Fortune

DW01+

One Cell Lithium-ion/Polymer Battery Protection IC

General Description

The DW01+ battery protection IC is designed to protect lithium-ion/polymer battery from damage or degrading the lifetime due to overcharge, overdischarge, and/or overcurrent for one-cell lithium-ion/polymer battery powered systems, such as cellular phones.

The ultra-small package and less required external components make it ideal to integrate the DW01+ into the limited space of battery pack. The accurate ±50mV overcharging detection voltage ensures safe and full utilization charging. The very low standby current drains little current from the cell while in storage.

Features

- **Reduction in Board Size due to Miniature Package SOT-23-6.**
- **Ultra-Low Quiescent Current at 3 μ A (Vcc=3.9V).**
- **Ultra-Low Power-Down Current at 0.1 μ A (Vcc=2.0V).**
- **Precision Overcharge Protection Voltage 4.3V ± 50mV**
- **Load Detection Function during Overcharge Mode.**
- **Two Detection Levels for Overcurrent Protection.**
- **Delay times are generated by internal circuits. No external capacitors required.**

Ordering Information

DW01+

PACKAGE TYPE
SOT-23-6

TEMPERATURE RANGE
-40°C~+85°C

OVERCHARGE PROTECTION
4.3V± 50mV

DW01+P

PACKAGE TYPE
SOT-23-6 (Pb-free)

TEMPERATURE RANGE
-40°C~+85°C

OVERCHARGE PROTECTION
4.3V± 50mV

Applications

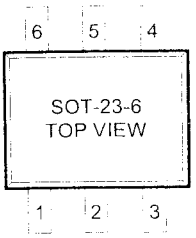
- **Protection IC for One-Cell Lithium-Ion / Lithium-Polymer Battery Pack**

Product Name List

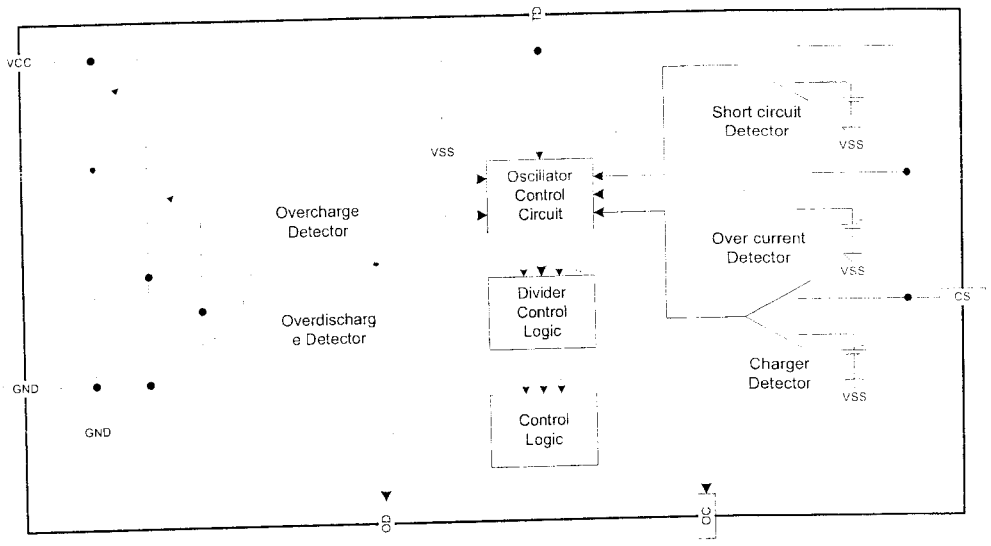
Model	Package	Overcharge detection voltage [VOCP] (V)	Overcharge release voltage [VOCR] (V)	Overdischarge detection voltage [VODP] (V)	Overdischarge release voltage [VODR] (V)	Overcurrent detection voltage [VOI1] (mV)
	SOT-23-6					
DW01+	DW01+	4.300±0.050	4.100±0.050	2.40±0.100	3.0±0.100	150±30

Pin Configuration

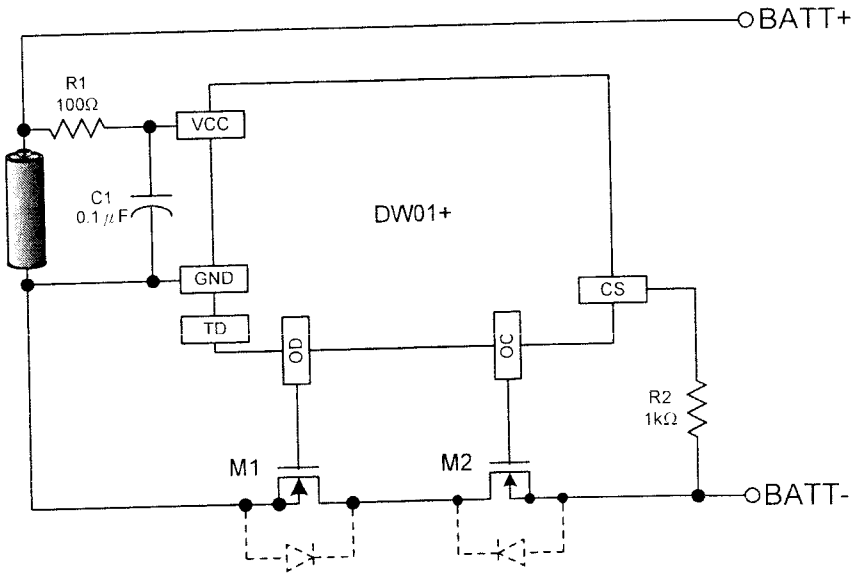
Pin No.	Symbol	Description
1	OD	MOSFET gate connection pin for discharge control
2	CS	Input pin for current sense, charger detect
3	OC	MOSFET gate connection pin for charge control
4	TD	Test pin for reduce delay time
5	VCC	Power supply, through a resistor (R1)
6	GND	Ground pin



Functional Block Diagram



Typical Application Circuit



Electrical Characteristics

(Ta=25°C unless otherwise specified)

PARAMETER	TEST CONDITIONS	SYMBOL	Min	Typ	Max	UNIT
Supply Current	VCC=3.9V	ICC		3.0	6.0	μA
Power-Down Current	VCC=2.0V	IPD			0.1	μA
Overcharge Protection Voltage	DW01+	VOCP	4.25	4.30	4.35	V
Overcharge Release Voltage		VOCR	4.05	4.10	4.15	V
Overdischarge Protection Voltage		VODP	2.30	2.40	2.50	V
Overdischarge Release Voltage		VODR	2.90	3.00	3.10	V
Overcurrent Protection Voltage		VOIP(VOI1)	120	150	180	mV
Short Current Protection Voltage	VCC=3.6V	VSIP (VOI2)	1.00	1.35	1.70	V
Overcharge Delay Time		TOC		80	200	ms
Overdischarge Delay Time	VCC=3.6V to 2.0V	TOD		40	100	ms
Overcurrent Delay Time (1)	VCC=3.6V	TOI1		10	20	ms
Overcurrent Delay Time (2)	VCC=3.6V	TOI2		5	50	μs
Charger Detection Threshold Voltage		VCHA	-1.2	-0.7	-0.2	V
OD Pin Output "H" Voltage		VDH	VCC-0.1	VCC-0.02		V
OD Pin Output "L" Voltage		VDL		0. 1	0.5	V
OC Pin Output "H" Voltage		VCH	VCC-0.1	VCC-0.02		V
OC Pin Output "L" Voltage		VCL		0.1	0.5	V

Description of Operation

1. Overcharge Protection

When the voltage of the battery cell exceeds the overcharge protection voltage (V_{OCP}) beyond the overcharge delay time (T_{OC}) period, charging is inhibited by turning off of the charge control MOSFET. The overcharge condition is released in two cases:

1) The voltage of the battery cell becomes lower than the overcharge release voltage (V_{OCR}) through self-discharge.

2) The voltage of the battery cell falls below the overcharge protection voltage (V_{OCP}) and a load is connected.

When the battery voltage is above V_{OCP}, the overcharge condition will not release even a load is connected to the pack.

2. Overdischarge Protection

When the voltage of the battery cell goes below the overdischarge protection voltage (V_{ODP}) beyond the overdischarge delay time (T_{OD}) period, discharging is inhibited by turning off the discharge control MOSFET. The default of overdischarge delay time is 10ms. Inhibition of discharging is immediately released when the voltage of the battery cell becomes higher than overdischarge release voltage (V_{ODR}) through charging.

3. Overcurrent Protection

In normal mode, the DW01+ continuously monitors the discharge current by sensing the voltage of CS pin. If the voltage of CS pin exceeds the overcurrent protection voltage (V_{OIP}) beyond the overcurrent delay time (T_{OI1}) period, the overcurrent protection circuit operates and discharging is inhibited by turning off the discharge control MOSFET. The overcurrent condition returns to the normal mode when the load is released or the impedance between BATT+ and BATT- is larger than 500kΩ. The DW01+ provides two overcurrent detection levels (0.15V and 1.35V) with two overcurrent delay time (T_{OI1} and T_{OI2}) corresponding to each overcurrent detection level.

4. Charge Detection after Overdischarge

When overdischarge occurs, the discharge control MOSFET turns off and discharging is inhibited. However, charging is still permitted through the parasitic diode of MOSFET. Once the charger is connected to the battery pack, the DW01+ immediately turns on all the timing generation and detection circuitry. Charging progress is sensed if the voltage between CS and GND is below charge detection threshold voltage (V_{CH}).

5. Power-Down after Overdischarge

When overdischarge occurs, the DW01+ will enter into power-down mode, turning off all the timing generation and detection circuitry to reduce the quiescent current to 0.1 μA (VCC=2.0V). At the same time, the CS pin is pull-up to V_{CC} through an internal resistor.

Design Guide

1. Selection of External Control MOSFET

Because the overcurrent protection voltage is preset, the threshold current for overcurrent detection is determined by the turn-on resistance of the charge and discharge control MOSFETs. The turn-on resistance of the external control MOSFETs can be determined by the equation: $R_{ON}=V_{OIP}/(2 \times I_T)$ (I_T is the overcurrent threshold current). For example, if the overcurrent threshold current I_T is designed to be 3A, the turn-on resistance of the external control MOSFET must be 25mΩ. Be aware that turn-on resistance of the MOSFET changes with temperature variation due to heat dissipation. It changes with the voltage between gate and source as well. (Turn-on resistance of MOSFET increases as the voltage between gate and source decreases). As the turn-on resistance of the external MOSFET changes, the design of the overcurrent threshold current changes accordingly.

