

Datasheet

# FS325

One Cell Lithium-ion/Polymer Battery Protection IC

FORTUNE  
Properties  
For Reference Only

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## 1. General Description

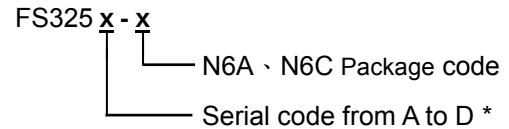
FS325 is a series of lithium-ion and lithium-polymer rechargeable battery protection ICs with high accurate voltage detection and delay circuits.

These ICs are suitable for protection of single cell lithium-ion or lithium polymer battery packs from over charge, over discharge and over current.

## 2. Features

- Low supply current  
Normal Operation :  $2.5 \mu\text{A}$  typ. @VDD=3.9V  
Power-down mode :  $0.05 \mu\text{A}$  typ. @VDD=2.0V  
Auto recovery function :  $1.8 \mu\text{A}$  typ. @VDD=2.0V
- Overcharge detection voltage [ VOCU ]  
4.25V~4.31V, Accuracy of  $\pm 25\text{mV}$
- Overcharge release voltage [ VOCR ]  
4.05V~4.11V, Accuracy of  $\pm 50\text{mV}$
- Overdischarge detection voltage [ VODL ]  
2.30V~2.40V, Accuracy of  $\pm 100\text{mV}$
- Overdischarge release voltage [ VODR ]  
2.30V~2.90V, Accuracy of  $\pm 100\text{mV}$
- Over current detection voltage [ VOI1 ]  
0.10V~0.13V, Accuracy of  $\pm 10\text{mV}$
- Short circuit detection voltage [ VOI2 ]  
0.7V~0.9V, Accuracy of  $\pm 10\text{mV}$
- Charger over current detection voltage [ VCH ]  
-0.09V~0.10V, Accuracy of  $\pm 20\text{mV}$
- Delay times are generated by an internal circuit. (External capacitors are unnecessary.)
- Reset resistance for Over current protection  
>150k $\Omega$
- Wide supply voltage range 1.5 ~ 5.5V
- Small package SOT-23-5 , SSOP-6
- 0V-Battery charging function

## 3. Ordering Information



(N6A : 1.8\*2.0mm SSOP-6 Green-Package)

(N6C : 1.6\*1.6mm SSOP-6 Green-Package)

\*: Refer to the product name list on next page.

## 4. Applications

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

**5. Product Name List**

| Model      | Package          | Overcharge detection voltage [VOCU] (V) | Overcharge release voltage [VOCR] (V) | Overdischarge detection voltage [VODL] (V) | Overdischarge release voltage [VODR] (V) | Overcurrent detection voltage [VOI1] (V) | Charger over current detection voltage [VCH] (V) | 0V change function | Standby function release |
|------------|------------------|-----------------------------------------|---------------------------------------|--------------------------------------------|------------------------------------------|------------------------------------------|--------------------------------------------------|--------------------|--------------------------|
| FS325A     | SOT-23-5         | 4.310±25mV                              | 4.110±50mV                            | 2.300±77mV                                 | 2.300±77mV                               | 0.130±10mV                               | -0.090±20mV                                      | YES                | Connection of charger    |
| FS325B     | SOT-23-5         | 4.250±25mV                              | 4.050±50mV                            | 2.400±100mV                                | 2.900±100mV                              | 0.100±10mV                               | -                                                | YES                | AUTO recovery            |
| FS325C     | SOT-23-5         | 4.275±25mV                              | Note: 1                               | 2.300±100mV                                | 2.300±100mV                              | 0.100±10mV                               | -0.100±20mV                                      | YES                | Connection of charger    |
| FS325D     | SOT-23-5         | 4.280±25mV                              | 4.080±50mV                            | 2.300±100mV                                | 2.300±100mV                              | 0.130±10mV                               | -0.100±20mV                                      | 0.65V              | Connection of charger    |
| FS325D-N6A | SSON-6 (1.8×2.0) | 4.280±25mV                              | 4.080±50mV                            | 2.300±100mV                                | 2.300±100mV                              | 0.130±10mV                               | -0.100±20mV                                      | 0.65V              | Connection of charger    |
| FS325D-N6C | SSON-6 (1.6×1.6) | 4.280±25mV                              | 4.080±50mV                            | 2.300±100mV                                | 2.300±100mV                              | 0.130±10mV                               | -0.100±20mV                                      | 0.65V              | Connection of charger    |

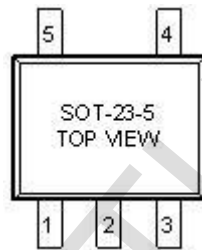
Note: 1. FS325C VOIC release conditions : VDD<VOCU & VCSI>VOI1 (100mV)

2. FS325D series 0V charging prohibit range: 0.4V~1.1V (typ=0.65V)

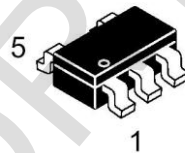
3. FS325D-N6C SSON-6 similar to Seiko SNT-6A Package

## 6. Pin Configuration and Package Marking Information

| Pin No. | Symbol | Description                                   |
|---------|--------|-----------------------------------------------|
| 1       | CSI    | Input pin for current sense, charger detect   |
| 2       | VDD    | Positive power input pin                      |
| 3       | VSS    | Negative power input pin                      |
| 4       | OD     | FET gate connection pin for discharge control |
| 5       | OC     | FET gate connection pin for charge control    |

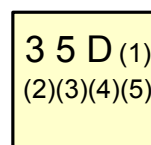
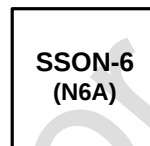


Top Point : Lot No.  
Bottom Point : Year  
w : week, A~Z & A ~ Z

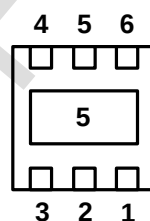


| Pin No. | Symbol | Description                                   |
|---------|--------|-----------------------------------------------|
| 1       | NC     | NC                                            |
| 2       | OC     | FET gate connection pin for charge control    |
| 3       | OD     | FET gate connection pin for discharge control |
| 4       | VSS    | Negative power input pin                      |
| 5       | VDD    | Positive power input pin                      |
| 6       | CSI    | Input pin for current sense, charger detect   |

### Top View



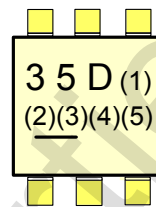
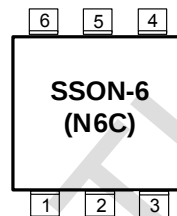
### Bottom View



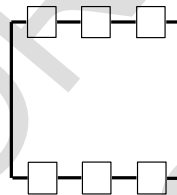
(1) : Year Code, 0~9  
(2)(3) : Week Code, 01~54  
(4)(5) : Serial Code, 01~99

| Pin No. | Symbol | Description                                   |
|---------|--------|-----------------------------------------------|
| 1       | NC     | NC                                            |
| 2       | OC     | FET gate connection pin for charge control    |
| 3       | OD     | FET gate connection pin for discharge control |
| 4       | VSS    | Negative power input pin                      |
| 5       | VDD    | Positive power input pin                      |
| 6       | CSI    | Input pin for current sense, charger detect   |

### Top View

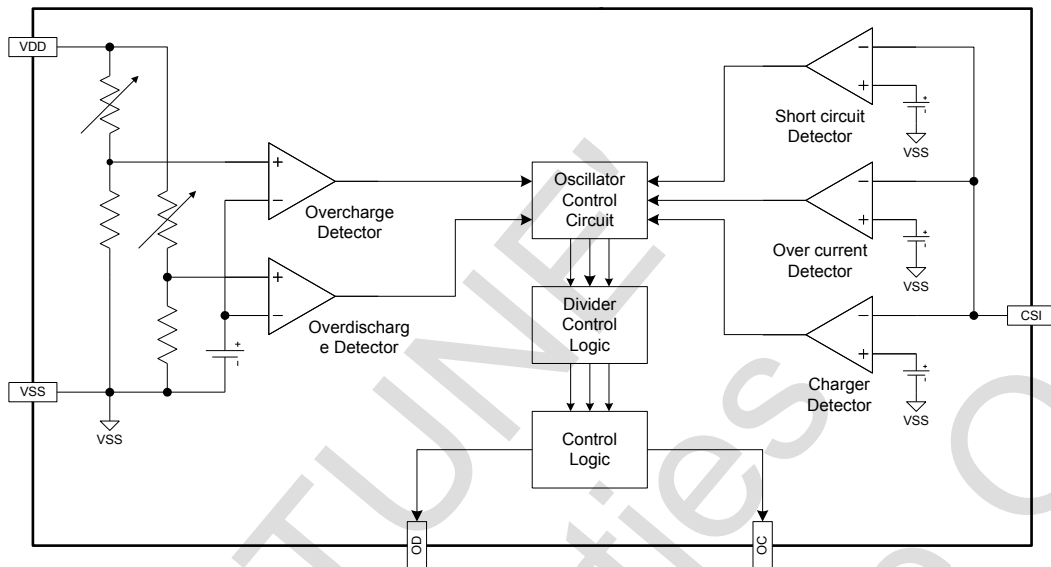


### Bottom View

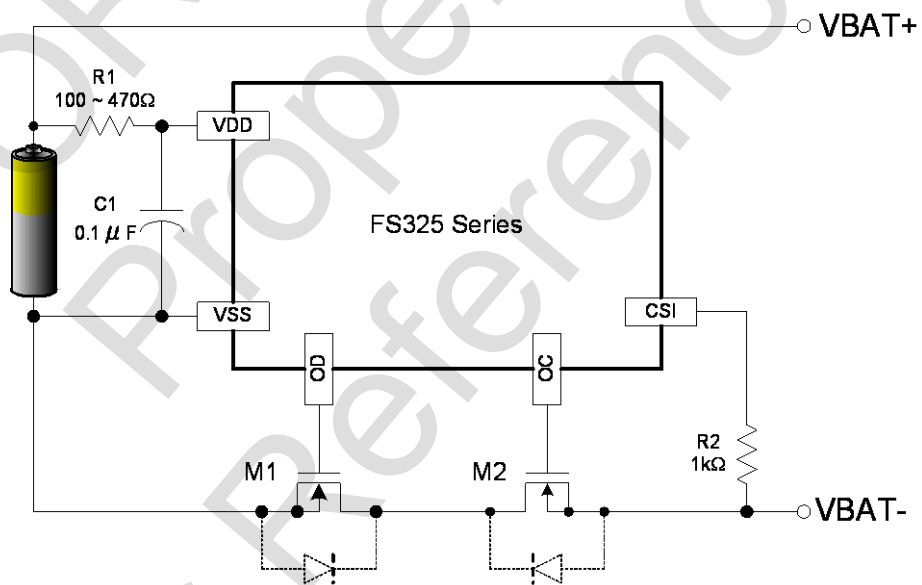


(1) : Year Code, 0~9  
(2)(3) : Week Code, 01~54  
(4)(5) : Serial Code, 01~99  
— : Pin1 mark

