Advanced Linear Charger IC for A Single Lithium-ion Battery

FEATURES

- Ideal for a single Li-ion battery
- Input voltage range: 4.5V~6.5V
- Programmable charge current Up to 600mA
- No MOSFET, sense resistor or blocking diode required
- Constant current/Constant voltage operation with thermal regulation to maximize charge rate without risk of overheating
- Charges single cell Li-Ion batteries directly from USB port
- Better than ±1% voltage regulation accuracy
- Automatic battery recharge
- Two LEDs charge status indication
- Charge termination by minimum current
- 25μA supply current in shutdown
- Less than 1μA battery current in standby mode
- Short protection
- Automatic low-power sleep mode when V_{CC} is lower than the battery voltage
- Few external components
- SOP8-E with expose pad

APPLICATIONS

- E-cigarette
- MP3
- DCS
- GPS
- Charger

DESCRIPTION

CV1055P is a single cell Lithium-Ion (Li-Ion) linear charger IC designed for cost-sensitive and compact portable electronics. It combines high-accuracy current, voltage regulation, battery condition monitoring, thermal regulation, charge termination, and charge status indication in a single 8-pin IC.

CV1055P 's LED has clear state as follow:

State	LED1 / RED	LED2 / GREEN
No load	OFF	ON
Charging	ON	OFF
Short	OFF	OFF
Full	OFF	ON

TYPICAL APPLICATION DIAGRAM

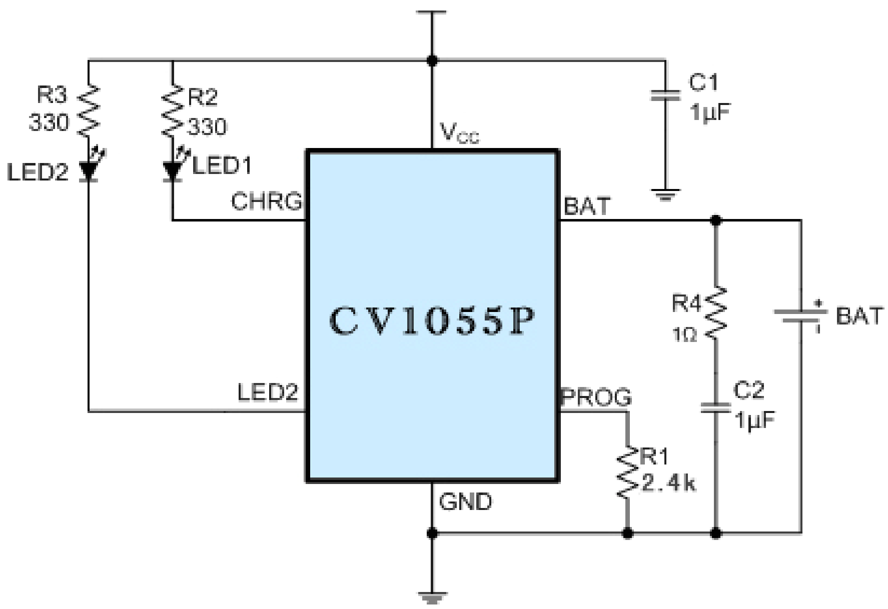


Figure 1 CV1055P Functional Diagram

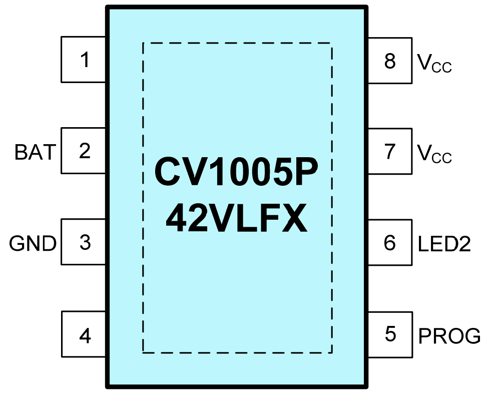
ORDERING INFORMATION

[Table 1] Ordering Information

MODEL	OUTPUT VOLTAGE	PACKAGE	PIN COUNT	PRINT MARKING
CV1055P	4.2V	SOP8-E	8	CV1055P 42VLFX

PIN CONFIGURATIONS

Top View



SOP8-E

Figure 2 CV1055P Pin Configurations (Not to scale)