2. Suppressing the Ripple and Disturbance from Charger

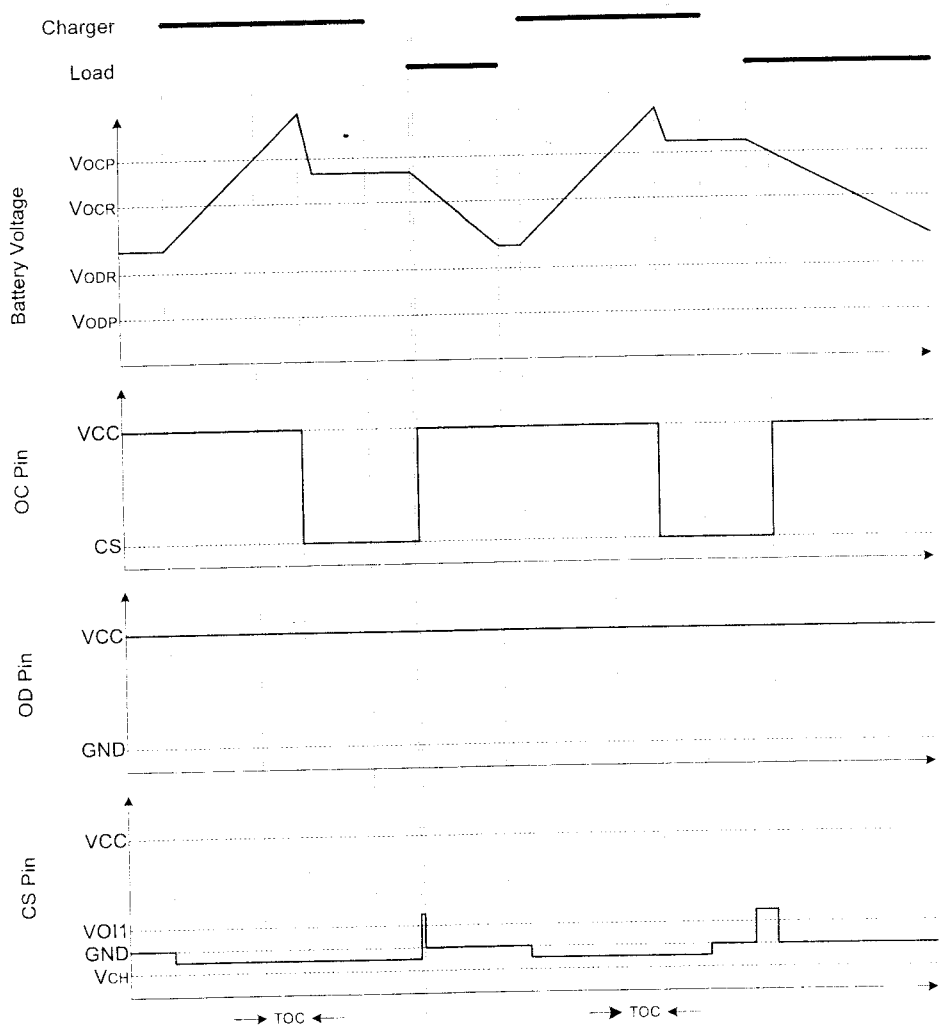
To suppress the ripple and disturbance from charger, connecting R1 and C1 to V_{CC} is recommended.

3. Protection the CS pin

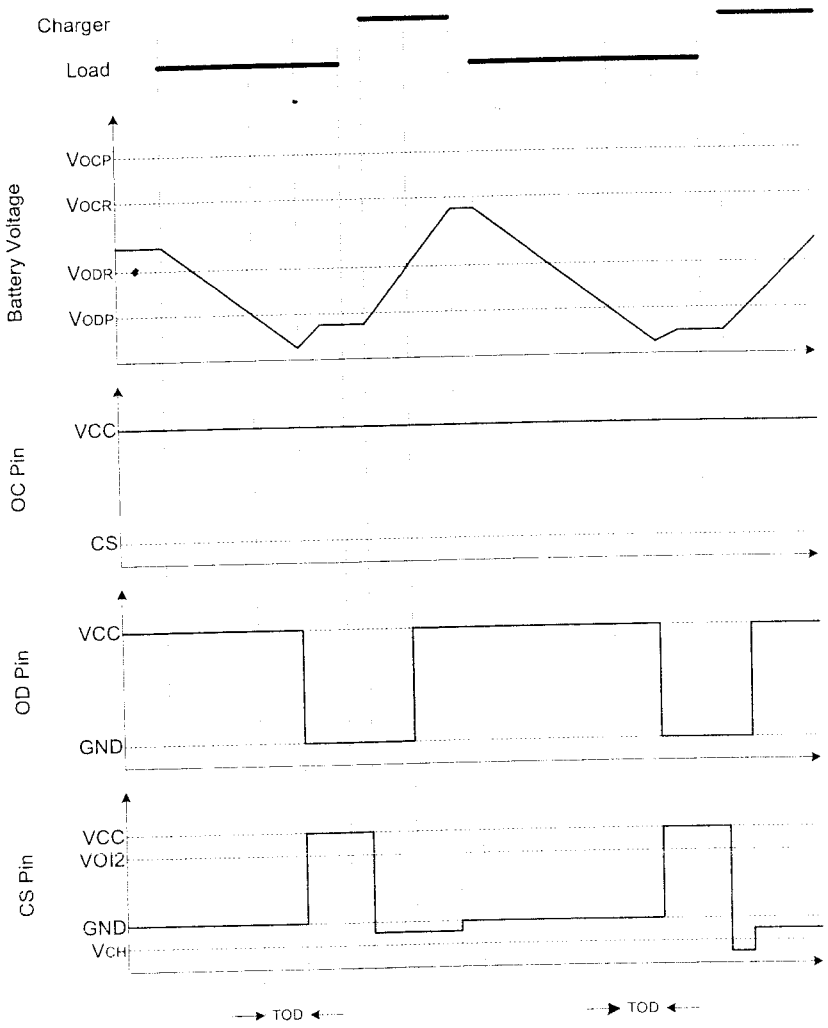
R2 is used for latch-up protection when charger is connected under overdischarge condition and overstress protection at reverse connecting of a charger.

Timing Diagram

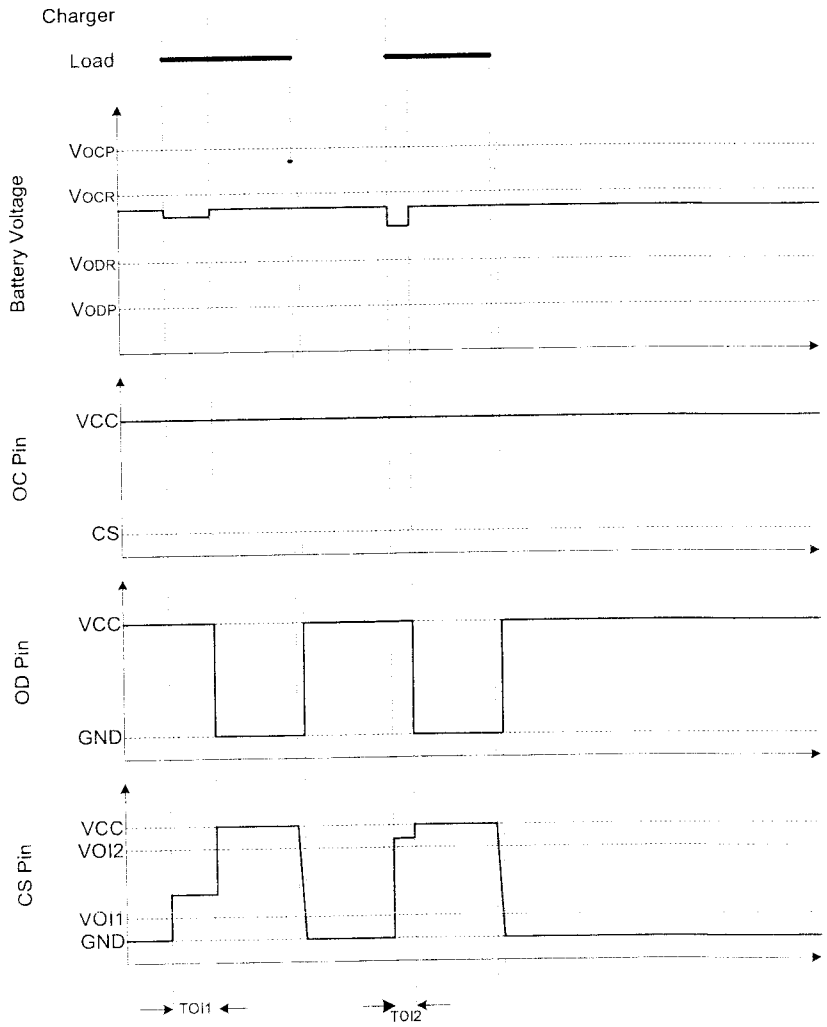
1. Overcharge Condition →Load Discharging → Normal Condition



2. Overdischarge Condition → Charging by a Charger →Normal Condition

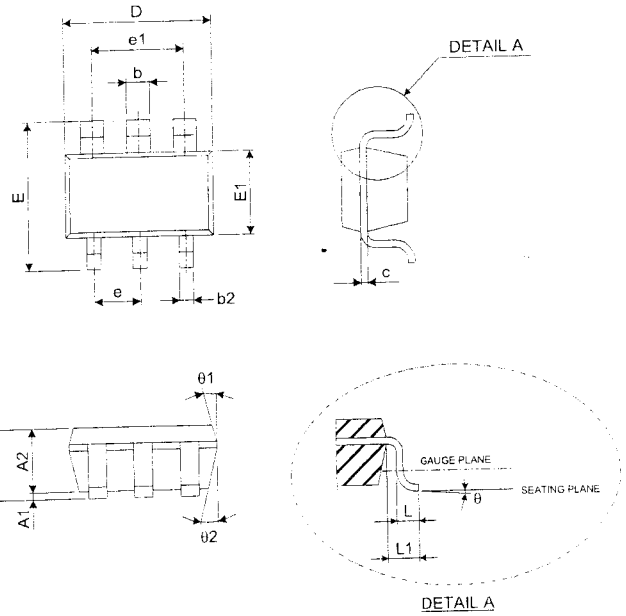


3. Over Current Condition → Normal Condition



Package Outline

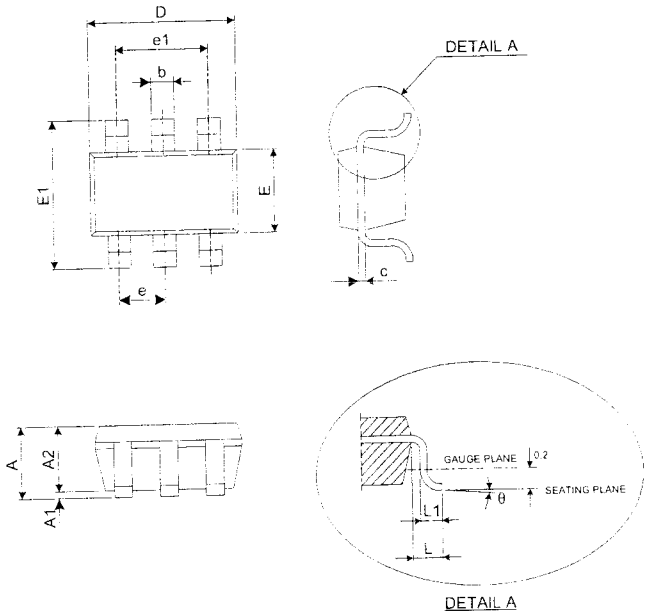
Dimension (Package A)



