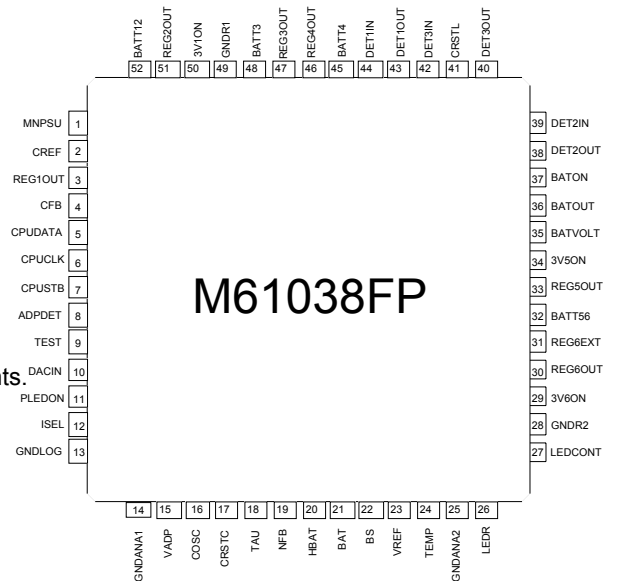


MITSUBISHI STANDARD LINEAR M61038FP

LI-ION BATTERY CHARGE CONTROL, POWER MANAGEMENT IC

Pin configuration (Top view)



Out line 52PJV

DESCRIPTION

M61038FP is a semiconductor integrated circuit designed for Lithium-ion battery charge control, power management IC.

Built-in stand-alone charge control circuit for Lithium-ion 1 cell battery, series regulator, detection circuit allows for simplified power supply circuit by a small number of external components.

Charge control circuit corresponds to high precision constant voltage/current charge, and integrates various kinds of protection circuits to be suitable for Lithium-ion battery charging.

Battery operated power supply circuit as low dropper series regulators are of low power dissipation.

Small CSP package is suitable for housing in portable electronic instruments.

FEATURES

*Built-in 6 channel low dropper, low power dissipation series regulator, vibrator driver circuit, 3 channel detector circuits

*Low ripple series regulator rejecting input voltage change

*Low power dissipation design allows for saving battery power at stand-by ...12uA(typ.)

*Built-in stand-alone charge control circuit for Lithium-ion 1 cell high precision charging

*Built-in various kind of protection circuits as low voltage detection, overvoltage detection, overvoltage detection, overcurrent detection(charge, adaptor), battery temp. detection, overcharge timer, adaptor detection.

*Full charge detection and re-charge function

*1 channel LED driver circuit for indicating charge state

*Automatic recovery type thermal shut-down circuit(operation stops at 150deg.C)

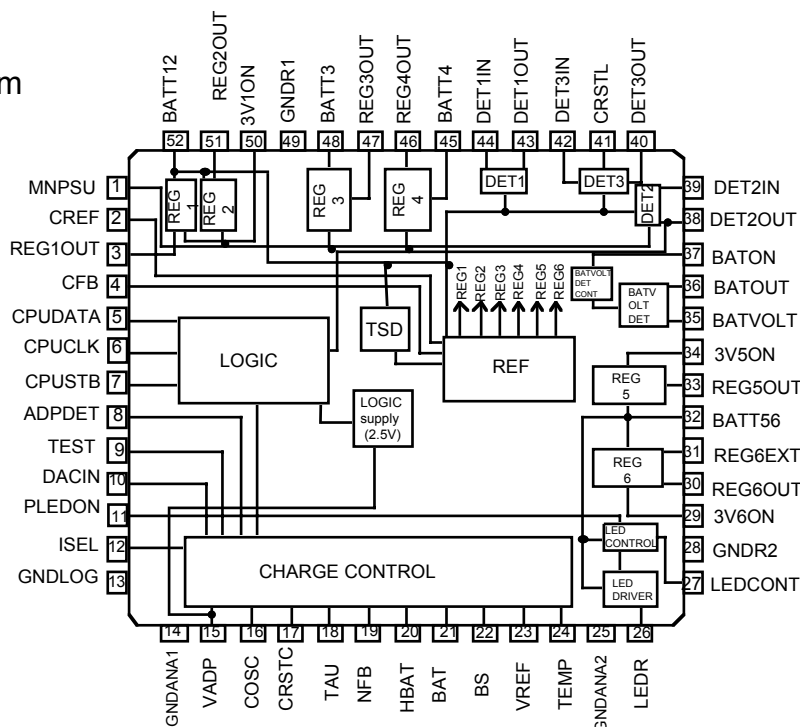
*3-wired serial data transfer system for communication from MCU

*52pin small CSP package saving mounting space(0.4mm lead pitch, body size:7x7mm)

APPLICATION

Handheld phone, PDA, and so forth(electronic equipments operated by 1 cell Lithium-ion battery)

Block diagram



1. ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Ratings	Unit	Remarks
Supply voltage	Vmax	-0.3 to +7.0	V	
Power dissipation	Pd	(2000)	mW	Allowable power dissipation is defined under the conditions below and when the device is mounted on the board. It depends upon board materials and wind velocity.(#)
Operating temperature	Topr.	-20 to +75	deg. C	
Storage temperature	Tstg.	-40 to +125	deg. C	

2. Guaranteed operation range

Parameter	Limits			Unit	Remarks
	Min.	Typ.	Max.		
Battery supply voltage	3.0	-	5.0	V	
Adaptor supply voltage	2.95	-	6.2	V	

(#) *95x100mm, 1.6mm(4 layered)

*Cu: internal layer 70%, external layer 30%

*Wind velocity: 0m/sec.