PIN DESCRIPTION

[Table 2] Pin Description

NAME	ORDER	I/O	FUNCTION
BAT	1、2	I/O	Charge current output and battery voltage sense input
GND	3	POW	Connect to the negative of power supply.
CHRG	4	O	Open-drain charge status output. When the battery is charging, the CHRG pin is pulled low by an internal N-MOSFET. When a charge cycle is completed or the charger detects an under voltage lockout condition, CHRG is forced high impedance.
PROG	5	POW	Charge current set and shutdown pin.
LED2	6	O	Open-drain charge status output. When the battery is charging or the charger detects an under voltage lockout condition, the LED2 pin is forced high impedance. When a charge cycle is completed, the LED2 pin is pulled low by an internal N-MOSFET.
V_{CC}	7、8	POW	Power Supply Input
EP			Expose Pad，Connect this pad to GND.

ABSOLUTE MAXIMUM RATING

Supply Voltage (V_{CC}), BAT, CHRG, LED2 Input Voltage... -0.3V~-7V

PROG Input Voltage ....-0.3V~V_{CC}+0.3V

Operating Ambient Temperature Range, T_A ....-40℃~+85℃

Junction Temperature ....150℃

Total Power Dissipation, P_D（T_A=25℃）

SOP8-E package (θ_{JA}=50℃/W)..................... 2W

Storage Temperature Range .... -65℃~150℃

Lead Temperature（Soldering，10 seconds） 260℃

ESD (HBM) 5kV

Note: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond the recommended operating condition are not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{CC} = 5V, T_A = 25℃ unless otherwise specified.)

[Table 3] Electrical Specification

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Power Supply Voltage	V_{CC}		4.5		6.5	V
Power Supply Current	I_{CC}	Charging, R1=2K		550		μA
		Charge End.		65		μA
		Shutdown Mode. R1 is not connected. V_{BAT}=1.5V~4.2V		20		μA
		Sleep Mode. V_{BAT}=1.5V~4.2V		15		μA
Battery Current	I_{BAT}	CC Mode. R1=2.4K		420		mA
		Standby Mode. V_{BAT}=4.2V			-1	μA
		Shutdown Mode. R1 is not connected. V_{BAT}=1.5V~4.2V			-1	μA
		Sleep Mode. V_{CC}=0V			-1	μA
Input Voltage Under Voltage Lockout High Threshold	V_{UVH}			3.8		V
Input Voltage Under Voltage Lockout Low Threshold	V_{UVL}			3.6		V
Regulation Voltage	V_{REG}	R1=2K(CV Mode) I_{BAT}=40mA	4.16	4.22	4.27	V
Preconditioning Voltage High Threshold	V_{PREH}			3.0		V
Preconditioning Voltage Low Threshold	V_{PREL}			2.8		V
Output Short Circuit Threshold	V_{SHORT}			1.4		V
Charge current under battery short condition	$I_{SHORT-CHG}$			3.3%*I_{BAT}		
Output Current Set Voltage	V_{PROG}			1		V
Output Current Set Factor	K_{SET}			1000		
CHRG Pin Output Low Voltage	V_{CHRG}	I_{CHRG} =10mA		70		mV
LED2 Pin Output Low Voltage	V_{LED2}	I_{LED2}=10mA		70		mV
Soft Start Time	T_{SS}			100		μS
Recharge Delay Time	T_{RECHRG}			2		ms
Charge Terminate Delay Time	T_{TERM}			1		ms
PROG Pull-up Current	I_{PROG}			1		μA
Power PMOS on Resistance	R_{ON}	I_{BAT}=100mA		1		Ω

