V ; switch SW6 from A to B and again to A ; then measure the A8 current Icc1.
Consumption current 3	Set V1=Vcc, and measure the resulting A8 current Icc3.
Output voltage	Set V1=0V, V6=4.5V; switch SW6 from A to B and again to A ; then measure the T6 voltage Vo.
Current limit	Set V1=0V, set the voltage V6 about 1V lower than the potential at T6 (output voltage), and set SW6 to B ; then measure the T5 voltage VCL.
CEL-CS leakage current	Set Vcc=0V, V1=0V; set the voltage V6 to 5V; and set SW6 to B and SW7 to C. Then measure the A6 current ICEL.
SW input current	With V1=0V, measure the A1 current Isw1.
SW input voltage	Set the voltage V6 1V lower than the T6 potential (output voltage), and set SW6 to B. With the voltage V1 variable, when the A6 current is 100mA or higher this voltage is equal to the charge-on voltage (VL), and when the current is within ±10µA it is equal to the charge-off voltage (VH).
Low-voltage detection voltage	Set V1=0 V, set V6 to 1V lower than the T6 potential (output voltage), and set switch SW6 to B. Then gradually lower the voltage V6 ; the voltage V6 at which the A6 current is within ±10µA is LV.
EXT pin input voltage	Measure the A7 current IS with V1=0V, SW6 set to B, SW7 set to B, V6=3V, and V7=4V.
EXT pin output voltage	Set V1=0 V, SW6 to B, and SW7 to C. The T7 voltage when V6=3V and V6=5V is VEXT.
Full-charge detection voltage	Set V1=0V and SW4 to B. Gradually lower the voltage V4 from 50mV ; the voltage V4 when the T2 potential falls to 1V or lower from (Vcc-1) V or higher is VIC.
Full-charge detection output L	Measure the T2 voltage VCOL when V1=0V, SW4 is at B and V4=0V.
Full-charge detection output leakage current	Measure the A2 current Ico when V1=0V, SW4 is at B, V4=50mV, SW2 is at B, and V2=5V.

Warnings regarding use

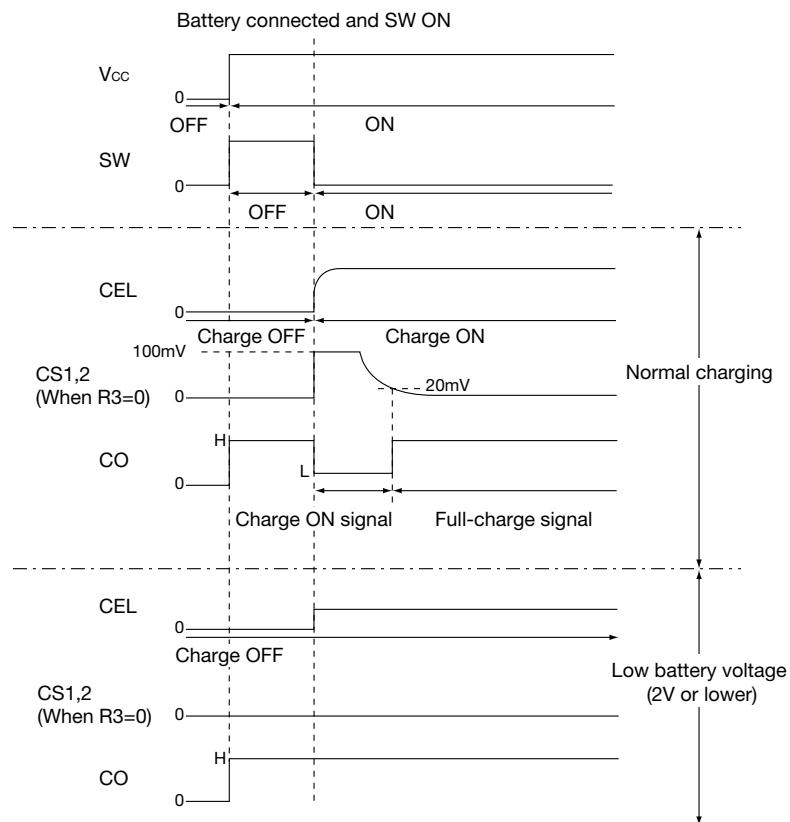
- The following components should be added in preparation for use.
 - A capacitance of several µF or so between Vcc and GND
 - A 10µF capacitor between CEL and CS
 - A diode to prevent backflow between the collector of the external PNP transistor and pin 6
 - A current-limiting 150Ω resistor between the base of the external PNP transistor and EXT
- The full charge detection circuit detects voltages of order several mV, and so no hysteresis is applied. Chattering will occur, and should be born in mind.
- There is an internal low-voltage detection circuit. If a voltage of at least 2V is not applied to the CEL pin, no output will be obtained.

