EM6180 Li-Ion Battery Protection Circuit

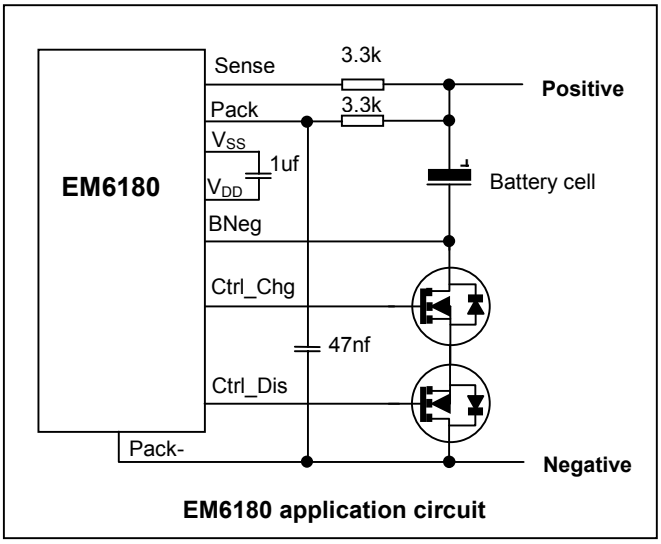
Features

- Low current consumption
- High accuracy voltage and current trigger levels through laser trimming
- External power-mos devices driven with an elevated supply voltage to reduce their on-resistance (internal charge pump)
- Precise reaction delays through laser trimming of on-chip oscillator frequency
- 2.5 to 4.0 A overcurrent trigger level with typical power-mos, 10ms reaction delay
- Short-circuit detection (~20A) with short reaction delay (<1.5ms), decreasing with decreasing current level
- Negative temperature coefficient of overcurrent trigger level for increased safety
- Minimum power-mos turn-on and turn-off times limited to reduce external disturbances and inductive voltage spikes at switch-off
- Good immunity against GSM current pulses due to special filtering
- Low external parts count
- Small package SO8

Typical Applications

- Mobile Phones (GSM,DECT)
- Li-Ion Battery Packs
- Portable medical equipment
- PDAs

Typical Operating Configuration



EM6180 application circuit

Fig. 1

Pin Assignment

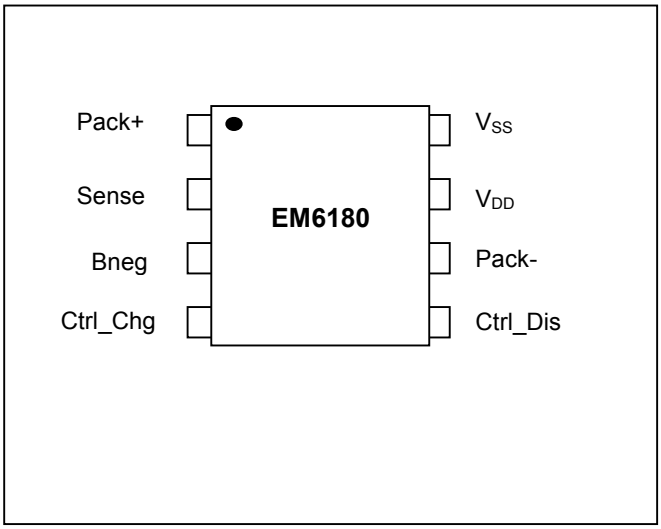


Fig. 2

Description

The function of the EM6180 is to protect a single Li-Ion cell against overcharge and overdischarge for reasons of safety and cell lifetime. The EM6180 constantly monitors the battery voltage and provides signals to control two external power-mos devices as seen in the circuit of Fig.1 . The two power-mos devices allow blocking the current during both charge and discharge. The current flowing through the power-mos is measured to detect overcurrent conditions. This current measurement is made without a supplementary series measurement resistor, reducing the internal resistance of a battery pack and also the resulting power losses. The overcurrent trigger level is temperature-dependant to avoid thermal avalanche. The trigger delay is 10ms to prevent false triggering at turn-on or due to a GSM pulse. At very high currents (>20A) the EM6180 reacts more rapidly with decreasing delay times (<1.5ms) with increasing current level. After detecting an overcurrent or short-circuit condition the EM6180 tests to see if the overcurrent condition has been corrected before completely switching off. During discharge the test is performed 64 times, once every 2 seconds. If at the end of this time the overcurrent is still present, the circuit switches off and is only reactivated by the detection of charge current. During charge the test is performed every 4 seconds until the over-voltage level is reached.