3. ELECTRICAL CHARACTERISTICS(Ta=25deg.C, VADP=5.5V unless otherwise noted.)

3-1.Charge section

(Current detection resistor=0.33ohm, Adaptor supply voltage=5.5V)

Parameter			Symbol	Limits			Unit	Remarks
				MIN.	TYP.	MAX		
Circuit current			Icc	-	2.5	-	mA	
Charge control voltage			Vchg	4.17	4.20	4.23	V	
Forced pre-charge current			Ichg1	-	63	-	mA	1C/8 current
Pre-charge current			Ichg2	-	63	-	mA	1C/8 current
Rapid charge current			Irap	-	500	-	mA	1C current (ISEL=GND)
Cont. volt. control timer current			Ilim1	-	250	-	mA	1C/2 current
Overcurrent protect. detect. current			Ilim2	-	1000	-	mA	2C current
Terminal dislocate detect. current			Ilim3	-	14	35	mA	
Charge completion current			Ilim4	40	55	70	mA	
Low voltage detection voltage			Vlow	1.00	1.10	1.20	V	
Rapid charge start voltage			Vrap	2.85	2.90	2.95	V	
Rapid charge start volt. hysteresis			Vraphis	50	100	150	mV	
Overvoltage protect.detect. volt.			Vov	4.25	4.35	4.45	V	
Full charge detect voltage			Vfull	4.00	4.05	4.10	V	
Trickle charge start voltage			Vrechg	3.90	3.95	4.00	V	
Rapid charge const. volt. charge	TEMP terminal threshold voltage	H	Vtmph1	1.839	1.891	1.940	V	Typ.-3deg.C+/- 3deg.C
		L	Vtmpl1	0.648	0.685	0.725	V	Typ.53deg.C+/- 3deg.C
Pre-charge		H	Vtmph2	1.839	1.891	1.940	V	Typ.-3deg.C+/- 3deg.C
		L	Vtmpl2	0.815	0.861	0.912	V	Typ.43deg.C+/- 3deg.C
Battery detection voltage			Vtmp	2.18	2.30	2.42	V	Also for charge start volt. for power-on reset
Adaptor detection voltage	L	Vadpl	2.68	2.80	2.92	V		
	H	Vadph	5.80	6.00	6.20	V		
Adaptor detection volt. hysteresis			Vadphis	40	80	120	mV	
VREF terminal output voltage			Vvref	2.47	2.50	2.53	V	
Internal oscillator frequency			Fosc	200	250	300	H	COSC=4700pF
Forced pre-charge time			Tpre1	800	1000	2400	msec	COSC=4700pF
Pre-charge time			Tpre2	12	15	18	min	COSC=4700pF
2 hour timer time			T2hr	95	120	145	min	COSC=4700pF
4 hour timer time			T4hr	190	240	290	min	COSC=4700pF
Battery open time			Topn	3.00	4.00	6.00	sec	COSC=4700pF
Power-on reset delay time			Tpor	30	50	70	msec	CRSTC=0.1uF
BAT terminal flow-in current			Ibat	-	-	0.5	uA	VBAT=4.2V
HBAT terminal flow-in current			Ihbat	-	-	0.5	uA	VBAT=4.2V

3-2. Dissipation current

Parameter	Limits			Unit	Condition
	Min	Typ	Max		
Dissipation current1	-	12	20	uA	REG1,REG2,DET1,DET3=ON REG:No load, Supply volt.=4.2V TSD,REF:ON
Dissipation current2	-	3	-	uA	REG1=ON,the others:OFF, REG:No load
Dissipation current3	-	3	-	uA	REG2=ON,the others:OFF, REG:No load
Dissipation current4	-	15	-	u A	REG3=ON,the others:OFF, REG:No load
Dissipation current5	-	15	-	uA	REG4=ON,the others:OFF, REG:No load
Dissipation current6	-	15	-	uA	REG5=ON,the others:OFF, REG:No load
Dissipation current7	-	25	-	uA	REG6=ON,the others:OFF, REG:No load

3-3.Regulator section

REG1(ON/OFF control at 3V1ON)

Parameter		Limits			Unit	Condition
		Min	Typ	Max		
Output voltage		1.764	1.800	1.836	V	Iout=5mA
Load regulation		-	10	60	m V	Iout=1 to 20mA
Input regulation		-	10	60	m V	Vin=3.3 to 4.5V, Iout=5mA
Output volt. temperature coefficient		-	(0.20)	-	mV/deg.	Ta=-25 to +70deg.C, Iout=5mA
Ripple rejection ratio		50	62	-	dB	Vin=3.6V, Iout=5mA, Vrr=-20dBV, frr=100Hz
Transient characteristics	Amplitude UP	-	100	-	m V	Vin 3.2V to 3.6V Iout=5mA
	Settling time	-	50	-	u sec	
	Amplitude DOWN	-	100	-	m V	Vin 3.6V to 3.2V Iout=5mA
	Settling time	-	50	-	u sec	
Rise-up delay time		-	500	-	u sec	
Output noise voltage		-	75	-	uVrms	Iout=5mA, 20Hz<f<80kHz
Leak current		-	-	1.3	uA	Vin=4.2V, 3V1ON="L"
Control terminal flow-in current		-	0.0	1.0	u A	Vin=4.2V

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REG1(ON/OFF control at 3V1ON)