Timing Chart

MM1333J, H

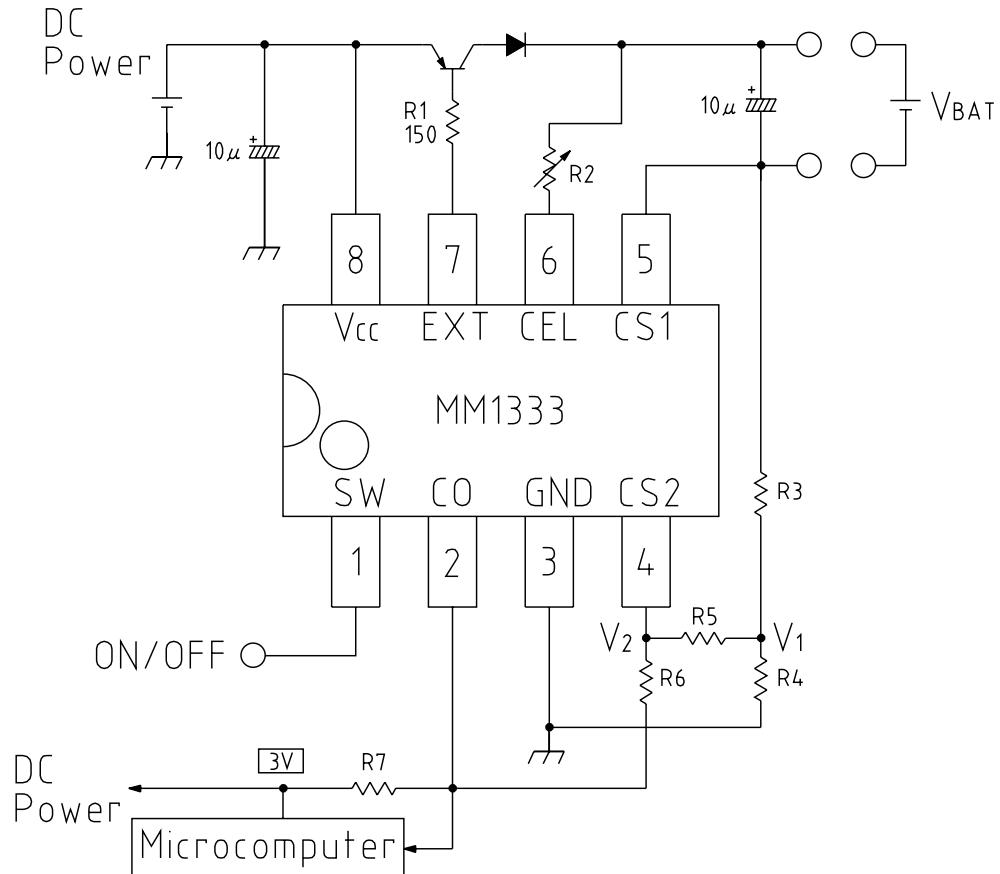


MM1333D



Note: In the case of rank D, the Co output voltage level changes to "L" when charging is turned ON. (The function is reversed in the case of ranks H and J).

Application circuits



1. A diode is required to prevent reverse current from the battery.
2. Even higher precision can be obtained by inserting R2 for output voltage adjustment.
CEL intake current is used to adjust output voltage with R2. CEL intake current is around 3 ~ 10μA.