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
		V_{CC}=4.2V				
Junction Temperature in Constant Temperature Mode	T_{LIM}			120		℃
Manual Shut Down High Threshold Voltage	V_{SHDNH}			1.23		V
Manual Shut Down Low Threshold Voltage	V_{SHDNL}			1.0		V
V_{CC}-V_{BAT} Lockout High Threshold Voltage	V_{ASDH}	V_{CC} from low to high.		100		mV
V_{CC}-V_{BAT} Lockout Low Threshold Voltage	V_{ASDL}	V_{CC} from high to low.		30		mV
Standby Charging Current Threshold	I_{TERM}			10%* I_{BAT}		

TYPICAL PERFORMANCE CHARACTERISTICS

(V_{CHG}=5.0V, V_{BAT}=3.6V, R1=2.0K, T_A=25℃， Unless otherwise specified)

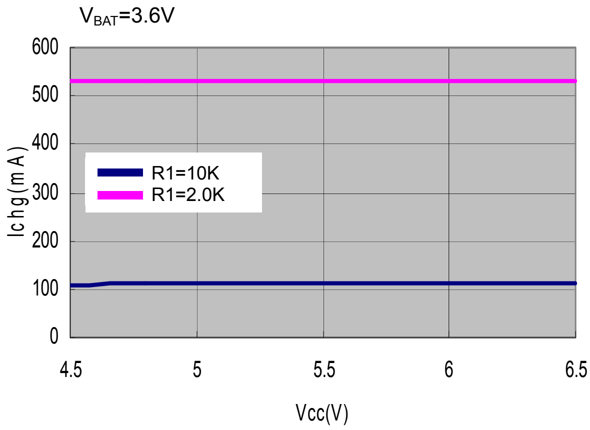


Figure 5 I_{CHG} vs V_{CC}

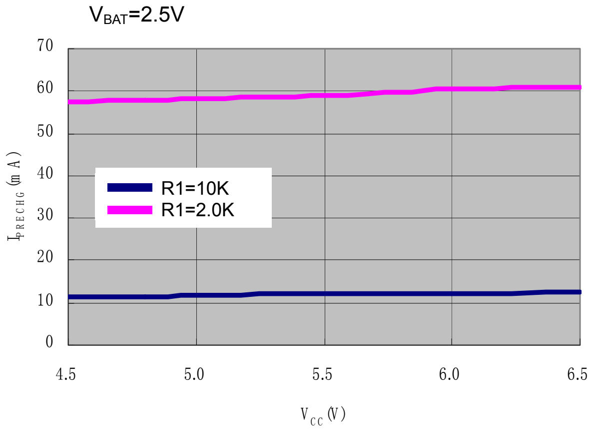


Figure 6 I_{PRECHG} vs V_{CC}

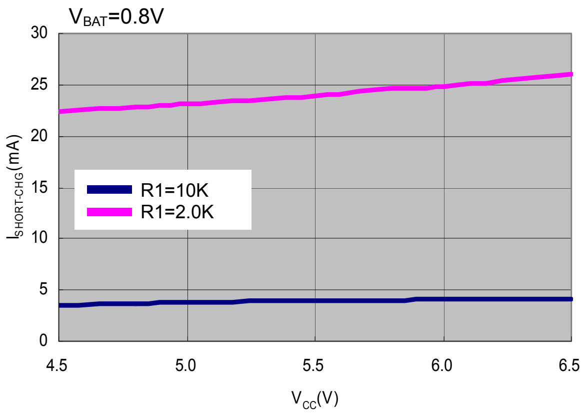


Figure 7 $I_{SHORT-CHG}$ vs V_{CC}

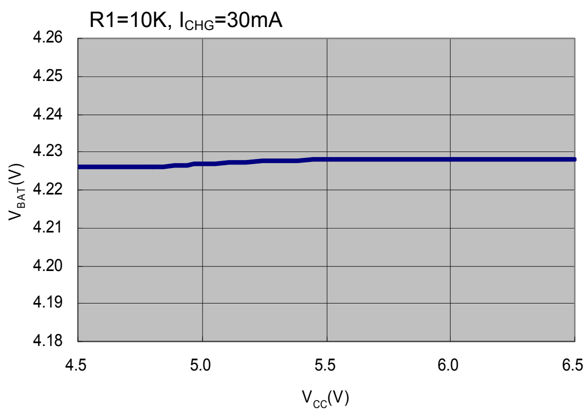


Figure 8 V_{BAT} vs V_{CC}

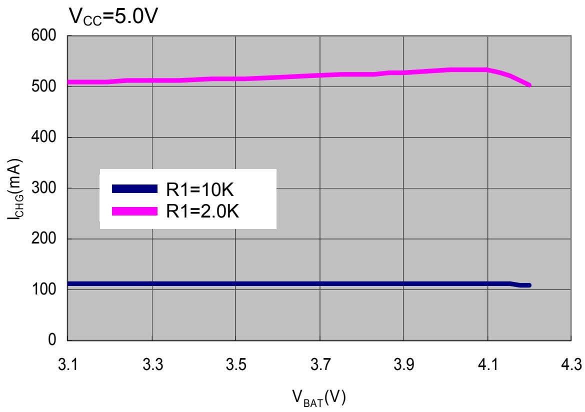


Figure 9 I_{CHG} vs V_{BAT}

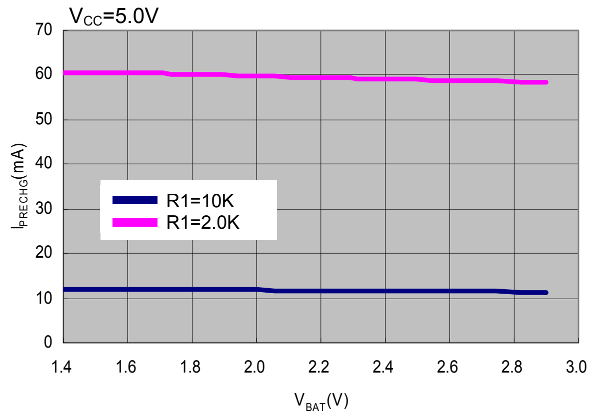


Figure 10 I_{PRECHG} vs V_{BAT}

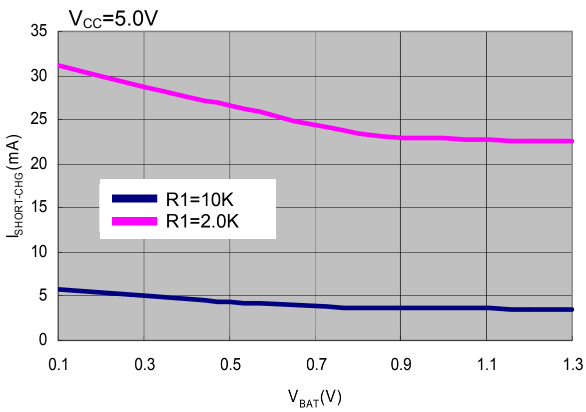


Figure 11 $I_{SHORT-CHG}$ vs V_{BAT}

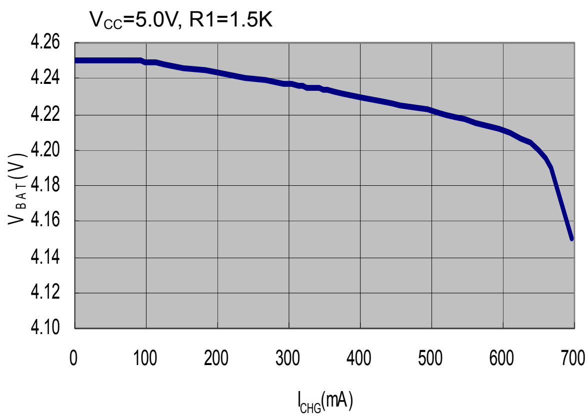


Figure 12 V_{BAT} vs I_{CHG}

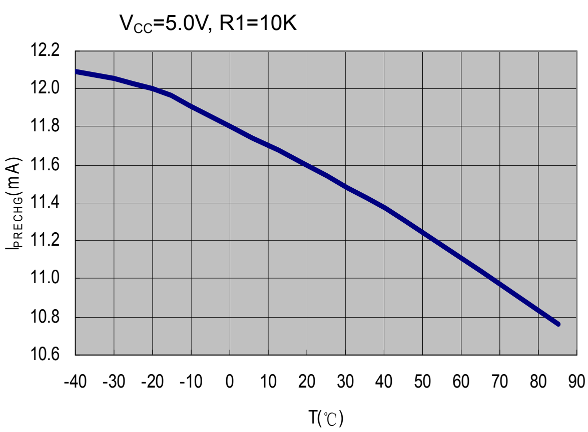


Figure 13 I_{PRECHG} vs Temperature

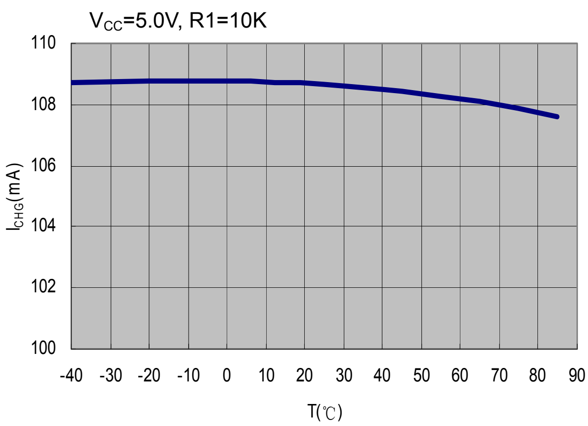


Figure 14 I_{CHG} vs Temperature

V_{CC}=5.0V, R1=10K

V_{CC}=5.0V, R1=2K

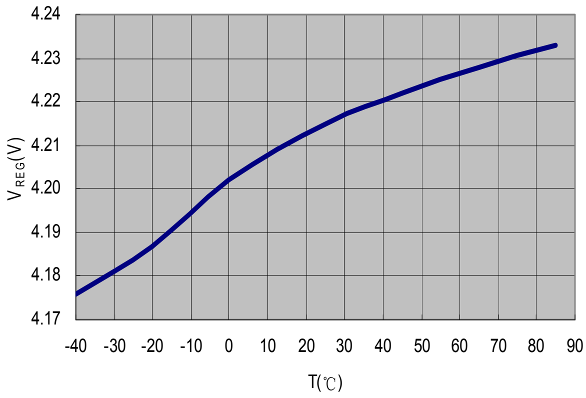


Figure 15 V_{REG} vs Temperature

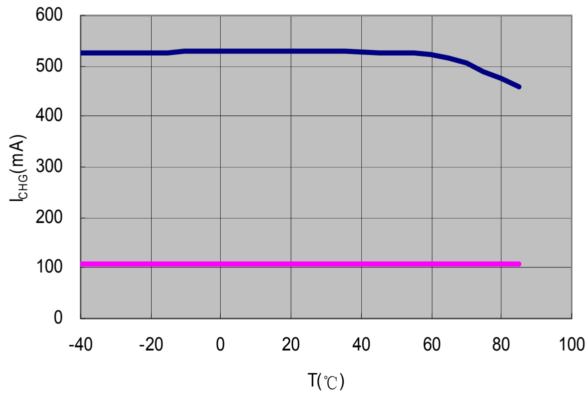