Unit : mm

SYMBOL	MIN.	TYP.	MAX
A	1.05	-	1.35
A1	0.05	-	0.15
A2	1.00	1.10	1.20
b	0.40	-	0.55
b2	0.25	-	0.40
c	0.08	-	0.20
D	2.70	2.90	3.00
E	2.60	2.80	3.00
E1	1.59	1.60	1.70
L	0.35	0.45	0.55
L1		0.60 REF.	
e		0.95 BSC.	
e1		1.90 BSC.	
θ	0°	5°	10°
θ1	3°	5°	7°
θ2	6°	8°	10°

Dimension (Package B)



Unit : mm

SYMBOL	MIN.	TYP.	MAX
A	1.050	-	1.250
A1	0.000	-	0.100
A2	1.050	-	1.150
b	0.300	-	0.400
c	0.100	-	0.200
D	2.820	-	3.020
E	1.500	-	1.700
E1	2.650	-	2.950
e		0.950 TYP.	
e1	1.800	-	2.000
L		0.700REF.	
L1	0.300	-	0.600
θ	0°	-	8°

Datasheet

DW01+

One Cell Lithium-ion/Polymer Battery Protection IC

Fortune

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1. General Description

The DW01+ battery protection IC is designed to protect lithium-ion/polymer battery from damage or degrading the lifetime due to overcharge, overdischarge, and/or overcurrent for one-cell lithium-ion/polymer battery powered systems, such as cellular phones.
The ultra-small package and less required external components make it ideal to integrate the DW01+ into the limited space of battery pack. The accurate ±50mV overcharging detection voltage ensures safe and full utilization charging. The very low standby current drains little current from the cell while in storage.

2. Features

- **Reduction in Board Size due to Miniature Package SOT-23-6.**
- **Ultra-Low Quiescent Current at 3μA (Vcc=3.9V).**
- **Ultra-Low Power-Down Current at 0.1μA (Vcc=2.0V).**
- **Precision Overcharge Protection Voltage 4.3V ± 50mV**
- **Load Detection Function during Overcharge Mode.**
- **Two Detection Levels for Overcurrent Protection.**
- **Delay times are generated by internal circuits. No external capacitors required.**

3. Ordering Information

DW01+
PACKAGE TYPE
SOT-23-6

TEMPERATURE RANGE
-40°C~+85°C

OVERCHARGE PROTECTION
4.3V± 50mV

DW01+P
PACKAGE TYPE
SOT-23-6 (Pb-free)

TEMPERATURE RANGE
-40°C~+85°C

OVERCHARGE PROTECTION
4.3V± 50mV

4. Applications

- **Protection IC for One-Cell Lithium-Ion / Lithium-Polymer Battery Pack**

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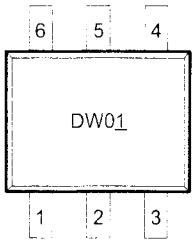
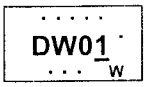
5. Product Name List

Model	Package	Overcharge detection voltage [VOCP] (V)	Overcharge release voltage [VOCR] (V)	Overdischarge detection voltage [VODP] (V)	Overdischarge release voltage [VODR] (V)	Overcurrent detection voltage [VOI1] (mV)
	SOT-23-6					
DW01+	DW01+	4.300±0.050	4.100±0.050	2.40±0.100	3.0±0.100	150±30

6. Pin Configuration and Package Marking Information

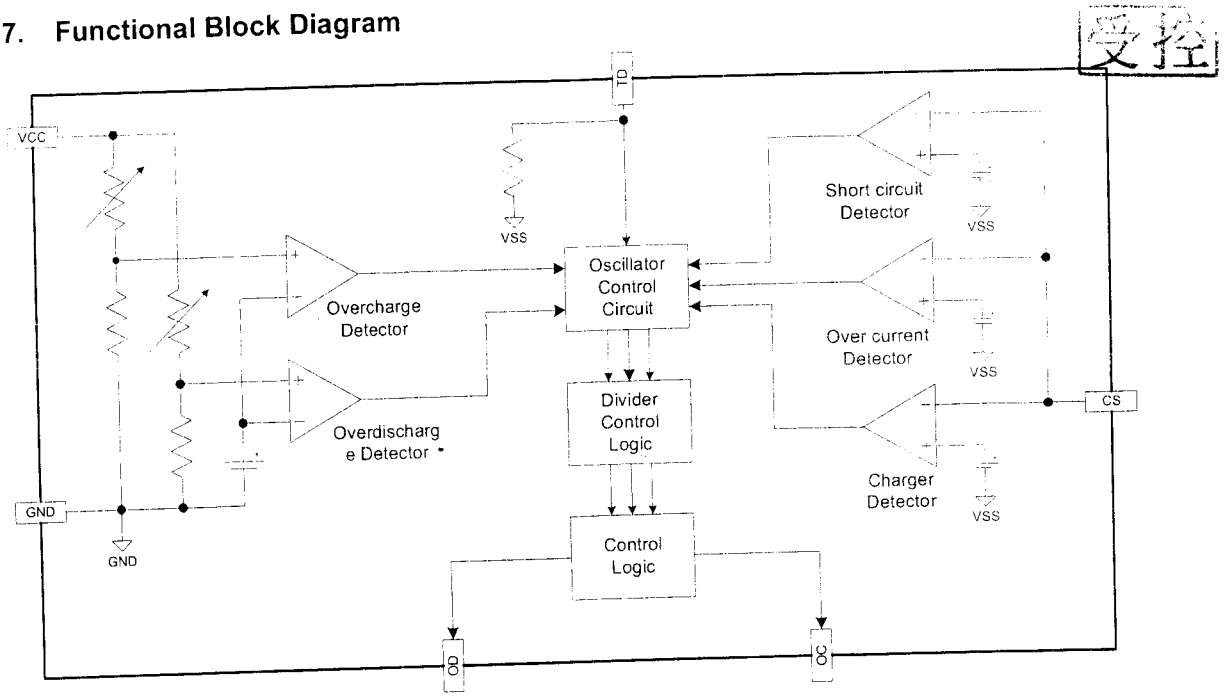
Pin No.	Symbol	Description
1	OD	MOSFET gate connection pin for discharge control
2	CS	Input pin for current sense, charger detect
3	OC	MOSFET gate connection pin for charge control
4	TD	Test pin for reduce delay time
5	VCC	Power supply, through a resistor (R1)
6	GND	Ground pin



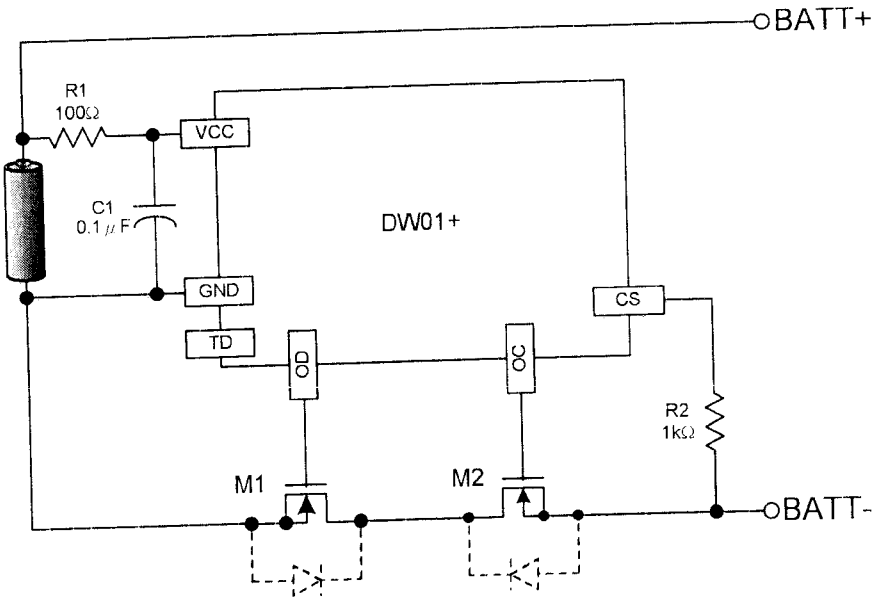


Top Point : Lot No.
Bottom Point : Year
w : week, A~Z & A ~ Z
A dot after marking : Pb Free

7. Functional Block Diagram



8. Typical Application Circuit



9. Absolute Maximum Ratings

(GND=0V, Ta=25°C unless otherwise specified)

Item	Symbol	Rating	Unit
Input voltage between VCC and GND *	VCC	GND-0.3 to GND+10	V
OC output pin voltage	VOC	VCC -24 to VCC +0.3	V
OD output pin voltage	VOD	GND-0.3 to VCC +0.3	V
CS input pin voltage	VCS	VCC -24 to VCC +0.3	V
Operating Temperature Range	TOP	-40 to +85	°C
Storage Temperature Range	TST	-40 to +125	°C

Note: DW01+ contains a circuit that will protect it from static discharge; but please take special care that no excessive static electricity or voltage which exceeds the limit of the protection circuit will be applied to it.

10. Electrical Characteristics

(Ta=25°C unless otherwise specified)

PARAMETER	TEST CONDITIONS	SYMBOL	Min	Typ	Max	UNIT
Supply Current	VCC=3.9V	ICC		3.0	6.0	μA
Power-Down Current	VCC=2.0V	IPD			0.1	μA
Overcharge Protection Voltage	DW01+	VOCP	4.25	4.30	4.35	V
Overcharge Release Voltage		VOCR	4.05	4.10	4.15	V
Overdischarge Protection Voltage		VODP	2.30	2.40	2.50	V
Overdischarge Release Voltage		VODR	2.90	3.00	3.10	V
Overcurrent Protection Voltage		VOIP (VOI1)	120	150	180	mV
Short Current Protection Voltage	VCC=3.6V	VSIP (VOI2)	1.00	1.35	1.70	V
Overcharge Delay Time		TOC		80	200	ms
Overdischarge Delay Time	VCC=3.6V to 2.0V	TOD		40	100	ms
Overcurrent Delay Time (1)	VCC=3.6V	TOI1		10	20	ms
Overcurrent Delay Time (2)	VCC=3.6V	TOI2		5	50	μs
Charger Detection Threshold Voltage		VCHA	-1.2	-0.7	-0.2	V
OD Pin Output "H" Voltage		VDH	VCC-0.1	VCC-0.02		V
OD Pin Output "L" Voltage		VDL		0. 1	0.5	V
OC Pin Output "H" Voltage		VCH	VCC-0.1	VCC-0.02		V
OC Pin Output "L" Voltage		VCL		0.1	0.5	V

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11. Description of Operation

11.1 Normal Condition

If VODP<VCC<VOCP and VCH<VCS<VOI1, M1 and M2 are both turned on. The charging and discharging processes can be operated normally.