3. Charging current can be set with R3+R4.

Example : To set to 0.25A $V_{CL}/(R3+R4) = 0.1V/0.4\Omega = 0.25A$

4. Full charge detection current can be adjusted by the ratio between R3 and R4.

Example : H rank $V_{IC}/(V_{CL} \times R4/(R3 + R4)) = 0.031V/(0.1 \times 0.21\Omega/(0.19\Omega + 0.21\Omega)) = 0.59$

This makes the ratio between charging current and full charge detection current 1 : 0.59.

Charging current was set at 0.25A in step 3 above, so full charge detection current is $0.25A \times 0.59 = 0.148A$.

5. R5 and R6 are resistors for positive feedback (hysteresis). Hysteresis is applied for the amount of R5 voltage drop, and should be set below (about 1/3) full charge voltage.

Also, at this time, full charge detection voltage changes by the amount of R5 voltage drop.

Example : Setting full charge detection current using H rank and taking hysteresis voltage into account.

Setting conditions : charge current 0.25A ($R3 + R4 = 0.4\Omega$), full charge current 0.1A, MPU power supply 5V, full charge hysteresis 10mV

Full charge current is set by comparing the reference voltage ($VIC = 0.031V$) and CS2 pin voltage ($V2$) inside the IC. An example of calculation for setting full charge current at 0.1A is shown below.

$$(V2 - V1) + IBATT \times R4 = 0.031V$$

Here, $V2 - V1$ (potential at ends of R5) is the hysteresis. In order to set hysteresis at 10mV, find R4 as follows.

$$R4 = (0.031V - (V2 - V1)) / IBATT = (0.031V - 0.01V) / 0.1A = 0.21\Omega$$

$$\text{From } R3 + R4 = 0.4\Omega, R3 = 0.4\Omega - 0.21\Omega = 0.19\Omega.$$

Hysteresis Setting (R5 ~ R7)

The current values that flow on R5~R7 from 3V are minute due to the high impedance of the CS2 pin, and so do not cause a problem. (It is assumed that the effects of noise, etc. must be considered for each individual set.) Here the setting is for 10 μ A. CO is low level during full charge detection, so $V2 - V1 = 0V$. When $V2 - V1$ is set to 10mV during charging (CO high), then $R5 + R6 + R7 = 3V / 10\mu A = 300k\Omega$. ($R4$ is extremely small as compared to R5~R7 and thus is ignored.)

$$3V : 0.01V = (R5 + R6 + R7) : R5$$

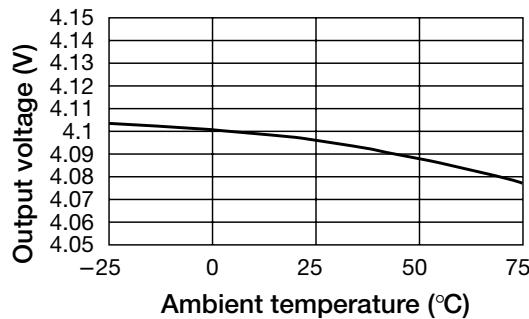
From the above equation, $R5 = 1k\Omega$, $R6 + R7 = 299k\Omega$, and R6 and R7 resistance values must be set so that CS1 can be low level. If CS1 sink current is 0.15mA, then $R7 = 3V / 0.15mA = 20k\Omega$, $R6 = 299k\Omega - 20k\Omega = 279k\Omega$.

Therefore, $R3 = 0.19\Omega$, $R4 = 0.21\Omega$, $R5 = 1k\Omega$, $R6 = 279k\Omega$, $R7 = 20k\Omega$.