Absolute maximum ratings

Parameter	Symbol	Conditions
Supply voltage (Pack)	V_{PACK+}	-1.3 to +9.0V
Clamped supply voltage	V_{dd}	6.9V
Voltage at inputs pins	V_{in}	-0.3 to Vdd+0.3V
Voltage at remaining pins	V_{pin}	-0.3 to Vdd+0.3V
Storage temperature	T_{store}	-65 to +150 °C

Stresses above these listed maximum ratings may cause permanent damage to the device. Exposure beyond specified electrical characteristics may affect device reliability or cause malfunction

Handling Procedures

This device has built-in protection against high static voltages or electric fields; however, anti-static precautions should be taken as for any other CMOS component. Unless otherwise specified, proper operation can only occur when all terminal voltages are kept within the supply voltage range.

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Operating temperature	T_A	-20		80	°C
Supply Voltage	V_{PACK+}	1.3	3.6	8.5	V

An appropriate layout of the module must be done to keep the device within operating temperature limit.

Electrical Characteristics

V_{PACK+} = 3.6V, T_A = 25 °C, unless otherwise specified

Suppy voltage and Current Consumption

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply voltage range	V_{PACK+}	via 3.3kOhm	1.3		8.5	V
V_{DD} voltage range	V_{DD}	V_{PACK+}=8.5V via 3.3kOhm	1.3		V_{clmp}	V
V_{DD} clamp voltage	V_{clmp}		6.0	6.45	6.9	V
Current consumption	I_{dd} I_{dd}	User: 4.0V Mos ON User: 2.2V Mos OFF		10 3.7	12 5	µA µA

NOTE1 :if VDD falls below VDD min , the P6180 is forced in reset mode.

Oscillator Frequency

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Oscillator Frequency	F_{osc}		52	64	76	kHz

State Transitions Levels

Parameter	Symbol	Conditions	Min.	Typ	Max.	Unit
Product EM6180-01						
Overvoltage high	V_{ovh}	V_{PACK+} to V_{BNEG}	4.200	4.250	4.300	V
Temp. drift of Vovh [1]	TC V_{ovh}	V_{PACK+} to V_{BNEG}		0.9		mV/°C
Overvoltage low [2]	V_{ovl}	V_{PACK+} to V_{PACK-}; V_{PACK+}= 4V	3.800	3.900	4.000	V
Undervoltage high	V_{uvh}	V_{PACK+} to V_{PACK-}	3.400	3.500	3.600	V
Undervoltage low	V_{uvl}	V_{PACK+} to V_{BNEG}	2.300	2.375	2.450	V
Product EM6180-02						
Overvoltage high	V_{ovh}	V_{PACK+} to V_{BNEG}	4.300	4.350	4.400	V
Temp. drift of Vovh [1]	TC V_{ovh}	V_{PACK+} to V_{BNEG}		0.9		mV/°C
Overvoltage low [2]	V_{ovl}	V_{PACK+} to V_{PACK-}; V_{PACK+}= 4V	3.889	3.992	4.094	V
Undervoltage high	V_{uvh}	V_{PACK+} to V_{PACK-}	3.480	3.582	3.685	V
Undervoltage low	V_{uvl}	V_{PACK+} to V_{BNEG}	2.354	2.431	2.508	V

Note1: Worst case T.C., accordingly lower T.C.'s for the other levels
Note2: See OVL vs V_{PACK+}, tested at 4.0V, page 3

Vdd backup duration

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Backup Time of Chip Supply after short-circuit (Pack+ to Pack-)	T_{back}	C_{backup} = 1µF,Jump V_{PACK+} = 2.5V to 1V V_{dd} stays > 1.5V	100	200		ms

Reaction times

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Overvoltage dead time	t_{oh}		26	32	38	ms
Undervoltage dead time	t_{uv}		26	32	38	ms
Overcurrent dead time	t_{oc}		6	12	14	ms
Short-circuit dead time	t_{sh}	decreases with increasing Vdet		1.5	2	ms

POWER MOS Transistors Parameters

2 PowerMOS with a typical ON-resistance of typically 25mohms (@ 2A) each are mounted externally. See LION module device specification. The POWER MOS Transistors to implement onto the module are to be selected according the RDSON required and the SIZE available on the module.

