5.5V 4A Load Switch with Reverse Current Protection and Controlled Turn On

General Description

The ET3565 is a small, ultra-low R_{ON} load switch with controlled turn on. The device contains a low R_{ON} N-Channel MOSFET that can operate over an input voltage range of 1 V to 5.5 V and switch currents of up to 4 A. An integrated charge pump biases the NMOS switch in order to achieve a low switch ON-Resistance. The switch is controlled by an on/off input (ON), which is capable of interfacing directly with low-voltage GPIO control signals. The rise time of the ET3565 device is internally controlled in order to avoid inrush current.

The ET3565 provides reverse current protection. When the power switch is disabled, the device will not allow the flow of current towards the input side of the switch. The reverse current protection feature is active only when the device is disabled so as to allow for intentional reverse current (when the switch is enabled) for some applications.

The ET3565 is available in a small, space-saving WLCSP6 package and is characterized for operation over the free air temperature range of -40°C to 85°C.

Features

- Integrated N-MOSFET Load Switch
- Input Voltage Range: 1.0V to 5.5V
- Ultra-Low On-Resistance
  -- R_{ON} = 17.5mΩ @ V_{IN} = 3.3V
- Reverse Current Protection (When Disabled)
- Low Shutdown Current: 135nA (TYP)
- Low Threshold 1.2V GPIO Control Input
- Controlled Slew Rate to Avoid Inrush Current
- Bi-directional Power Supplier for Power Zone Application
- Part No. and Package

Part No.	Package	MSL
ET3565	WLCSP6 (1.36mm*0.86mm*0.55mm)	Level 1

Applications

- Smartphone
- Notebook Computer and Ultra-book
- Tablet PC Computer
- Solid State Drive (SSD)
- DTV/IP Set Top Box
- POS Terminal and Media Gateway

Pin Configuration

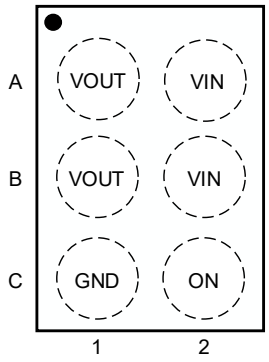


Fig 1. Top View

Pin Function

Pin Name	Symbol	Pin Description
A1, B1	VOUT	Switch Output.
A2, B2	VIN	Switch Input. Use a bypass capacitor (ceramic) to ground.
C1	GND	Ground.
C2	ON	Switch Control Input. Do not float this pin. Logic high turns on power switch

Block Diagram

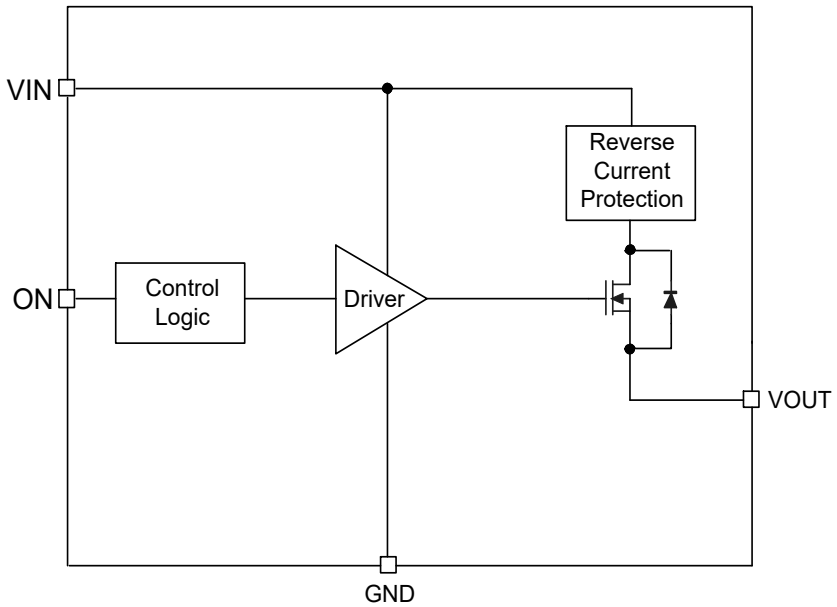


Fig 2. Functional Block Diagram

Functional Description

ON/OFF Control

The ON pin controls the switch. The ON pin is compatible with standard GPIO logic threshold. It can be used with any micro-controller with 1.2V,1.8V,2.5V,3.3V or 5.5V GPIO.