Figure 16 I_{CHG} vs Temperature

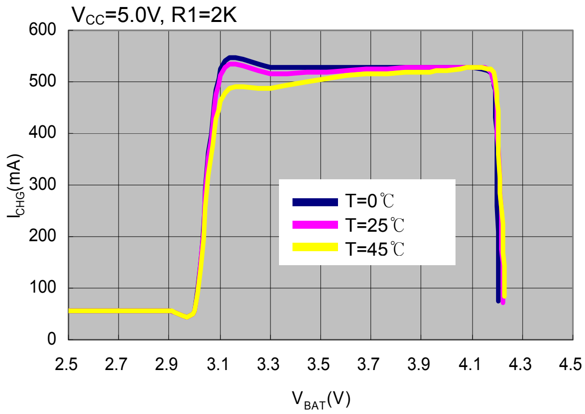


Figure 17 I_{CHG} vs V_{BAT}

FUNCTION DESCRIPTION

Normal Charge Cycle

A charge cycle begins when the voltage at the V_{CC} pin rises above the UVLO threshold level and a 1% program resistor is connected from the PROG pin to ground. If the voltage at the BAT pin is less than 3V, the charger enters trickle charge mode. In this mode, CV1055P supplies approximately 1/10 of the programmed charge current to bring the battery voltage up to a safe level for full current charging.

When the BAT pin voltage rises above 3V, the charger enters the constant-current mode, where the programmed charge current is supplied to the battery. When the BAT pin voltage approaches the final regulation voltage (4.2V), CV1055P enters the constant voltage mode and the charge current begins to decrease. If the charge current drops to 1/10 of the programmed value, the charge cycle ends.

Programming Charge Current

The charge current is programmed using a single resistor from the PROG pin to ground. The battery charge current is 1000 times the current out of the PROG pin. The program resistor and the charge current are calculated using the following equations:

$$R1 = \frac{1000V}{I_{CHG}}, I_{CHG} = \frac{1000V}{R1}$$

The charge current out of the BAT pin can be determined at any time by monitoring the PROG pin voltage using the following equation:

$$I_{BAT} = \frac{V_{PROG}}{R1} \times 1000$$

Charge Termination