Overcurrent protection limit

The overcurrent protection of the module triggers, when the drain-to-source voltage of the external Power-MOS, if in the ON-state, exceeds V_{det}.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Overcurrent trigger voltage 1)	V_{det}	I_{limit} duration ≥ 8 to 12 ms	140	170	200	mV
Short-circuit trigger voltage	V_{detsc}	trigger delay 1.5ms or less		1.0		V

Note1 : will lead to Imax = Vdet / rdson(PowerMOS). Refer also to LION module device specification.
Note : with a typical R_{fet} = 50mΩ, I_{max} 2.4A to 4A
Note : for thermal drift of Vdet see curve below
Note : trigger delay of short-circuit detection decreases with increasing current level

Overcurrent protection test period

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
T overcurrent period	T_{iover}	Charge Mode User Mode		4 2		sec
Number of Tiover tests	N_{tests}	Charge Mode User Mode		unlimited 64		sec

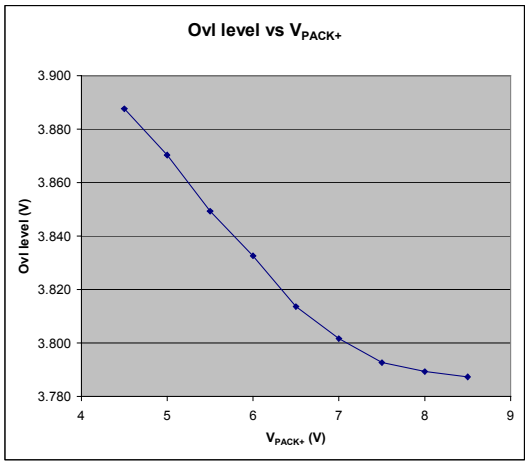


Fig.3

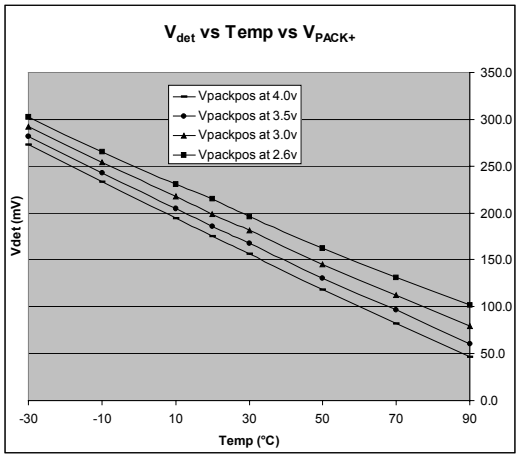


Fig.4

Note: Together with thermal characteristics of the Power MOS a temperature drift of approximately - 30mA/°C is resulting (see Lion Module Device Specification).

Pin Description

Pin# (SO8)	Name	I/O	Description
1	PACK+	Supply	Asic Positive Input, positive terminal for the user
2	Sense	Input	Input for voltage comparator
3	Bneg	Supply	Battery Negative Terminal
4	Ctrl_Chg	Output	Battery Charge PwrMos Control gate
5	Ctrl_Dis	Output	Battery User PwrMos Control gate
6	PACK-	Supply	Battery Pack, negative Terminal for the user
7	V_{DD}	Supply	Asic Positive Supply Terminal
8	V_{SS}	Supply	Asic Substrate Connection 1