Parameter		Limits			Unit	Condition
		Min	Typ	Max		
Output voltage		2.793	2.850	2.907	V	I _{out} =80mA
Input/output differential		-	250	300	mV	V _{in} =2.8V, I _{out} =100mA
Load regulation		-	10	60	mV	I _{out} =1 to 100mA
Input regulation		-	10	60	mV	V _{in} =3.2 to 4.5V, I _{out} =80mA
Output volt. temperature coefficient		-	0.3	-	mV/deg.	T _a =-25 to +70deg.C, I _{out} =80mA
Ripple rejection ratio		50	62	-	dB	V _{in} =3.6V, I _{out} =80mA, V _{rr} =-20dBV, f _{rr} =100Hz
Transient characteristics	Amplitude UP	-	100	-	mV	V _{in} 3.2V to 3.6V I _{out} =80mA
	Settling time	-	50	-	μsec	
	Amplitude DOWN	-	100	-	mV	V _{in} 3.6V to 3.2V I _{out} =80mA
	Settling time	-	50	-	μsec	
Rise-up delay time		-	500	-	μsec	
Output noise voltage		-	70	-	μV _{rms}	I _{out} =80mA, 20Hz<f<80kHz
Leak current		-	-	1.3	μA	V _{in} =4.2V, 3V1ON="L"

REG3(ON/OFF control at MNPSU)

Parameter		Limits			Unit	Condition
		Min	Typ	Max		
Output voltage		1.764	1.800	1.856	V	I _{out} =150mA
Load regulation		-	10	60	mV	I _{out} =1 to 200mA
Input regulation		-	10	60	mV	V _{in} =2.8 to 4.5V, I _{out} =150mA
Output volt. temperature coefficient		-	(0.20)	-	mV/deg.	T _a =-25 to +70deg.C
Ripple rejection ratio		50	63	-	dB	V _{in} =3.6V, I _{out} =150mA, V _{rr} =-20dBV, f _{rr} =100Hz
Transient characteristics	Amplitude UP	-	50	-	mV	V _{in} 3.2V to 3.6V I _{out} =150mA
	Settling time	-	10	-	μsec	
	Amplitude DOWN	-	100	-	mV	V _{in} 3.6V to 3.2V I _{out} =150mA
	Settling time	-	10	-	μsec	
Rise-up delay time		-	500	-	μsec	
Output noise voltage		-	55	-	μV _{rms}	I _{out} =150mA, 20Hz<f<80kHz
Leak current		-	-	5	μA	V _{in} =4.2V, MNPSU="L"
Control terminal flow-in current		-	-	2.5	μA	MNPSU=2.8V

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REG4(ON/OFF control at MNPSU)

Parameter		Limits			Unit	Condition
		Min	Typ	Max		
Output voltage		2.807	2.850	2.893	V	I _{out} =100mA
Input/output differential		-	200	250	mV	V _{in} =2.8V, I _{out} =100mA
Load regulation		-	10	60	mV	I _{out} =1 to 200mA
Input regulation		-	10	60	mV	V _{in} =3.2 to 4.5V, I _{out} =150mA
Output volt. temperature coefficient		-	0.3	-	mV/deg.	T _a =-25 to +70deg.C
Ripple rejection ratio		50	62	-	dB	V _{in} =3.6V, I _{out} =30mA, V _{rr} =-20dBV, f _{rr} =100Hz
Transient characteristics	Amplitude UP	-	50	-	mV	V _{in} 3.2V to 3.6V I _{out} =100mA
	Settling time	-	10	-	μsec	
	Amplitude DOWN	-	50	-	mV	V _{in} 3.6V to 3.2V I _{out} =100mA
	Settling time	-	10	-	μsec	
Rise-up delay time		-	500	-	μsec	
Output noise voltage		-	70	-	μV _{rms}	I _{out} =200mA, 20Hz<f<80kHz
Leak current		-	-	5	μA	V _{in} =4.2V, MNPSU="L"

REG5(ON/OFF control at 3V5ON)

Parameter		Limits			Unit	Condition
		Min	Typ	Max		
Output voltage		2.793	2.850	2.907	V	I _{out} =150mA
Input/output differential		-	250	300	mV	V _{in} =2.8V, I _{out} =100mA
Load regulation		-	20	60	mV	I _{out} =1 to 100mA
Input regulation		-	20	60	mV	V _{in} =3.2 to 4.5V, I _{out} =100mA
Output volt. temperature coefficient		-	0.3	-	mV/deg.	T _a =-25 to +70deg.C
Ripple rejection ratio		50	60	-	dB	V _{in} =3.6V, I _{out} =30mA, V _{rr} =-20dBV, f _{rr} =100Hz
Transient characteristics	Amplitude UP	-	50	-	mV	V _{in} 3.2V to 3.6V I _{out} =100mA
	Settling time	-	10	-	μsec	
	Amplitude DOWN	-	50	-	mV	V _{in} 3.6V to 3.2V I _{out} =100mA
	Settling time	-	10	-	μsec	
Rise-up delay time		-	500	-	μsec	
Output noise voltage		-	100	-	μV _{rms}	I _{out} =100mA, 20Hz<f<80kHz
Leak current		-	-	5	μA	V _{in} =4.2V, 3V5ON="L"
Control terminal flow-in current		-	1.0	2.5	μA	3V5ON=2.8V

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REG6(ON/OFF control at 3V6ON, Basic characteristics below depends upon external Tr.)

