General Description

The EC3651 is a high performance buck boost converter that the output voltage can be programed from 0.9V up to 16V through external resistor. The EC3651 implements the Buck Boost converter with a single inductor architecture that operates from input voltages above, below or equal to the output voltage. And support 2-switch boost mode for higher efficiency. The integrated low Rds(on) MOSFET minimizes physical footprint, maximizes efficiency, which reduces the power dissipation. Constant current control is utilized to protect the device from overshooting in unwanted conditions. Built-in loop compensation simplifies the circuit and design.
EC3651 guarantees robustness with under voltage lockout, short circuit protection and thermal protection.

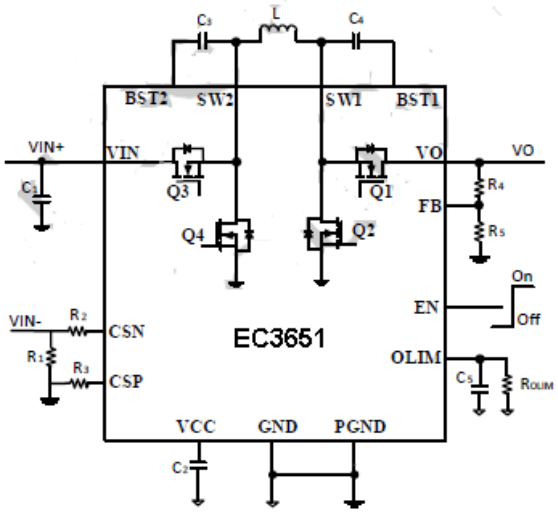
Features

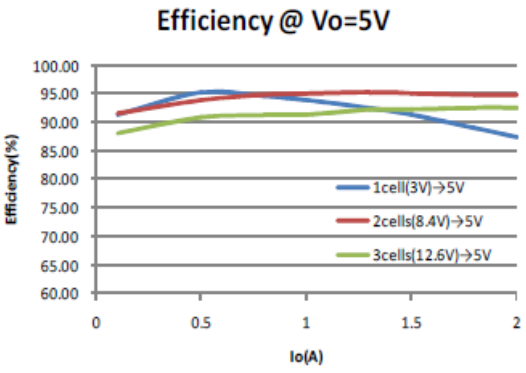
◆Integrate low RDS (on) power MOSFET
◆Wide VINrange:3.0V-16V
◆Wide VO range:0.9V-16V
◆Compatible with 4-switch buck-boost mode
◆and 2-switch boost mode.
◆Fixed frequency 500kHz
◆Programmable input and output current limit
◆Output Constant Current Control.
◆Quiescent current: <50uA
◆Integrate output overvoltage protection and
◆output short protection
◆Integrate thermal protection
◆QFN3*4 package

Applications

◆Power bank systems
◆USB Power Delivery
◆Industrial applications
◆Automotive Systems

Typical application





Ordering/Marking Information

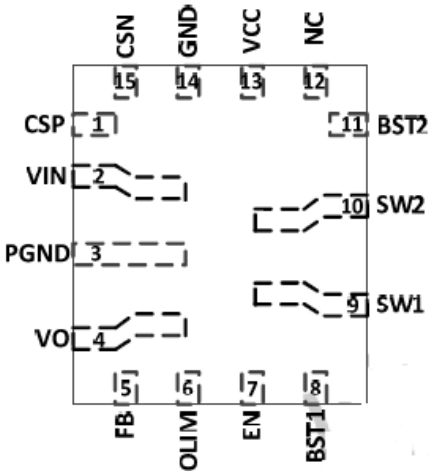
EC3651 XX X X

- XX: Package Type：Q4=QFN3*4-15L
- X: F：Pb Free / G：Green
- X: R：Tape & Reel

Device	Marking	Package	Mark information
EC3651Q4XR		QFN3*4-15L	

Pin Configurations

TOP VIEW



Absolute Maximum Ratings

VO, VIN, SW1, SW2Pin	-0.3Vto20V
BST1-SW1, BST2-SW2	-0.3Vto 6.5V
All Other Pins	-0.3Vto 6.5V
JunctionTemperature2)3)	150ºC
Lead Temperature	260ºC
Storage Temperature	-65ºC to +150ºC
ESD Susceptibility (Human Body Model)	2kV

