Secondary-Side Synchronous Rectifier Driver

DESCRIPTION

The ETA8003 is a high performance and highly integrated secondary side synchronous rectification controller in switch mode power supply system. It drivers a much lower voltage drop N-channel MOSFET to replaces the output rectifier diode in a flyback topology. This can reduce heat dissipation, improve system efficiency, and simplify thermal design. It can effectively help power system meet the latest DOE2.0 standard average efficiency requirement. Very low quiescent current in standby mode ensures lower system standby power.

The ETA8003 is suitable for flyback converter operating in continuous conduction mode (CCM), discontinuous conduction mode (DCM), and quasi-resonant mode. Especially for CCM, to guarantee system reliability, Patented Gate voltage adjustment technology and Fast shutdown judgment methods are used in SR turn-off control.

The ETA8003 can support wide range of system output voltage 5-20V offline AC/DC flyback converter with universal AC inputs, such as PD/QC adaptor e.g. It is suitable for fast charging power solutions within 45W.

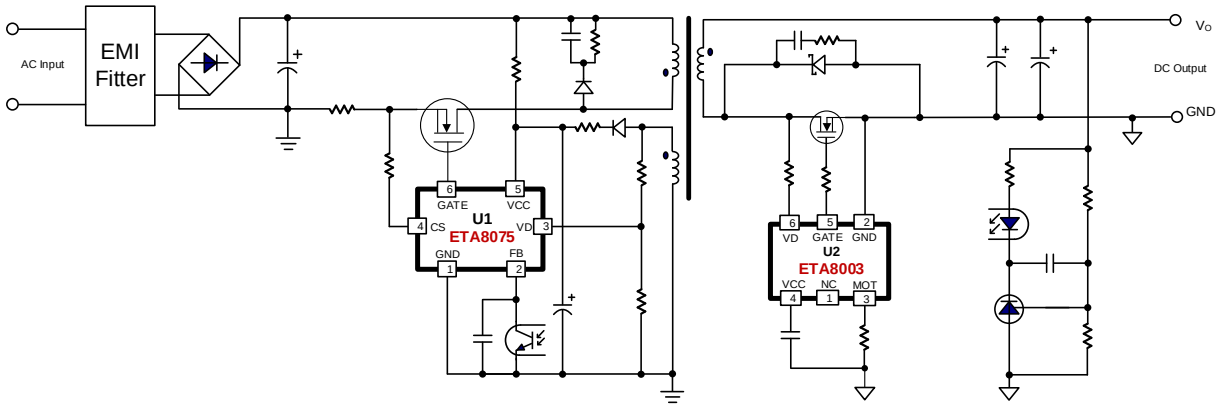
FEATURES

- Supports CCM, DCM and QR Operation Mode
- Suitable for 10-200KHz switching frequency
- Externally adjustable minimum on time
- Up to 120V VD pin high voltage
- Power savings in standby mode or light load
- Self-powered technology without extra Winding
- Fast turns on/off
- Supports both High/Low Side Rectification
- Available in a Standard SOT23-6 Package
- RoHS Compliant

APPLICATIONS

- Universal AC-DC adaptors
- USB QC/PD Quick Chargers/Adaptors
- Flyback Power Supplies with Variable Output Voltage
- High Output Current Flybacks
- High Efficiency Flybacks

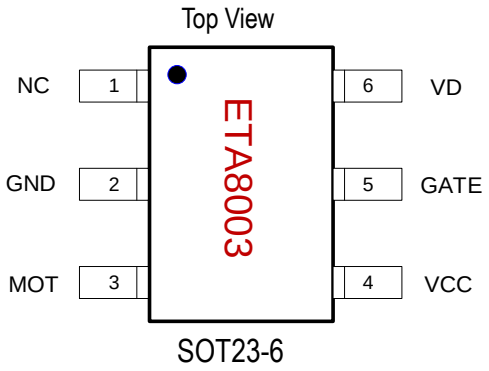
TYPICAL APPLICATION



ORDERING INFORMATION

PART No.	PACKAGE	TOP MARK	Pcs/Reel
ETA8003S2G	SOT23-6	YWWXL	3000

PIN CONFIGURATION



ABSOLUTE MAXIMUM RATINGS

(Note: Exceeding these limits may damage the device. Exposure to absolute maximum rating conditions for long periods may affect device reliability.)