## 7. Functional Block Diagram



## 8. Typical Application Circuit



## 9. Absolute Maximum Ratings

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

| Item                                | Symbol | Rating             | Unit |
|-------------------------------------|--------|--------------------|------|
| Input voltage between VDD and VSS * | VDD    | VSS-0.3 to VSS+12  | V    |
| OC output pin voltage               | VOC    | VDD-26 to VDD+0.3  | V    |
| OD output pin voltage               | VOD    | VSS-0.3 to VDD+0.3 | V    |
| CSI input pin voltage               | VCSI   | VDD-26 to VDD+0.3  | V    |
| Operating Temperature Range         | TOP    | -40 to +85         | °C   |
| Storage Temperature Range           | TST    | -40 to +125        | °C   |

Note: FS325 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.

\* Pulse ( $\mu$  sec) noise exceeding the above input voltage (VSS+12V) may cause damage to the IC.

## 10. Electrical Characteristics

FS325A(VSS=0V, Ta=25°C unless otherwise specified)

| PARAMETER                              | CONDITIONS                         | SYMBOL | Min    | Typ    | Max    | UNIT |
|----------------------------------------|------------------------------------|--------|--------|--------|--------|------|
| <b>CURRENT CONSUMPTION</b>             |                                    |        |        |        |        |      |
| Supply Current                         | VDD=3.9V                           | IDD    |        | 2.5    | 5.2    | μA   |
| Power-Down Current                     | VDD=2.0V                           | IPD    |        | 0.05   | 1.0    | μA   |
| <b>OPERATING VOLTAGE</b>               |                                    |        |        |        |        |      |
| Operating input voltage1               | VDD-VSS                            | VDS1   | 1.5    |        | 5.5    | V    |
| Operating input voltage2               | VDD-CSI                            | VDS2   | 1.5    |        |        | V    |
| <b>DETECTION VOLTAGE</b>               |                                    |        |        |        |        |      |
| Overcharge detection voltage           |                                    | VOCU   | 4.285  | 4.310  | 4.335  | V    |
| Overcharge release voltage             |                                    | VOCR   | 4.060  | 4.110  | 4.160  | V    |
| Overdischarge detection voltage        |                                    | VODL   | 2.223  | 2.300  | 2.377  | V    |
| Overdischarge release voltage          |                                    | VODR   | 2.223  | 2.300  | 2.377  | V    |
| Over current detection voltage         |                                    | VOI1   | 0.120  | 0.130  | 0.140  | V    |
| Short circuit detection voltage        | VDD=3.6V                           | VOI2   | 0.80   | 0.90   | 1.00   | V    |
| Charger over current detection voltage | VDD=3.6V                           | VCH    | -0.11  | -0.09  | -0.07  | V    |
| Release pull up resistor               | VDD=2.0V,CS=VDD-1.0V               | Rdown  | 75     | 150    | 300    | kohm |
| Release pull down resistor             | VDD=3.6V,CS=VDD                    | Rshort | 15     | 30     | 150    | kohm |
| Faulty charger detect voltage          |                                    | Vdet   | 5.5    | 8.0    | 10.5   | V    |
| Faulty charger recovery voltage        |                                    | Vrec   | 5.3    | 7.3    | 9.3    | V    |
| 0V charging prohibit                   |                                    | VST    | 0      | 0      | 0      | V    |
| Power-Down detect voltage              |                                    | Vstd   | 0.3VCC | 0.5VCC | 0.7VCC | V    |
| <b>DELAY TIME</b>                      |                                    |        |        |        |        |      |
| Overcharge detection delay time        | VDD=4.0V to 4.4V                   | TOC    | 4      | 6.25   | 8.5    | s    |
| Overdischarge detection delay time     | VDD=3.0V to 2.0V                   | TOD    | 65     | 100    | 135    | ms   |
| Over current detection delay time      | VDD=3.6V                           | TOI1   | 7.365  | 11.0   | 14.25  | ms   |
| Short circuit detection delay time     | VDD=3.6V                           | TOI2   | 0.45   | 0.750  | 1.4    | ms   |
| Charger over current delay time        | VDD=3.6V                           | Tdet   | 16.25  | 32.5   | 48.75  | ms   |
| Overcharge timer reset delay time      |                                    | Td1    | 5.0    | 16     | 50.0   | ms   |
| Charge release delay time              |                                    | Td2    | 5.0    | 16     | 50.0   | ms   |
| Charge connection detection delay      |                                    | Tdr1   | 0.3    | 1      | 3.0    | ms   |
| <b>OTHER</b>                           |                                    |        |        |        |        |      |
| Output high level voltage              | VDD=3.6V, Ioh=-20 μA, CSI=0V OC,OD | VOH    | 3.1    |        |        | V    |
| Output low level voltage               | VDD=3.6V, Ioh=+20 μA, CSI=0V OC,OD | VOL    |        |        | 0.5    | V    |

FS325A(VSS=0V, Ta=-5 to +55 °C unless otherwise specified)

| PARAMETER                              | CONDITIONS                          | SYMBOL | Min    | Typ    | Max    | UNIT |
|----------------------------------------|-------------------------------------|--------|--------|--------|--------|------|
| <b>CURRENT CONSUMPTION</b>             |                                     |        |        |        |        |      |
| Supply Current                         | VDD=3.9V                            | IDD    |        | 2.5    | 5.5    | μ A  |
| Power-Down Current                     | VDD=2.0V                            | IPD    |        | 0.05   | 1.0    | μ A  |
| <b>OPERATING VOLTAGE</b>               |                                     |        |        |        |        |      |
| Operating input voltage1               | VDD-VSS                             | VDS1   | 1.5    |        | 5.5    | V    |
| Operating input voltage2               | VDD-CSI                             | VDS2   | 1.5    |        |        | V    |
| <b>DETECTION VOLTAGE</b>               |                                     |        |        |        |        |      |
| Overcharge detection voltage           |                                     | VOCU   | 4.280  | 4.310  | 4.340  | V    |
| Overcharge release voltage             |                                     | VOCR   | 4.060  | 4.110  | 4.160  | V    |
| Overdischarge detection voltage        |                                     | VODL   | 2.223  | 2.300  | 2.377  | V    |
| Overdischarge release voltage          |                                     | VODR   | 2.223  | 2.300  | 2.377  | V    |
| Over current detection voltage         |                                     | VOI1   | 0.120  | 0.130  | 0.140  | V    |
| Short circuit detection voltage        | VDD=3.6V                            | VOI2   | 0.80   | 0.90   | 1.00   | V    |
| Charger over current detection voltage | VDD=3.6V                            | VCH    | -0.11  | -0.09  | -0.07  | V    |
| Release pull up resistor               | VDD=2.0V,CS=VDD-1.0V                | Rdown  | 75     | 150    | 300    | kohm |
| Release pull down resistor             | VDD=3.6V,CS=VDD                     | Rshort | 15     | 30     | 150    | kohm |
| Faulty charger detect voltage          |                                     | Vdet   | 6.0    | 8.0    | 10.0   | V    |
| Faulty charger recovery voltage        |                                     | Vrec   | 5.8    | 7.3    | 8.8    | V    |
| 0V charging prohibit                   |                                     | VST    | 0      | 0      | 0      | V    |
| Power-Down detect voltage              |                                     | Vstd   | 0.3VCC | 0.5VCC | 0.7VCC | V    |
| <b>DELAY TIME</b>                      |                                     |        |        |        |        |      |
| Overcharge detection delay time        | VDD=4.0V to 4.4V                    | TOC    | 3.125  | 6.25   | 9.375  | s    |
| Overdischarge detection delay time     | VDD=3.0V to 2.0V                    | TOD    | 50     | 100    | 150    | ms   |
| Over current detection delay time      | VDD=3.6V                            | TOI1   | 5.5    | 11.0   | 16.85  | ms   |
| Short circuit detection delay time     | VDD=3.6V                            | TOI2   | 0.37   | 0.75   | 1.48   | ms   |
| Charger over current delay time        | VDD=3.6V                            | Tdet   | 13     | 32.5   | 76.5   | ms   |
| Overcharge timer reset delay time      |                                     | Td1    | 5.0    | 16     | 50.0   | ms   |
| Charge release delay time              |                                     | Td2    | 5.0    | 16     | 50.0   | ms   |
| Charge connection detection delay      |                                     | Tdr1   | 0.3    | 1      | 3.0    | ms   |
| <b>OTHER</b>                           |                                     |        |        |        |        |      |
| Output high level voltage              | VDD=3.6V, Ioh=-20 μ A, CSI=0V OC,OD | VOH    | 3.1    |        |        | V    |
| Output low level voltage               | VDD=3.6V, Ioh=+20 μ A, CSI=0V OC,OD | VOL    |        |        | 0.5    | V    |