A charge cycle is terminated when the charge current falls to 1/10 of the programmed value after the final regulation voltage is reached. This condition is detected by using an internal, filtered comparator to monitor the PROG pin. When the PROG pin voltage falls below 100mV for longer than T_{TERM} (typically 1ms), charging is terminated. The charge current is latched off and CV1055P enters the standby mode, where the input supply current drops to 65μA. (Note: C/10 termination is disabled in trickle charging and thermal limiting modes).

When charging, transient loads on the BAT pin can cause the PROG pin to fall below 100mV for short periods of time before the DC charge current has dropped to 1/10 of the programmed value. The 1ms filter time (T_{TERM}) on the termination comparator ensures that transient loads of this nature do not result in premature charge cycle termination. Once the average charge current drops below 1/10 of the programmed value, CV1055P terminates the charge cycle and ceases to provide any current through the BAT pin. In this state, all loads on the BAT pin must be supplied by the battery.

CV1055P constantly monitors the BAT pin voltage in the standby mode. If this voltage drops below the recharge threshold (V_{RECHRG}), another charge cycle begins and current is once again supplied to the battery. To manually restart a charge cycle in the standby mode, the input voltage must be removed and reapplied, or the charger must be shut down and restarted by using the PROG pin.

Charge Status Indicator（CHRG, LED2 Pin）

The CHRG and LED2 pin has two different states: pull-down and high impedance. When the charger detects an under voltage lockout condition or charger voltage is less than 100mV above the BAT pin voltage, the CHRG and LED2 pin is forced high impedance. When the battery is charging, the CHRG pin is pulled low by internal N-MOSFET and the LED2 pin is forced high impedance. When a charge cycle is completed, the LED2 pin is pulled low by an internal N-MOSFET and the CHRG pin is forced high impedance.

Thermal Limiting

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 120℃. This feature protects CV1055P from excessive temperature and allows the user to push the limits of the power handling capability of a given circuit board without risk of damaging CV1055P. The charge current can be set according to typical (not worst-case) ambient temperature with the assurance that the charger will automatically reduce the current in worst-case conditions.

Under Voltage Lockout (UVLO)

An internal under voltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until V_{CC} rises above the under voltage lockout threshold. The UVLO circuit has a built-in hysteresis of 200mV. Furthermore, to protect against reverse current in the power MOSFET, the UVLO circuit keeps the charger in shutdown mode if V_{CC} falls to within 30mV of the battery voltage. If the UVLO comparator is tripped, the charger will not come out of shutdown mode until V_{CC} rises 100mV above the battery voltage.