11.2 Overcharge Protection

When the voltage of the battery cell exceeds the overcharge protection voltage (VOCP) beyond the overcharge delay time (TOC) period, charging is inhibited by turning off of the charge control MOSFET. The overcharge condition is released in two cases:

The voltage of the battery cell becomes lower than the overcharge release voltage (VOCR) through self-discharge.

The voltage of the battery cell falls below the overcharge protection voltage (VOCP) and a load is connected. When the battery voltage is above VOCP, the overcharge condition will not release even a load is connected to the pack.

11.3 Overdischarge Protection

When the voltage of the battery cell goes below the overdischarge protection voltage (VODP) beyond the overdischarge delay time (TOD) period, discharging is inhibited by turning off the discharge control MOSFET.

The default of overdischarge delay time is 10ms. Inhibition of discharging is immediately released when the voltage of the battery cell becomes higher than overdischarge release voltage (VODR) through charging.

11.4 Overcurrent Protection

In normal mode, the DW01+ continuously monitors the discharge current by sensing the voltage of CS pin. If the voltage of CS pin exceeds the overcurrent protection voltage (VOIP) beyond the overcurrent delay time (TOI1) period, the overcurrent protection circuit operates and discharging is inhibited by turning off the discharge control MOSFET. The overcurrent condition returns to the normal mode when the load is released or the impedance between BATT+ and BATT- is larger than 500kΩ. The DW01+ provides two overcurrent detection levels (0.15V and 1.35V) with two overcurrent delay time (TOI1 and TOI2) corresponding to each overcurrent detection level.

11.5 Charge Detection after Overdischarge

When overdischarge occurs, the discharge control MOSFET turns off and discharging is inhibited. However, charging is still permitted through the parasitic diode of MOSFET. Once the charger is connected to the battery pack, the DW01+ immediately turns on all the timing generation and detection circuitry. Charging progress is sensed if the voltage between CS and GND is below charge detection threshold voltage (VCH).

11.6 Power-Down after Overdischarge

When overdischarge occurs, the DW01+ will enter into power-down mode, turning off all the timing generation and detection circuitry to reduce the quiescent current to 0.1 μA (VCC=2.0V). At the same time, the CS pin is pull-up to VCC through an internal resistor.

Note: When a battery is connected to DW01+ for the first time, it may not enter the normal condition (dischargeable may not be enabled). In this case, short the CS and VSS pins or connect to a charger to restore to the normal condition.

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12. Design Guide

12.1 Selection of External Control MOSFET

Because the overcurrent protection voltage is preset, the threshold current for overcurrent detection is determined by the turn-on resistance of the charge and discharge control MOSFETs. The turn-on resistance of the external control MOSFETs can be determined by the equation: RON=VOIP/ (2 x IT) (IT is the overcurrent threshold current). For example, if the overcurrent threshold current IT is designed to be 3A, the turn-on resistance of the external control MOSFET must be 25mΩ. Be aware that turn-on resistance of the MOSFET changes with temperature variation due to heat dissipation. It changes with the voltage between gate and source as well. (Turn-on resistance of MOSFET increases as the voltage between gate and source decreases). As the turn-on resistance of the external MOSFET changes, the design of the overcurrent threshold current changes accordingly.

12.2 Suppressing the Ripple and Disturbance from Charger

To suppress the ripple and disturbance from charger, connecting R1 and C1 to VCC is recommended.

12.3 Protection the CS pin

R2 is used for latch-up protection when charger is connected under overdischarge condition and overstress protection at reverse connecting of a charger.

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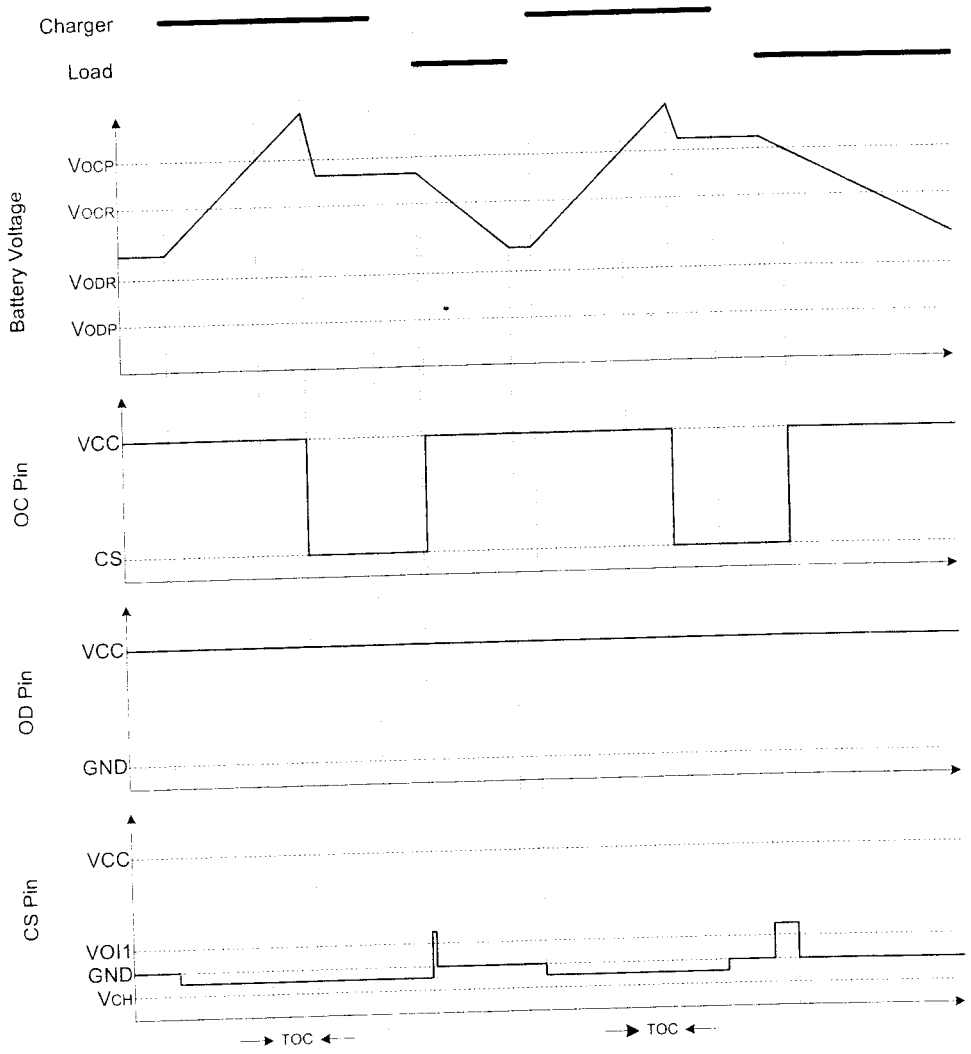
13. Timing Diagram

13.1 Overcharge Condition →Load Discharging → Normal Condition



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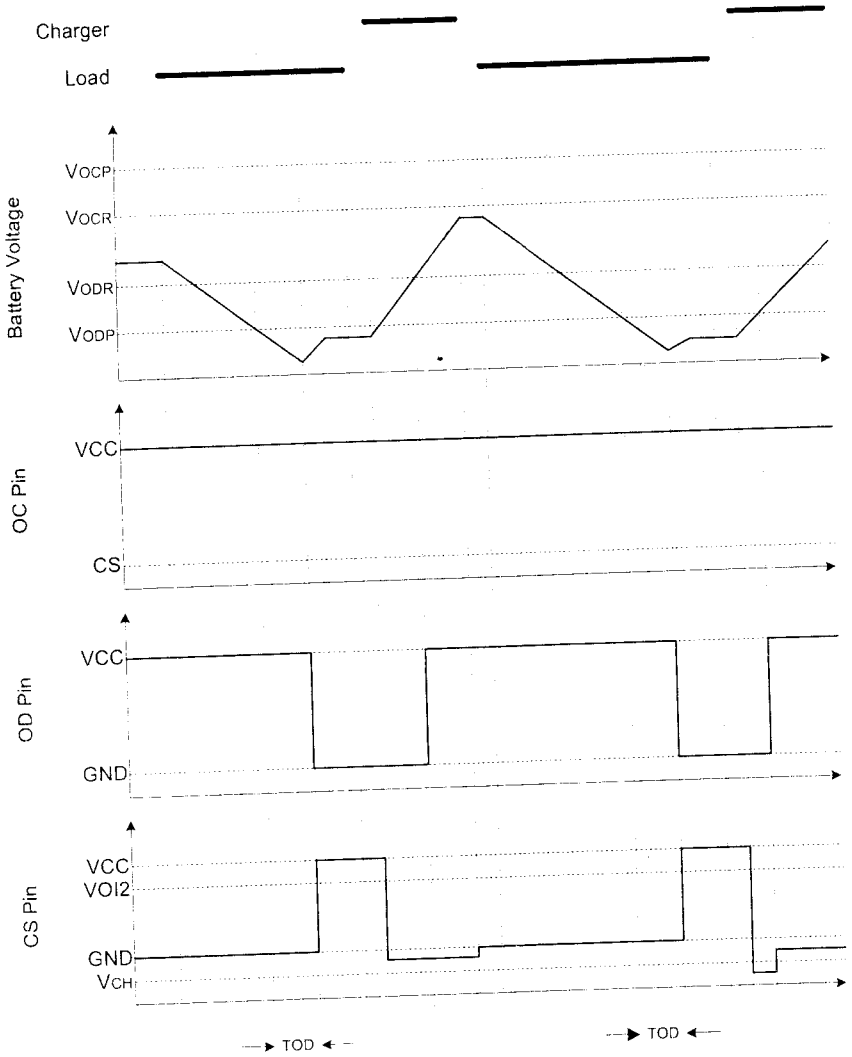
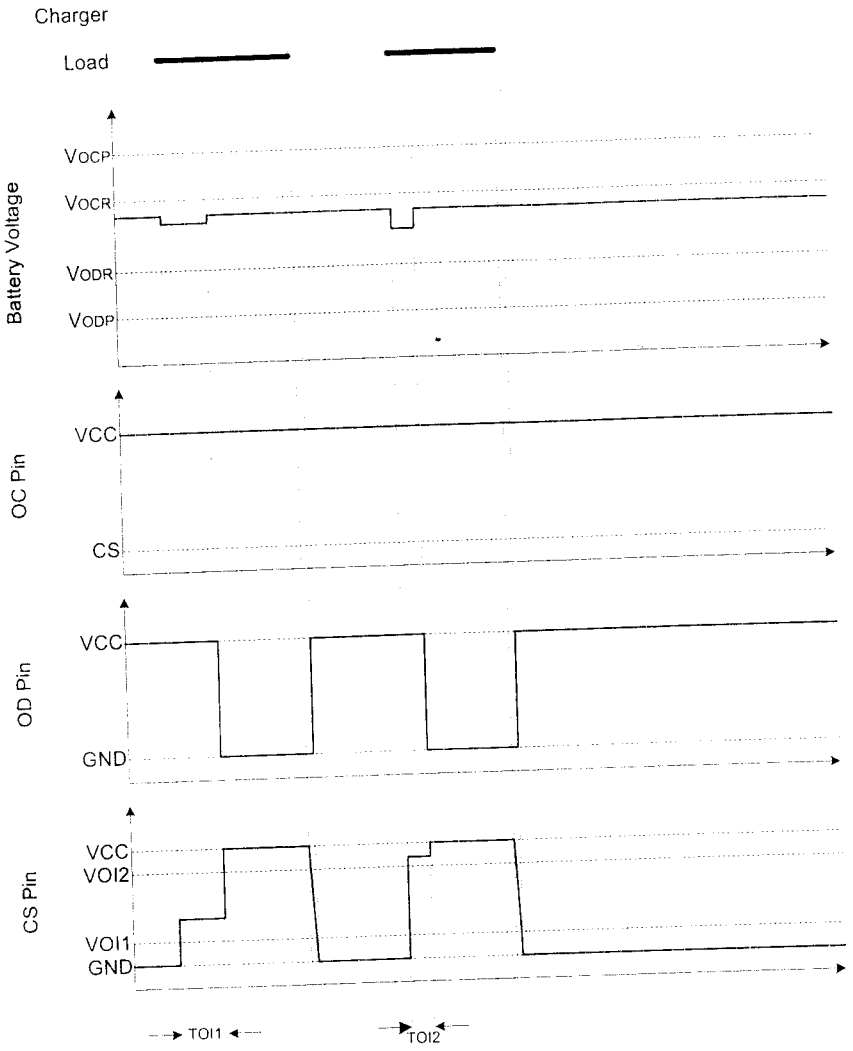
13.2 Overdischarge Condition → Charging by a Charger →Normal Condition

