

Characterization

The TM6603 is a tactile feedback driver designed to address common obstacles in driving tactile feedback elements in eccentric rotor motor drivers (ERM). The TM6603 is also used to provide drive power for drivers commonly used in portable devices with low latency, very high efficiency, and large drive strength. The TM6603 also has a power correction function to ensure constant vibration strength without power regulation, allowing connection to a high efficiency DC battery. This product has excellent performance and reliable quality.

Functional features

- Flexible touch feedback /vibra driver
-ERM (eccentric rotor motor)
- Continuous vibration intensity exceeds the scope of supply
- Automatic input level conversion
- 0% to 100% duty cycle control range
- Wide supply voltage range from 2.7V to 5.2v
- 1.8V compatible, 5V tolerance digital pin
- Package form: SOT23-6, dfn6le
- Application fields: mobile phones, tablet computers, touch enabled devices

Pin arrangement

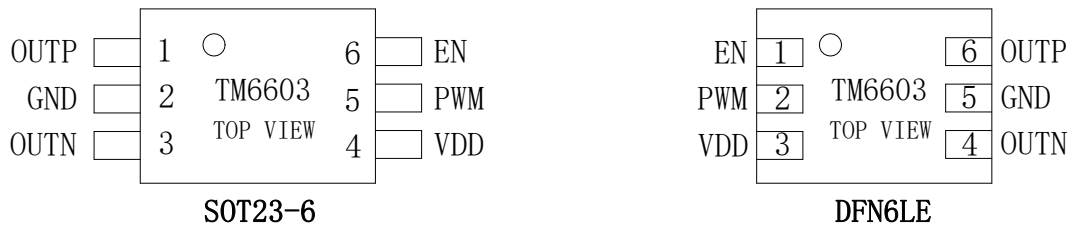


Figure 1

Pin function

Pin name	Pin serial number		I/O	Function description
	SOT23-6	DFN6LE		
OUTP	1	6	-	Positive tactile driver differential output
GND	2	5	-	land
OUTN	3	4	-	Negative tactile driver differential output
VDD	4	3	-	Power input
PWM	5	2		Input signal
EN	6	1	--	Enable, highly effective



Integrated circuits are electrostatic sensitive devices, which are prone to generate a large amount of static electricity when used in dry seasons or dry environments. Electrostatic discharge may damage integrated circuits. Titan Micro Electronics recommends taking all appropriate integrated circuit preventive measures and improper operations

Welding may cause ESD damage or performance degradation, and the chip cannot work normally.

Electrical characteristics
Extreme working conditions

Parameter name	Parameter symbols	Limit value	Unit
working voltage	Vdd	-0.3~6.0	V
input voltage	Vin	-0.3~VDD+0.3	V
Ambient temperature range	Ta	-40~85	°C
Junction temperature	Tj	-40~150	°C
Storage temperature range	Tstg	-65~150	°C
ESD	HBM (manikin)	±2	KV
	Mm (machine model)	±500	V

(1) If the chip works under the above limit parameters for a long time, the reliability of the device may be reduced or permanently damaged. Tianmicroelectronics does not recommend that any parameter reach or exceed these limits in actual use.

(2) All voltage values are tested relative to the system ground.

Recommended working conditions

Under the test conditions of vdd=5v and ta=+25 °C			TM6603			Unit
Parameter name	Parameter symbols	Test conditions	minimum value	Typical value	Maximum value	
supply voltage	Vdd	VDD	2.7		5.2	V
PWM input frequency	Fpwm		10		250	kHz
Load impedance	RI	VDD=5.2V	8			Ω
Digital input low voltage	Vil	EN, PWM			0.6	V
Digital input high voltage	Vih	EN, PWM	1.2			V
Ambient temperature range	Ta		-40		85	°C
Junction to ambient thermal resistance	Rθja			153.7		°C/W
Junction to box (top) thermal resistance	Rθjc(top)			86		°C/W
Thermal resistance of contact plate	Rθjb			70.4		°C/W
Connect to top characterization parameter	ψjt			1.3		°C/W
Point to plate characteristic parameters	ψjb			70.4		°C/W

