LPB1010HQVF

1-Cell Li-Battery Protection IC with Integrated MOSFET

Features

- Integrated N-MOSFET with low R_{ON}: 60mΩ
- Ultra-low current consumption: 0.5μA
- Ultra-low shutdown current: <10nA
- High accuracy Voltage Protection (±25mV)
- Low Over-Current Protection
  - Discharge Over-Current Protection: 150mA
  - Charge Over-Current Protection: 300mA
  - Discharge Short-Circuit Protection: 450mA
- Reverse battery connection protection
- Thermal shutdown protection
- Shipping-Mode with GPIO control
- 0V battery charging support
- ESD Protection:
  - Human Body Model: 2kV
  - Charged Device Model: 0.5kV
- DFN-4 Package with 1mm x 1mm size

Applications

- Bluetooth Earphone
- One-Cell Lithium-ion Battery Pack
- Lithium-Polymer Battery Pack
- Wearable Device

General Description

The LPB1010H is a series FET integrated IC for Li-Battery protection.

The device contains a 60mΩ N-channel MOSFET which connect system ground with battery cathode. The device supports all protection for lithium-ion/polymer battery including over-charge voltage and over-discharge voltage protection, over-discharge current and over-discharge current protection, load short-circuit protection, over-temperature protection and so on.

The LPB1010H has very low current to save system consumption. Thanks to the high accuracy over-charge voltage protection, the LPB1010H can ensure safe and full utilized charging process.

These parts are available in a space-saving 4 pin DFN package with only 1mm x 1mm size.

Ordering and Package Information

Device	Marking	Over Discharge Current Protection	Over Charge Current Protection	Over Charge Voltage Protection	Shipping Mode	Package	Shipping
LPB1010HQVF	FWX	150 mA	300 mA	4.275V ± 0.025V	Yes	DFN-4	12K/REEL
LPB1010HQVF-435	SWX	150 mA	300 mA	4.425V ± 0.025V	Yes	DFN-4	12K/REEL
LPB1010HQVF-44	RWX	150 mA	300 mA	4.475V ± 0.025V	Yes	DFN-4	12K/REEL
Marking indication: W: Production Week, X: Series Number							

Typical Application Circuitry

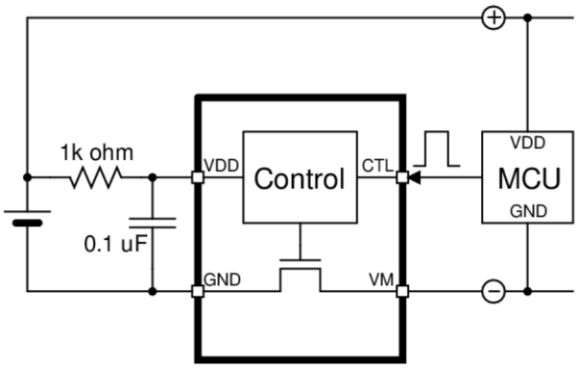
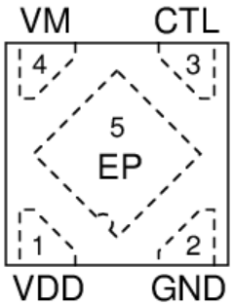
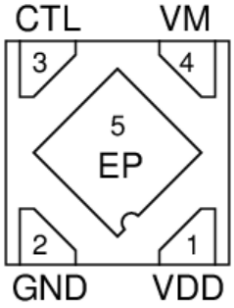


Figure 1. Typical Application Circuitry

Pin Configuration



Top View



Bottom View

Pin Description

Pin	Description
GND	IC Ground, connected to battery cathode
VDD	Power supply, connected to battery anode
VM	Output of internal switch, connected to system ground
CTL	Control pin for shipping mode, connected to MCU GPIO
EP	Exposed thermal pad, ground connection is suggested