VD Voltage .....–0.7V to 130V
VCC, VG Voltage .....–0.3V to 15V
MOT Voltage .....–0.3V to 6V
Maximum Power Dissipation (SOT23-6) 0.45W
Operating Temperature Range ....–40°C to 105°C
Storage Temperature Range.....–55°C to 150°C

Thermal Resistance	θ_{JC}	θ_{JA}
SOT23-6	110	220 °C/W

Lead Temperature (Soldering, 10sec) .....260°C

ELECTRICAL CHARACTERISTICS

(V_{CC} = 10V, unless otherwise specified. Typical values are at TA = 25°C.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Supply (VCC PIN)					
VCC Turn-On Voltage	VCC Rising from 0	4	5	6	V
VCC Turn-Off Voltage	VCC Falling after Turn-on	3	3.4	3.8	V
VCC Operation Normal Voltage	VCC Rising from 0	9	10	11	V
VCC Charging Current	VCC Rising from 0		40		mA
VCC Supply Current	VCC=12V,CL=2.2nF,Freq=100K		6	8	mA
Quiescent Supply Current	VCC=12V, after VCC Turn-on		0.3	0.45	mA
Startup Supply Current	VCC=3V, before VCC Turn-on		50	100	μA
Voltage Detection (VD PIN)					
Turn-off Threshold (VD-GND)	VCC=12V, CL=2.2nF	-11	-6	-1	mV
Turn-on Threshold	VCC=12V, CL=2.2nF	-340	-280	-220	mV
Turn-on slew rate detection timer	VCC=12V, CL=2.2nF	20	30	40	nS
Forward regulation voltage (VD - GND)	VCC=12V, CL=2.2nF	-50	-40	-30	mV
Turn-on Blanking Time	VCC=12V, CL=2.2nF		1/3MOT		nS
Turn-on Delay Time	VCC=12V, CL=2.2nF		30		nS
Turn-off Blanking Time	VCC=12V, CL=2.2nF		1		us
Turn-off Delay Time	VCC=12V, CL=2.2nF		25		nS
VD Leakage Current	VD=120V			1	uA
Gate Drive (GATE PIN)					
Gate High Level current source	VGATE = 10V, CL=2.2nF		2		A

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Gate Low Level current sink	VGATE=5V, CL=2.2nF		3		A
Gate Low Voltage	VCC=12V, CL=2.2nF			0.2	V
Gate High Voltage	VCC=12V, CL=2.2nF	9	10	11	V
	3V<VCC<10V, CL=2.2nF		VCC		V
Pull up resistance	VCC=12V, CL=2.2nF		4		Ω
Pull down resistance	VCC=12V, CL=2.2nF		0.7		Ω
Turn on propagation delay	VCC=12V, CL=2.2nF		10		nS
Turn off propagation delay	VCC=12V, CL=2.2nF		7		nS
Gate Dropping Clamp Voltage	VCC=12V, CL=2.2nF		3		V
Minimum On Time (MOT PIN)					
Minimum On Time	MOT Short		300		nS
	R_{MOT}=68K, Vcc=12V		1.2		μS
	R_{MOT}=300K, Vcc=12V		5.5		μS
	MOT Floating		1		μS
MOT Threshold Voltage			1		V
Minimum Off Time			100		nS

PIN DESCRIPTION

PIN #	NAME	DESCRIPTION
1	NC	Not connect.
2	GND	IC Ground.
3	MOT	Minimum on time control pin, A resistor is connected from this pin to GND.
4	VCC	Power Supply. This pin provides bias power for the IC during startup and steady state operation.
5	GATE	Gate Drive. Gate driver for the external Low Rdson MOSFET transistor.
6	VD	Voltage Detection. External N- MOSFET transistor drains voltage sense.

FUNCTIONAL DECRIPTIONS

The ETA8003 is designed for flyback converters, which can work in secondary side current discontinuous conduction mode (DCM), continuous conduction mode (CCM), and quasi-resonant (QR) mode. The control circuitry turns on the SR MOSFET when MOSFET's body diode conduct and turn off it when secondary side current drops to near zero level. The IC can support both high side and low side.