Parameter		Limits			Unit	Condition
		Min	Typ	Max		
Output voltage		2.793	2.850	2.907	V	I _{out} =300mA
Input/output differential		-	250	300	mV	V _{in} =2.8V, I _{out} =300mA
Load regulation		-	20	60	mV	I _{out} =1 to 300mA
Input regulation		-	20	60	mV	V _{in} =3.3 to 4.5V, I _{out} =300mA
Output volt. temperature coefficient		-	0.3	-	mV/deg.	T _a =-25 to +70deg.C, I _{out} =300mA
Ripple rejection ratio		50	60	-	dB	V _{in} =3.6V, I _{out} =80mA, V _{rr} =-20dBV, f _r =100Hz
Transient characteristics	Amplitude UP	-	100	-	mV	V _{in} 3.2V to 3.6V I _{out} =300mA
	Settling time	-	10	-	μsec	
	Amplitude DOWN	-	150	-	mV	V _{in} 3.6V to 3.2V I _{out} =300mA
	Settling time	-	10	-	μsec	
Rise-up delay time		-	500	-	μsec	
Output noise voltage		-	100	-	μV _{rms}	I _{out} =300mA, 20Hz<f<80kHz
Leak current		-	-	10	μA	V _{in} =4.2V, 3V5ON="L"
Control terminal flow-in current		-	1.0	2.5	μA	3V5ON=3.0V

3-4.Voltage detector section

DET1

Parameter	Limits			Unit	Condition
	Min	Typ	Max		
Detection voltage	3.038	3.100	3.162	V	
Detection voltage hysteresis	93	155	217	mV	
Detection volt.temp.coefficient	-	0.3	-	mV/deg	T _a =-25 to +70deg.C
Output voltage 'L' level	-	0.1	0.2	V	I _{out} =100μA
Output off leak current	-	0.0	0.5	μA	
Input terminal flow-in current	-	1.0	3.0	μA	V _{in} =4.2V

DET2

Parameter	Limits			Unit	Condition
	Min	Typ	Max		
Detection voltage	2.450	2.500	2.550	V	
Detection voltage hysteresis	75	125	175	mV	
Detection volt.temp.coefficient	-	0.25	-	mV/deg.	Ta=-25 to +70deg.C
Output voltage 'L'level	-	0.1	0.2	V	Iout=100uA
Output off leak current	-	0.0	0.5	u A	
Input terminal flow-in current	-	3.0	8.0	u A	Vin=3.0V

DET3

Parameter	Limits			Unit	Condition
	Min	Typ	Max		
Detection voltage	2.254	2.300	2.346	V	
Detection voltage hysteresis	69	115	161	mV	
Detection volt.temp.coefficient	-	0.2	-	mV/deg.	Ta=-25 to +70deg.C
Output voltage 'L'level	-	0.1	0.2	V	Iout=100uA
Output delay time	100	200	400	msec	Ta=-25 to +70deg.,CRSTL=0.1uF
Output off leak current	-	0.0	0.5	uA	
Input terminal flow-in current	-	1.0	3.0	uA	Vin=3.0V

3-5. BATVOLTDET SECTION

Parameter	Limits			Unit	Condition
	Min	Typ	Max		
Output voltage at ON	2.12	2.16	2.20	V	VBAT=3.6V, REG4:operative BATON>2.0V
Output voltage at OFF	-	0.0	0.3	V	VBAT=3.6V, REG4:operative -0.3V<BATON<0.7V
Control terminal flow-in current	-	0.0	3.0	u A	BATON=3.6V

3-6. DC characteristics for control section

Parameter	Symbol	Limits			Unit	Condition
		Min	Typ	Max		
Input 'H' voltage	Vih	2.0	-	BATT	V	
Input 'L' voltage	Vil	-0.3	-	0.7	V	
Leak current when output is off Open drain	I1	-	-	0.5	uA	Vin=2.85V
Output 'L' voltage open drain	Vol1	-	-	0.2	V	Iout=50uA
Output 'H' voltage CMOS output	Voh2	2.0	-	3.0	V	Iout=50uA
Output 'L' voltage CMOS output	Vol2	0.0	-	0.5	V	Iout=50uA

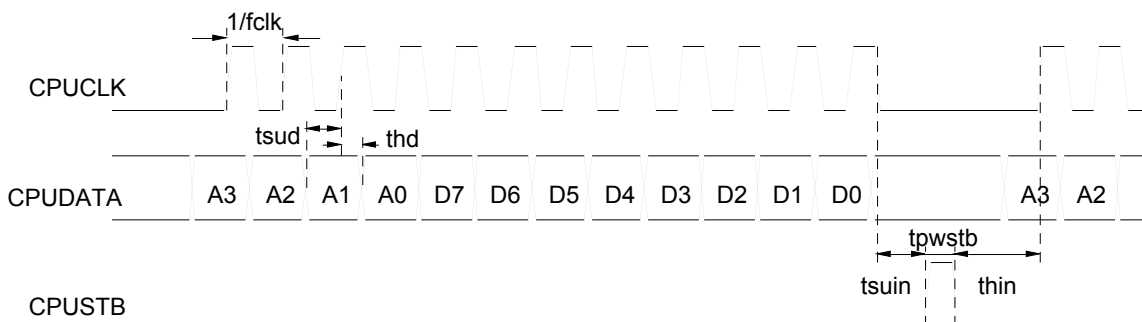
4. Serial Interface

4-1. DC characteristics

Parameter	Symbol	Limits			Unit	Condition
		Min	Typ	Max		
'H' input voltage	VINH	2.0	-	-	V	
'L' input voltage	VINL	-	-	0.5	V	
'H' input current	IINH	-	0.0	3.0	uA	
'L' input current	IINL	-0.3	0.0	-	uA	

4-2. AC characteristics

Parameter	Symbol	Limits			Unit	Condition
		Min	Typ	Max		
Clock frequency	fclk	-	-	1.0	MHz	
Data input set-up time	tsud	100	-	-	nsec	
Data input hold time	thd	100	-	-	nsec	
Input set-up time	tsuin	100	-	-	nsec	
Input hold time	thin	500	-	-	nsec	
CPUSTB strobe pulse width	tpwstb	500	-	-	nsec	



*CPUDATA for 12 times CPUCLK right before the generation of CPUSTB rise-up edge is judged to be valid.