Functional Block Diagram

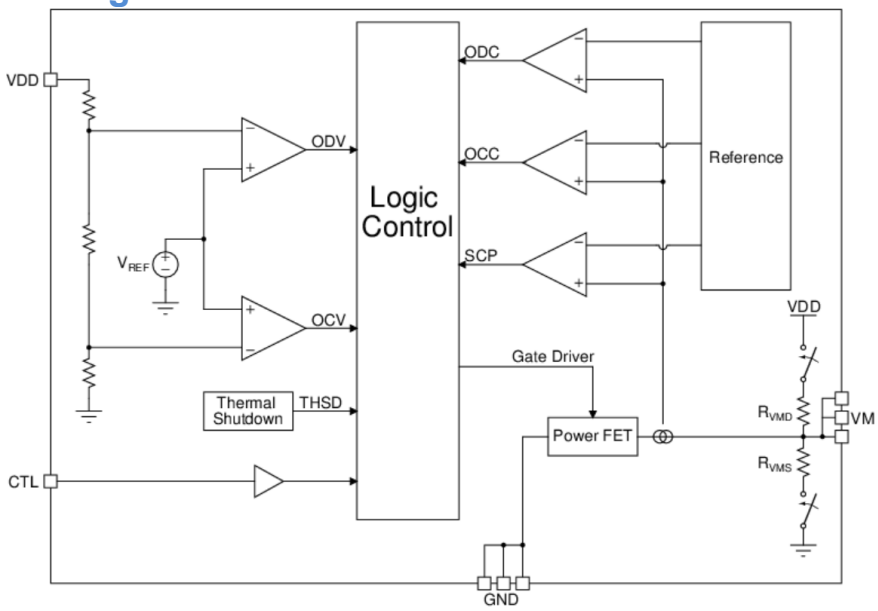


Figure 2. Internal Block Diagram

Absolute Maximum Ratings (Note 1)

- VDD to GND ---------- -0.3V to +7V
- VM to GND ---------- -7V to +7V
- CTL to GND ---------- -7V to +7V
- Maximum Junction Temperature (T_A) ---------- +150°C
- Storage Temperature Range ---------- -65°C to +150°C
- Maximum Soldering Temperature (at leads, 10 seconds) ---------- +260°C

Note 1: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, instead of functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Thermal Information

- Maximum Power Dissipation (P_D, T_A <= 25℃) ---------- 0.6W
- Thermal Resistance (From junction to ambient, θ_{JA}) (Note 2)---------- 170 °C/W

Note 2: It is based on 2S2P JEDEC standard PCB.

ESD Ratings

- HBM (Human Body Model, JEDEC JS-001) ---------- ±2000V
- CDM (Charged Device Model, JEDEC JS-002) ---------- ±500V

Recommended Operating Conditions

- VDD Voltage ---------- 0V to +4.2V
- VM Voltage ---------- 0V to +4.2V
- CTL Voltage ---------- 0V to +4.2V
- Ambient Temperature ---------- -40°C to 85°C

Electrical Characteristics

The following parameters are guaranteed under condition T_J = 25°C unless otherwise noted.

Parameters	Symbol	Test conditions	Min	Typ	Max	Unit
Resistance						
Power FET On-resistance	$R_{DS(ON)}$	V_{VDD} = 3.6V, I_{OUT}=100mA		60	75	mΩ
Pull-up resistance on VM	R_{VMD}	V_{VDD} = 2V, V_{VM} = 0V		300		kΩ
Pull-down resistance on VM	R_{VMS}	V_{VDD} = 3.6V, V_{VM} = 1V		25		kΩ
Current Consumption						
Input quiescent current	I_Q	V_{VDD} = 3.6V, VM floating		0.5	0.8	μA
Input current in shipping mode	I_{SM}	V_{VDD} = 3.6V, VM floating			10	nA
Over-Current Protection						
Over-charge current protection	I_{OCC}	V_{VDD} = 3.6V	200	300	400	mA
Over-discharge current protection	I_{ODC}	V_{VDD} = 3.6V	100	150	200	mA
Short circuit protection level (3)	I_{SHORT}	V_{VDD} = 3.6V	350	450	550	mA
Over/Under Voltage Protection						
Over-charge voltage protection	V_{CU}	T_J = 25°C, LPB1010HQVF	4.250	4.275	4.300	V
		T_J = 25°C, LPB1010HQVF-435	4.400	4.425	4.450	V
		T_J = 25°C, LPB1010HQVF-44	4.450	4.475	4.500	V
		T_J = -20°C to 65°C, LPB1010HQVF	4.235	4.275	4.315	V
		T_J = -20°C to 65°C, LPB1010HQVF-435	4.385	4.425	4.465	V
		T_J = -20°C to 65°C, LPB1010HQVF-44	4.435	4.475	4.515	V
Over-charge release level	V_{CL}	T_J = 25°C, LPB1010HQVF	4.025	4.075	4.125	V
		T_J = 25°C, LPB1010HQVF-435	4.375	4.225	4.275	V
		T_J = 25°C, LPB1010HQVF-44	4.225	4.275	4.325	V
Over-discharge voltage protection	V_{DL}	T_J = 25°C	2.7	2.8	2.9	V
Over-discharge release level	V_{DU}	T_J = 25°C	2.9	3.0	3.1	V