Startup and under voltage lockout (UVLO)

During startup, the VCC capacitor is charged by VD pin. When VCC capacitor is charged to VCC_ON threshold, the device wakes up quickly. And then The IC will monitor VD voltage. Once the conditions meet, the GATE will output immediately.
When Vcc is below the UVLO threshold, the ETA8003 enters sleep mode, and GATE remains at a low level.

Turn On/Off Blanking

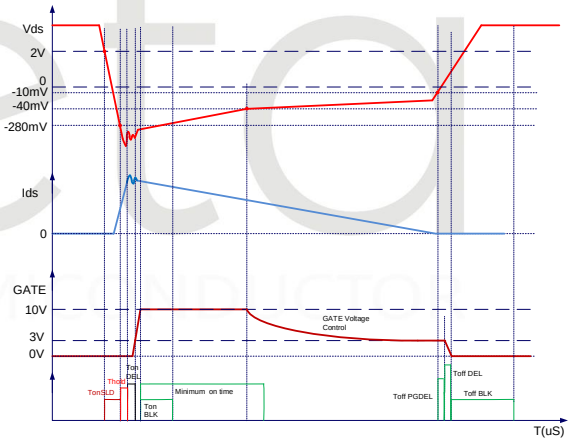
The logic circuitry contains two blanking functions. When the MOSFET turns on, the logic circuit ensures that the on state lasts for a specific period of time. The turn-on blanking time is to prevent an accidental turn-off due to the ringing. However, if VDS reaches 2V within the turn-on blanking time, VGS is pulled low immediately.
The gate is pulled to zero when VDS reaches the turn-off threshold. A turn-off blanking time is applied, during which the gate driver signal is latched off. Such logic control can avoid the false turn on of SR MOSFET, even the shoot-through during demagnetizing period, for the demagnetizing ring may reach the VDS turn on threshold and turn on the SR MOSFET by mistake. Even if this will limit the maximum supported frequency, it is still worthwhile in terms of system security.

Gate Driver

In order to guarantee fast turn-on and turn-off of SR MOSFET, ETA8003's gate driver offer strong driver capability, typical 2A source and 3A sink current. Under the same SR MOSFET conditions, ETA8003 provides a 10V driving voltage, higher than the conventional 5V gate driver, resulting in smaller RDSON of SR MOSFET to reduce power loss.
The drive voltage of ETA8003 will start automatic loop adjustment when VDS is greater than -40mV after the blanking time. The gate voltage may be drop to its minimum value 3V.This makes ETA8003 prepare for even the fast turn-off operation.
In any other case except to actively turn on the SR MOSFET, the GATE keeps at a low impedance to pull down the SR MOSFET gate voltage to prevent false turn-on.

Turn on/off phase

When the switch current flows through the body diode of the MOSFET, there is negative VDS across the MOSFET. When VDS drops to ~2V, a turn-on timer begins counting. If VDS reaches -280mV turn on threshold from 2V within the Tonsld, and VDS keeps less than - 280mv for more than THOLD, The MOSFET is turned on after a turn-on delay.



In DCM/QR/CCM mode, when VDS rises to trigger the turn off threshold (-5mV), the gate voltage is pulled to zero after a very short turn-off propagation delay. The turn off delay time is generally within 25ns, benefit from ETA8003's larger pull-down current 3A and GATE voltage intelligent adjustment which will reduce to gate voltage in advance according to the VDS. High shutdown speed ensures the safety of CCM system and further improves the efficiency.

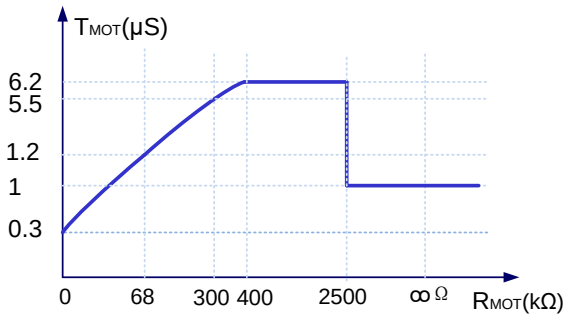
Sleep Mode

Sleep Mode is a low-power operating mode. This

mode automatically reduces switching losses under light-load conditions by pulling Vg output low whenever the detected synchronous conduction time is less than 1.0uS. While in sleep Mode, the MOSFET body-diode conduction time is continuously monitored. When this time exceeds 1.12uS, the device will turn on Vg in the next switching cycle

Minimum On Time (MOT)

MOT stands for the minimum on time of synchronous MOSFET or the maximum duty cycle of primary MOSFET. The MOT can be adjusted by a resistor connected to MOT pin. The relation between MOT and the resistor is shown in below figure. Floating MOT will result in commonly used typical value 1uS, MOT resistance value between 400k~2.5M will get the maximum on time (6.2uS), and shorting MOT to GND turns out to a minimum on time (~300nS) for high frequency applications.