4-3. Register map

Address 0

BIT	INIT	NAME	FUNCTION
7	0	-	
6	0	-	
5	0	-	
4	0	CHGOFF	Charge stop
3	0	-	
2	0	-	
1	0	CHGRST	Charge logic reset
0	0	TESTMODE	Test mode. Test pin(9pin) works for basic clock input pin for internal logic.

Address 1

BIT	INIT	NAME	FUNCTION
7	0	-	
6	0	-	
5	0	-	
4	0	-	
3	0	-	
2	0	-	
1	0	-	
0	0	-	

Address 2

BIT	INIT	NAME	FUNCTION
7	0	-	
6	0	-	
5	0	-	
4	0	-	
3	0	-	
2	0	-	
1	0	-	
0	0	-	

Address 3

BIT	INIT	NAME	FUNCTION
7	0	-	
6	0	-	
5	0	-	
4	0	-	
3	0	MON3	Bit for setting TEST pin output status
2	0	MON2	Bit for setting TEST pin output status
1	0	MON1	Bit for setting TEST pin output status
0	0	MON0	Bit for setting TEST pin output status

Test pin output set bit

MON3	MON2	MON1	MON0	Test pin output (Hi condition)
0	0	0	0	Adaptor voltage/ battery temperature is normal.
0	0	0	1	Battery voltage is 1.1V or less.
0	0	1	0	Battery voltage is 2.9V or more.
0	0	1	1	Battery voltage is 4.05V/3.95V or more.
0	1	0	0	Battery voltage is 4.35V or more.
0	1	0	1	Charge current is equal or less than the detection current for open terminal.
0	1	1	0	Charge current is equal or less than charge completion current.
0	1	1	1	Charge current is equal or less than constant voltage control timer current.
1	0	0	0	Charge current is equal or more than overcurrent protection detection current.
1	0	0	1	Battery temperature is normal.
1	0	1	0	Battery connection is detected.
1	0	1	1	Adaptor voltage is normal.
1	1	0	0	Abnormal charge
1	1	0	1	Reset
1	1	1	0	Forced pre-charge
1	1	1	1	Battery voltage is open.

5.Terminal notation

PIN	PIN notation	Explanations on Terminals	I/O	Input/Output structure	Protection diode	
					positive	negative
1	MNPSU	REG3,REG4,DET2 control terminal	I	CMOS input	BATT	GND
2	CREF	Capacitor terminal for stabilized ref. voltage		-	BATT	GND
3	REG1OUT	REG1 output terminal	O	-	BATT	GND
4	CFB	Capacitor terminal for stabilized REG. ref. volt.		-	BATT	GND
5	CPUDATA	CPU I/F data input terminal	I	CMOS input	BATT	GND
6	CPUCLK	CPU I/F clock input terminal	I	CMOS input	BATT	GND
7	CPUSTB	CPU I/F strobe signal input terminal	I	CMOS input	BATT	GND
8	ADPDET	ADPDET output terminal	O	NMOS open drain output	BATT	GND
9	TEST	Test monitor output terminal	O	CMOS input	BATT	GND
10	DACIN	Full charge detection voltage set terminal	I	Bipolar Tr. base input	VADP	GND
11	PLEDON	Reception signal input	I	CMOS input	BATT	GND
12	ISEL	Rapid charge current choice terminal	I	CMOS input	VADP	GND
13	GNDLOG	Logic GND for charge section		-	-	-
14	GNDANA1	Analog GND		-	-	-
15	VADP	Adaptor power supply input	I	-	-	GND
16	COSC	CPU I/F data input terminal		-	VADP	GND
17	CRSTC	Cap. term'l for int'l OSC freq. set in charge sect.		-	VADP	GND
18	TAU	Cap. term'l for int'l logic reset in charge sect.		-	VADP	GND
19	NFB	Charge control output terminal in charge sect.	O	-	VADP	GND
20	HBAT	Charge current detection terminal(H)	I	Bipolar Tr. base input	BATT	GND
21	BAT	Charge current detection terminal(L)	I	Bipolar Tr. base input	BATT	GND
22	BS	Battery voltage detection terminal	I	Bipolar Tr. base input	BATT	GND
23	VREF	Ref. voltage output for temp. detection	O	PNP collector output	VADP	GND
24	TEMP	Battery temp. detection terminal	I	Bipolar Tr. base input	VADP	GND
25	GNDANA2	GND for LED driver		-	-	-
26	LEDR	Charge LED drive terminal	O	NPN collector output	BATT	GND
27	LEDCONT	SW control terminal for charge LED SW control	I	CMOS input	BATT	GND
28	GNDR2	GND for REG5, REG6, battery voltage monitor		-	-	-
29	3V6ON	REG6 control terminal	I	CMOS input	BATT	GND
30	REG6OUT	REG6 output voltage monitor terminal	I	-	BATT	GND
31	REG6EXT	REG6 external Tr. terminal	O		BATT	GND
32	BATT56	REG5, REG6 battery input terminal	I	-	-	GND