FS325A(VSS=0V, Ta=-30 to +70 °C unless otherwise specified)

| PARAMETER                              | CONDITIONS                              | SYMBOL | Min    | Typ    | Max    | UNIT    |
|----------------------------------------|-----------------------------------------|--------|--------|--------|--------|---------|
| <b>CURRENT CONSUMPTION</b>             |                                         |        |        |        |        |         |
| Supply Current                         | VDD=3.9V                                | IDD    |        | 2.5    | 6      | $\mu$ A |
| Power-Down Current                     | VDD=2.0V                                | IPD    |        | 0.05   | 1.0    | $\mu$ A |
| <b>OPERATING VOLTAGE</b>               |                                         |        |        |        |        |         |
| Operating input voltage1               | VDD-VSS                                 | VDS1   | 1.5    |        | 5.5    | V       |
| Operating input voltage2               | VDD-CSI                                 | VDS2   | 1.7    |        |        | V       |
| <b>DETECTION VOLTAGE</b>               |                                         |        |        |        |        |         |
| Overcharge detection voltage           |                                         | VOCU   | 4.245  | 4.310  | 4.345  | V       |
| Overcharge release voltage             |                                         | VOCR   | 4.025  | 4.110  | 4.165  | V       |
| Overdischarge detection voltage        |                                         | VODL   | 2.223  | 2.300  | 2.377  | V       |
| Overdischarge release voltage          |                                         | VODR   | 2.223  | 2.300  | 2.377  | V       |
| Over current detection voltage         |                                         | VOI1   | 0.115  | 0.130  | 0.145  | V       |
| Short circuit detection voltage        | VDD=3.6V                                | VOI2   | 0.80   | 0.90   | 1.00   | V       |
| Charger over current detection voltage | VDD=3.6V                                | VCH    | -0.115 | -0.09  | -0.065 | V       |
| Release pull up resistor               | VDD=2.0V,CS=VDD-1.0V                    | Rdown  | 75     | 150    | 300    | kohm    |
| Release pull down resistor             | VDD=3.6V,CS=VDD                         | Rshort | 15     | 30     | 150    | kohm    |
| Faulty charger detect voltage          |                                         | Vdet   | 5.5    | 8.0    | 10.5   | V       |
| Faulty charger recovery voltage        |                                         | Vrec   | 5.3    | 7.3    | 9.3    | V       |
| 0V charging prohibit                   |                                         | VST    | 0      | 0      | 0      | V       |
| Power-Down detect voltage              |                                         | Vstd   | 0.3VCC | 0.5VCC | 0.7VCC | V       |
| <b>DELAY TIME</b>                      |                                         |        |        |        |        |         |
| Overcharge detection delay time        | VDD=4.0V to 4.4V                        | TOC    | 2.50   | 6.25   | 10.60  | s       |
| Overdischarge detection delay time     | VDD=3.0V to 2.0V                        | TOD    | 40     | 100    | 170    | ms      |
| Over current detection delay time      | VDD=3.6V                                | TOI1   | 5.0    | 11.0   | 20.0   | ms      |
| Short circuit detection delay time     | VDD=3.6V                                | TOI2   | 0.225  | 0.75   | 2.000  | ms      |
| Charger over current delay time        | VDD=3.6V                                | Tdet   | 13.0   | 32.5   | 76.5   | ms      |
| Overcharge timer reset delay time      |                                         | Td1    | 5.0    | 16     | 50.0   | ms      |
| Charge release delay time              |                                         | Td2    | 5.0    | 16     | 50.0   | ms      |
| Charge connection detection delay      |                                         | Tdr1   | 0.3    | 1      | 3.0    | ms      |
| <b>OTHER</b>                           |                                         |        |        |        |        |         |
| Output high level voltage              | VDD=3.6V, Ioh=-20 $\mu$ A, CSI=0V OC,OD | VOH    | 3.1    |        |        | V       |
| Output low level voltage               | VDD=3.6V, Ioh=+20 $\mu$ A, CSI=0V OC,OD | VOL    |        |        | 0.5    | V       |

FS325B(VSS=0V, Ta=25°C unless otherwise specified)

| PARAMETER                              | CONDITIONS                         | SYMBOL | Min   | Typ   | Max   | UNIT |
|----------------------------------------|------------------------------------|--------|-------|-------|-------|------|
| <b>CURRENT CONSUMPTION</b>             |                                    |        |       |       |       |      |
| Supply Current                         | VDD=3.9V                           | IDD    |       | 2.5   | 5.5   | μA   |
| Overdischarge Current                  | VDD=2.0V                           | IOD    |       | 1.8   | 4.5   | μA   |
| <b>OPERATING VOLTAGE</b>               |                                    |        |       |       |       |      |
| Operating input voltage1               | VDD-VSS                            | VDS1   | 1.5   |       | 5.5   | V    |
| Operating input voltage2               | VDD-CSI                            | VDS2   | 1.5   |       |       | V    |
| <b>DETECTION VOLTAGE</b>               |                                    |        |       |       |       |      |
| Overcharge detection voltage           |                                    | VOCU   | 4.225 | 4.250 | 4.275 | V    |
| Overcharge release voltage             |                                    | VOCR   | 4.000 | 4.050 | 4.100 | V    |
| Overdischarge detection voltage        |                                    | VODL   | 2.300 | 2.400 | 2.500 | V    |
| Overdischarge release voltage          |                                    | VODR   | 2.800 | 2.900 | 3.000 | V    |
| Over current detection voltage         |                                    | VOI1   | 0.090 | 0.100 | 0.110 | V    |
| Short circuit detection voltage        | VDD=3.6V                           | VOI2   | 0.80  | 0.90  | 1.00  | V    |
| Charger over current detection voltage | VDD=3.6V                           | VCH    |       | NO    |       | V    |
| Release pull up resistor               | VDD=2.0V,CS=VDD-1.0V               | Rdown  | 75    | 150   | 300   | Kohm |
| Release pull down resistor             | VDD=3.6V,CS=VDD                    | Rshort | 15    | 30    | 150   | Kohm |
| Faulty charger detect voltage          |                                    | Vdet   | 6.0   | 8.0   | 10.0  | V    |
| Faulty charger recovery voltage        |                                    | Vrec   | 5.8   | 7.3   | 10.0  | V    |
| 0V charging prohibit                   |                                    | VST    | 0     | 0     | 0     | V    |
| Power-Down detect voltage              |                                    | Vstd   |       | NO    |       | V    |
| <b>DELAY TIME</b>                      |                                    |        |       |       |       |      |
| Overcharge detection delay time        | VDD=4.0V to 4.4V                   | TOC    | 0.6   | 1.00  | 1.35  | s    |
| Overdischarge detection delay time     | VDD=3.0V to 2.0V                   | TOD    | 65    | 100   | 140   | ms   |
| Over current detection delay time      | VDD=3.6V                           | TOI1   | 8.37  | 12.5  | 17.13 | ms   |
| Short circuit detection delay time     | VDD=3.6V                           | TOI2   | 0.275 | 0.50  | 1.30  | ms   |
| Charger over current delay time        | VDD=3.6V                           | Tdet   |       | NO    |       | ms   |
| Overcharge timer reset delay time      |                                    | Td1    | 1     | 6     | 20    | ms   |
| Charge release delay time              |                                    | Td2    | 1     | 6     | 20    | ms   |
| Charge connection detection delay      |                                    | Tdr1   | --    | --    | --    | ms   |
| <b>OTHER</b>                           |                                    |        |       |       |       |      |
| Output high level voltage              | VDD=3.6V, Ioh=-20 μA, CSI=0V OC,OD | VOH    | 3.1   |       |       | V    |
| Output low level voltage               | VDD=3.6V, Ioh=+20 μA, CSI=0V OC,OD | VOL    |       |       | 0.5   | V    |

FS325B(VSS=0V, Ta=-5 to +55 °C unless otherwise specified)

| PARAMETER                              | CONDITIONS                              | SYMBOL | Min   | Typ   | Max   | UNIT    |
|----------------------------------------|-----------------------------------------|--------|-------|-------|-------|---------|
| <b>CURRENT CONSUMPTION</b>             |                                         |        |       |       |       |         |
| Supply Current                         | VDD=3.9V                                | IDD    |       | 2.5   | 5.5   | $\mu$ A |
| Overdischarge Current                  | VDD=2.0V                                | IOD    |       | 1.8   | 4.5   | $\mu$ A |
| <b>OPERATING VOLTAGE</b>               |                                         |        |       |       |       |         |
| Operating input voltage1               | VDD-VSS                                 | VDS1   | 1.5   |       | 5.5   | V       |
| Operating input voltage2               | VDD-CSI                                 | VDS2   | 1.5   |       |       | V       |
| <b>DETECTION VOLTAGE</b>               |                                         |        |       |       |       |         |
| Overcharge detection voltage           |                                         | VOCU   | 4.220 | 4.250 | 4.280 | V       |
| Overcharge release voltage             |                                         | VOCR   | 4.000 | 4.050 | 4.100 | V       |
| Overdischarge detection voltage        |                                         | VODL   | 2.300 | 2.400 | 2.500 | V       |
| Overdischarge release voltage          |                                         | VODR   | 2.800 | 2.900 | 3.000 | V       |
| Over current detection voltage         |                                         | VOI1   | 0.090 | 0.100 | 0.110 | V       |
| Short circuit detection voltage        | VDD=3.6V                                | VOI2   | 0.80  | 0.90  | 1.00  | V       |
| Charger over current detection voltage | VDD=3.6V                                | VCH    |       | NO    |       | V       |
| Release pull up resistor               | VDD=2.0V,CS=VDD-1.0V                    | Rdown  | 75    | 150   | 300   | Kohm    |
| Release pull down resistor             | VDD=3.6V,CS=VDD                         | Rshort | 15    | 30    | 150   | Kohm    |
| Faulty charger detect voltage          |                                         | Vdet   | 6.0   | 8.0   | 10.0  | V       |
| Faulty charger recovery voltage        |                                         | Vrec   | 5.8   | 7.3   | 10.0  | V       |
| 0V charging prohibit                   |                                         | VST    | 0     | 0     | 0     | V       |
| Power-Down detect voltage              |                                         | Vstd   |       | NO    |       | V       |
| <b>DELAY TIME</b>                      |                                         |        |       |       |       |         |
| Overcharge detection delay time        | VDD=4.0V to 4.4V                        | TOC    | 0.5   | 1.00  | 1.5   | s       |
| Overdischarge detection delay time     | VDD=3.0V to 2.0V                        | TOD    | 50    | 100   | 150   | ms      |
| Over current detection delay time      | VDD=3.6V                                | TOI1   | 6.25  | 12.5  | 19.1  | ms      |
| Short circuit detection delay time     | VDD=3.6V                                | TOI2   | 0.25  | 0.50  | 1.50  | ms      |
| Charger over current delay time        | VDD=3.6V                                | Tdet   |       | NO    |       | ms      |
| Overcharge timer reset delay time      |                                         | Td1    | 1     | 6     | 20    | ms      |
| Charge release delay time              |                                         | Td2    | 1     | 6     | 20    | ms      |
| Charge connection detection delay      |                                         | Tdr1   | --    | --    | --    | ms      |
| <b>OTHER</b>                           |                                         |        |       |       |       |         |
| Output high level voltage              | VDD=3.6V, Ioh=-20 $\mu$ A, CSI=0V OC,OD | VOH    | 3.1   |       |       | V       |
| Output low level voltage               | VDD=3.6V, Ioh=+20 $\mu$ A, CSI=0V OC,OD | VOL    |       |       | 0.5   | V       |