Over Temperature Protection						
Thermal shutdown level	T_{SD}			140		°C
Thermal shutdown release level	T_{SDR}			120		°C
Deglitch Timing						
Over-charge voltage protection deglitch time (3)	t_{CU}		70	110	150	ms
Over-charge voltage protection release time (3)	t_{CL}		6	9	12	ms
Over-discharge voltage protection deglitch time (3)	t_{DL}		30	40	50	ms
Over-charge current protection deglitch time (3)	t_{OCC}	V_{VDD} = 3.6V	6	9	12	ms
Over-discharge current protection deglitch time (3)	t_{ODC}	V_{VDD} = 3.6V	6	9	12	ms
Discharge short-circuit protection deglitch time (3)	t_{SHORT}	V_{VDD} = 3.6V		100		μs
Shipping mode deglitch time (3)	t_{SM}	V_{VDD} = 3.6V	30	50	70	ms
Logic Voltage Level						
VM logic high voltage level	V_{IH}	V_{VDD} = 3.6V	1.4			V
VM logic high voltage level	V_{IL}	V_{VDD} = 3.6V			0.4	V

Note 3. The parameter is guaranteed by design and characterization.

Typical Timing Diagram

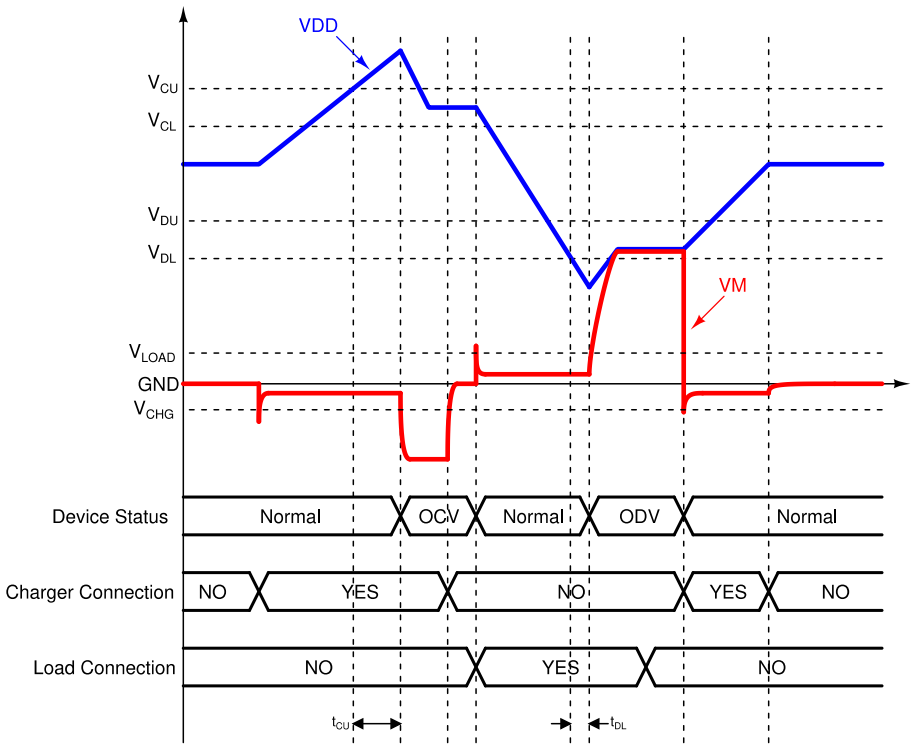


Figure 3. Typical Timing for Over-Charge Voltage and Over-Discharge Voltage Detection