Table 1. Function Table

On State	V_{IN} to V_{OUT}
L	Off
H	On

Reverse Current Protection

The reverse current protection feature prevents the current to flow from V_{OUT} to V_{IN} when ET3565 are disabled. This feature is particularly useful when the outputs of ET3565 need to be driven by another voltage source after ET3565 are disabled (for example in a power multiplexer application).
In order for this feature to work, ET3565 have to be disabled and either of the following conditions shall be met: V_{IN} > 1V or V_{OUT} > 1V.

Application Information

Input Capacitor

It is recommended to place a capacitor (C_{IN}) between VIN and GND pins of ET3565. This capacitor helps to limit the voltage drop on the input voltage supply when the switch turns ON into a discharged load capacitor. A 1μF ceramic capacitor that is placed close to the IC pins is usually sufficient. Higher values of C_{IN} can be used to further reduce the voltage drop in high current applications.

Output Capacitor

It is recommended to place a capacitor (C_{OUT}) between VOUT and GND pins of ET3565. This capacitor acts as a low pass filter along with the switch ON-resistance to remove any voltage glitches coming from the input voltage source. It is generally recommended to have C_{IN} greater than C_{OUT} so that once the switch is turned ON, C_{OUT} can charge up to V_{IN} without V_{IN} dropping significantly. A 0.1μF ceramic capacitor that is placed close to the IC pins is usually sufficient.

Standby Power Reduction

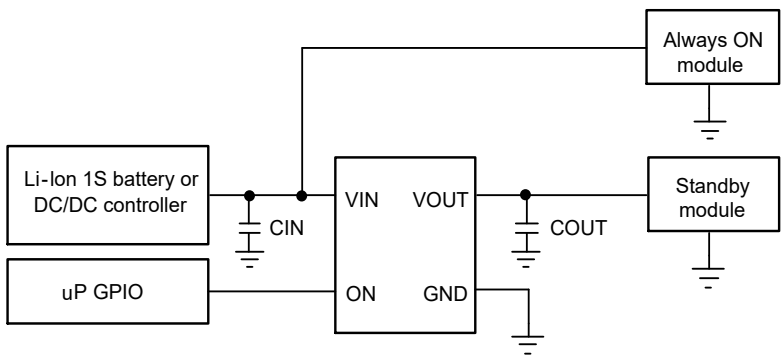


Fig3. Typical Application

Any end equipment that is being powered from the battery has a need to reduce current consumption in order to keep the battery charged for a longer time. ET3565 helps to accomplish this by turning off the supply to the modules that are in standby state and hence significantly reduces the leakage current overhead of the standby modules, shows in Fig3.

Power Supply Sequencing Without a GPIO Input

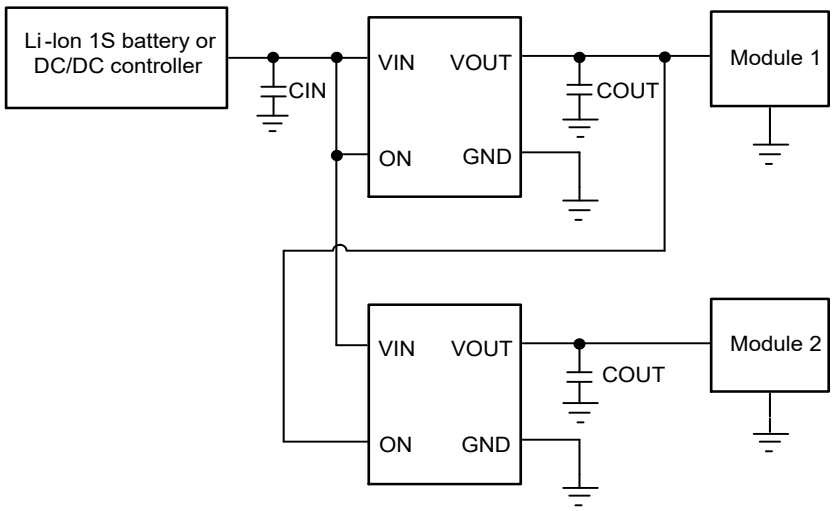


Fig 4. Power Supply Sequencing Without a GPIO Input

In many end equipment, there is a need to power up various modules in a predetermined manner. ET3565 can solve the problem of power sequencing without adding any complexity to the overall system. Fig4 shows the configuration required for powering up two modules in a fixed sequence. The output of the first load switch is tied to the enable of the second load switch, so when Module 1 is powered the second load switch is enabled and Module 2 is powered.

Typical Application

ET3565 is an ultra-low ON-resistance, 4A integrated load switch that is capable of interfacing directly with 1S battery in portable consumer devices such as smartphones, tablets etc. Its wide input voltage range (1 V to 5.5 V) makes it suitable to be used for lower voltage rails as well inside different end equipments to accomplish power sequencing, inrush current control and reducing leakage current in subsystems that are in standby mode.