FS325B(VSS=0V, Ta=-30 to +70 °C unless otherwise specified)

| PARAMETER                              | CONDITIONS                              | SYMBOL | Min   | Typ   | Max   | UNIT    |
|----------------------------------------|-----------------------------------------|--------|-------|-------|-------|---------|
| <b>CURRENT CONSUMPTION</b>             |                                         |        |       |       |       |         |
| Supply Current                         | VDD=3.9V                                | IDD    |       | 2.5   | 6     | $\mu$ A |
| Overdischarge Current                  | VDD=2.0V                                | IOD    |       | 1.8   | 5     | $\mu$ A |
| <b>OPERATING VOLTAGE</b>               |                                         |        |       |       |       |         |
| Operating input voltage1               | VDD-VSS                                 | VDS1   | 1.5   |       | 5.5   | V       |
| Operating input voltage2               | VDD-CSI                                 | VDS2   | 1.5   |       |       | V       |
| <b>DETECTION VOLTAGE</b>               |                                         |        |       |       |       |         |
| Overcharge detection voltage           |                                         | VOCU   | 4.185 | 4.250 | 4.285 | V       |
| Overcharge release voltage             |                                         | VOCR   | 3.965 | 4.050 | 4.105 | V       |
| Overdischarge detection voltage        |                                         | VODL   | 2.300 | 2.400 | 2.500 | V       |
| Overdischarge release voltage          |                                         | VODR   | 2.800 | 2.900 | 3.000 | V       |
| Over current detection voltage         |                                         | VOI1   | 0.085 | 0.100 | 0.115 | V       |
| Short circuit detection voltage        | VDD=3.6V                                | VOI2   | 0.80  | 0.90  | 1.00  | V       |
| Charger over current detection voltage | VDD=3.6V                                | VCH    |       | NO    |       | V       |
| Release pull up resistor               | VDD=2.0V,CS=VDD-1.0V                    | Rdown  | 75    | 150   | 300   | Kohm    |
| Release pull down resistor             | VDD=3.6V,CS=VDD                         | Rshort | 15    | 30    | 150   | Kohm    |
| Faulty charger detect voltage          |                                         | Vdet   | 5.5   | 8.0   | 10.5  | V       |
| Faulty charger recovery voltage        |                                         | Vrec   | 5.3   | 7.3   | 9.3   | V       |
| 0V charging prohibit                   |                                         | VST    | 0     | 0     | 0     | V       |
| Power-Down detect voltage              |                                         | Vstd   |       | NO    |       | V       |
| <b>DELAY TIME</b>                      |                                         |        |       |       |       |         |
| Overcharge detection delay time        | VDD=4.0V to 4.4V                        | TOC    | 0.4   | 1.00  | 1.7   | s       |
| Overdischarge detection delay time     | VDD=3.0V to 2.0V                        | TOD    | 40    | 100   | 170   | ms      |
| Over current detection delay time      | VDD=3.6V                                | TOI1   | 5.00  | 12.5  | 21.6  | ms      |
| Short circuit detection delay time     | VDD=3.6V                                | TOI2   | 0.2   | 0.50  | 1.80  | ms      |
| Charger over current delay time        | VDD=3.6V                                | Tdet   |       | NO    |       | ms      |
| Overcharge timer reset delay time      |                                         | Td1    | 1     | 6     | 20    | ms      |
| Charge release delay time              |                                         | Td2    | 1     | 6     | 20    | ms      |
| Charge connection detection delay      |                                         | Tdr1   | --    | --    | --    | ms      |
| <b>OTHER</b>                           |                                         |        |       |       |       |         |
| Output high level voltage              | VDD=3.6V, Ioh=-20 $\mu$ A, CSI=0V OC,OD | VOH    | 3.1   |       |       | V       |
| Output low level voltage               | VDD=3.6V, Ioh=+20 $\mu$ A, CSI=0V OC,OD | VOL    |       |       | 0.5   | V       |

FS325C(VSS=0V, Ta=25 °C unless otherwise specified)

| PARAMETER                              | CONDITIONS                                  | SYMBOL | Min                  | Typ    | Max    | UNIT    |
|----------------------------------------|---------------------------------------------|--------|----------------------|--------|--------|---------|
| <b>CURRENT CONSUMPTION</b>             |                                             |        |                      |        |        |         |
| Supply Current                         | VDD=3.9V                                    | IDD    |                      | 2.5    | 5.5    | $\mu$ A |
| Power-Down Current                     | VDD=2.0V                                    | IPD    |                      | 0.05   | 1.0    | $\mu$ A |
| <b>OPERATING VOLTAGE</b>               |                                             |        |                      |        |        |         |
| Operating input voltage1               | VDD-VSS                                     | VDS1   | 1.5                  |        | 5.5    | V       |
| Operating input voltage2               | VDD-CSI                                     | VDS2   | 1.5                  |        |        | V       |
| <b>DETECTION VOLTAGE</b>               |                                             |        |                      |        |        |         |
| Overcharge detection voltage           |                                             | VOCU   | 4.250                | 4.275  | 4.300  | V       |
| Overcharge release voltage             |                                             | VOCR   | VDD<VOCU & VCSI>VOI1 |        |        | V       |
| Overdischarge detection voltage        |                                             | VODL   | 2.200                | 2.300  | 2.400  | V       |
| Overdischarge release voltage          |                                             | VODR   | 2.200                | 2.300  | 2.400  | V       |
| Over current detection voltage         |                                             | VOI1   | 0.090                | 0.100  | 0.110  | V       |
| Short circuit detection voltage        | VDD=3.6V                                    | VOI2   | 0.80                 | 0.90   | 1.00   | V       |
| Charger over current detection voltage | VDD=3.6V                                    | VCH    | -0.12                | -0.10  | -0.08  | V       |
| Release pull up resistor               | VDD=2.0V,CS=VDD-1.0V                        | Rdown  | 75                   | 150    | 300    | Kohm    |
| Release pull down resistor             | VDD=3.6V,CS=VDD                             | Rshort | 15                   | 30     | 150    | Kohm    |
| Faulty charger detect voltage          |                                             | Vdet   | 6.0                  | 8.0    | 10.0   | V       |
| Faulty charger recovery voltage        |                                             | Vrec   | 5.8                  | 7.3    | 8.8    | V       |
| 0V charging prohibit                   |                                             | VST    | 0                    | 0      | 0      | V       |
| Power-Down detect voltage              |                                             | Vstd   | 0.3VCC               | 0.5VCC | 0.7VCC | V       |
| <b>DELAY TIME</b>                      |                                             |        |                      |        |        |         |
| Overcharge detection delay time        | VDD=4.0V to 4.4V                            | TOC    | 0.6                  | 1      | 1.35   | s       |
| Overdischarge detection delay time     | VDD=3.0V to 2.0V                            | TOD    | 65                   | 100    | 140    | ms      |
| Over current detection delay time      | VDD=3.6V                                    | TOI1   | 10.8                 | 16.5   | 21.6   | ms      |
| Short circuit detection delay time     | VDD=3.6V                                    | TOI2   | 0.3                  | 0.50   | 1.3    | ms      |
| Charger over current delay time        | VDD=3.6V                                    | Tdet   | 12.5                 | 25.0   | 37.5   | ms      |
| Overcharge timer reset delay time      |                                             | Td1    | 5.0                  | 16.0   | 50.0   | ms      |
| Charge release delay time              |                                             | Td2    | 5.0                  | 16.0   | 50.0   | ms      |
| Charge connection detection delay      |                                             | Tdr1   | 3.0                  | 8.0    | 16.0   | ms      |
| <b>OTHER</b>                           |                                             |        |                      |        |        |         |
| Output high level voltage              | VDD=3.6V, Ioh=-20 $\mu$ A<br>, CSI=0V OC,OD | VOH    | 3.1                  |        |        | V       |
| Output low level voltage               | VDD=3.6V, Ioh=+20 $\mu$ A<br>, CSI=0V OC,OD | VOL    |                      |        | 0.5    | V       |