Block Diagram

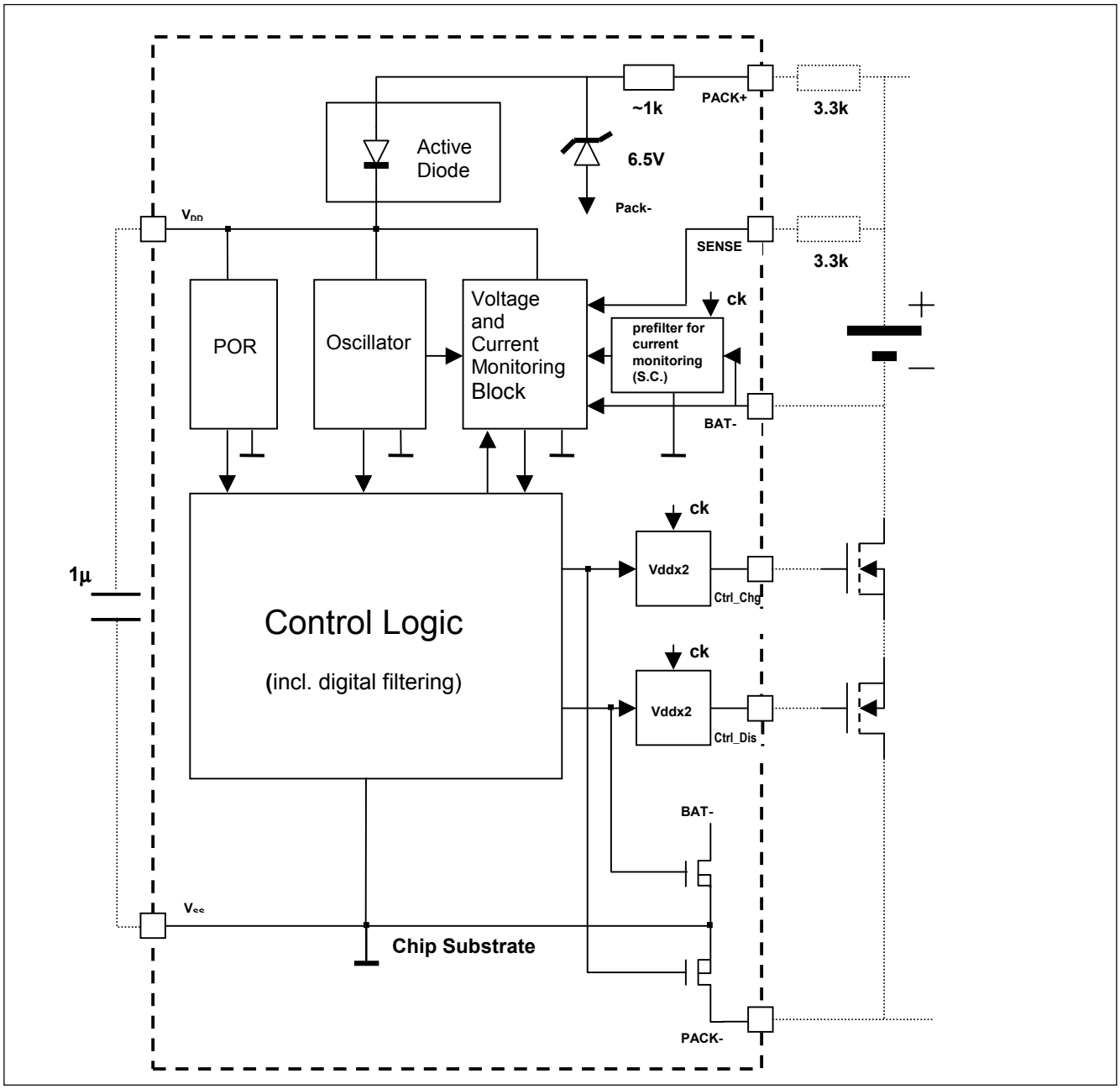


Fig.5

Functional Description

Definition of terms:

Itesten	Normally high, set low in case of overcurrent
Encharge	High if $V_{battneg} > V_{PACK-}$
Enuser	High if $V_{PACK-} > V_{battneg}$
Delay	Minimun Time after which the pwrmos mos can be set back ON if set OFF
Ctrlcharge	Gate signal of the power mos charge, high if power mos charge ON
Ctrluser	Gate signal of the power mos user, high if power mos user ON
Uvl	Set low at the level under which the power mos user is set and forced off .
Uvh	In user mode, level over which the power mos user can be set back on If set off due to an undervoltage or overcurrent detection.
Ovl	In charge mode, level under which the power mos charge is set back on If set off due to an overvoltage or overcurrent detection.
Ovh	Set to high at the level over which the power mos charge is set and forced off
Gtov	Set high at the level above ovh and set low at the level below ovl
Ltuv/	Set low for levels below uvl and set high for levels above uvh
Ckpla	Internal clock of state-machine (1kHz)

Set on and off conditions of power mos charge and user.