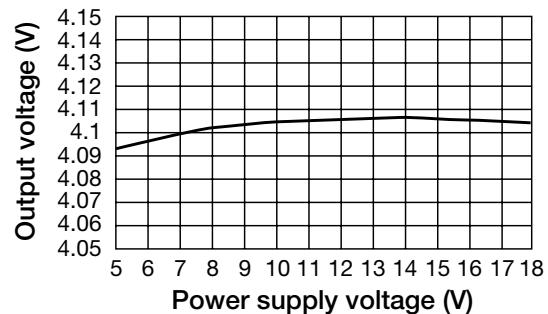
Please note that the above figures are examples given for reference purposes, and should be used in actual practice only after sufficient examination.

Characteristics

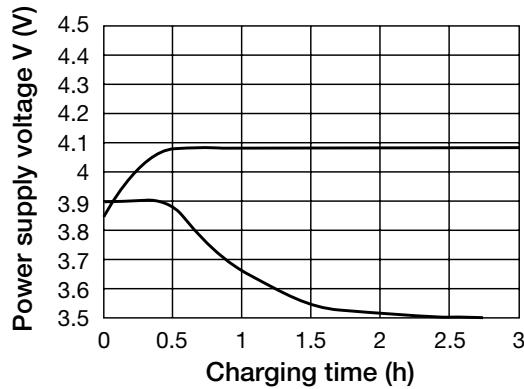
■ Output voltage vs ambient temperature
(V_{cc}=5V, Output voltage 4.1V)



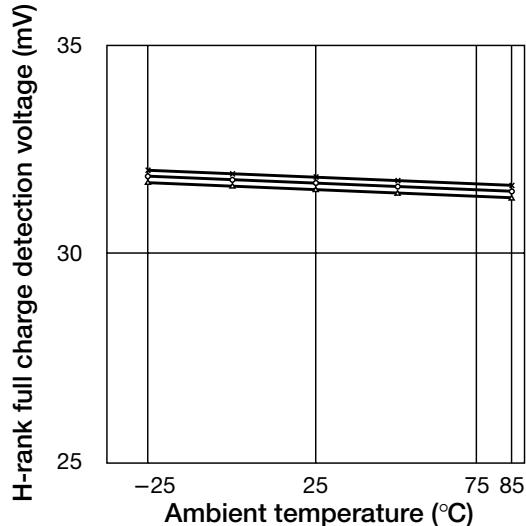
■ Output voltage vs power supply voltage
(Ta=25°C, Output voltage 4.1V)



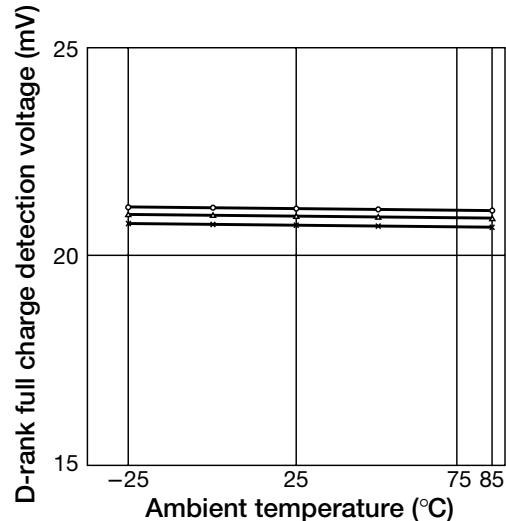
■ Charging (V_{cc}=5V, Output voltage 4.1V)



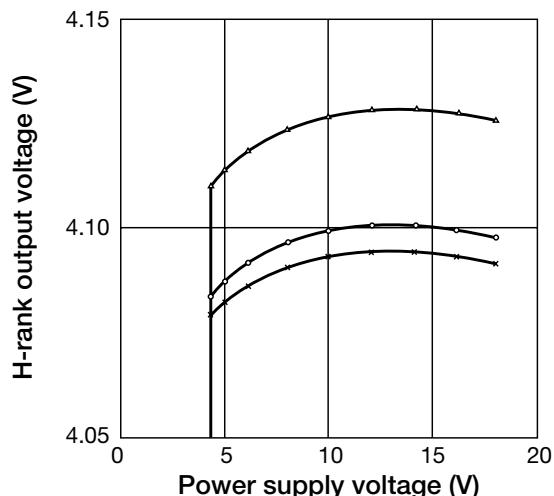
■ H-rank full charge detection voltage [mV]