FS325C(VSS=0V, Ta=-5 to +55°C unless otherwise specified)

| PARAMETER                              | CONDITIONS                                  | SYMBOL | Min                  | Typ    | Max    | UNIT    |
|----------------------------------------|---------------------------------------------|--------|----------------------|--------|--------|---------|
| <b>CURRENT CONSUMPTION</b>             |                                             |        |                      |        |        |         |
| Supply Current                         | VDD=3.9V                                    | IDD    |                      | 2.5    | 5.5    | $\mu$ A |
| Power-Down Current                     | VDD=2.0V                                    | IPD    |                      | 0.05   | 1.0    | $\mu$ A |
| <b>OPERATING VOLTAGE</b>               |                                             |        |                      |        |        |         |
| Operating input voltage1               | VDD-VSS                                     | VDS1   | 1.5                  |        | 5.5    | V       |
| Operating input voltage2               | VDD-CSI                                     | VDS2   | 1.5                  |        |        | V       |
| <b>DETECTION VOLTAGE</b>               |                                             |        |                      |        |        |         |
| Overcharge detection voltage           |                                             | VOCU   | 4.245                | 4.275  | 4.305  | V       |
| Overcharge release voltage             |                                             | VOCR   | VDD<VOCU & VCSI>VOI1 |        |        | V       |
| Overdischarge detection voltage        |                                             | VODL   | 2.200                | 2.300  | 2.400  | V       |
| Overdischarge release voltage          |                                             | VODR   | 2.200                | 2.300  | 2.400  | V       |
| Over current detection voltage         |                                             | VOI1   | 0.090                | 0.100  | 0.110  | V       |
| Short circuit detection voltage        | VDD=3.6V                                    | VOI2   | 0.80                 | 0.90   | 1.00   | V       |
| Charger over current detection voltage | VDD=3.6V                                    | VCH    | -0.12                | -0.10  | -0.08  | V       |
| Release pull up resistor               | VDD=2.0V,CS=VDD-1.0V                        | Rdown  | 75                   | 150    | 300    | Kohm    |
| Release pull down resistor             | VDD=3.6V,CS=VDD                             | Rshort | 15                   | 30     | 150    | Kohm    |
| Faulty charger detect voltage          |                                             | Vdet   | 6.0                  | 8.0    | 10.0   | V       |
| Faulty charger recovery voltage        |                                             | Vrec   | 5.8                  | 7.3    | 8.8    | V       |
| 0V charging prohibit                   |                                             | VST    | 0                    | 0      | 0      | V       |
| Power-Down detect voltage              |                                             | Vstd   | 0.3VCC               | 0.5VCC | 0.7VCC | V       |
| <b>DELAY TIME</b>                      |                                             |        |                      |        |        |         |
| Overcharge detection delay time        | VDD=4.0V to 4.4V                            | TOC    | 0.5                  | 1      | 1.5    | s       |
| Overdischarge detection delay time     | VDD=3.0V to 2.0V                            | TOD    | 50                   | 100    | 150    | ms      |
| Over current detection delay time      | VDD=3.6V                                    | TOI1   | 8.0                  | 16.5   | 25.0   | ms      |
| Short circuit detection delay time     | VDD=3.6V                                    | TOI2   | 0.25                 | 0.50   | 1.5    | ms      |
| Charger over current delay time        | VDD=3.6V                                    | Tdet   | 5.0                  | 25.0   | 37.5   | ms      |
| Overcharge timer reset delay time      |                                             | Td1    | 5.0                  | 16.0   | 50.0   | ms      |
| Charge release delay time              |                                             | Td2    | 5.0                  | 16.0   | 50.0   | ms      |
| Charge connection detection delay      |                                             | Tdr1   | 3.0                  | 8.0    | 16.0   | ms      |
| <b>OTHER</b>                           |                                             |        |                      |        |        |         |
| Output high level voltage              | VDD=3.6V, Ioh=-20 $\mu$ A<br>, CSI=0V OC,OD | VOH    | 3.1                  |        |        | V       |
| Output low level voltage               | VDD=3.6V, Ioh=+20 $\mu$ A<br>, CSI=0V OC,OD | VOL    |                      |        | 0.5    | V       |

FS325C(VSS=0V, Ta=-30 to 70 °C unless otherwise specified)

| PARAMETER                              | CONDITIONS                              | SYMBOL | Min                  | Typ    | Max    | UNIT |
|----------------------------------------|-----------------------------------------|--------|----------------------|--------|--------|------|
| <b>CURRENT CONSUMPTION</b>             |                                         |        |                      |        |        |      |
| Supply Current                         | VDD=3.9V                                | IDD    |                      | 2.5    | 6      | μ A  |
| Power-Down Current                     | VDD=2.0V                                | IPD    |                      | 0.05   | 1.0    | μ A  |
| <b>OPERATING VOLTAGE</b>               |                                         |        |                      |        |        |      |
| Operating input voltage1               | VDD-VSS                                 | VDS1   | 1.5                  |        | 5.5    | V    |
| Operating input voltage2               | VDD-CSI                                 | VDS2   | 1.5                  |        |        | V    |
| <b>DETECTION VOLTAGE</b>               |                                         |        |                      |        |        |      |
| Overcharge detection voltage           |                                         | VOCU   | 4.240                | 4.275  | 4.320  | V    |
| Overcharge release voltage             |                                         | VOCR   | VDD<VOCU & VCSI>VOI1 |        |        | V    |
| Overdischarge detection voltage        |                                         | VODL   | 2.200                | 2.300  | 2.400  | V    |
| Overdischarge release voltage          |                                         | VODR   | 2.200                | 2.300  | 2.400  | V    |
| Over current detection voltage         |                                         | VOI1   | 0.085                | 0.100  | 0.125  | V    |
| Short circuit detection voltage        | VDD=3.6V                                | VOI2   | 0.80                 | 0.90   | 1.00   | V    |
| Charger over current detection voltage | VDD=3.6V                                | VCH    | -0.125               | -0.10  | -0.075 | V    |
| Release pull up resistor               | VDD=2.0V,CS=VDD-1.0V                    | Rdown  | 75                   | 150    | 300    | Kohm |
| Release pull down resistor             | VDD=3.6V,CS=VDD                         | Rshort | 15                   | 30     | 150    | Kohm |
| Faulty charger detect voltage          |                                         | Vdet   | 5.5                  | 8.0    | 10.5   | V    |
| Faulty charger recovery voltage        |                                         | Vrec   | 5.3                  | 7.3    | 9.3    | V    |
| 0V charging prohibit                   |                                         | VST    | 0                    | 0      | 0      | V    |
| Power-Down detect voltage              |                                         | Vstd   | 0.3VCC               | 0.5VCC | 0.7VCC | V    |
| <b>DELAY TIME</b>                      |                                         |        |                      |        |        |      |
| Overcharge detection delay time        | VDD=4.0V to 4.4V                        | TOC    | 0.4                  | 1      | 1.7    | s    |
| Overdischarge detection delay time     | VDD=3.0V to 2.0V                        | TOD    | 40                   | 100    | 170    | ms   |
| Over current detection delay time      | VDD=3.6V                                | TOI1   | 2.5                  | 14.5   | 28.9   | ms   |
| Short circuit detection delay time     | VDD=3.6V                                | TOI2   | 0.25                 | 0.50   | 1.75   | ms   |
| Charger over current delay time        | VDD=3.6V                                | Tdet   | 5.5                  | 25.0   | 69.0   | ms   |
| Overcharge timer reset delay time      |                                         | Td1    | 5.0                  | 16.0   | 50.0   | ms   |
| Charge release delay time              |                                         | Td2    | 5.0                  | 16.0   | 50.0   | ms   |
| Charge connection detection delay      |                                         | Tdr1   | 3.0                  | 8.0    | 16.0   | ms   |
| <b>OTHER</b>                           |                                         |        |                      |        |        |      |
| Output high level voltage              | VDD=3.6V, Ioh=-20 μ A<br>, CSI=0V OC,OD | VOH    | 3.1                  |        |        | V    |
| Output low level voltage               | VDD=3.6V, Ioh=+20 μ A<br>, CSI=0V OC,OD | VOL    |                      |        | 0.5    | V    |

FS325D、FS325D-N6A、FS325D-N6C  
(VSS=0V, Ta=25°C unless otherwise specified)

| PARAMETER                              | CONDITIONS                                  | SYMBOL | Min    | Typ    | Max    | UNIT    |
|----------------------------------------|---------------------------------------------|--------|--------|--------|--------|---------|
| <b>CURRENT CONSUMPTION</b>             |                                             |        |        |        |        |         |
| Supply Current                         | VDD=3.9V                                    | IDD    |        | 2.5    | 5.5    | $\mu$ A |
| Power-Down Current                     | VDD=2.0V                                    | IPD    |        | 0.05   | 1.0    | $\mu$ A |
| <b>OPERATING VOLTAGE</b>               |                                             |        |        |        |        |         |
| Operating input voltage1               | VDD-VSS                                     | VDS1   | 1.5    |        | 5.5    | V       |
| Operating input voltage2               | VDD-CSI                                     | VDS2   | 1.5    |        |        | V       |
| <b>DETECTION VOLTAGE</b>               |                                             |        |        |        |        |         |
| Overcharge detection voltage           |                                             | VOCU   | 4.255  | 4.280  | 4.305  | V       |
| Overcharge release voltage             |                                             | VOCR   | 4.030  | 4.080  | 4.130  | V       |
| Overdischarge detection voltage        |                                             | VODL   | 2.200  | 2.300  | 2.400  | V       |
| Overdischarge release voltage          |                                             | VODR   | 2.200  | 2.300  | 2.400  | V       |
| Over current detection voltage         |                                             | VOI1   | 0.120  | 0.130  | 0.140  | V       |
| Short circuit detection voltage        | VDD=3.6V                                    | VOI2   | 0.60   | 0.70   | 0.80   | V       |
| Charger over current detection voltage | VDD=3.6V                                    | VCH    | -0.120 | -0.100 | -0.080 | V       |
| Release pull up resistor               | VDD=2.0V,CS=VDD-1.0V                        | Rdown  | 75     | 150    | 300    | Kohm    |
| Release pull down resistor             | VDD=3.6V,CS=VDD                             | Rshort | 15     | 30     | 150    | Kohm    |
| Faulty charger detect voltage          |                                             | Vdet   | 6.0    | 8.0    | 10.0   | V       |
| Faulty charger recovery voltage        |                                             | Vrec   | 5.8    | 7.3    | 8.8    | V       |
| 0V charging prohibit                   |                                             | VST    | 0.40   | 0.65   | 1.10   | V       |
| Power-Down detect voltage              |                                             | Vstd   | 0.3VCC | 0.5VCC | 0.7VCC | V       |
| <b>DELAY TIME</b>                      |                                             |        |        |        |        |         |
| Overcharge detection delay time        | VDD=4.0V to 4.4V                            | TOC    | 0.6    | 1      | 1.35   | s       |
| Overdischarge detection delay time     | VDD=3.0V to 2.0V                            | TOD    | 65     | 100    | 140    | ms      |
| Over current detection delay time      | VDD=3.6V                                    | TOI1   | 13.3   | 20.0   | 26.5   | ms      |
| Short circuit detection delay time     | VDD=3.6V                                    | TOI2   | 0.60   | 1.0    | 1.80   | ms      |
| Charger over current delay time        | VDD=3.6V                                    | Tdet   | -      | -      | -      | ms      |
| Overcharge timer reset delay time      |                                             | Td1    | 5.0    | 16.0   | 50.0   | ms      |
| Charge release delay time              |                                             | Td2    | 5.0    | 16.0   | 50.0   | ms      |
| Charge connection detection delay      |                                             | Tdr1   | 0.5    | 1.0    | 2.0    | ms      |
| <b>OTHER</b>                           |                                             |        |        |        |        |         |
| Output high level voltage              | VDD=3.6V, Ioh=-20 $\mu$ A<br>, CSI=0V OC,OD | VOH    | 3.1    |        |        | V       |
| Output low level voltage               | VDD=3.6V, Ioh=+20 $\mu$ A<br>, CSI=0V OC,OD | VOL    |        |        | 0.5    | V       |