VCC internal LDO regulator

When primary switch is on, VD pin can go to very high and through internal LDO regulator to charge the cap on VCC pin. The voltage on VCC pin is the supply of the chip. This is regulated at 12V maximum and can get 10V Vg voltage without another Winding when VOUT is 5V.

Thermal Shutdown

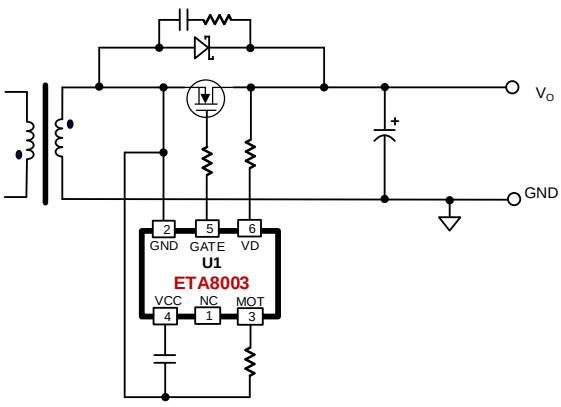
If the junction temperature of the chip exceeds 150°C, VG is pulled low, and the ETA8003 stops switching. The ETA8003 resumes normal operation after the junction temperature drops to 130°C.

APPLICATION INFORMATION

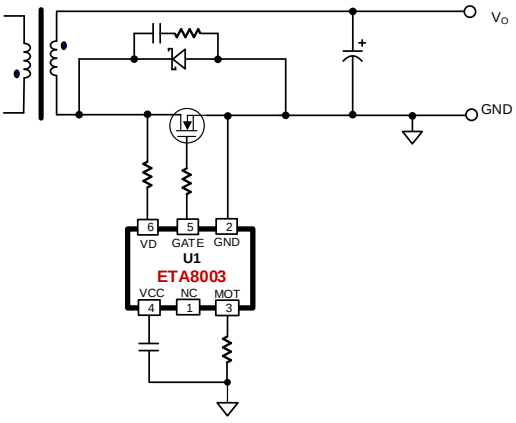
High/Low Side Rectification

The ETA8003 can support for high/low side rectification in most applications. The detailed circuit connection is as follows:

High side rectification



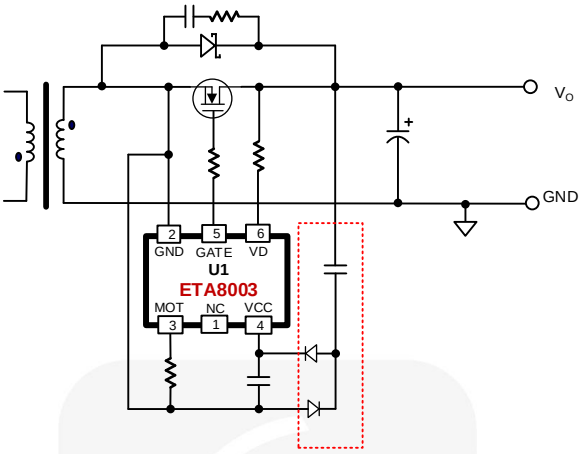
Low side rectification



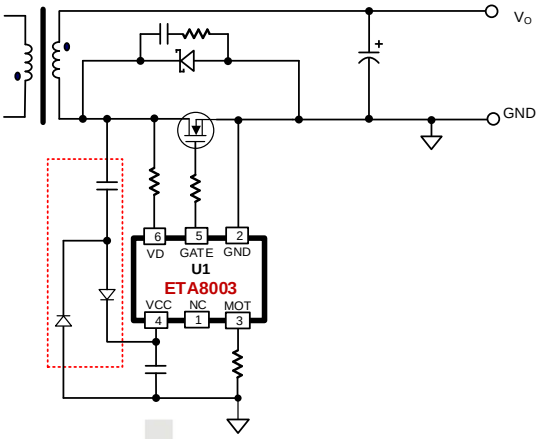
VCC Power Supply

The power supply of VCC is realized by rectifying of the VD pin to charge the VCC capacitor when the primary switch is turned on. When the on-time of the primary switch is very short or the energy is very small in other similar situations, some circuits as follows can be added to enhance the power supply capability so that the chip can work normally.