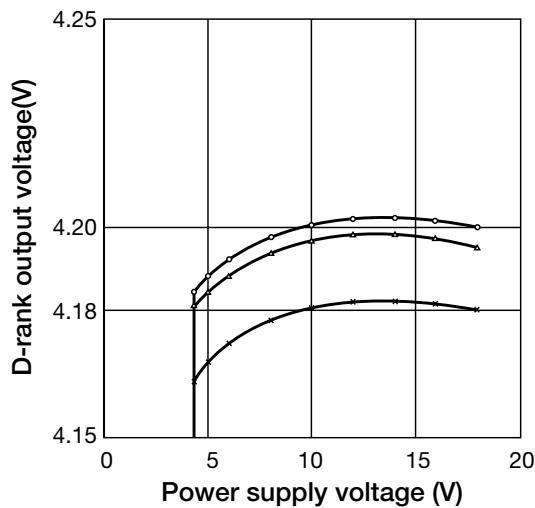
■ D-rank full charge detection voltage [mV]



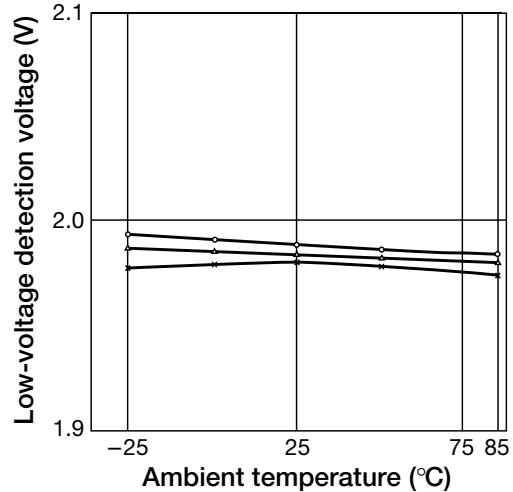
■ H-rank output voltage [V]



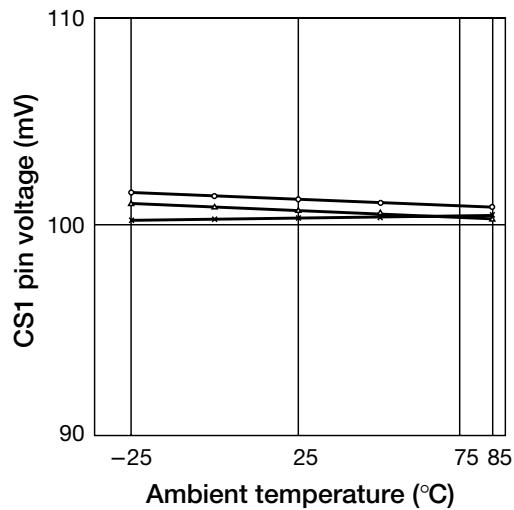
■ D-rank output voltage [V]



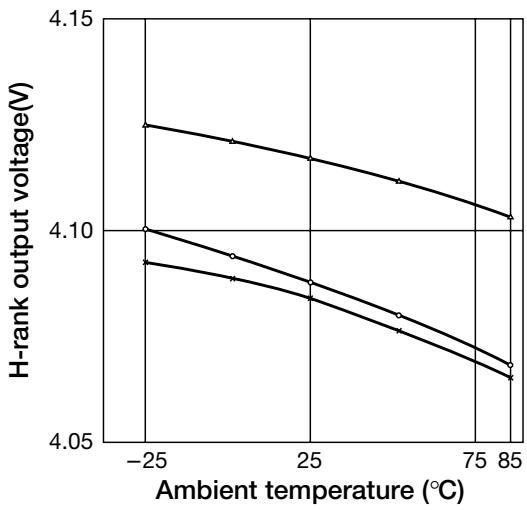
■ Low-voltage detection voltage [V]



■ CS1 pin voltage [V]



■ H-rank output voltage [V]



■ D-rank output voltage [V]