Recommended Operating Conditions

Input Voltage VIN	3.0Vto 16V
Output Voltage VO	0.9Vto 16V
Operation Junction Temp (TJ)	-40ºCto +125ºC

Thermal Performance

QFN3X4-15	48	11ºC/W

Note
1) Exceeding these ratings may damage the device.
2) The EC3651 guarantees robust performance from -40°Cto 150°C junction temperature. The junction temperature range specification is assured by design, characterization and correlation with statistical process controls.
3) The EC3651 includes thermal protection that is intended to protect the device in overload conditions. Thermal protection is active when junction temperature exceeds the maximum operating junction temperature. Continuous operation over the specified absolute maximum operating junction temperature may damage the device.
4) Measured on JESD51-7, 4-layer PCB.

Electrical Characteristics

VIN=12V, TA=25 , unless otherwise stated						
Item	**Symbol**	**Condition**	**Min.**	**Typ.**	**Max**	**Units**
General parameters						
VIN voltage range	VIN		3.0		16	V
VIN under voltage lockout	VINUVLO	VIN increasing	2.9	3.0	3.	V
VIN UVLO hysteresis	VINHYS		320	400	48	mV
VCC output voltage	VCC		4.8	4.9	5.	V
VCC output current limit	IVCC	VVCC=0V		50		mA
Supply current in shut-	IQ	VIN=12V, VEN=0V		50	80	µA
EN Logic HIGH	VENH	VEN increasing			2.	V
EN Logic LOW	VENL	VEN decreasing	1.6			V
Switch frequency	Fsw	Optional switch frequency through tri m	400	500	60 0	kHz
Switch minimum off time	Toff_min		80	100	12	ns
Bucktop switch on-resistance	RdsbkTG			20	28	m
Buck bottom switch on-	RdsbkBG			20	28	m
Boost top switch on-resistance	RdsbstTG			20	28	m
Boost bottom switch on-	RdsbstBG			20	28	m
Feedback voltage	VFB		0.88	0.9	0.9	V
Input average current limit	IIN_LIM	R1=10m ; R2=R3=3k ;		3		A
OLIM pin output current sense r	KOLIM	IO=2A	4	5	6	µA/A
OLIM pin regulate voltage	VOLIM		380	400	42	mV
Output average current limit	IO_LIM	ROLIM=40K	1.9	2	2.	A
Buck region, (IL Valley)	ICOMP(MAX)	VVCC 4.8V		7		A
Boost region, (IL Peak)		VVCC 4.8V		7		
Protection						
VO over voltage threshold	VO_OVP	VO increasing		23.2		V
		VO decreasing		21.5		V
VO OVP deglitch time	tOVP		1.8	2	2.	µS
Thermal shutdown threshold5)	TSHUT			150		°C
Thermal recovery threshold5)	TREC			130		°C

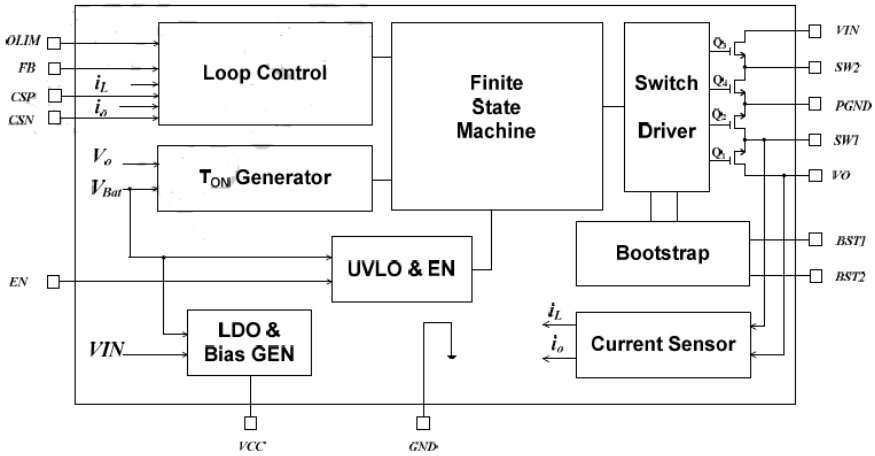
Notes:
5) Guaranteed by design.