FS325D、FS325D-N6A、FS325D-N6C

(VSS=0V, Ta=-5 to +55°C unless otherwise specified)

| PARAMETER                              | CONDITIONS                             | SYMBOL | Min    | Typ    | Max    | UNIT |
|----------------------------------------|----------------------------------------|--------|--------|--------|--------|------|
| <b>CURRENT CONSUMPTION</b>             |                                        |        |        |        |        |      |
| Supply Current                         | VDD=3.9V                               | IDD    |        | 2.5    | 5.5    | μA   |
| Power-Down Current                     | VDD=2.0V                               | IPD    |        | 0.05   | 1.0    | μA   |
| <b>OPERATING VOLTAGE</b>               |                                        |        |        |        |        |      |
| Operating input voltage1               | VDD-VSS                                | VDS1   | 1.5    |        | 5.5    | V    |
| Operating input voltage2               | VDD-CSI                                | VDS2   | 1.5    |        |        | V    |
| <b>DETECTION VOLTAGE</b>               |                                        |        |        |        |        |      |
| Overcharge detection voltage           |                                        | VOCU   | 4.250  | 4.280  | 4.310  | V    |
| Overcharge release voltage             |                                        | VOCR   | 4.030  | 4.080  | 4.130  | V    |
| Overdischarge detection voltage        |                                        | VODL   | 2.200  | 2.300  | 2.400  | V    |
| Overdischarge release voltage          |                                        | VODR   | 2.200  | 2.300  | 2.400  | V    |
| Over current detection voltage         |                                        | VOI1   | 0.120  | 0.130  | 0.140  | V    |
| Short circuit detection voltage        | VDD=3.6V                               | VOI2   | 0.60   | 0.70   | 0.80   | V    |
| Charger over current detection voltage | VDD=3.6V                               | VCH    | -0.120 | -0.100 | -0.080 | V    |
| Release pull up resistor               | VDD=2.0V,CS=VDD-1.0V                   | Rdown  | 75     | 150    | 300    | Kohm |
| Release pull down resistor             | VDD=3.6V,CS=VDD                        | Rshort | 15     | 30     | 150    | Kohm |
| Faulty charger detect voltage          |                                        | Vdet   | 6.0    | 8.0    | 10.0   | V    |
| Faulty charger recovery voltage        |                                        | Vrec   | 5.8    | 7.3    | 8.8    | V    |
| 0V charging prohibit                   |                                        | VST    | 0.40   | 0.65   | 1.10   | V    |
| Power-Down detect voltage              |                                        | Vstd   | 0.3VCC | 0.5VCC | 0.7VCC | V    |
| <b>DELAY TIME</b>                      |                                        |        |        |        |        |      |
| Overcharge detection delay time        | VDD=4.0V to 4.4V                       | TOC    | 0.5    | 1      | 1.5    | s    |
| Overdischarge detection delay time     | VDD=3.0V to 2.0V                       | TOD    | 50     | 100    | 150    | ms   |
| Over current detection delay time      | VDD=3.6V                               | TOI1   | 10.0   | 20.0   | 30.0   | ms   |
| Short circuit detection delay time     | VDD=3.6V                               | TOI2   | 0.55   | 1.0    | 1.85   | ms   |
| Charger over current delay time        | VDD=3.6V                               | Tdet   | -      | -      | -      | ms   |
| Overcharge timer reset delay time      |                                        | Td1    | 5.0    | 16.0   | 50.0   | ms   |
| Charge release delay time              |                                        | Td2    | 5.0    | 16.0   | 50.0   | ms   |
| Charge connection detection delay      |                                        | Tdr1   | 0.5    | 1.0    | 2.0    | ms   |
| <b>OTHER</b>                           |                                        |        |        |        |        |      |
| Output high level voltage              | VDD=3.6V, Ioh=-20 μA<br>, CSI=0V OC,OD | VOH    | 3.1    |        |        | V    |
| Output low level voltage               | VDD=3.6V, Ioh=+20 μA<br>, CSI=0V OC,OD | VOL    |        |        | 0.5    | V    |

FS325D、FS325D-N6A、FS325D-N6C

(VSS=0V, Ta=-30 to +70°C unless otherwise specified)

| PARAMETER                              | CONDITIONS                             | SYMBOL | Min    | Typ    | Max    | UNIT |
|----------------------------------------|----------------------------------------|--------|--------|--------|--------|------|
| <b>CURRENT CONSUMPTION</b>             |                                        |        |        |        |        |      |
| Supply Current                         | VDD=3.9V                               | IDD    |        | 2.5    | 6      | μA   |
| Power-Down Current                     | VDD=2.0V                               | IPD    |        | 0.05   | 1.0    | μA   |
| <b>OPERATING VOLTAGE</b>               |                                        |        |        |        |        |      |
| Operating input voltage1               | VDD-VSS                                | VDS1   | 1.5    |        | 5.5    | V    |
| Operating input voltage2               | VDD-CSI                                | VDS2   | 1.5    |        |        | V    |
| <b>DETECTION VOLTAGE</b>               |                                        |        |        |        |        |      |
| Overcharge detection voltage           |                                        | VOCU   | 4.215  | 4.280  | 4.315  | V    |
| Overcharge release voltage             |                                        | VOCR   | 3.995  | 4.080  | 4.135  | V    |
| Overdischarge detection voltage        |                                        | VODL   | 2.200  | 2.300  | 2.400  | V    |
| Overdischarge release voltage          |                                        | VODR   | 2.200  | 2.300  | 2.400  | V    |
| Over current detection voltage         |                                        | VOI1   | 0.115  | 0.130  | 0.145  | V    |
| Short circuit detection voltage        | VDD=3.6V                               | VOI2   | 0.60   | 0.70   | 0.80   | V    |
| Charger over current detection voltage | VDD=3.6V                               | VCH    | -0.125 | -0.100 | -0.075 | V    |
| Release pull up resistor               | VDD=2.0V,CS=VDD-1.0V                   | Rdown  | 75     | 150    | 300    | Kohm |
| Release pull down resistor             | VDD=3.6V,CS=VDD                        | Rshort | 15     | 30     | 150    | Kohm |
| Faulty charger detect voltage          |                                        | Vdet   | 5.5    | 8.0    | 10.5   | V    |
| Faulty charger recovery voltage        |                                        | Vrec   | 5.3    | 7.3    | 9.3    | V    |
| 0V charging prohibit                   |                                        | VST    | 0.40   | 0.65   | 1.10   | V    |
| Power-Down detect voltage              |                                        | Vstd   | 0.3VCC | 0.5VCC | 0.7VCC | V    |
| <b>DELAY TIME</b>                      |                                        |        |        |        |        |      |
| Overcharge detection delay time        | VDD=4.0V to 4.4V                       | TOC    | 0.4    | 1      | 1.7    | s    |
| Overdischarge detection delay time     | VDD=3.0V to 2.0V                       | TOD    | 40     | 100    | 170    | ms   |
| Over current detection delay time      | VDD=3.6V                               | TOI1   | 8.0    | 20.0   | 34.4   | ms   |
| Short circuit detection delay time     | VDD=3.6V                               | TOI2   | 0.40   | 1.0    | 2.50   | ms   |
| Charger over current delay time        | VDD=3.6V                               | Tdet   | -      | -      | -      | ms   |
| Overcharge timer reset delay time      |                                        | Td1    | 5.0    | 16.0   | 50.0   | ms   |
| Charge release delay time              |                                        | Td2    | 5.0    | 16.0   | 50.0   | ms   |
| Charge connection detection delay      |                                        | Tdr1   | 0.5    | 1.0    | 2.0    | ms   |
| <b>OTHER</b>                           |                                        |        |        |        |        |      |
| Output high level voltage              | VDD=3.6V, Ioh=-20 μA<br>, CSI=0V OC,OD | VOH    | 3.1    |        |        | V    |
| Output low level voltage               | VDD=3.6V, Ioh=+20 μA<br>, CSI=0V OC,OD | VOL    |        |        | 0.5    | V    |

## 11. Description of Operation

### Normal Condition

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

### 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.

### 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 100ms. Inhibition of discharging is immediately released when the voltage of the battery cell becomes higher than overdischarge release voltage (VODR) through charging.

### Overcurrent Protection

In normal mode, the FS325 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 150kΩ. The FS325 provides two overcurrent detection levels (0.13V and

0.9V) with two overcurrent delay time (TOI1 and TOI2) corresponding to each overcurrent detection level.

### 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 FS325 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 (VST).

### Power Down after Overdischarge

When overdischarge occurs, the FS325 will enter into power-down mode, turning off all the timing generation and detection circuitry to reduce the quiescent current to 0.05μA ( $VCC=2.0V$ ). At the same time, the CS pin is pull-up to VCC through an internal resistor.

### Auto Power Down recovery

The IC continues to operate even after the overdischarge state has been entered. The battery voltage rising to the overdischarge release voltage (VODR) or higher is the only required condition for the IC to return to the normal state.