High side rectification



Low side rectification



SR MOSFET Selection

SR MOSFET selection is a trade-off between the RDS(ON) and QG. To achieve higher efficiency, the MOSFET with the smaller RDS(ON) is preferred. Typically, QG is larger with a smaller RDS(ON), which makes the turn-on/turnoff speed lower and leads to larger power loss and driver loss. The ETA8003 recommends using SR MOSFET with the RDS(ON) within the range of 5~25mΩ and input capacitance within 5nF.

VD Clamp

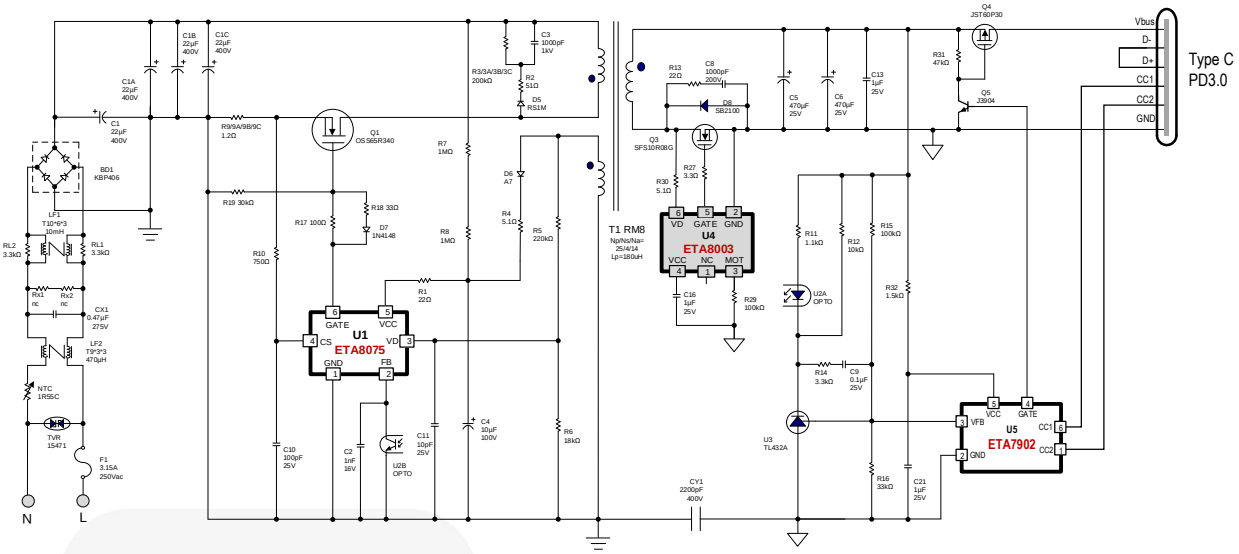
To avoid excessive currents when VD goes below -0.7V, a small resistor (1~33 Ω) is recommended between VD and the drain of the external SR MOSFET.

RC Series Snubber Circuit

In many conditions, the voltage spike across the synchronous rectifier is often very high, so a snubber circuit with a conventional resistor and capacitor in series is recommended to be placed between the DRAIN and SOURCE terminals of the SR MOSFET.

Reference Schematic

Reference Application Circuit --- 40W (15V2.66A/12V3A/9V3A/5V3A) PD adaptor:

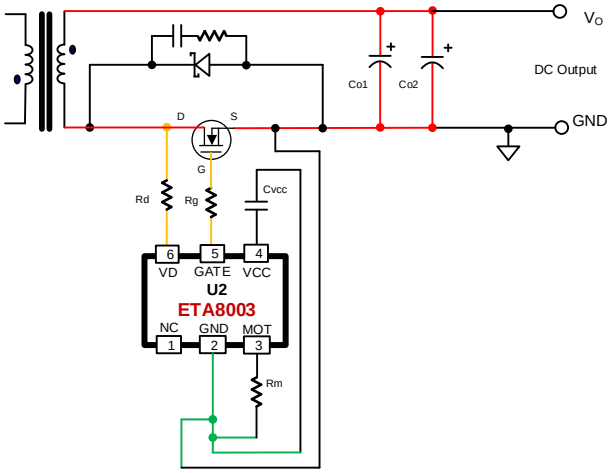


Bill of Materials

Item	Reference	Description	QTY	Manufacturer
1	U1	AC/DC PWM IC, ETA8075P45,SOT23-6	1	ETA
2	U2	OPTO, EL817A,CTR:100~200%,DIP-4,	1	Ever-Light
3	U3	Ref IC, TL432A,Vref=1.25V,0.5%, SOT23	1	SK
4	U4	SR IC, ETA8003,SOT23-6	1	ETA
5	U5	PD interface IC, ETA7902, SOT23-6	1	ETA
6	F1	Fuse,3.15A/250V	1	Xcfuse
7	LF1	CM Inductor, 10mH, T10*6*3, 360mΩ，744821120,	1	Wurth
8	LF2	CM Inductor, 1mH, T9*3*3, 100mΩ，744801911	1	Wurth
9	NTC	Thermal resistor, 1 ohm, 5A	1	Xcfuse
10	TVR	Varistor, 25471, Φ10,820513011	1	Wurth
11	CX1	Safety X1,Capacitor,0.47uF/275Vac,Dip,890324024005	1	Wurth
12	CY1	Safety Y1,Capacitor,2.2nF/400V,Dip	1	Wurth
13	BD1	KBP407,800V/4.0A,DIP4	1	PANJIT
14	C1,C1A,C1B,C1C	Capacitor, Electrolytic,22uF/400V, 860021375012	4	Wurth
15	C4	Capacitor, Electrolytic,10uF/100V, 6x11mm,860130873003	1	Wurth
16	C5,C6	Capacitor, Aluminum Electrolytic,470uF/25V,865080353015	2	Wurth
17	Q1	N-Mosfet Transistor, OSS65R340DF,TO-126	1	Oriental-Semi
18	Q3	N-Mosfet Transistor, SFS10R08DF, 8mohm 100V, TO-220F	1	Oriental-Semi
19	Q4	P-Mosfet Transistor, JST60P30,DFN3*3	1	JESTE
20	Q5	NPN Transistor, JST3904,SOT23	1	JESTE
21	P1	Standard Type C USB connector, 632723100011	1	Wurth
22	P2	Vercial standard USBA connector, 692121430000	1	Wurth
23	T1	High Frequency Transformer, Lp=0.18mH, RM8, Vertical	1	Fuzhou SY
24	D5	Fast Recovery Rectifier, RS1M,1000V/1.0A, RMA	1	MDD
25	D6	Rectifier Diode, A7,1000V/1.0A, SOD-123F	1	MDD
26	D8	Schottky Diode Rectifier, MBR2100,100V/2A, Low Vf, RMA	1	Good-ark
27	D7	Switching Diode, 1N4148, 75V/0.2A, 0805	1	SK
28	C2	Capacitor, Ceramic, 1nF/25V, 0603,SMD,885012206059	1	Wurth