Pin Description

Pin No.	Name	Description
1	CSP	Positive terminal of current sense.
2	VIN	Input pin, place bypass capacitor close to this pin.
3	PGND	Power Ground.
4	VO	Output pin, place bypass capacitor close to this pin.
5	FB	Output feedback pin.
6	OLIM	Output current limit program pin. Connect a resistor to GND to set the maximum average current. And in the light load, it could be output current detection pin.
7	EN	Enable control pin. Forcing the pin below 1.6V shuts down the converter, reducing quiescent current. Once the EN pin rises above 2.0V, the IC is turned on.
8	BST1	VO side bootstrap supply pin for top switch. 0.1uF capacitor is connected between BST1 and SW1 pins.
9	SW1	VO side power switching node.
10	SW2	VIN side power switching node. Connect to SW1 with inductor
11	BST2	VIN side bootstrap supply pin for top switch. 0.1uF capacitor is connected between BST2 and SW2 pins.
12	NC	No connection.
13	VCC	4.9V LDO for power driver and internal circuit. Must be bypassed to GND with a minimum of 10uF ceramic capacitor for stable operation.
14	GND	Signal GND.
15	CSN	Negative terminal of current sense.

Notes:
Highlighted pins are high current pins

Block Diagram

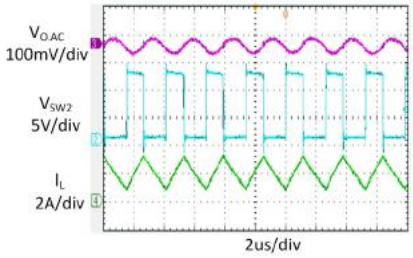


Typical Performance Characteristics

VIN =12V, VO = 5.0V, L = 3.3µH, CO = 40µF, TA = +25°C, unless otherwise noted

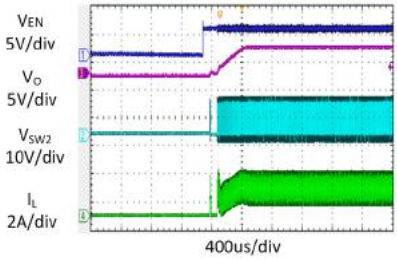
Steady State Test

VIN=12V, VO=5.0V
IO=2A



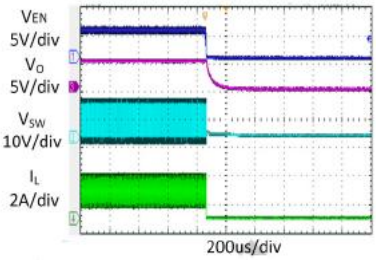
Startup through Enable

VIN=12V, VO=5.0V
IO=2A(Resistive load)



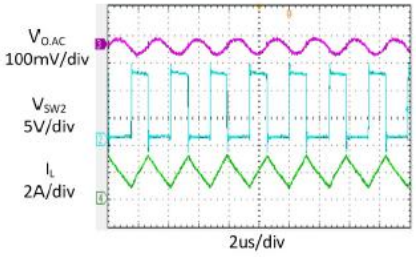
Shutdown through Enable

VIN=12V, VO=5.0V
IO=2A(Resistive load)