Manual Shutdown

At any point in the charge cycle, CV1055P can be put into shutdown mode by removing R1 thus floating the PROG pin. This reduces the battery drain current to less than 1μA and the supply current to less than 50μA. A new charge cycle can be initiated by reconnecting the program resistor.

Automatic Recharge

Once the charge cycle is terminated, CV1055P continuously monitors the voltage on the BAT pin using a comparator with a 2ms filter time (T_{RECHRG}). A charge cycle restarts when the battery voltage falls below 4.2V. This ensures that the battery is kept at or near a fully charged condition and eliminates the need for periodic charge cycle initiations. CHRG output enters pull down state during recharge cycles.

Short Protection

When the voltage of the BAT pin is lower than the output short circuit threshold (V_{SHORT}), the charging current of the V_{CC} pin is reduced to 3.3% of the programmed charge current.

APPLICATION NOTES

Stability Considerations

The constant voltage mode feedback loop is stable without an output capacitor provided a battery is connected to the charger output. With no battery present, an output capacitor is recommended to reduce ripple voltage. When using high value, low ESR ceramic capacitors, it is recommended to add a 1 Ω resistor in series with the capacitor. No series resistor is needed if tantalum capacitors are used.

In constant current mode, the PROG pin is in the feedback loop, not the battery. The constant current mode stability is affected by the impedance at the PROG pin. With no additional capacitance on the PROG pin, the charger is stable with program resistor values as high as 20k. However, additional capacitance on this node reduces the maximum allowed program resistor. The pole frequency at the PROG pin should be kept above 100kHz. Therefore, if the PROG pin is loaded with a capacitance, C_{PROG}, the following equation can be used to calculate the maximum resistance value for R1:

$$R1 \le \frac{V_{PROG}}{2\pi \times 10^5 \times C_{PROG}}$$

Average, rather than instantaneous, charge current may be of interest to the user. For example, if a switching power supply operating in low current mode is connected in parallel with the battery, the average current being pulled out of the BAT pin is typically of more interest than the instantaneous current pulses. In such a case, a simple RC filter can be used on the PROG pin to measure the average battery current. A 10kΩ resistor has been added between the PROG pin and the filter capacitor to ensure stability.

Power Dissipation

The conditions that cause the CV1055P to reduce charge current through thermal feedback can be approximated by considering the power dissipated in the IC. Nearly all of this power dissipation is generated by the internal MOSFET, this is calculated to be approximately:

$$P_D = (V_{CC} - V_{BAT}) \times I_{BAT}$$

Where P_D is the power dissipated, V_{CC} is the input supply voltage, V_{BAT} is the battery voltage and I_{BAT} is the charge current. The approximate ambient temperature at which the thermal feedback begins to protect the IC is:

$$T_A = 120°C - P_D \theta_{JA}$$

$$T_A = 120°C - (V_{CC} - V_{BAT}) \times I_{BAT} \times \theta_{JA}$$

Moreover, when thermal feedback reduces the charge current, the voltage at the PROG pin is also reduced proportionally as discussed in the Function Description section.

It is important to remember that CV1055P applications do not need to be designed for worst-case thermal conditions since the IC will automatically reduce power dissipation when the junction temperature reaches approximately 120℃.

V_{CC} Bypass Capacitor

Many types of capacitors can be used for input bypassing, however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, such as connecting the charger input to a live power source. Adding a 1.5Ω resistor in series with an X5R ceramic capacitor will minimize start-up voltage transients.

Reverse Polarity Input Voltage Protection

In some applications, protection from reverse polarity voltage on V_{CC} is desired. If the supply voltage is high enough, a series blocking diode can be used. In other cases, where the voltage drop must be kept low a P-MOSFET can be used (as shown in Figure 19).