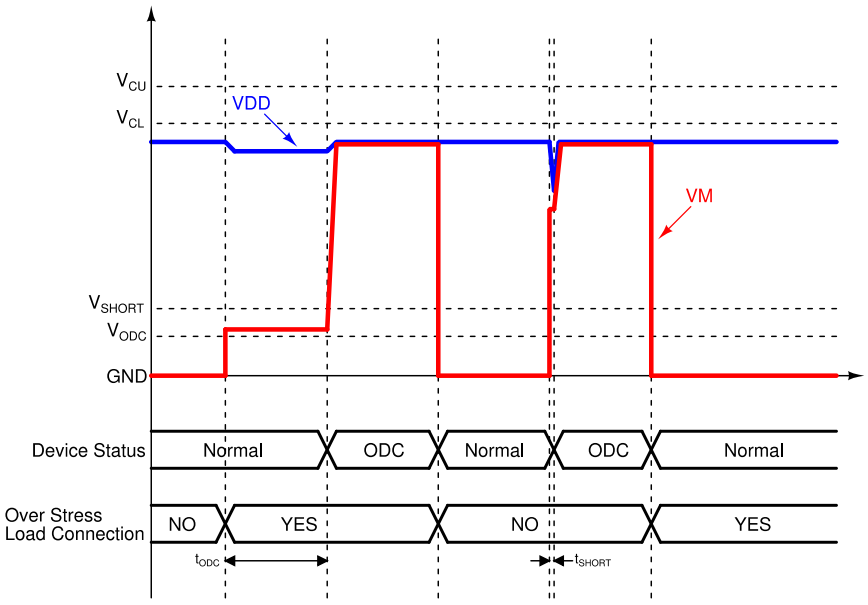


Figure 4. Typical Timing for Over-Discharge Current and Short Detection

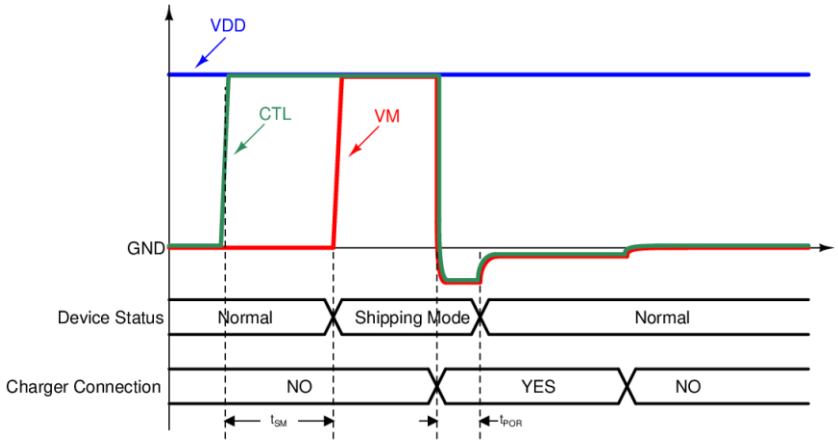


Figure 5. Typical Timing for Shipping Mode

Typical Characteristics and Diagrams

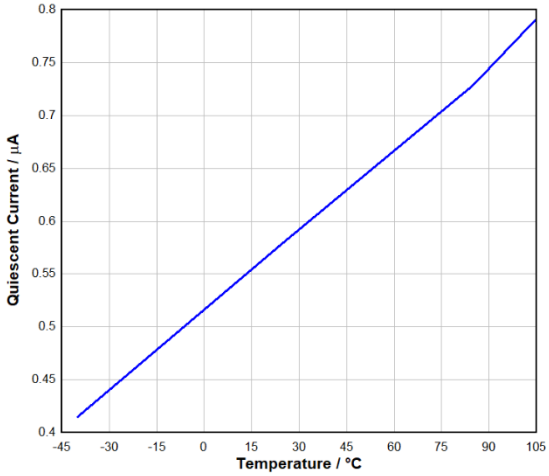


Figure 6. IQ vs Temperature (V_{DD} =3.6V)