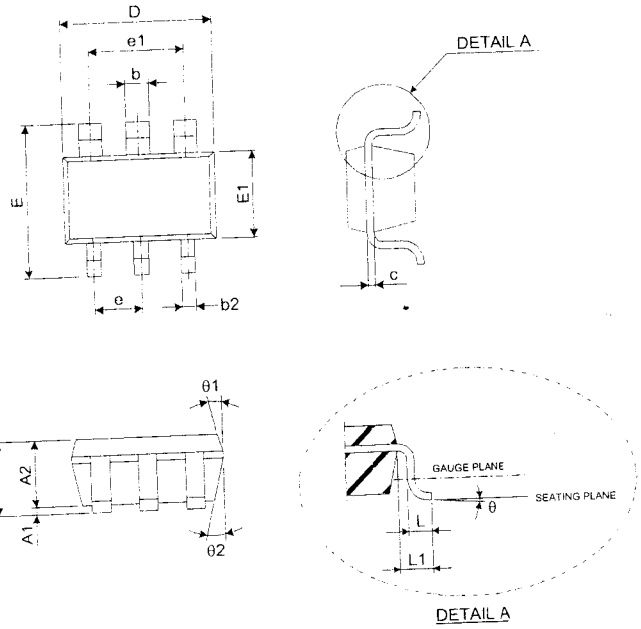


13.3 Over Current Condition → Normal Condition



14. Package Outline

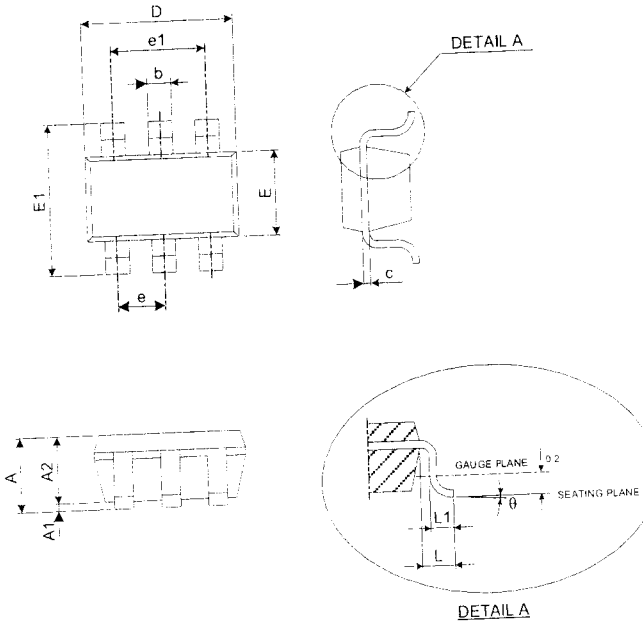
Dimension (Package A)



Unit : mm

SYMBOL	MIN.	TYP.	MAX.
A	1.05	-	1.35
A1	0.05	-	0.15
A2	1.00	1.10	1.20
b	0.40	-	0.55
b2	0.25	-	0.40
c	0.08	-	0.20
D	2.70	2.90	3.00
E	2.60	2.80	3.00
E1	1.50	1.60	1.70
L	0.35	0.45	0.55
L1	0.60 REF.		
e	0.95 BSC.		
e1	1.90 BSC.		
θ	0°	5°	10°
θ1	3°	5°	7°
θ2	6°	8°	10°

Dimension (Package B)



Unit : mm

SYMBOL	MIN.	TYP.	MAX.
A	1.050	-	1.250
A1	0.000	-	0.100
A2	1.050	-	1.150
b	0.300	-	0.400
c	0.100	-	0.200
D	2.820	-	3.020
E	1.500	-	1.700
E1	2.650	-	2.950
e	0.950 TYP		
e1	1.800	-	2.000
-	0.700REF		
L1	0.300	-	0.600
θ	0°	-	8°

SGS

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Test Report

No. SH8012360/CHEM Date: Jan. 31, 2008

NINGBO LIYUAN TECHNOLOGY CO., LTD
NO.30, GANGDONG ROAD, NINGBO FREE TRADE ZONE (EAST) ZHEJIANG PROVINCE

The following sample(s) was/were submitted and identified by/on behalf of the client as:

Sample Name	: SOT FAMILY/SOT LEAD/SC FAMILY/SC LEAD
SGS Ref No.	: 10821375
Sample Receiving Date	: Jan.24, 2008
Testing Period	: Jan.24–30, 2008
Test Requested	: In accordance with the RoHS Directive 2002/95/EC, and its amendment directives.
Test Method	: With reference to IEC 62321/2nd CDV (111/95/CDV) Procedures for the Determination of Levels of Regulated Substances in Electrotechnical Products (1) Determination of Cadmium by ICP. (2) Determination of Lead by ICP and AAS. (3) Determination of Mercury by ICP. (4) Determination of Hexavalent Chromium by Spot test / Colorimetric Method. (5) Determination of PBBs and PBDEs by GC/MS.
Test Results	: Please refer to next pages
Conclusion	: Based on the performed tests on submitted samples, the results comply with the RoHS Directive 2002/95/EC and its subsequent amendments.

Signed for and on behalf of
SGS-CSTC Chemical Laboratory

Ella Zhang
Section Manager

Signed for and on behalf of
SGS-CSTC Chemical Laboratory

Sandy Hao

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Lab Manager

Test results by chemical method (Unit: mg/kg)

Test Item(s):	Method (refer to)	1	3	MDL	RoHS Limit
Cadmium(Cd)	(1)	ND	ND	2	100
Lead (Pb)	(2)	ND	ND	2	1000
Mercury (Hg)	(3)	ND	ND	2	1000
Hexavalent Chromium (CrVI) by alkaline extraction	(4)	ND	ND	2	1000
Sum of PBBs	(5)	ND	ND	-	1000
Monobromobiphenyl		ND	ND	5	-
Dibromobiphenyl		ND	ND	5	-
Tribromobiphenyl		ND	ND	5	-
Tetrabromobiphenyl		ND	ND	5	-
Pentabromobiphenyl		ND	ND	5	-
Hexabromobiphenyl		ND	ND	5	-
Heptabromobiphenyl		ND	ND	5	-
Octabromobiphenyl		ND	ND	5	-
Nonabromobiphenyl		ND	ND	5	-
Decabromobiphenyl		ND	ND	5	-
Sum of PBDEs (Note 4)		ND	ND	-	1000
Monobromodiphenyl ether		ND	ND	5	-
Dibromodiphenyl ether		ND	ND	5	-
Tribromodiphenyl ether		ND	ND	5	-
Tetrabromodiphenyl ether		ND	ND	5	-
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Nonabromodiphenyl ether		ND	ND	5	-
Decabromodiphenyl ether		ND	ND	5	-
Sum of PBDEs (Mono to Deca)		ND	ND	-	-

Test Item(s):	Method (refer to)	2	4	MDL	RoHS Limit
Cadmium(Cd)	(1)	ND	ND	2	100
Lead (Pb)	(2)	ND	ND	2	1000
Mercury (Hg)	(3)	ND	ND	2	1000
Hexavalent Chromium (CrVI) by spot test / boiling-water extraction	(4)	Negative	Negative	See Note (5)	#

Test Part Description:

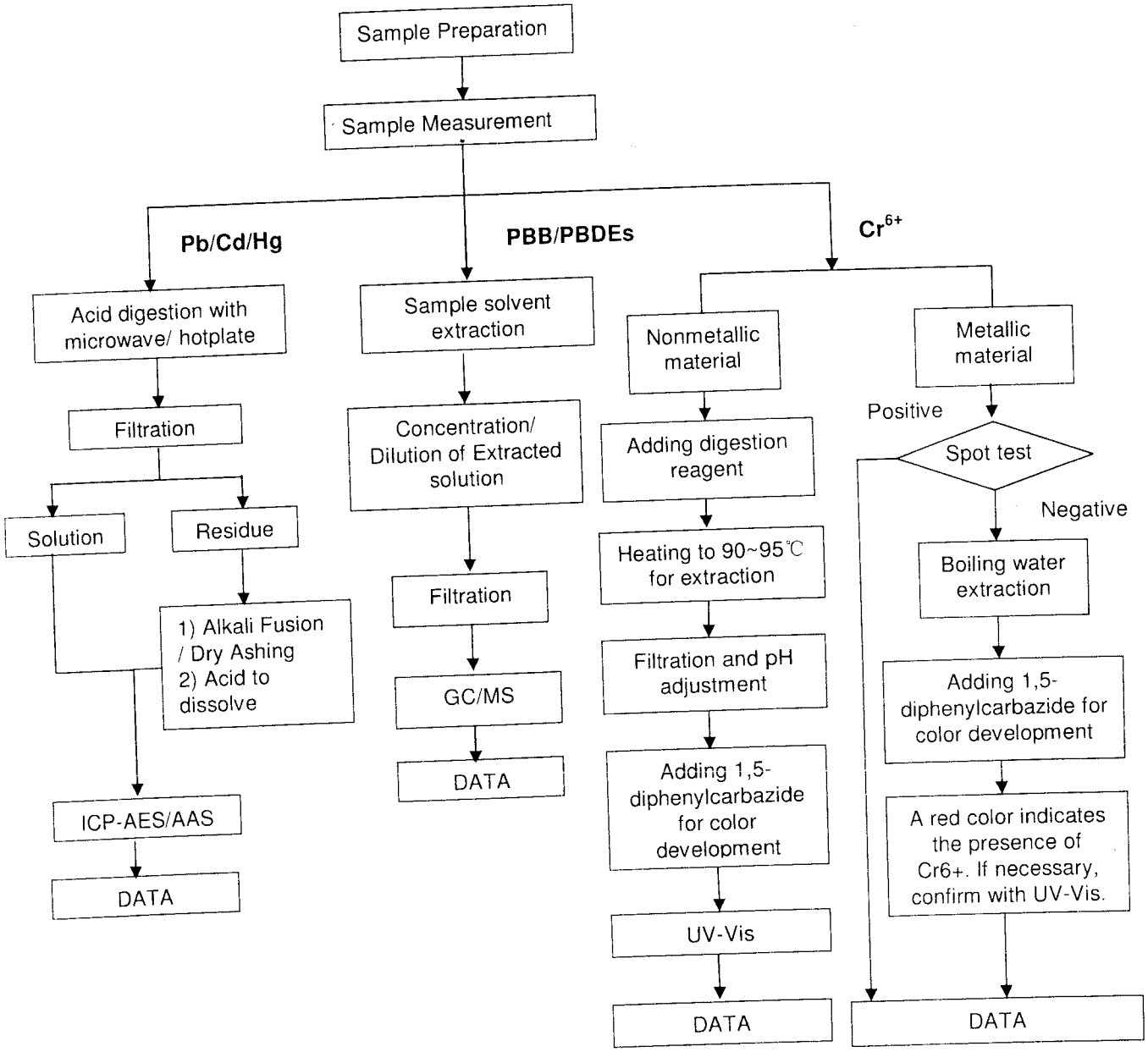
1. Black body part
2. Silvery metal pin part
3. Black body part
4. Silvery metal pin part

Note:

(1) mg/kg = ppm
(2) ND = Not Detected
(3) MDL = Method Detection Limit
(4) Sum of Mono to NonaBDE & according to 2005/717/EC DecaBDE is exempt.
(5) Spot-test:
Negative = Absence of CrVI coating, Positive = Presence of CrVI coating;
(The tested sample should be further verified by boiling-water-extraction method if the spot test result is Negative or cannot be confirmed.)
Boiling-water-extraction:
Negative = Absence of CrVI coating
Positive = Presence of CrVI coating; the detected concentration in boiling-water-extraction solution is equal or greater than 0.02 mg/kg with 50 cm^2 sample surface area.
(6) # = Positive indicates the presence of Hexavalent Chromium on the tested areas.
Negative indicates the absence of CrVI on the tested areas.
(7) "-" = Not Regulated
(8) The maximum permissible limit is quoted from the document 2005/618/EC amending RoHS directive 2002/95/EC

ATTACHMENTS

1) Name of the person who made measurement: Cathy Cai/George Xu/Diane Wang
2) Name of the person in charge of measurement: Terry Wang/Tracy Yue
3) These samples were dissolved totally by pre-conditioning method according to below flow chart. (Cr6+ and PBB/PBDEs test method excluded)



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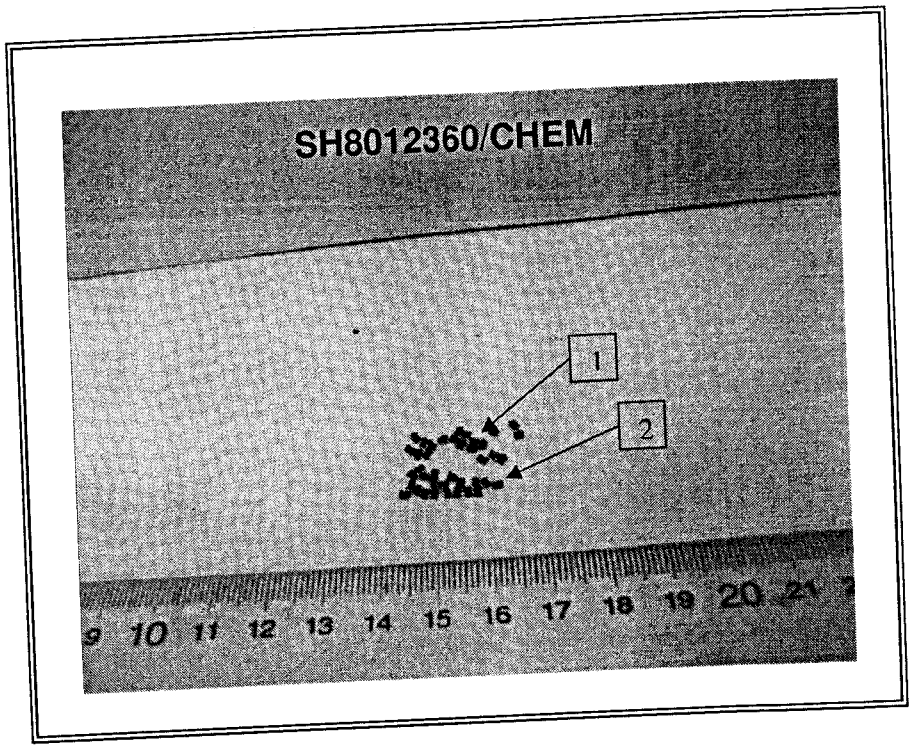

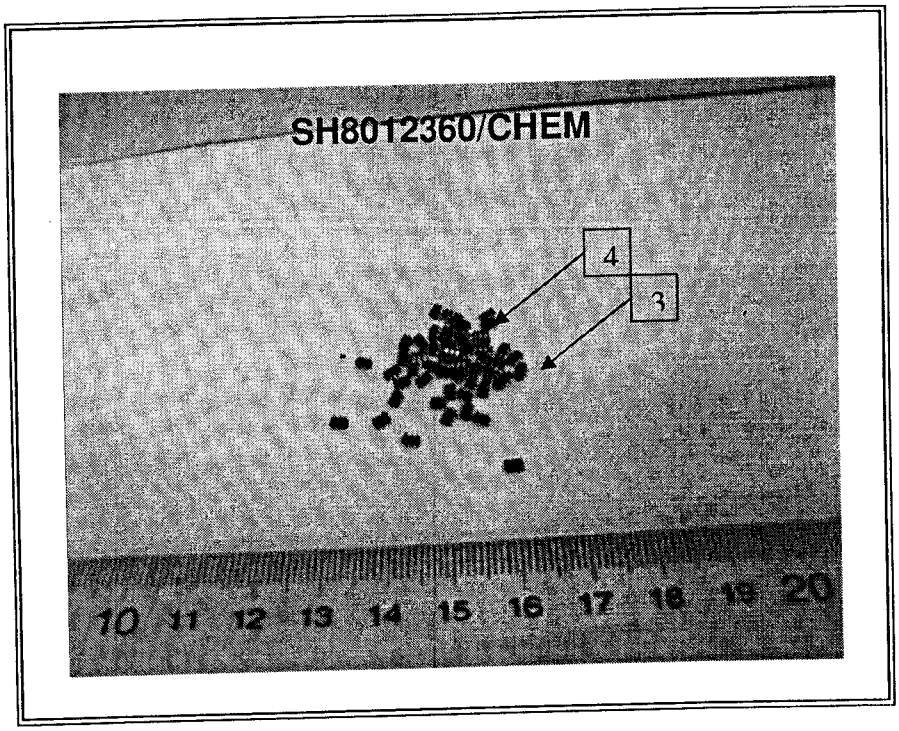

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SGS

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Test Report

No. SH8012360/CHEM Date: Jan. 31, 2008

NINGBO LIYUAN TECHNOLOGY CO., LTD
NO.30, GANGDONG ROAD, NINGBO FREE TRADE ZONE (EAST) ZHEJIANG PROVINCE

The following sample(s) was/were submitted and identified by/on behalf of the client as:

Sample Name : SOT FAMILY/SOT LEAD/SC FAMILY/SC LEAD
SGS Ref No. : 10821375

Sample Receiving Date : Jan.24, 2008
Testing Period : Jan.24–30, 2008

Test Requested : In accordance with the RoHS Directive 2002/95/EC, and its amendment directives.

Test Method : With reference to IEC 62321/2nd CDV (111/95/CDV)
Procedures for the Determination of Levels of Regulated Substances in Electrotechnical Products
(1) Determination of Cadmium by ICP.
(2) Determination of Lead by ICP and AAS.
(3) Determination of Mercury by ICP.
(4) Determination of Hexavalent Chromium by Spot test / Colorimetric Method.
(5) Determination of PBBs and PBDEs by GC/MS.

Test Results : Please refer to next pages

Conclusion : Based on the performed tests on submitted samples, the results comply with the RoHS Directive 2002/95/EC and its subsequent amendments.