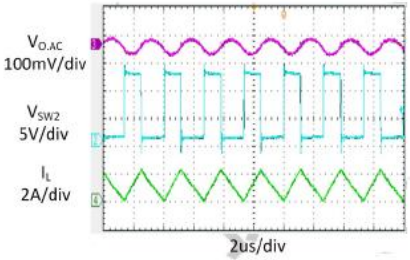
Heavy Load Operation

2A LOAD



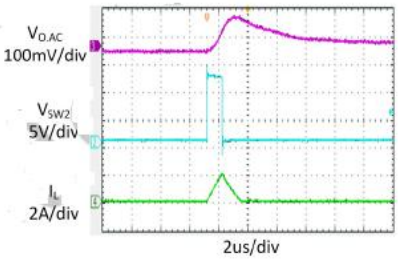
Medium Load Operation

1A LOAD



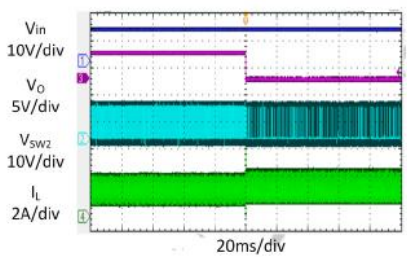
Light Load Operation

0 A LOAD



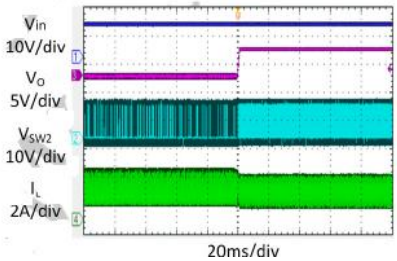
Short Circuit Protection

VIN=12V, VO=5.0V
IO=1.93A-Short



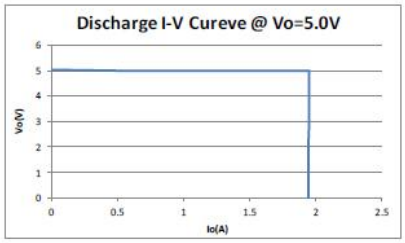
Short Circuit Recovery

VIN=12V, VO=5.0V
IO=Short-1.93A



Discharge I-V Curve

VIN=12V, VO=5.0V
IO_LIM=2A



Functional Description

EC3651 is a monolithic buck-boost DC to DC converter that can operate over a wide input voltage range of 3.0V to 16V. The output voltage can be programmed between 0.9V to 16V and deliver 3A of load current. Internal, low RDSON N-channel power switches reduce the solution complexity and efficiency.

Flexible Buck-Boost Converter

The EC3651 contains flexible buck-boost converter for either buck or boost converter. When VINis higher than output voltage, it is a buck converter. When VIN is lower than output voltage, it is a boost converter. The DC-DC converter utilizes proprietary single inductor current-mode control to guarantee smooth transition between buck and boost operation with better dynamic response and cycle-by-cycle current protection. EC3651 regulates the output voltage and output current.

Output Voltage

The output voltage is set by an external feedback resistive divider. The feedback signal is compared with internal precision 0.9V voltage reference by the error amplifier. The output voltage is given by the equation:

$$V_O(\mathrm{V}) = \frac{0.9(\mathrm{V}) \times (R_4 + R_5)}{R_5}$$

Where R4 and R5 are defined in typical application figure.

Programmable Input/Output Current Limit

As shown in figure1, the current sense resistor RCS should be placed input terminal or output terminal and closed To the RISET. The input/output current limit is set by RISET and RCS, which is optional. If the input/output current limit is not desired, the CSN pin should be shorted to VCC, and the CSP pin shorted to GND.

$$I_{IN/O\_LIM}(\mathrm{A}) = \frac{R_{ISET}(\mathrm{k\Omega})}{R_{CS}(\mathrm{m\Omega})} \times 10(\mu\mathrm{A/A})$$

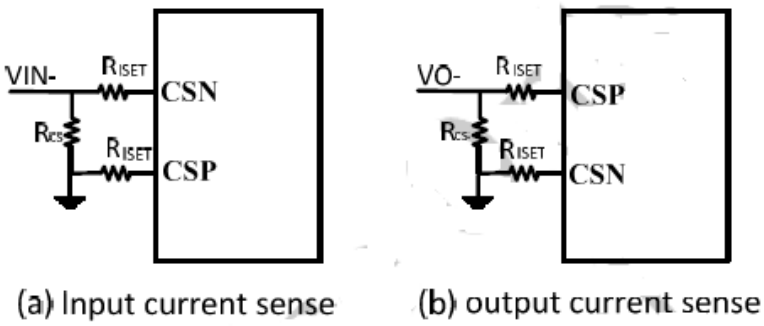


Figure1. Programmable current limit

If the input and output current limit are all necessary. The secondary output current limit can be programmable by ROLIM pin.

$$I_{O\_LIM}(\mathrm{A}) = \frac{0.4(\mathrm{V})}{R_{OLIM}(\mathrm{k\Omega})} \times 0.2(\mathrm{A/\mu A}) \times 1000$$

If the output current equals to theIO_LIM, the output current loop begins to work, it turns down output voltage to limit the output power. When OLIM is not used, it should be shorted to GND. When output is shorted to ground, the EC3651 works as a buck converter, the output current is continuously sensed and limited to IO_LIM. When the output short is removed, the regulator comes into normal operation again.

VIN UVLO

When VIN decreases to VIN_UVLO, the discharging process is terminated. When the VIN recovers and is larger than VIN_UVLO, the EC3651 can re-discharge if the VEN is still high.