Fig 5 shows the typical application circuit of ET3565.

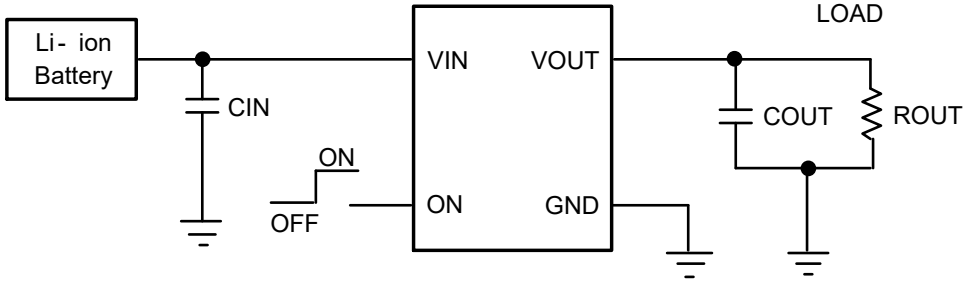


Fig 5. Typical Application Circuit

Power Supply Recommendations

The device is designed to operate with a V_{IN} range of 1 V to 5.5 V. This supply must be well regulated and placed as close to the device terminal as possible with the recommended 1 µF bypass capacitor.
If the supply is located more than a few inches from the device terminals, additional bulk capacitance may be required in addition to the ceramic bypass capacitors. If additional bulk capacitance is required, an electrolytic, tantalum, or ceramic capacitor of 10 µF may be sufficient.

Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted)

Symbol	Parameter	Rating	Unit
V_{IN}	Input voltage range	-0.3 to 6.0	V
V_{OUT}	Output voltage range	-0.3 to 6.0	V
V_{ON}	ON pin voltage range	-0.3 to 6.0	V
I_{MAX}	Maximum continuous switch current	4	A
T_J	Operating Junction Temperature	-40 to 150	°C
T_{STG}	Storage temperature range	-65 to 150	°C
T_{SLOD}	Lead Temperature (Soldering, 10 sec)	300	°C
$R_{\theta JA}$	Thermal Resistance, Junction-to-Air	83	°C/W
ESD	Human Body Model (JESD22-A114)	±4.0KV	V
	Charged Device Model (JESD22-C101)	±1.5KV	V
L_U	Latch Up(EIA/JESD78E)	±200	mA

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
V_{IN}	Input voltage range	1.0	5.5	V
V_{OUT}	Output voltage range	0	5.5	V
V_{ON}	ON pin voltage range	0	V_{IN}	V
T_A	Operating free air temperature range	-40	85	°C
C_{IN}	Input capacitor	1[(1)]		uF

Note1: Refer to the application section.

Electrical Characteristics

(Typical values are at T_A = +25°C, V_{IN} = 1V to 5.5V. unless otherwise noted.)

Symbol	Parameter	Conditions	T_A = +25°C			Unit
			Min	Typ	Max	
V_{IN}	Input Voltage Range		1.0[(2)]		5.5	V
I_{Q_VIN}	Quiescent Current	I_{OUT} = 0, V_{ON} = V_{IN} = 5.5V,T_A = +25°C		0.510	1.0	μA
		I_{OUT} = 0, V_{ON} = V_{IN} = 5.0V,T_A = +25°C		0.460	1.0	
		I_{OUT} = 0, V_{ON} = V_{IN} = 4.5V,T_A = +25°C		0.380	1.0	
		I_{OUT} = 0, V_{ON} = V_{IN} = 3.3V,T_A = +25°C		0.325	1.0	
		I_{OUT} = 0, V_{ON} = V_{IN} = 2.5V,T_A = +25°C		0.290	1.0	
		I_{OUT} = 0, V_{ON} = V_{IN} = 1.8V,T_A = +25°C		0.265	1.0	
		I_{OUT} = 0, V_{ON} = V_{IN} = 1.2V,T_A = +25°C		0.220	1.0	
		I_{OUT} = 0, V_{ON} = V_{IN} = 1.0V,T_A = +25°C		0.175	1.0	
I_{SD_VIN}	Shutdown Current	V_{ON} = 0V, V_{IN} = 5.5V, V_{OUT} = 0V,T_A = 25°C		0.135	0.5	μA
		V_{ON} = 0V, V_{IN} = 1V, V_{OUT} = 0V,T_A = +25°C		0.022	0.5	
R_{ON}	On-Resistance	V_{IN} = 5.5V, I_{OUT} = -200mA	8.5	17.0	26	mΩ
		V_{IN} = 3.3V, I_{OUT} = -200mA	9.0	17.5	28	
		V_{IN} = 1.8V, I_{OUT} = -200mA	10.0	18.0	30	
		V_{IN} = 1.0V, I_{OUT} = -200mA	12.0	24.0	40	
V_{IH}	ON High-level ON voltage	V_{IN} = 1.0V to 5.5 V	0.9			V
V_{IL}	ON Low-level ON voltage	V_{IN} = 1.0V to 5.5 V			0.4	V
I_{ON}	ON Pin Leakage Current	V_{ON} = 1.0V to 5.0V, V_{IN} = 5.5V		2	150	nA
I_{RC_VOUT}	Reverse Current When Disabled	V_{ON} = 0V, V_{IN}=3.0V, V_{OUT} = 3.8V		0.07	1.0	μA