Set power Mos Charge ON = ckpla x ltesten x ovh/ (gtov/ + enuser x ctrlcharge/ x delay)

Set power Mos Charge OFF = ckpla x ovh + ckpla x itesten/ x encharge

Set power Mos User ON = ckpla x uvl x ltesten x (ltuv/ + encharge x ctrluser/ x delay)

Set power Mos User OFF = ckpla x uvl/ + ckpla x itesten/ x enuser

Battery voltage sampling
The battery voltage is integrated over a capacitor, then is sampled. All together there are 5 levels to be evaluated. The evaluation sequence of one level requires 8 consecutive sampling separated by 4ms with a sampling period of 32ms. The comparator output bits are shifted into a register.

Battery Voltage below Vuvl in User Mode.
The PwrMos User is set OFF, the PwrMos charge stays ON. If the Battery level recovers and pass over UVH, the PwrMos User is set back ON.Otherwise, the Battery must be charged.

Battery Voltage below Vuvl in Charge Mode.
The PwrMos Charge is set ON , the PwrMos User stays OFF, the charge current flows through PwrMos User junction until the Battery Voltage pass over UVL.

Battery Voltage above Vovh
If the Battery is in the charge mode with the voltage passing above Vovh, the charging is disabled with the PwrMos Charge set Off , the PwrMos User stays ON. At the moment the battery voltage falls below the level OVL due to the selfdischarge , or if the charger is disconnected , the PwrMos Charge is set back ON.

Battery Voltage for Vuvh < Vbatt < Vovl
When the Battery voltage stands within this range both PwrMos are ON.
The flag UV/OV is in the tristate mode.

Battery Short-Circuit Current Protection

When the current flowing through the Battery is so high that the voltage drop across the Power Mos exceeds 1 volt, the switch off the PwrMos Charge or User will occur within 1.5ms.
The switch off delay is inverse proportional to the shorted current value.
I short = 1 volt divided by the Rdson of the 2 PwrMos in serie.

Battery Overcurrent Monitoring Protection

If the current flowing through the Battery exceeds the specified limit, the PwrMos Charge or User will be switched off if the overcurrent lasts for more than 10 ms, that means the current must pass above the limit for 5 successive measurements repeated at a period of 2ms.

Reaction in case of Overcurrent or Short-Circuit Current in Charge Mode

If Imax or Ishort is detected, the PwrMos Charge is switched off, the PwrMos User stays ON. After 4 seconds, the PwrMos Charge is set On again and if the current stays above Imax or Ishort it is switched off for 4 seconds. This sequence is repeated every 4 seconds until the current stays within the limits or until the battery voltage exceeds the level OVH.

Reaction in case of Overcurrent or Short-Circuit Current in User Mode

If Imax or Ishort is detected, the PwrMos User is switched off, the PwrMos Charge stays ON. After 2 seconds, the PwrMos User is set On again and if the current stays above Imax or Ishort it is switched off for 2 seconds.
This sequence is repeated every 2 seconds, 64 times or until the current stays within the limits or until the battery voltage drops below the level UVL. The battery must be plugged onto the charger to recover the normal operation.
Note that the 64x counter may be reset when the load current is close to the threshold. Also, it may occasionally be reset due to inductive voltage spikes at switch off, if long cables are used for the measurement.