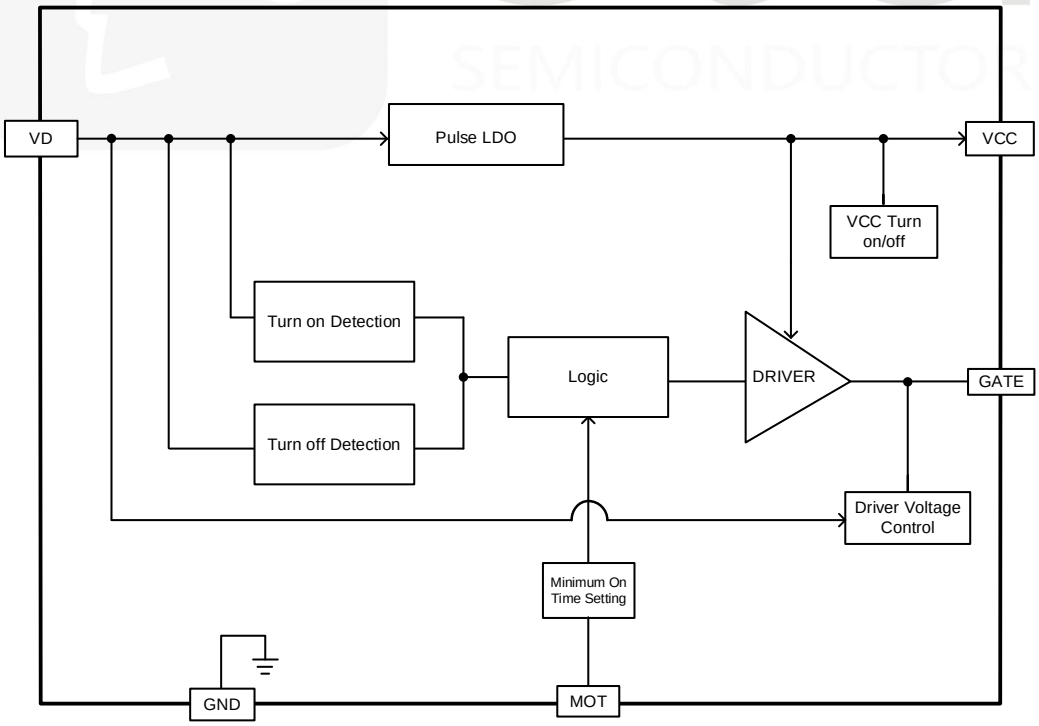
29	C3	Capacitor, Ceramic, 1000pF/1kV, 1206,SMD,885342208018	1	Wurth
29	C8	Capacitor, Ceramic, 1nF/200V, 0805,SMD, 885342007003	1	Wurth
30	C9	Capacitor, Ceramic,0.1uF/25V, 0603,SMD, 885012206071	1	Wurth
31	C10	Capacitor, Ceramic, 100pF/25V, 0603,SMD,885012206053	1	Wurth
32	C11	Capacitor, Ceramic, 10pF/25V, 0603,SMD,885012006032	1	Wurth
33	C12,13,21	Capacitor, Ceramic, 1uF/25V, 0603,SMD,885012206076	3	Wurth
34	R1	Chip Resistor, 22 ohm, 0805, 5%	1	UniOhm
35	R2	Chip Resistor, 51 ohm, 1206, 5%	1	UniOhm
36	R3,R3A,R3B,R3C	Chip Resistor, 200k ohm, 1206, 5%	4	UniOhm
37	R4	Chip Resistor, 5.1 ohm, 1206, 5%	1	UniOhm
38	R5	Chip Resistor, 220K ohm, 0603,1%	1	UniOhm
39	R6	Chip Resistor, 18K ohm, 0603, 1%	1	UniOhm
40	R7,8	Chip Resistor, 1M ohm, 1206, 5%	2	UniOhm
41	R9,9A,9B,9C	Chip Resistor, 1.2 ohm, 1206, 1%	4	UniOhm
42	R10	Chip Resistor, 750 ohm, 0603, 5%	1	UniOhm
43	R11	Chip Resistor, 3.3k ohm, 1206, 5%	1	UniOhm
44	R12	Chip Resistor, 10k ohm, 0603, 5%	1	UniOhm
45	R13	Chip Resistor, 22 ohm, 1206, 5%	1	UniOhm
46	R14	Chip Resistor, 3.3k ohm, 0603, 5%	1	UniOhm
47	R15	Chip Resistor, 100k ohm, 0603, 1%	1	UniOhm
48	R16	Chip Resistor, 33k ohm, 0603, 1%	1	UniOhm
49	R17	Chip Resistor, 100 ohm, 0603, 5%	1	UniOhm
50	R18	Chip Resistor, 33 ohm, 0603, 5%	1	UniOhm
51	R19	Chip Resistor, 30k ohm, 0603, 5%	1	UniOhm
52	R29	Chip Resistor, 100k ohm, 0603, 5%	1	UniOhm
53	RL1,RL2	Chip Resistor, 3.3k ohm, 0805, 5%	2	UniOhm
54	R27	Chip Resistor, 3.3 ohm, 0603, 5%	1	UniOhm
55	R30	Chip Resistor, 5.1 ohm, 0805, 5%	1	UniOhm
56	R31	Chip Resistor, 47k ohm, 0805, 5%	1	UniOhm
57	R32	Chip Resistor, 1.5k ohm, 0603, 5%	1	UniOhm
58	PCB1	FR-4, Double-sided Board, W*L*H=56mm*51mm*1.0mm	1	JDBPCB
59	PCB2	FR-4, Double-sided Board, W*L*H=20m*12mm*1.0 mm	1	JDBPCB