Note2: When V_{IN} <1.5V, we suggest to set V_{ON} ≥1.5V, which can reduce R_{ON}.

Switching Characteristics

Parameter		Conditions	T_A = +25°C			Unit
			Min	Typ	Max	
V_{IN} = 5.0V,T_A = +25°C, unless otherwise noted.						
t_{ON}	Turn-On Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	1200	1700	2200	μs
t_{OFF}	Turn-Off Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	3	10	20	
t_R	V_{OUT} Rise Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	900	1400	2100	
t_F	V_{OUT} Fall Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	0.5	2.1	10	
t_D	Delay Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	800	1300	1800	
V_{IN} = 3.3V,T_A = +25°C, unless otherwise noted.						
t_{ON}	Turn-On Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	1100	1600	2100	μs
t_{OFF}	Turn-Off Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	3	10	20	
t_R	V_{OUT} Rise Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	800	1300	2000	
t_F	V_{OUT} Fall Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	0.5	2.1	10	
t_D	Delay Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	600	1100	1600	
V_{IN} = 1.8V,T_A = +25°C, unless otherwise noted.						
t_{ON}	Turn-On Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	750	1500	2250	μs
t_{OFF}	Turn-Off Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	3	10	20	
t_R	V_{OUT} Rise Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	600	1100	1800	
t_F	V_{OUT} Fall Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	0.5	2	10	
t_D	Delay Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	600	1100	1600	
V_{IN} = 1.2V,T_A = +25°C, unless otherwise noted.						
t_{ON}	Turn-On Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	750	1500	2250	μs
t_{OFF}	Turn-Off Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	3	10	20	
t_R	V_{OUT} Rise Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	1200	2100	2800	
t_F	V_{OUT} Fall Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	0.5	2	10	
t_D	Delay Time	R_{OUT} = 10Ω, C_{IN} = 1μF, C_{OUT} = 0.1μF	700	1200	1700	

Typical Characteristics

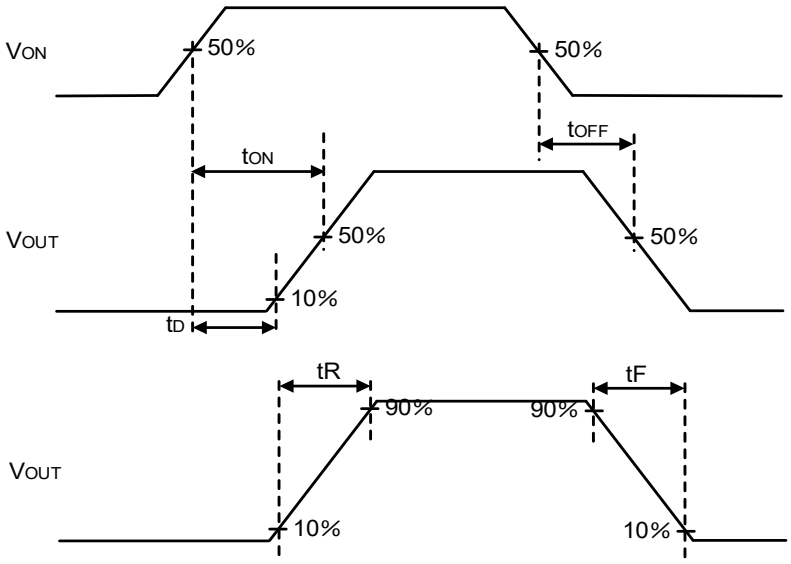
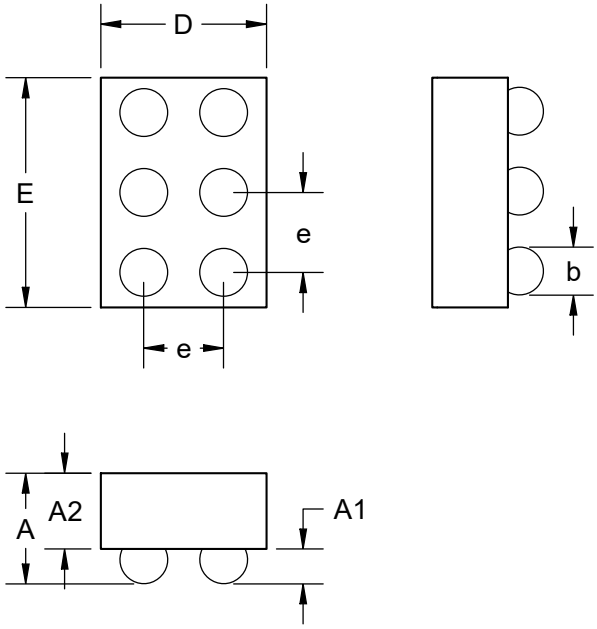