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Section Manager

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Lab Manager

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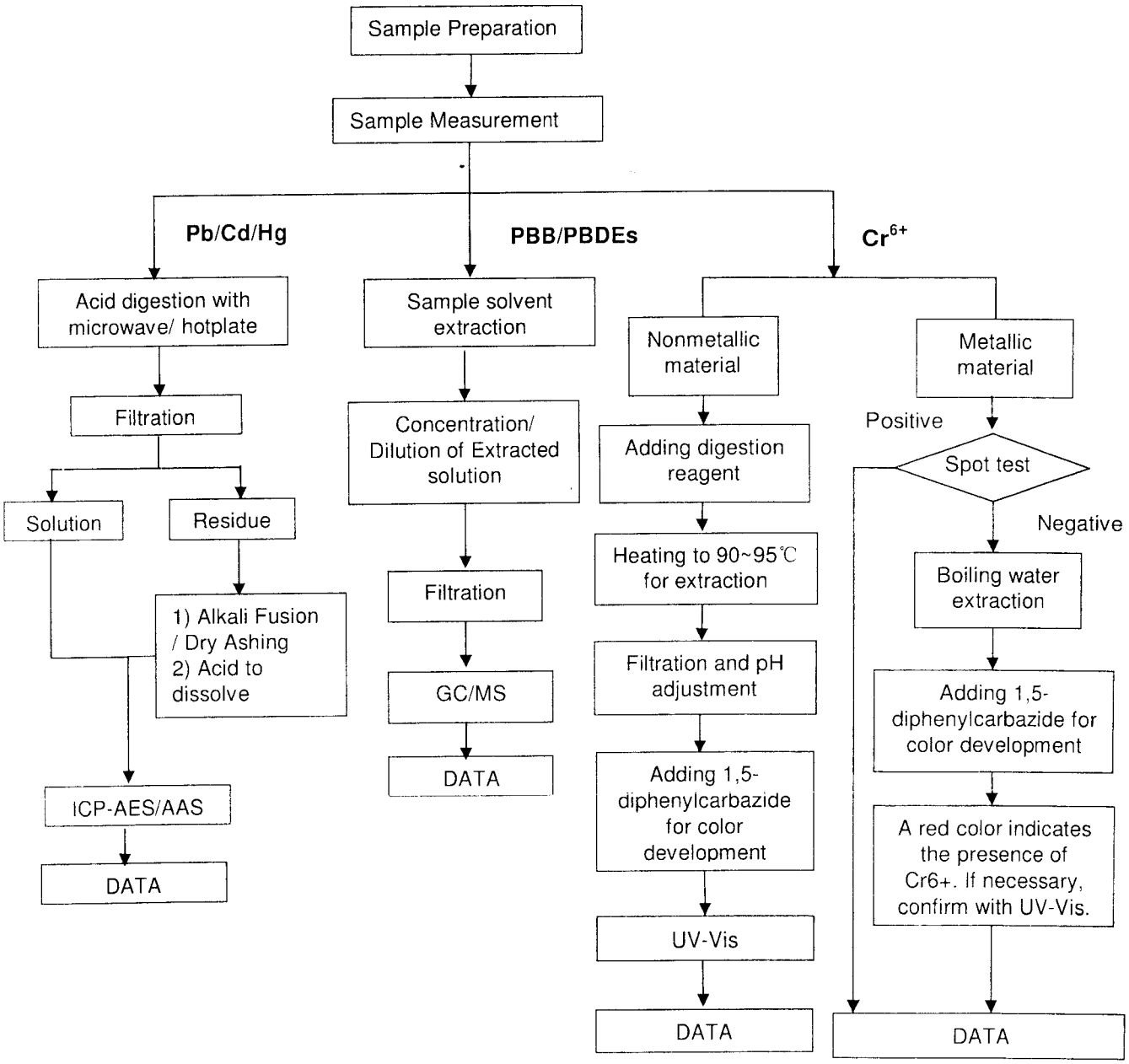
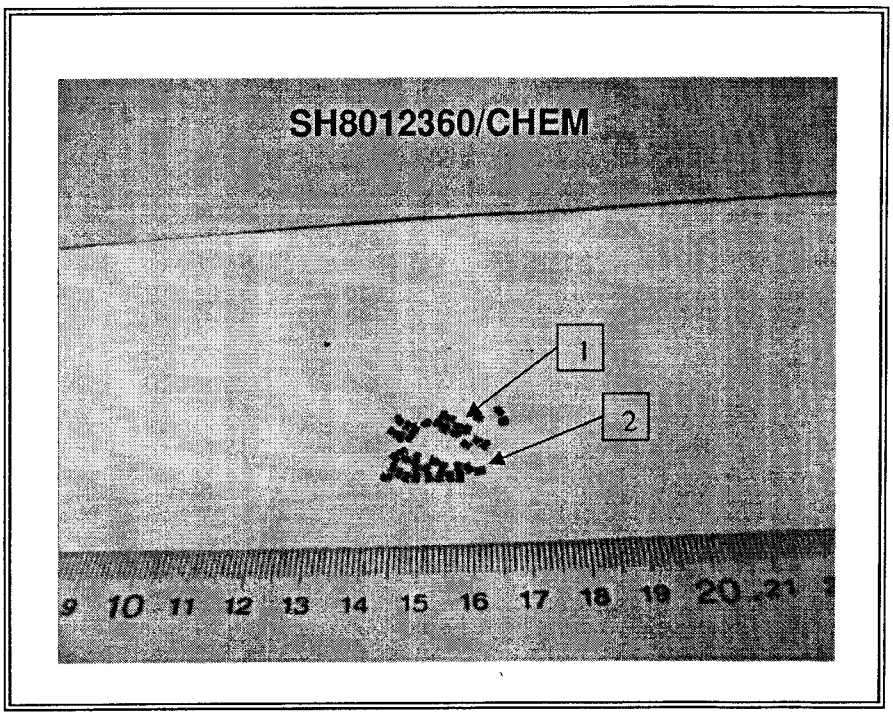
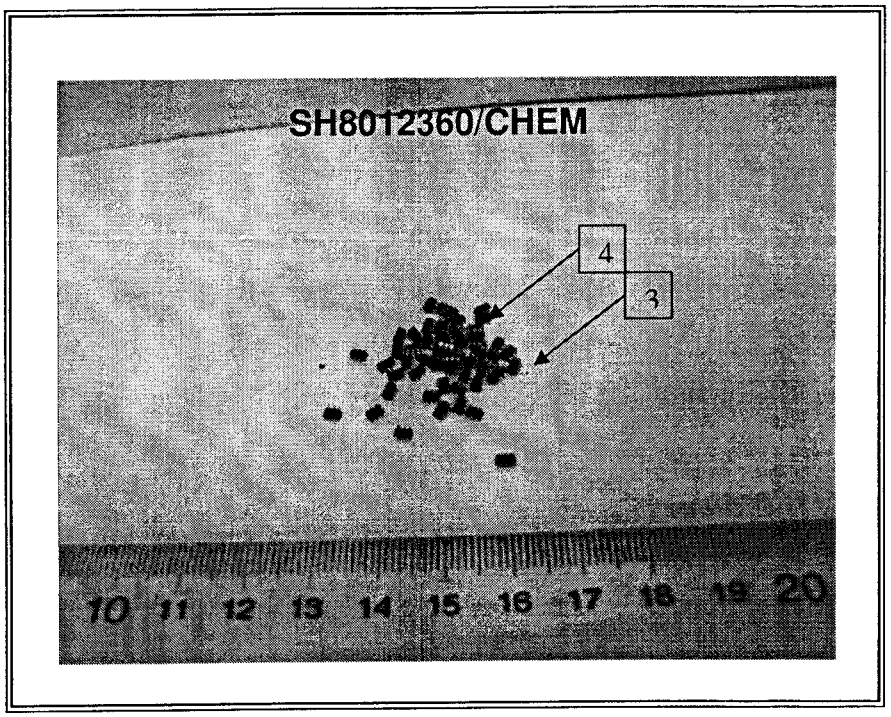


Sample photo:





SGS authenticate the photo on original report only

*** End of Report ***

10. Electrical Characteristics

(Ta=25°C unless otherwise specified)

PARAMETER	TEST CONDITIONS	SYMBOL	Min	Typ	Max	UNIT
Supply Current	VCC=3.9V	ICC		3.0	6.0	μA
Power-Down Current	VCC=2.0V	IPD			0.1	μA
Overcharge Protection Voltage	DW01+	VOCP	4.25	4.30	4.35	V
Overcharge Release Voltage		VOCR	4.05	4.10	4.15	V
Overdischarge Protection Voltage		VODP	2.30	2.40	2.50	V
Overdischarge Release Voltage		VODR	2.90	3.00	3.10	V
Overcurrent Protection Voltage		VOIP (VOI1)	120	150	180	mV
Short Current Protection Voltage	VCC=3.6V	VSIP (VOI2)	1.00	1.35	1.70	V
Overcharge Delay Time		TOC		80	200	ms
Overdischarge Delay Time	VCC=3.6V to 2.0V	TOD		40	100	ms
Overcurrent Delay Time (1)	VCC=3.6V	TOI1		10	20	ms
Overcurrent Delay Time (2)	VCC=3.6V	TOI2		5	50	μs
Charger Detection Threshold Voltage		VCHA	-1.2	-0.7	-0.2	V
OD Pin Output "H" Voltage		VDH	VCC-0.1	VCC-0.02		V
OD Pin Output "L" Voltage		VDL		0. 1	0.5	V
OC Pin Output "H" Voltage		VCH	VCC-0.1	VCC-0.02		V
OC Pin Output "L" Voltage		VCL		0.1	0.5	V

11. Description of Operation

11.1 Normal Condition

If VODP<VCC<VOCP and VCH<VCS<VOI1, M1 and M2 are both turned on. The charging and discharging processes can be operated normally.

11.2 Overcharge Protection

When the voltage of the battery cell exceeds the overcharge protection voltage (VOCP) beyond the overcharge delay time (TOC) period, charging is inhibited by turning off of the charge control MOSFET. The overcharge condition is released in two cases:

The voltage of the battery cell becomes lower than the overcharge release voltage (VOCR) through self-discharge.

The voltage of the battery cell falls below the overcharge protection voltage (VOCP) and a load is connected. When the battery voltage is above VOCP, the overcharge condition will not release even a load is connected to the pack.

11.3 Overdischarge Protection

When the voltage of the battery cell goes below the overdischarge protection voltage (VODP) beyond the overdischarge delay time (TOD) period, discharging is inhibited by turning off the discharge control MOSFET.

The default of overdischarge delay time is 10ms. Inhibition of discharging is immediately released when the voltage of the battery cell becomes higher than overdischarge release voltage (VODR) through charging.

11.4 Overcurrent Protection

In normal mode, the DW01+ continuously monitors the discharge current by sensing the voltage of CS pin. If the voltage of CS pin exceeds the overcurrent protection voltage (VOIP) beyond the overcurrent delay time (TOI1) period, the overcurrent protection circuit operates and discharging is inhibited by turning off the discharge control MOSFET. The overcurrent condition returns to the normal mode when the load is released or the impedance between BATT+ and BATT- is larger than 500kΩ. The DW01+ provides two overcurrent detection levels (0.15V and 1.35V) with two overcurrent delay time (TOI1 and TOI2) corresponding to each overcurrent detection level.

11.5 Charge Detection after Overdischarge

When overdischarge occurs, the discharge control MOSFET turns off and discharging is inhibited. However, charging is still permitted through the parasitic diode of MOSFET. Once the charger is connected to the battery pack, the DW01+ immediately turns on all the timing generation and detection circuitry. Charging progress is sensed if the voltage between CS and GND is below charge detection threshold voltage (VCH).

11.6 Power-Down after Overdischarge

When overdischarge occurs, the DW01+ will enter into power-down mode, turning off all the timing generation and detection circuitry to reduce the quiescent current to 0.1μA (VCC=2.0V). At the same time, the CS pin is pull-up to VCC through an internal resistor.

Note: When a battery is connected to DW01+ for the first time, it may not enter the normal condition (dischargeable may not be enabled). In this case, short the CS and VSS pins or connect to a charger to restore to the normal condition.