Thermal Control

When the junction temperature of the EC3651 rises above 135°C, it begins to reduce the output power to prevent the Temperature from rising further. If the junction temperature of the EC3651 rises above 150°C, the discharging process stops.

Shut-down Mode

The EC3651 shuts down when voltage at EN pin is below 1.6V. The entire regulator is off.

Output Over Voltage Protection

If the output voltage is larger than VO_OVP rising threshold, the device stops switching. Until the output voltage is Less than VO_OVP falling threshold, the device re-starts switching again.

PCB Layout Note

For minimum noise problem and best operating performance, the PCB is preferred to following the guidelines as reference.

1. Place the input decoupling capacitor as close to EC3651 (VIN pin and PGND) as possible to eliminate noise at the input pin. The loop area formed by input capacitor and GND must be minimized.
2. Put the feedback trace as far away from the inductor and noisy power traces as possible.
3. The ground plane on the PCB should be as large as possible for better heat dissipation.

Reference Design

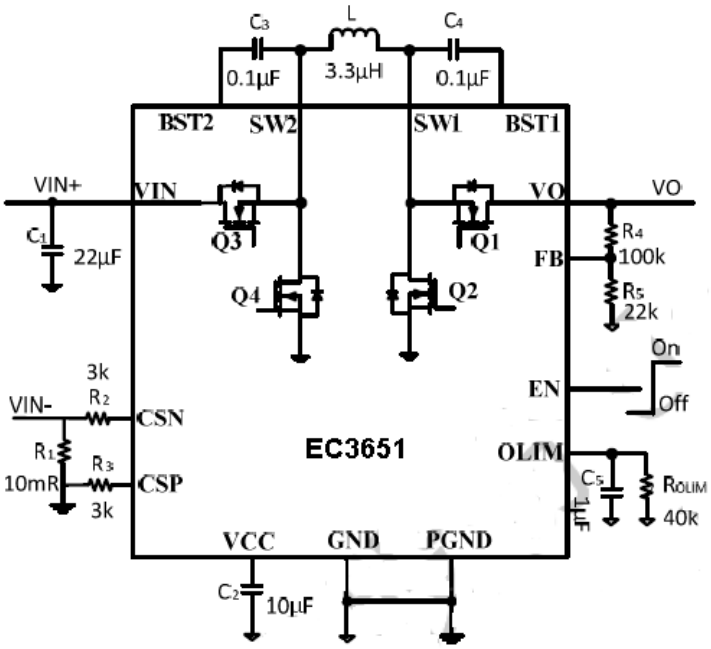
Reference 1：Input and output current limit set