PCB GUIDELINES



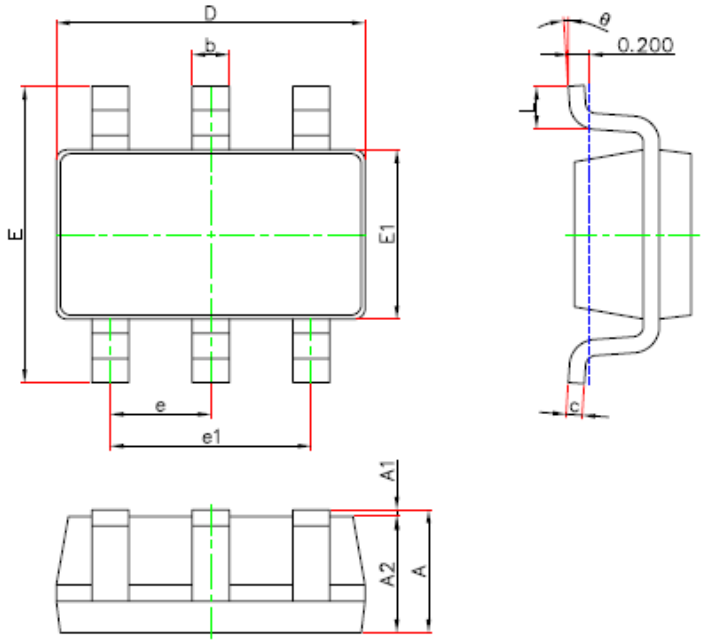
Good PCB layout is respectively to optimize IC and system performance. First, the ETA8003 body and related peripheral circuits should be kept away from the main current loop (red wire) which is as short and thick as possible in the secondary. Secondly, the connections of VD, GATE, GND and the external synchronization FET should be as close as possible and the loop should be as small as possible (yellow wire). Finally, the connection of the MOT resistor and the VCC capacitor to ground should directly connect to the ETA8003 GND pin (green wire). Connecting the output capacitor (C_{O1}) ground lead, the external synchronization FET source returns, and the ETA8003 GND pin to a single point (ETA8003 star ground configuration).

FUNCTIONAL BLOCK DIAGRAM



PACKAGE OUTLINE

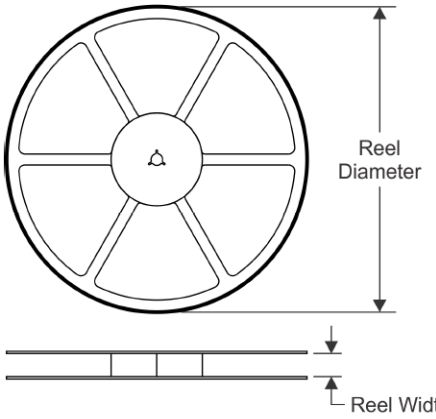
Package: SOT23-6



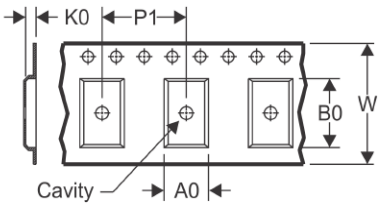
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E1	1.500	1.700	0.059	0.067
E	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

TAPE AND REEL INFORMATION

REEL DIMENSIONS

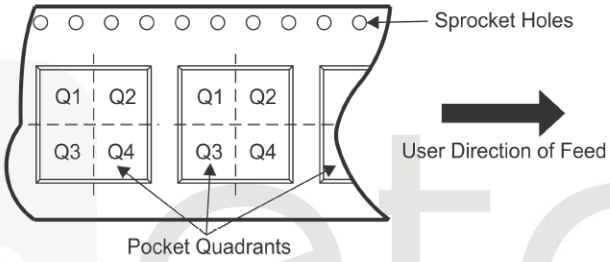


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



Device	Package Type	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
ETA8003S2G	SOT23-6	6	3000	180	9.5	3.17	3.23	1.37	4	8	Q3