### Supervising charger voltage

By supervising the charge voltage, charging can be prohibited instantly when a charger with overvoltage is connected. The charger voltage detection circuit supervises the voltage between the VDD and CSI pins. When this voltage exceeds  $V_{det}$  ( $V_{det} < (VDD - V_{CSI})$ ), regardless of the battery voltage, the charge FET control pin output low level (CSI level) signal and the charge FET is turned off. When the charger voltage drops to  $V_{rec}$  or lower, the charger FET control output level is dependent on battery voltage.

**Note: When a battery is connected to FS325 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

### 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.

### Suppressing the Ripple and Disturbance from Charger

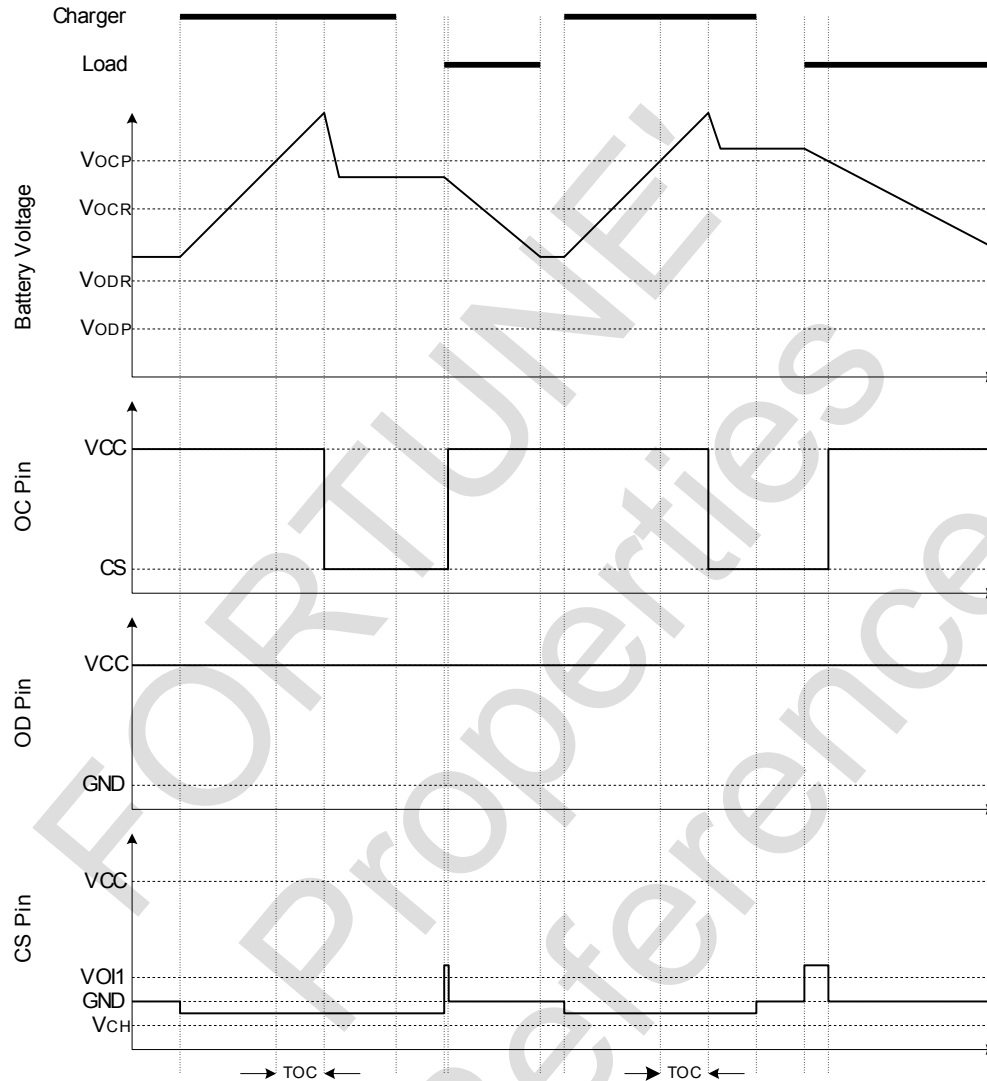
To suppress the ripple and disturbance from charger, connecting R1 and C1 to VCC is recommended.

### Protection the CS pin

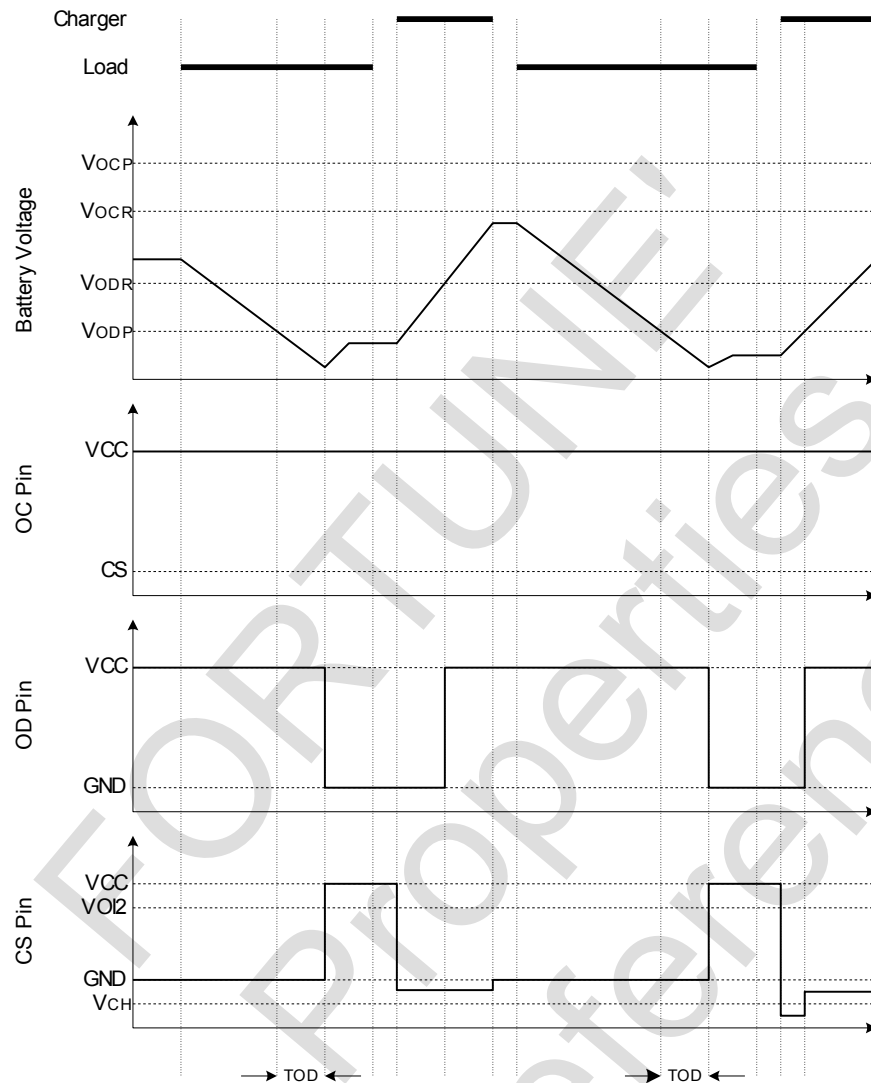
R2 is used for latch-up protection when charger is connected under overdischarge condition and overstress protection at reverse connecting of a charger.

### 13. Timing Diagram

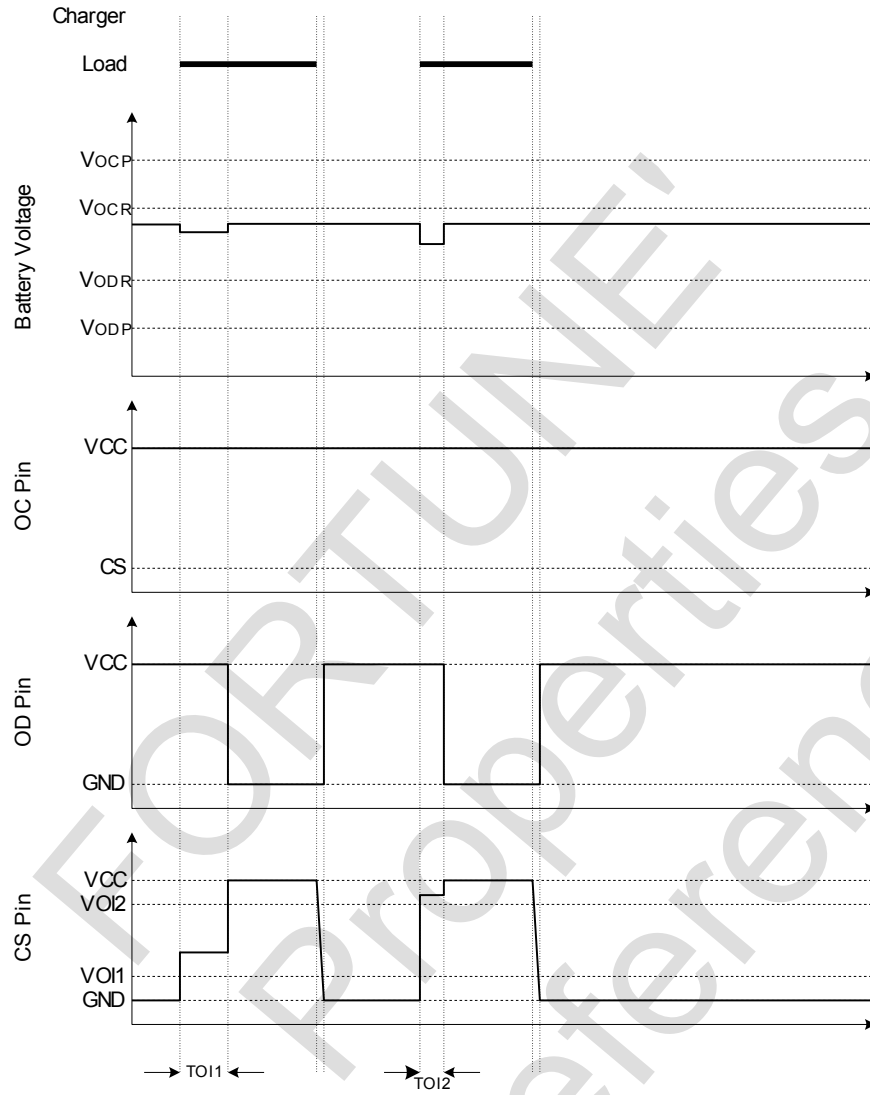
Overcharge Condition → Load Discharging → Normal Condition