VIN: 3.0V ~ 16 V

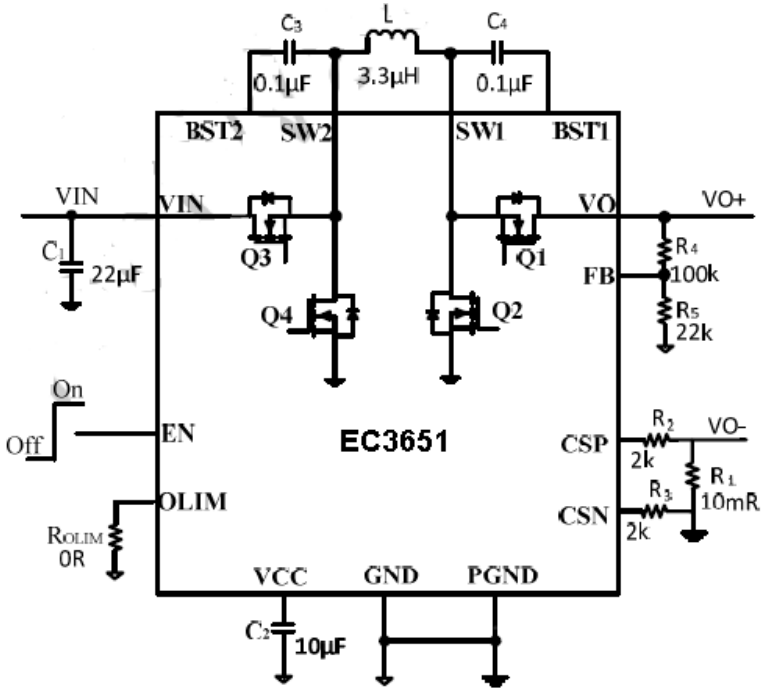
VOUT: 5.0V

IIN_LIM : 3A

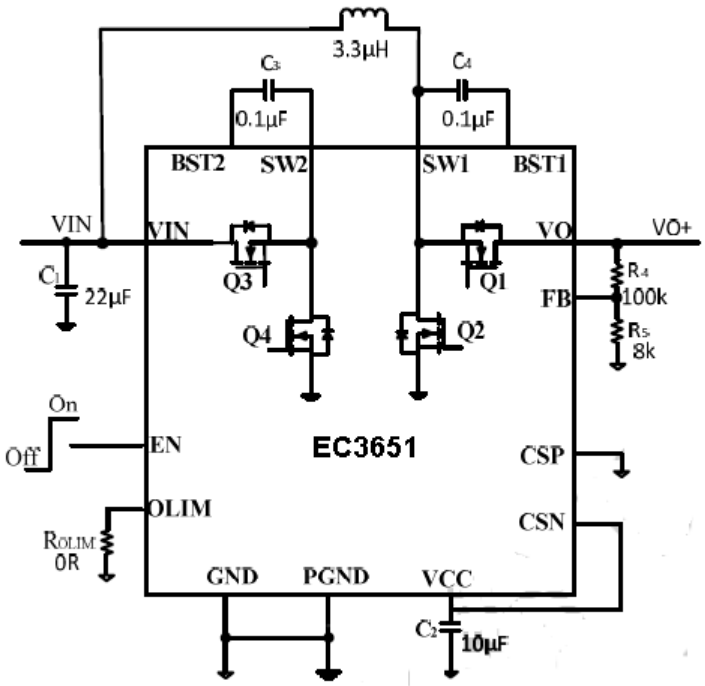
IO_LIM : 2A



Reference 2：Only output current limit set
VIN: 3.0V ~ 16 V
VOUT: 5.0V
IO_LIM : 2A

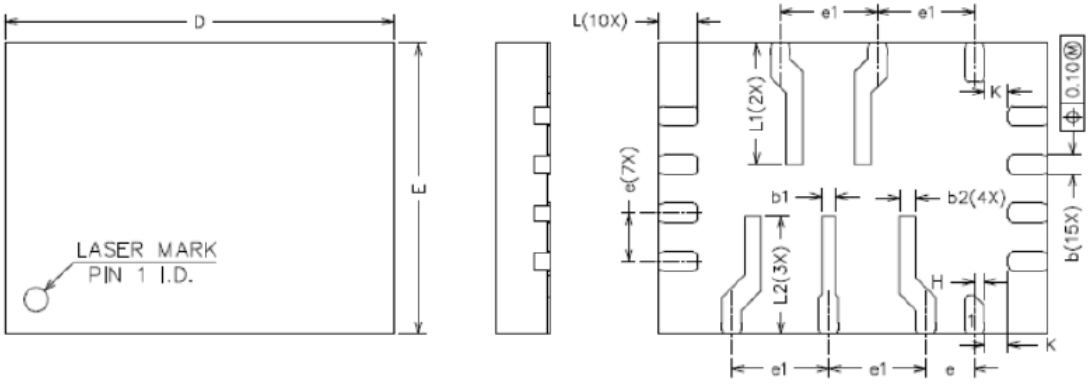


Reference 3：2-switch mode and no current limit
VIN: 5.0V ~ 10 V
VOUT: 12V
IO: 0~2A

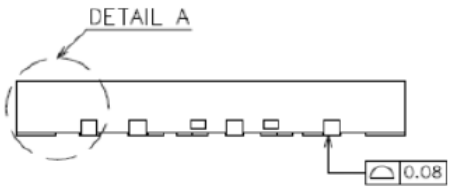


Package Outline

QFN3X4-15



TOP VIEW SIDE VIEW BOTTOM VIEW



SIDE VIEW

SYMBOL	MIN	NOM	MAX
A	0.50	0.55	0.60
A1	0.00	0.02	0.05
A3		0.15REF	
b	0.15	0.20	0.25
b1	0.09	0.14	0.19
b2	0.12	0.17	0.22
D	3.90	4.00	4.10
E	2.90	3.00	3.10
e	0.40	0.50	0.60
e1	0.90	1.00	1.10
H		0.10REF	
K	0.15	0.25	0.35
L	0.30	0.40	0.50
L1	1.15	1.25	1.35
L2	1.12	1.22	1.32