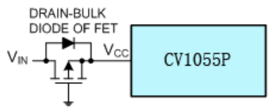


Figure 18 Low Loss Input Reverse Polarity Protection

USB and Wall Adapter Power

VA7204L1 allows charging from both a wall adapter and a USB port. Figure 20 shows an example of how to combine wall adapter and USB power inputs. A P-MOSFET, MP1 is used to prevent back conducting into the USB port when a wall adapter is present and a Schottky diode, D1, is used to prevent USB power loss through the 1k pull-down resistor.

Typically a wall adapter can supply more current than the 500mA-limited USB port. Therefore, an N-MOSFET, MN1, and an extra 10k program resistor are used to increase the charge current to 600mA when the wall adapter is present.

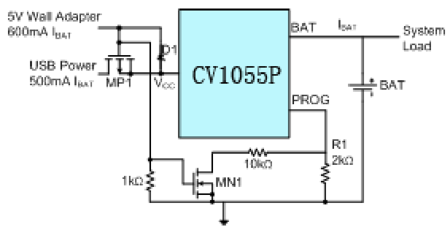


Figure 19 Combining Wall Adapter and USB Power

PACKAGE DIMENSION

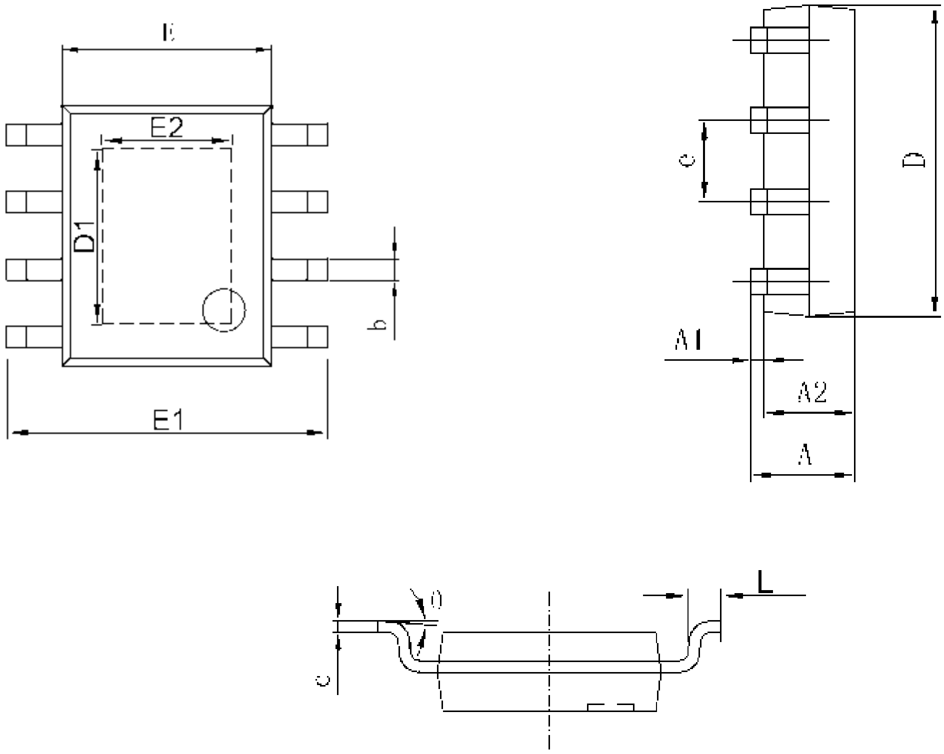


Figure 20 CV1055P 8-Pin SOP8-E Package

[Table 4] Physical dimensions in figure 20 (Unit:mm)

SYMBOL	MIN	MAX
A	1.350	1.750
A1	0.050	0.150
A2	1.350	1.550
b	0.330	0.510
c	0.170	0.250
D	4.700	5.100
D1	3.202	3.402
E	3.800	4.000
E1	5.800	6.200
E2	2.313	2.513
e	1.270 (TYP)	
L	0.400	1.270
θ	0º	8º