12. Design Guide

12.1 Selection of External Control MOSFET

Because the overcurrent protection voltage is preset, the threshold current for overcurrent detection is determined by the turn-on resistance of the charge and discharge control MOSFETs. The turn-on resistance of the external control MOSFETs can be determined by the equation: RON=VOIP/ (2 x IT) (IT is the overcurrent threshold current). For example, if the overcurrent threshold current IT is designed to be 3A, the turn-on resistance of the external control MOSFET must be 25mΩ. Be aware that turn-on resistance of the MOSFET changes with temperature variation due to heat dissipation. It changes with the voltage between gate and source as well. (Turn-on resistance of MOSFET increases as the voltage between gate and source decreases). As the turn-on resistance of the external MOSFET changes, the design of the overcurrent threshold current changes accordingly.

12.2 Suppressing the Ripple and Disturbance from Charger

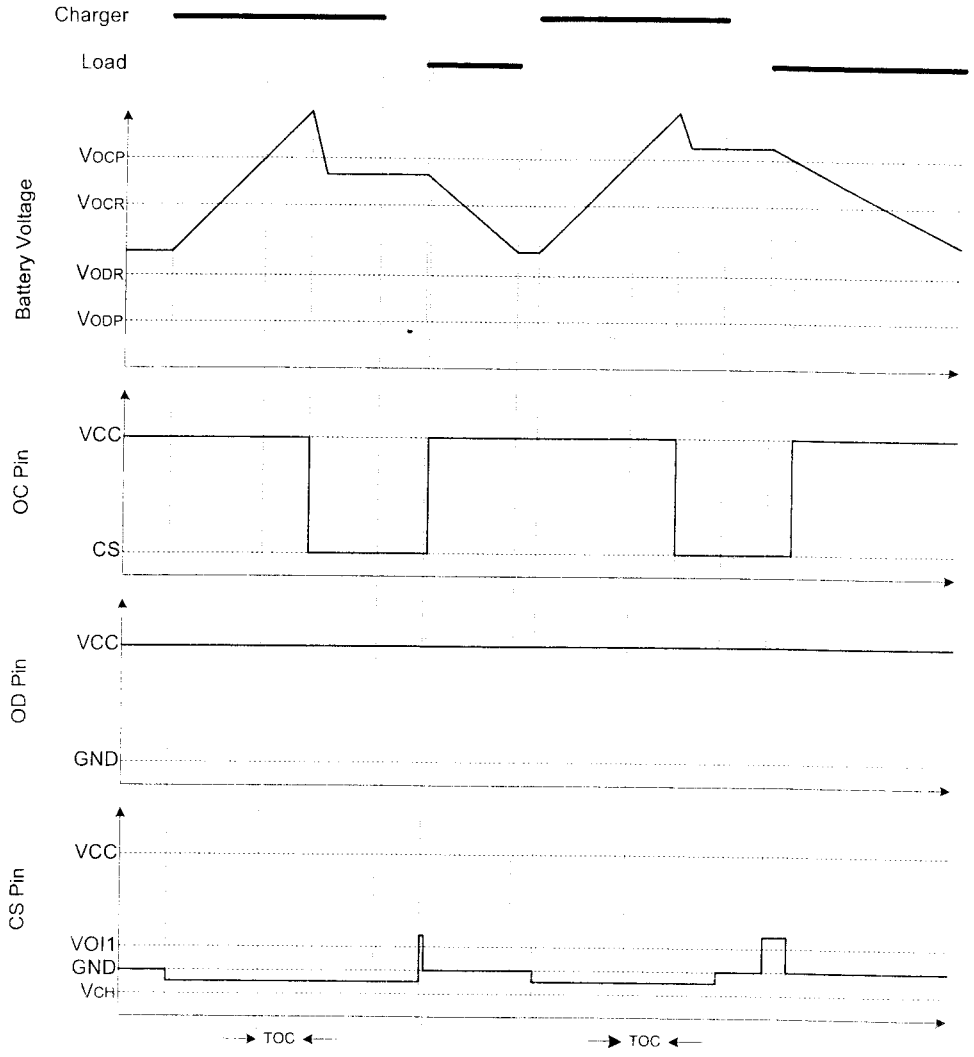
To suppress the ripple and disturbance from charger, connecting R1 and C1 to VCC is recommended.

12.3 Protection the CS pin

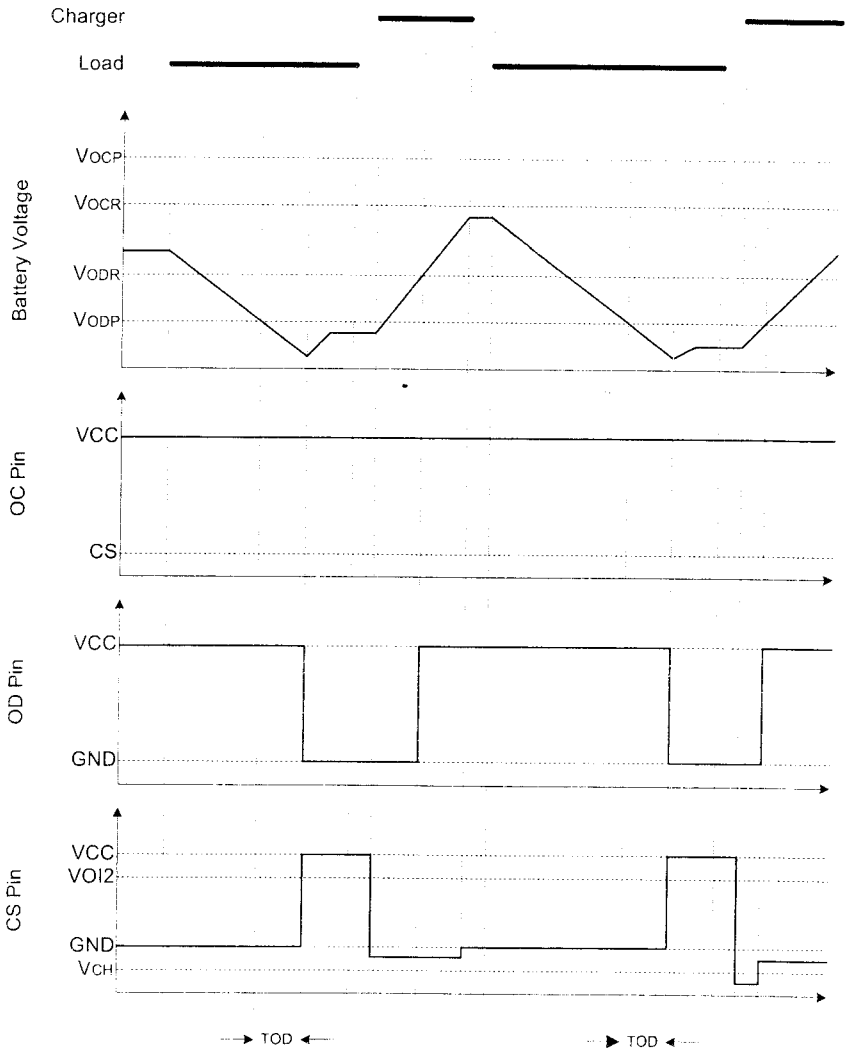
R2 is used for latch-up protection when charger is connected under overdischarge condition and overstress protection at reverse connecting of a charger.

13. Timing Diagram

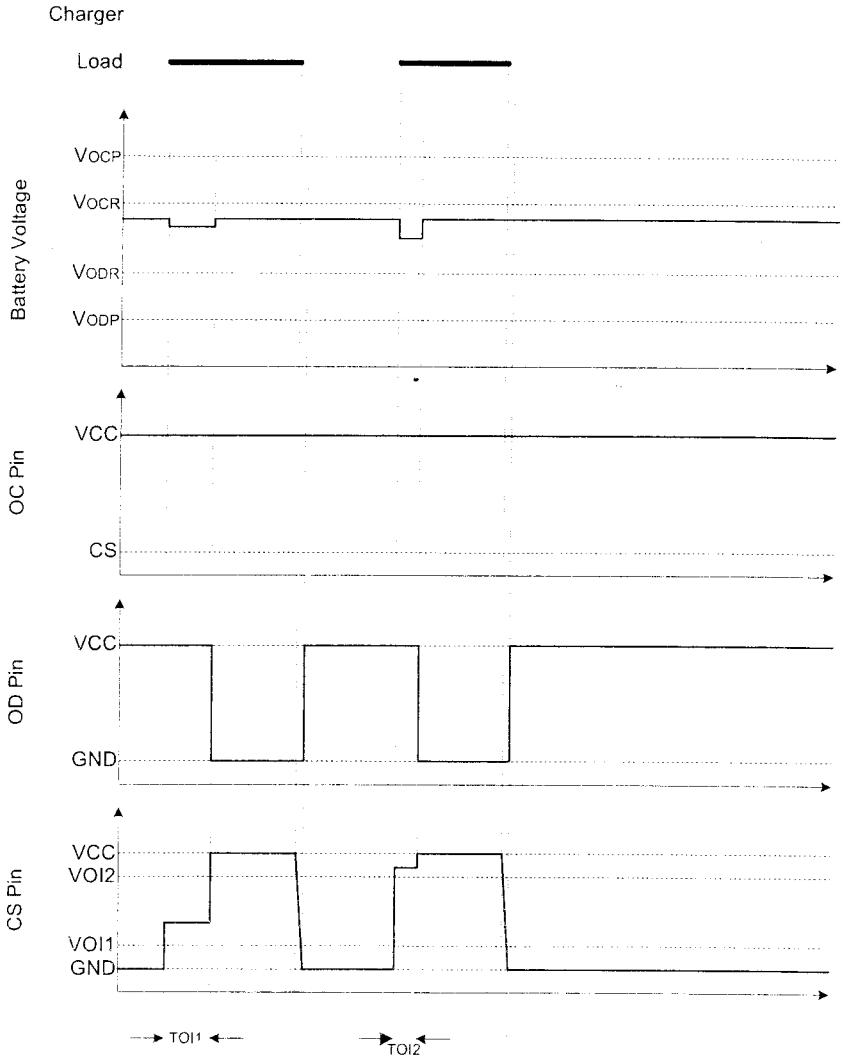
13.1 Overcharge Condition →Load Discharging → Normal Condition



13.2 Overdischarge Condition → Charging by a Charger →Normal Condition



13.3 Over Current Condition → Normal Condition



15. Revision History

Version	Date	Page	Description
1.1	2004/08/02	11	Add C-J China package outline dimension B.
2.0	2005/11/07	-	Revise to new datasheet and revision history format
2.0	2005/11/07	4	Revise Voc and Vcs rating to VCC -24 to VCC +0.3
2.0	2005/11/07	5	Revise Overdischarge delay time from 20ms(TYP)/60ms(MAX) to 40ms(TYP)/100ms(MAX)
2.1	2005/12/8	5	Revise Short Current Protection Voltage from 1.25V(Min) / 1.45V(MAX) to 1.00V (Min) / 1.70V(MAX)
2.2	2006/07/06	1	Add Pb-free DW01+P ordering information
2.3	2006/11/17		1. Revise to new format 2. Revise Pin Configuration and Add package marking information
2.4	2007/06/08	8,14	1. Add Normal Condition and Note 2. Add Revision History