Overdischarge Condition → Charging by a Charger → Normal Condition

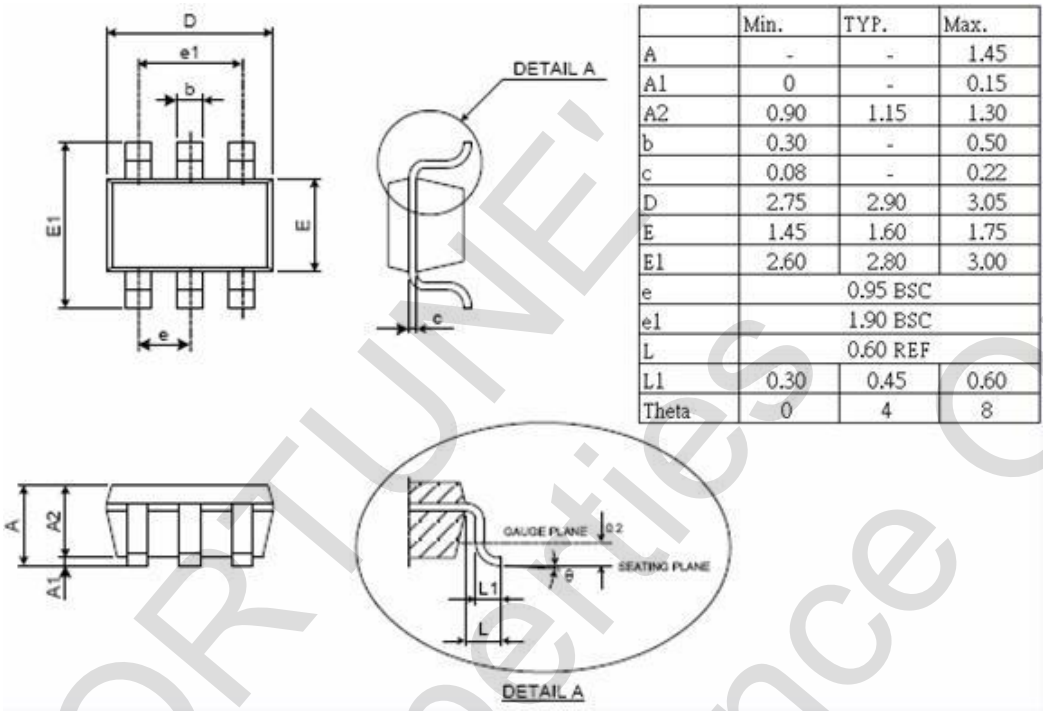


Over Current Condition → Normal Condition

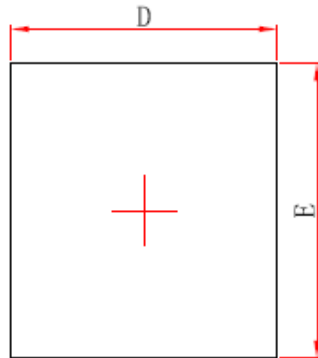


14. Package Outline

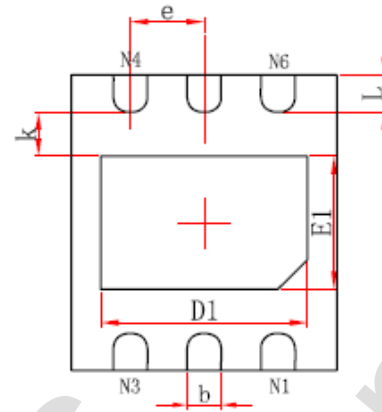
Dimension (SOT-23-5)



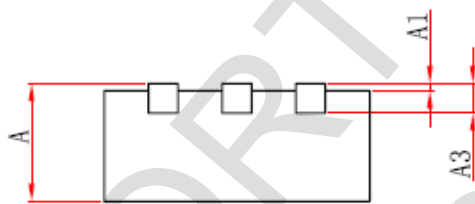
Dimension (SSON-6\_N6A)



Top View



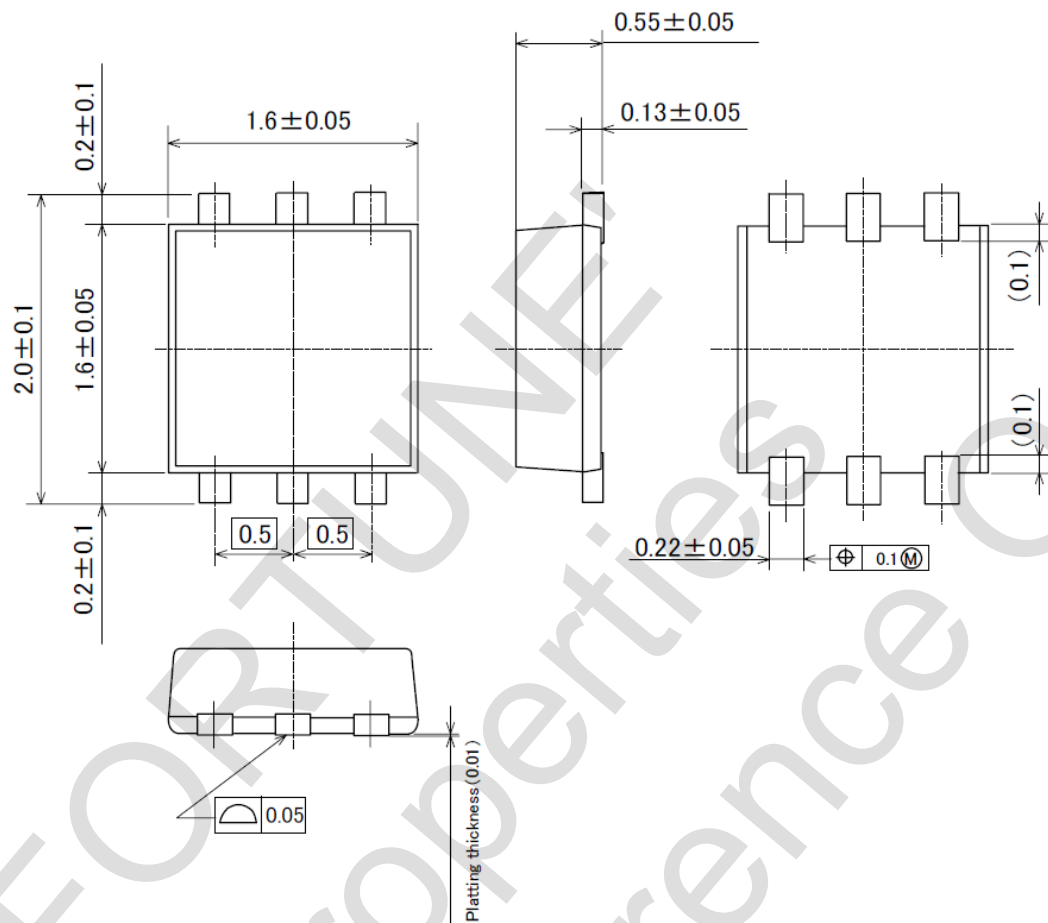
Bottom View



Side View

| Symbol | Dimensions In Millimeters |             | Dimensions In Inches |             |
|--------|---------------------------|-------------|----------------------|-------------|
|        | Min.                      | Max.        | Min.                 | Max.        |
| A      | 0.450/0.550               | 0.550/0.650 | 0.018/0.022          | 0.022/0.026 |
| A1     | 0.000                     | 0.050       | 0.000                | 0.002       |
| A3     | 0.150REF.                 |             | 0.006REF.            |             |
| D      | 1.724                     | 1.876       | 0.068                | 0.074       |
| E      | 1.924                     | 2.076       | 0.076                | 0.082       |
| D1     | 1.300                     | 1.500       | 0.051                | 0.059       |
| E1     | 0.800                     | 1.000       | 0.031                | 0.039       |
| k      | 0.200MIN.                 |             | 0.008MIN.            |             |
| b      | 0.180                     | 0.280       | 0.007                | 0.011       |
| e      | 0.500TYP.                 |             | 0.020TYP.            |             |
| L      | 0.174                     | 0.326       | 0.007                | 0.013       |

## Dimension (SSON-6\_N6C)



## 15. Revision History

| Version | Date       | Page           | Description                                                  |
|---------|------------|----------------|--------------------------------------------------------------|
| 1.0     | 2010/06/02 | ALL            | New release                                                  |
| 1.1     | 2011/07/08 | 4              | Revise Product name list package SOT-23-5                    |
| 1.2     | 2011/09/08 | 24             | Revise Package Outline                                       |
| 1.3     | 2012/04/17 | 4,13,14,15     | FS325C(VOCR) · FS325D(0V charging prohibit) function explain |
| 1.4     | 2012/10/08 | 16,17,18       | Revise FS325D VCH · Tdet Specified                           |
| 1.5     | 2012/10/16 | 3,4,5,17,18,19 | Add SSON-6 Package Information                               |
|         |            | 26             | Add SSON-6 Package Information                               |
| 1.6     | 2013/11/26 | 3,4,6,18,19,20 | Add FS325D-N6C SSON-6 Package Information                    |
|         |            | 28             | Add FS325D-N6C SSON-6 Package Information                    |
|         |            | 4,5,27         | Revise FS325D-N6A SSON-6 Package Information                 |
| 1.7     | 2013/12/25 | 4              | Revise VOI1 Specified Unit                                   |
|         |            | 28             | Revise SSON-6_N6C Package Outline                            |
| 1.8     | 2014/05/22 | 2              | Revised company address                                      |
| 1.9     | 2015/06/08 | 3,4,18,19,20   | Add Charger Over Current Detection Voltage Specified         |