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PIN	PIN notation	Explanations on Terminals	I/O	Input/Output structure	Protection diode	
					positive	negative
33	REG5OUT	REG5 output terminal	O	-	BATT	GND
34	3V5ON	REG5 control terminal	I	CMOS input	BATT	GND
35	BATVOLT	Volt. output terminal for divided battery volt.	O		BATT	GND
36	BATOUT	Batt. volt. output terminal for BATON cont. SW	O		BATT	GND
37	BATON	Control terminal for batt.voltage monitor SW	I	CMOS input	BATT	GND
38	DET2OUT	DET2 output terminal	O	Open drain	BATT	GND
39	DET2IN	DET2 input terminal	I	-	BATT	GND
40	DET3OUT	DET3 output terminal	O	Open drain	BATT	GND
41	CRSTL	Cap. terminal for DET3 output time const. set		-	BATT	GND
42	DET3IN	DET3 input terminal	I	-	BATT	GND
43	DET1OUT	DET1 output terminal	O	Open drain	BATT	GND
44	DET1IN	DET1 input terminal	I	-	BATT	GND
45	BATT4	Bat t. input terminal for REG4	I	-	-	GND
46	REG4OUT	REG4 output terminal	O	-	BATT	GND
47	REG3OUT	REG3 output terminal	O	-	BATT	GND
48	BATT3	Bat t. input terminal for REG3	I	-	-	GND
49	GNDR1	GND for REG1 to REG4		-	-	-
50	3V1ON	REG1,REG2 control terminal	I	CMOS input	BATT	GND
51	REG2OUT	REG2 output terminal	O	-	BATT	GND
52	BATT12	Batt. input terminal for REG1, REG2	I	-	-	GND

Operation explanation

6. Explanation for charge function (charge current stated below is for 0.33ohm charge current detection resistor.)

6-1. Forced pre-charge(1C/8 constant current charge)

Forced pre-charge gets started and LED turns on when the following conditions are satisfied.

*Adaptor voltage is less than 6V.(2.95V or more)

*Battery temperature is -3 deg.C or more and less than 43 deg. C.

1C/8 constant current charge continues for 1 sec.(COSC=4700uF). During this period, battery voltage detection for 1.1V less is not done, nor full-charge detection.

Overvoltage detection for 4.35V or more and overcurrent detection for 2C or more are done for abnormal detection.

When the battery temperature is detected as -3 deg. C or less or 43deg.C or more, charge mode enters into abnormal temperature stand-by mode, where output stops and stand-by mode continues until each timer is reset and temperature comes into the range between -3deg. C or more and 43deg.C or less.

6-2. Pre-charge(1C/8 constant current charge)

Pre-charge gets started after forced pre-charge for 1 sec. completes if battery voltage is less than 2.9V.

However, if battery voltage is less than 1.1V at this point in time, charge mode moves onto abnormal stop mode.

When open terminal current is detected, charge mode becomes battery open voltage detection mode(see below).

During pre-charge, (1) to (4)(each later referred to as abnormal detection) stand below are done.

(1) low voltage detection when battery voltage is 1.1V or less

(2) overvoltage detection when battery voltage is 4.35V or more

(3) overcurrent detection when charge current is 2C or more

(4) abnormal temperature detection when battery temperature is -3deg. C or less or 43deg. C or more

Pre-charge is finished by at least one of the following conditions.

*Battery voltage is still 2.9V or less even after 15 minutes since the start of pre-charge(COSC=4700pF).

(moves onto abnormal mode)

*When battery voltage is detected 2.9V or more(15min. Timer function is masked to move onto quick charge).

6-3 Quick charge

Below setting is done to move onto quick charge at the moment when forced pre-charge is finished and battery voltage is detected 2.9V or more.

*Detected temperature(high temp.) to be changed to 63deg. C from 43deg. C

Charge current setting

*SEL="L":500mA constant current charge internally set.

*SEL="H":fixed by adaptor limited current

Each abnormal detection is operative during quick charge. When open terminal current is detected, charge mode becomes battery open voltage detection mode(see below.)

Quick charge terminates by at least one of the following conditions.

*4hours after the start of quick charge(COSC=4700pF)(moves onto battery open voltage detection mode)

*Battery voltage is detected 4.2V(moves onto constant voltage charge)

6-4 Constant voltage charge

During quick charge, at the moment when battery voltage is detected 4.2V, 4.2V constant voltage charge gets started. And at the same time 2hour timer (COSC=4700pF) starts when charge current becomes 250mA or less. Each abnormal detection is operative during constant voltage charge. When open terminal current is detected, charge mode becomes battery open voltage detection mode(see below.)
Constant voltage charge terminates by at least one of the following conditions to enter battery open voltage detection mode(see below.).

*4hours after the start of quick charge

*2 hours after the detection of 250mA

*When charge current is judged as equal to or smaller than charge completion current. (during constant voltage charge, charge current is compared with charge completion current.)

(DACIN voltage is prioritized when internal set voltage is larger than DACIN input voltage.)

[current status]

Internal set voltage= $55\text{mA} \times 0.33\text{ohm} \times 30\text{times} = 544.5\text{mV}$

,where 55mA: charge completion current(typ.)

0.33ohm: charge current detection

resistor 30times: internal amplifier

Example1. When charge completion current is 30mA, DACIN input voltage= $30\text{mA} \times 0.33\text{ohm} \times 30\text{times} = 297\text{mV}$

internal set voltage=544.5mV>DACIN input voltage=297mV, so DACIN voltage is prioritized, and charge completion judge current is 30mA.

6-5. Battery open voltage detection mode

Charge stops at once in battery open voltage detection mode. Battery voltage is detected after 4sec (COSC=4700pF), and the voltage decides next operation. (charge LED is turned on when 4sec. stand-by.)

*Abnormal stop when battery voltage is 4.05V.

*When battery voltage is greater than 4.05V, charge stops, each timer is to be reset, charge LED is turned on, charge operation again starts depending upon the battery voltage.

Each abnormal detection operation is done during battery open voltage detection mode.

6-6. Built-in protection circuit for erroneous detection

Decision of the following detection signal has error detection protection circuit, and the decision value data of the detector are detected by the rising edge of 16Hz clock, and is confirmed by continuous agreement for 4 times detections.