EM6180 Flow-Chart

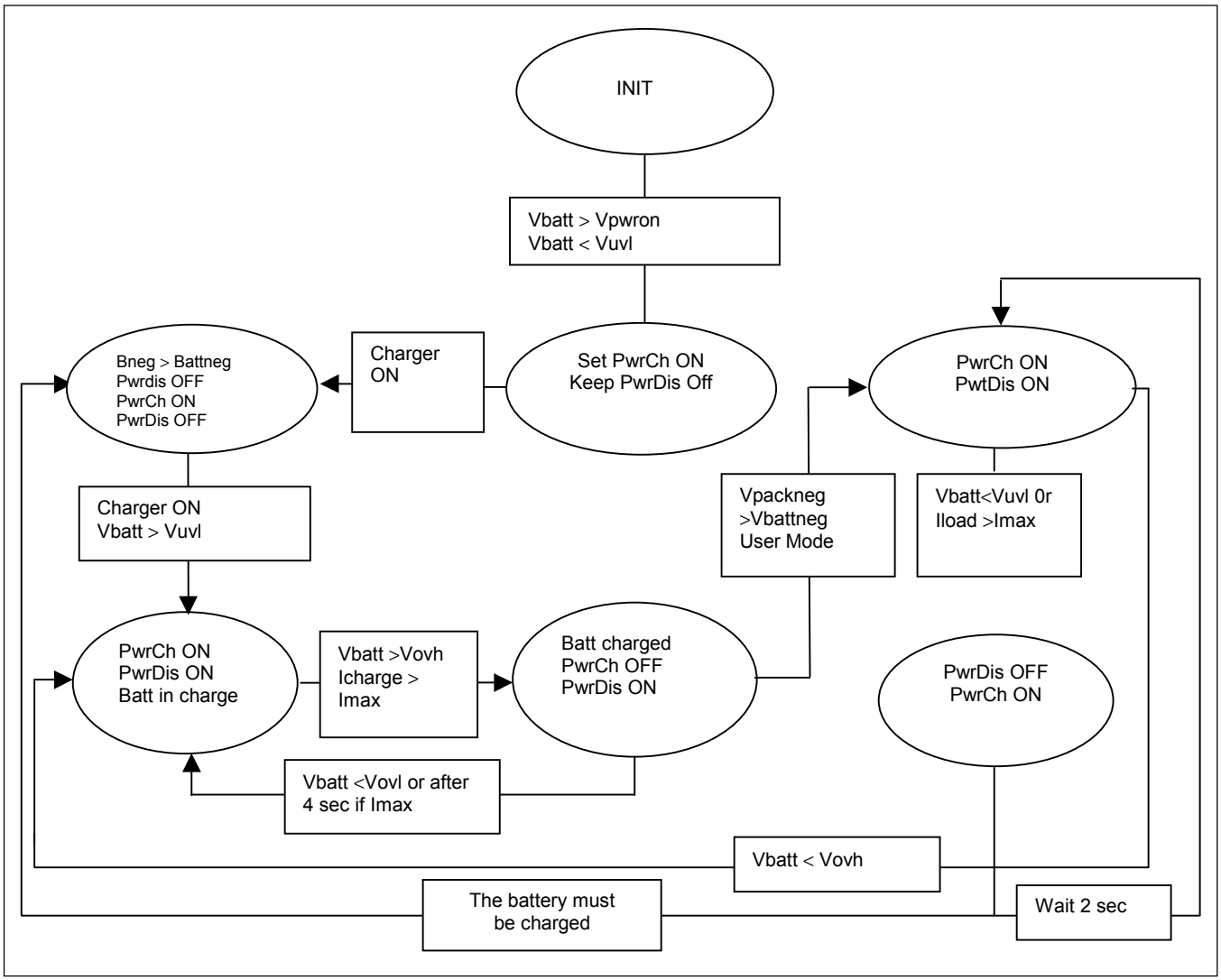


Fig. 7

Typical Applications

See Fig. 1

Ordering information

Product number: EM6180-**xx**-**yyy**-**z**

xx	**Version**	
01	Voh = 4.25V	
02	Voh = 4.35V	

yyy	**Package**	
B08	SO8	

z	**Delivery form**	
A	Stick	
B	EIA Reel	

Updates

Date ,Name Version	Chapter concerned	Old Version (Text, Figure, etc.)	New Version (Text, Figure, etc.)
0101, COR, B			Added -02, reaction times, ordering info Removed references to chip version