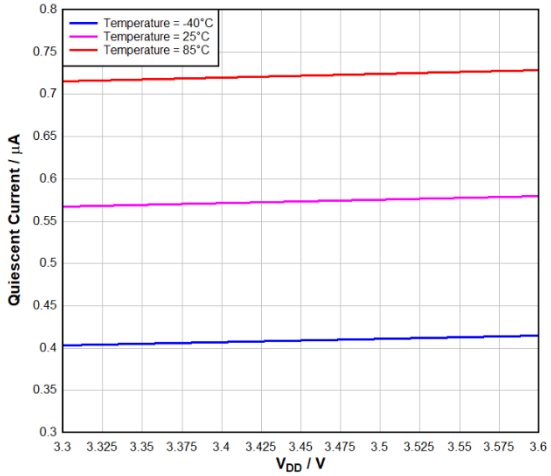


Figure 7. IQ vs Input Voltage

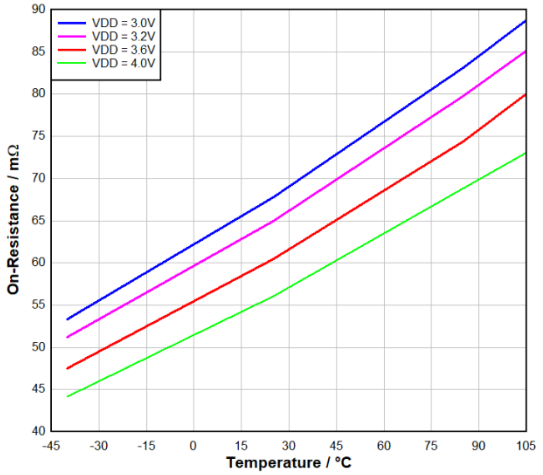


Figure 8. On-Resistance vs Temperature (C_{IN}=C_{OUT}=1µF, V_{EN}= 0V, no load, T_A = 25 °C)

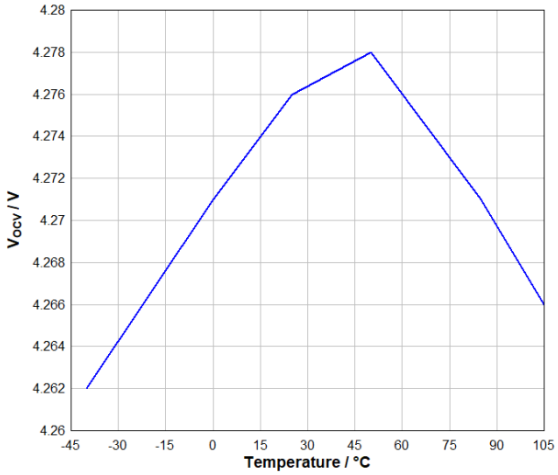


Figure 9. Over-Charge Voltage vs Temperature (Characterized typical device)

Function Description

LPB1010H series are power FET integrated IC solution for lithium-ion/polymer battery protection. The device will protect the battery from being damaged due to lots of system fault events including over-charge, over-discharge, over-current, short circuit, over-temperature and so on.

LPB1010H needs very limited external components. The small DFN-4 package with only 1mm x 1mm size will suit applications in very small PCB space.

Over-Charge Protection

The LPB1010H monitors the voltage between VDD pin and GND pin. When the battery is charged to a voltage higher than LPB1010H detection threshold (V_{CU}) for more than pre-set de-glitch time t_{CU} or longer, the device will disconnect the internal FET and stop charging. The IC enters over-charge protection status. In this status, there will be an internal diode connected VM pin and GND pin which allow current from VM to GND only.

The over-charge protection status is released in two cases:

1. When the VDD voltage falls below V_{CU} and the VM voltage is higher than V_{LOAD}.
2. When the VDD voltage falls below V_{CL} even if the VM voltage is lower than V_{LOAD}.

The above conditions means either the battery voltage has been discharged to low enough, or there is a loading is connected.

Over-Discharge Protection

When the battery voltage is dropped to a very low level, continue discharging will induce battery lifetime reduction. The LBP1010 will protect the battery in this case.

When the VDD voltage is dropped below V_{ODV} for t_{ODV} or longer, power FET will be turned off to stop discharging. This is called the over-discharge protection status. The charging current from GND to VM will still be allowed in this case. In this status, an internal resistor R_{VMD} will be connected between VM and VDD.

The over-discharge protection status will be released in the following two cases:

1. When the VDD voltage is higher than V_{ODVR}.
2. When the VM voltage is lower than V_{CHG}.

Under the over-discharge protection status, when the voltage difference between VDD and VM is smaller than V_{SD}, the LPB1010H will enter the shipping mode and the power consumption will be reduced to even lower (I_{SM}).