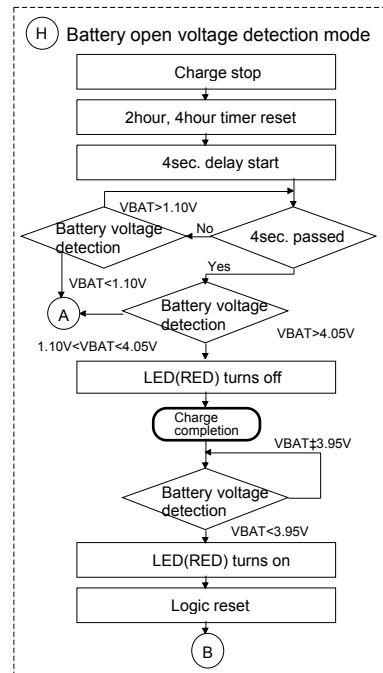
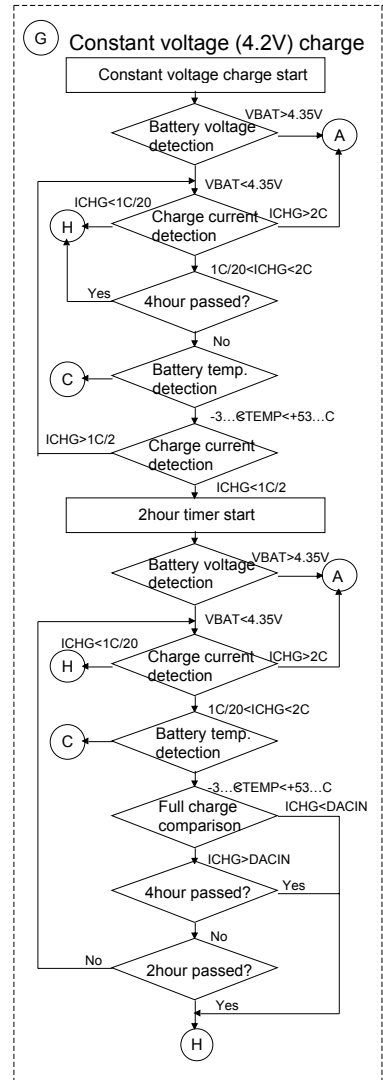
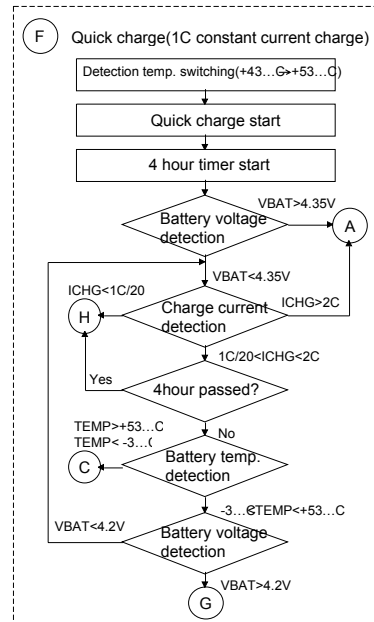
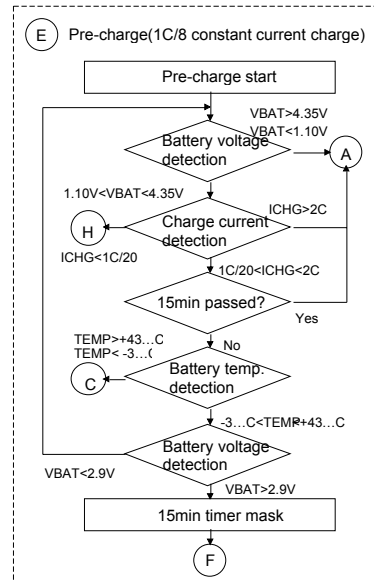
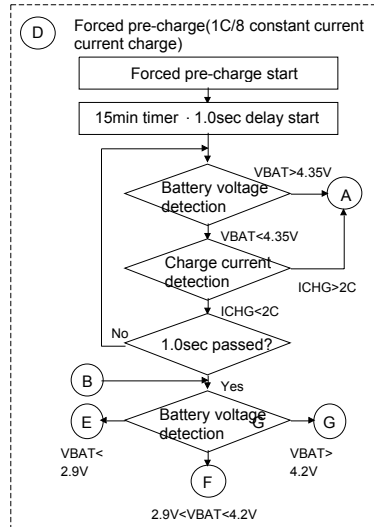
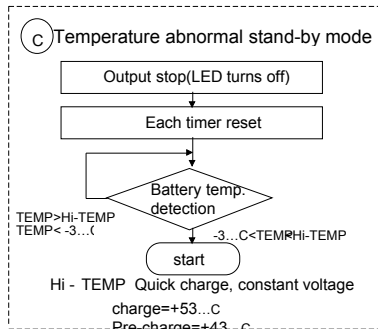
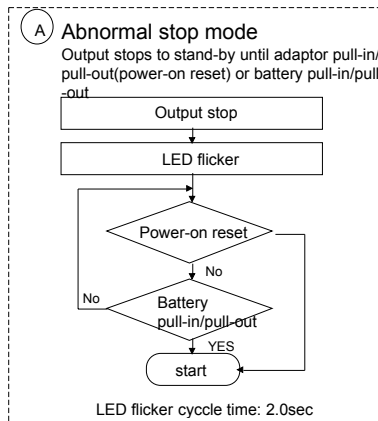
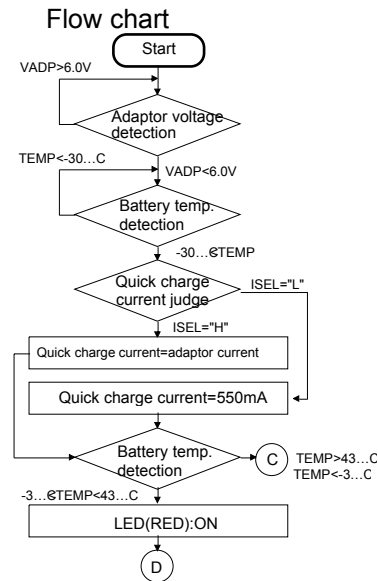
*Battery voltage detection: each decision for 1.1V, 2.9V, 3.95V/4.05V, 4.35V