Electrical characteristics

Under the test conditions of vdd=5v and ta=+25 °C			TM6603			Unit
Parameter name	Parameter symbols	Test conditions	minimum value	Typical value	Maximum value	
Digital input low current	Iil	EN,PWM,VDD=5.0V,VIN =0V			1	μA
Digital input high current	Iih	EN=VDD=5.0V,VIN=VDD			6	μA
		PWM,VDD=5.0V,VIN=VDD			3	μA
Closing current	I _{sd}	VEN = 0 V		0.3	3	μA
Quiescent current	I _{ddq}	Ven = VDD, ERM mode, 50% duty cycle input cycle, no load		1.7	2.5	mA

eight

Output impedance during shutdown	Rout	OUT+ to GND, OUT– to GND		15		kΩ
Start time	t _{SU}	Time from en high to output signal		1.3		ms
PWM output frequency	f _{SW}		19.5	20.3	21.5	kHz
Average battery current during normal operation	I _{bat,avg}	Duty cycle = 80%, ERM mode, RL = 17 Ω, 2V rated ERM		59		mA
Drain source resistance, high side	R _{ds-hs}			1.05		Ω
Drain source resistance, low side	R _{ds-ls}			0.85		Ω
Differential output voltage	V _{out}	Duty cycle = 100%, ERM mode, load = 20 Ω ERM		3.3 3.3		V V
Thermal threshold					145	
Thermal hysteresis					18	

parameter measurement

Test setup diagram

The output waveform of tm6603 can be checked by connecting oscilloscope.

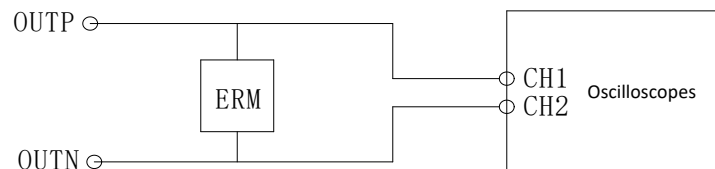


Figure 2

Function description

1. Power supply voltage suppression and PWM input logic level for constant vibration intensity

Tm6603 has power feedback, so it does not need external power regulation. If the power supply voltage is consumed over time (for example, due to battery discharge), as long as there is enough power supply voltage to maintain the required output voltage, the vibration intensity will remain unchanged. The tm6603 can be connected directly to the battery. As long as the PWM port input voltage meets the VIH and VIL levels, the vibration intensity will remain unchanged even if the digital levels are different.

2. Over temperature and over-current protection

Tm6603 chip over temperature protection will shut down the device to prevent internal overheating. For typical over temperature threshold, please refer to the electrical specification table. At the same time, it also has overcurrent protection to prevent damage under short-circuit conditions. This overcurrent protection monitors the current from VDD, GND, out+ and out-. Refer to the electrical specification sheet for typical overcurrent thresholds.

3. Edge rate control

Tm6603 output driver realizes edge rate control (ERC). This ensures that the rising and falling characteristics of the output driver do not release radiation levels that may interfere with other circuits in mobile and portable platforms. Due to ERC, no output filter or inductance is required.

4. Eccentric rotor motor (ERM)

Eccentric rotor motors, or ERMS, are usually DC controlled rod or coin motors. The ERM can be driven clockwise or counterclockwise according to the voltage polarity at both ends. In a single power supply system,

bidirectional drive is possible, and differential output can provide and absorb current. This feature helps to eliminate the long vibrating tail that is not needed in the tactile feedback system.

Another common method of driving DC motors is the concept of overdrive voltage. In order to overcome the inertia of the motor mass, they are usually over driven in a too short time, and then return to the rated voltage of the motor to maintain the rotation of the motor. Reverse overdrive quickly brakes the ERM motor by reversing the magnetic field of the drive coil.

Application information

1. Application introduction

Tm6603 chip is used to drive ERM motor of tactile feedback. ERM can be used in many tactile feedback applications, including vibration alarm, advanced vibration for touch surface or screen communication, button replacement, and tactile feedback.

The output of tm6603 is controlled by PWM input. The duty cycle of PWM determines the amplitude of the output waveform. By changing the duty cycle, you can create advanced tactile modes and programs, such as clicks, bumps, pulses, slopes, and so on.

If the PWM port is unavailable, the PWM pin of tm6603 can be controlled by GPIO; At this time, tm6603 will only be used as a switch. When GPIO is high, the output is 100%; When GPIO is low, the output is -100% (in the opposite direction).