Charge Over-Current Protection

The LPB1010H will monitor the battery charging current. When the charging current is higher than I_{OCC} for t_{OCC} or longer, the internal power FET will be turned off and charging is stopped. This is call charge over-current status.

The LPB1010H will release the charge over-current status when the VM voltage is higher than V_{LOAD}, which means the charger is removed and enough loading is connected.

The charge over-current protection does not work when the LPB1010H is in over-discharge protection status.

Discharge Over-Current and Short-Circuit

When the discharge current flow from VM to GND is higher than I_{ODC} and continues for t_{ODC} or longer, the internal power FET will be turned off and discharging will not be allowed. This is called discharge over-current status.

When the discharge current is higher than I_{SHORT} for t_{SHORT} or longer, the LPB1010H will enter the same status like over-current protection. This is the short-circuit protection.

An internal resistor R_{VMS} is connected between VM and GND in this status. However, VM voltage will be closed to VDD instead of GND because of the heavy loading between VDD and VM. Thanks to the R_{VMS}, once the short-circuit or loading is removed, the VM voltage will drop from VDD to lower level. The LPB1010H will release discharge over-current or short-circuit protection status when the voltage difference between VDD and VM is smaller larger than V_{ODCR} for more than t_{ODC}.

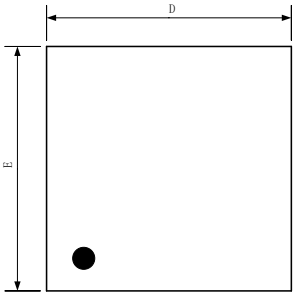
Shipping Mode

The LPB1010H supports GPIO controlled shipping mode. By entering the shipping mode, the LPB1010H will consume almost no current itself. At the same time, the discharge path to the system will be disabled. That means the system consumption will be cut-off to zero. The shipping mode will keep the system in “sleeping” and guarantee the battery in best status even after years “shipping” period.

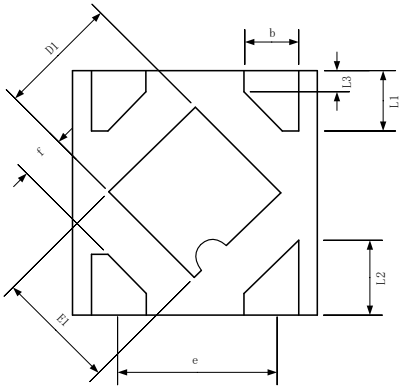
To enter to shipping mode, the CTL pin needs to be pulled up to high level and continues for t_{SM} or longer. There is internal pull-down resistor on CTL pin to keep the status stable even GPIO on CTL pin is floating.

Package Information

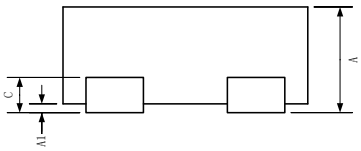
TDFN-4, 1mm x 1mm



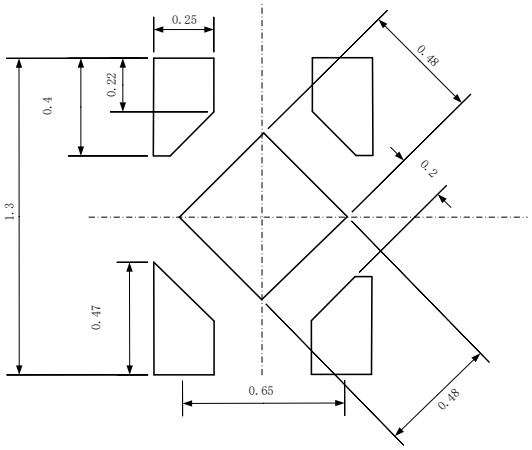
TOP VIEW



BOTTOM VIEW



SIDE VIEW



Recommended Land Pattern

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.35	-	0.40
A1	0.00	0.02	0.05
b	0.20	0.25	0.30
c	0.07	0.12	0.17
D	0.95	1.00	1.05
D1	0.43	0.48	0.55
E	0.95	1.00	1.05
E1	0.43	0.48	0.55
e	0.65BSC		
L1	0.2	0.25	0.30
L2	0.27	0.32	0.37
L3	0.09REF		
f	0.18REF		