Fig 6. Timing Diagram

Package Dimension

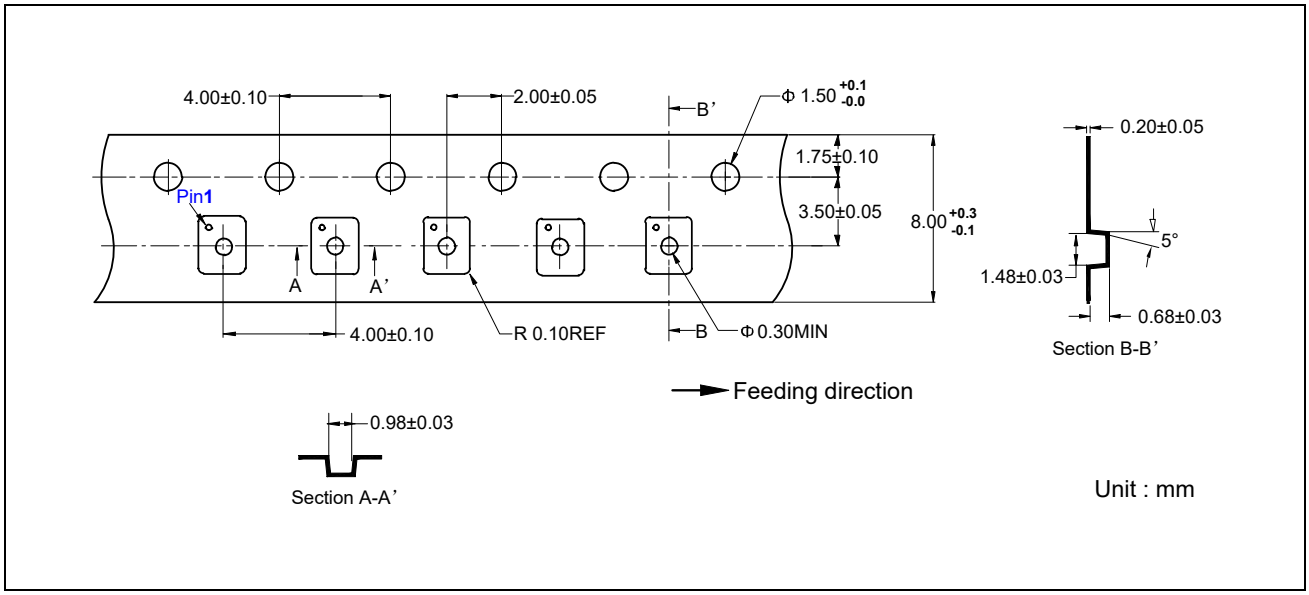
WLCSP6 (1.36mm×0.86mm)



Dimensions Table (Units: mm)

Symbol	Min	Nom	Max
A	0.52	0.55	0.58
A1	0.175	0.195	0.215
A2	0.340	0.355	0.370
b	0.245	0.265	0.285
D	0.84	0.86	0.88
E	1.34	1.36	1.38
e	0.500BSC		

Tape



Revision History and Checking Table

Version	Date	Revision Item	Modifier	Function & Spec Checking	Package & Tape Checking
0.0	2022-02-11	Preliminary Version	Wuxj	Wuxj	Liujy
0.1	2023-11-08	Update Format	Wangar Shibo	Tugz	Liujy
0.2	2024-01-24	Add SPEC & Tape & Marking	Tugz	Luh	Liujy
1.0	2024-03-27	Official Version Change V_{IN}=1.2V to 1.0V	Tugz	Luh	Liujy
1.1	2024-07-12	Update I_{RC_VOUT} Condition & Type Data	Tugz	Luh	Liujy