*Charge current detection: each decision for open terminal current, charge completion current, 1C/2, 2C

*Battery temp. detection: each decision for battery connection, -3deg.C, 43deg.C/53deg.C

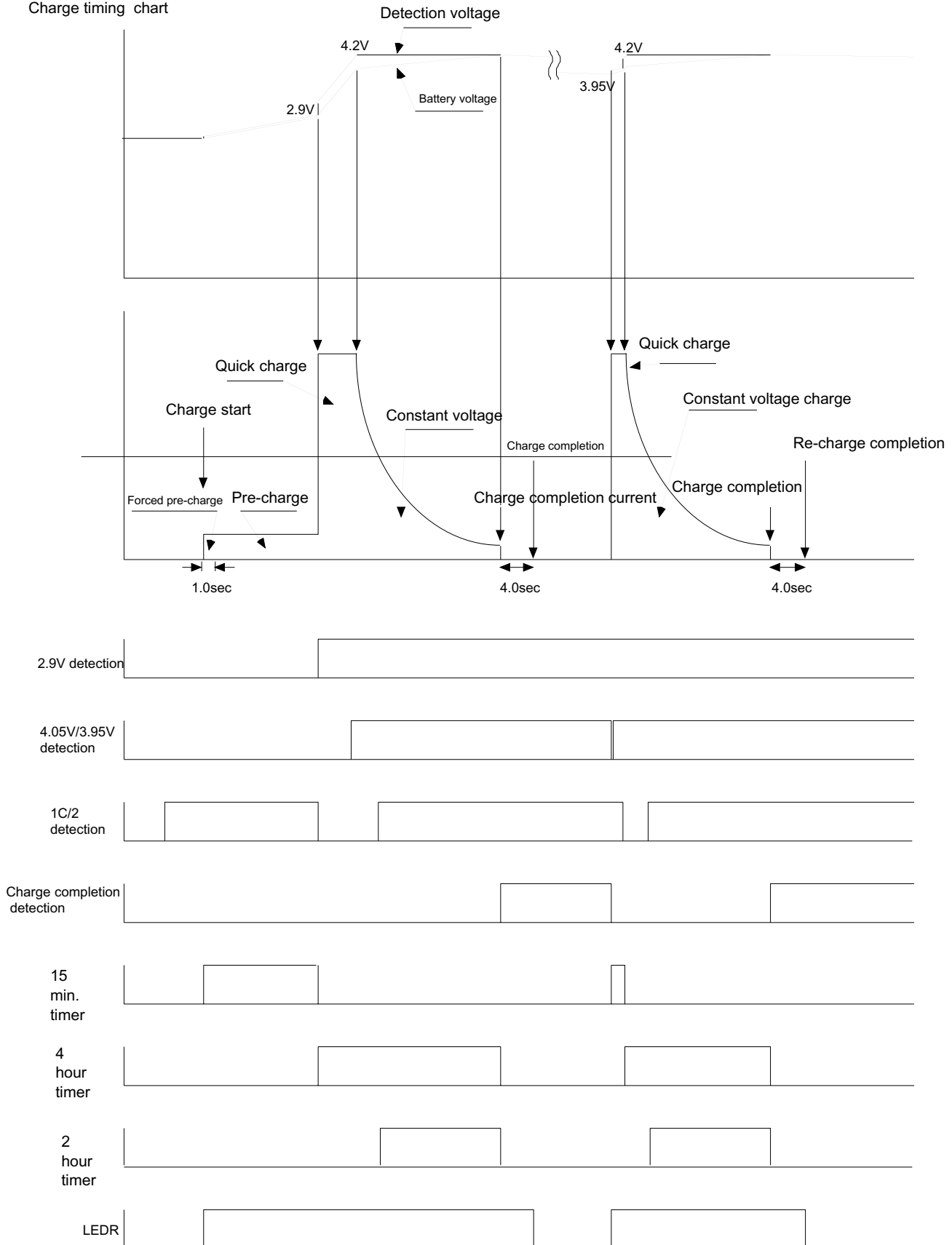
*Adaptor voltage detection: each decision for 2.8V, 6.0V

7. FLOW CHART



8. TIMING CHART

Charge timing chart



The schematic diagram illustrates the internal structure and external connections of the AD7745. Key components include:

- Internal Blocks:** LOGIC, REF (Reference), CHARGE CONTROL, TSD (Temperature Sensor), and various registers (REG 1-6).
- External Components:** Capacitors (e.g., 10uF, 0.1uF, 1uF), resistors (e.g., 10K, 100K, 1M, 4.7K), and a battery (BATT12).
- Pin Connections:** The diagram shows connections for pins 1 through 52, including power supply pins (VDD, VREF), control pins (CPUCLK, CPUDATA), and data pins (REG1OUT, REG2OUT, etc.).
- Functional Blocks:** REG 1, REG 2, REG 3, REG 4, REG 5, REG 6, DET1, DET2, DET3, DET4, DET5, DET6, BATVOLT DET, LED CONTROL, LED DRIVER, and LOGIC supply (2.5V).