Tm6603 chip is a compact, low-cost ERM motor drive solution. Most competitive solutions require external components for bias or level shifting, but the tm6603 requires only one decoupling capacitor with a total approximate circuit size of 2mm × 2 mm. This small solution has the characteristics of level conversion input, braking differential output, overvoltage constant drive intensity, edge rate control, and wide input PWM frequency range.

Tm6603 adopts a simple control scheme. 100% input duty cycle provides maximum intensity forward rotation, 50% input duty cycle does not provide rotation intensity, and 0% duty cycle provides maximum intensity reverse rotation. In the ERMS system, the motor speed is used for reverse rotation to realize motor braking. At different times, with different duty ratios, the output terminal will generate tactile motor control signals to accurately drive the motor.

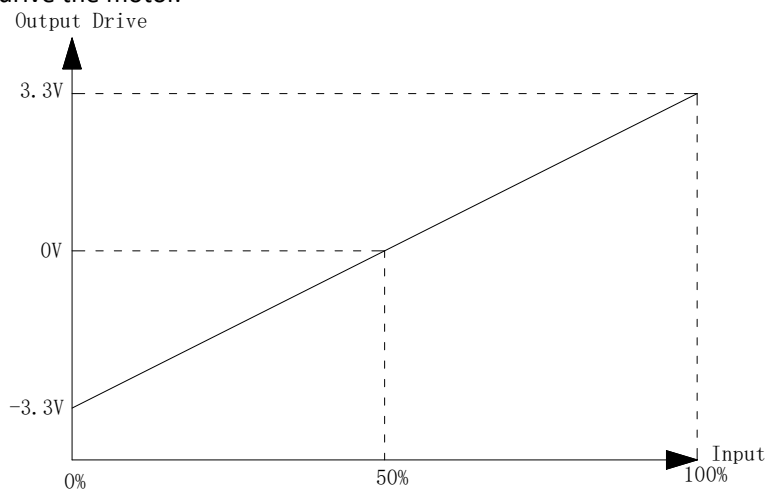


Figure 3

In ERM mode, the tm6603 full-scale, no-load output voltage is 3.6V. The nominal RDS is 1.9 Ω. When 20 Ω ERM is driven in full scale, the differential voltage seen at the output end is 3.3V. When 10 Ω ERM is driven, the output voltage is about 3 V. The functional relationship between output voltage and input duty cycle in the figure is shown in the following formula.

$$V_{OUT(RMS)} = V_{OUT(FULL-SCALE)} \left[\frac{Input\ Duty\ Cycle\ \%}{50} - 1 \right]$$

Since the tm6603 includes a constant output drive power supply voltage and an adjustable output PWM duty cycle, the above formula is correct no matter how the power supply voltage changes. The duty cycle in the output ERM mode can be approximated by the following equation.

$$\text{Output Duty Cycle (\%)} = \frac{V_{OUT(FULL-SCALE)}}{VDD} \left[\frac{\text{Input Duty Cycle \%}}{50} - 1 \right] 100\%$$

2. Typical applications

The following figure shows ERM application configuration.

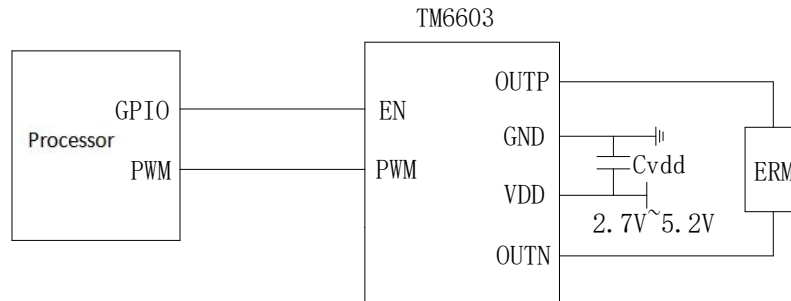


Figure 4

2.1 detailed design steps

2.1.1 driver selection

Many factors should be taken into consideration when selecting the driver, including cost, shape factor, vibration intensity, power consumption requirements, tactile acuity, reliability and audible noise performance. The choice of driver is one of the most important design considerations of tactile system, so driver should be the first component to be considered when designing the system. The following can be used to select the minimum supply voltage required.

1. Find the rated / maximum working voltage in the driver data sheet; Some drive data sheets may only list the rated voltage.
2. Using a larger rated value and maximum working voltage plus 250Mv is the minimum operating voltage. The addition of 250Mv provides operating margin for internal drive losses.
3. Check the power supply voltage to ensure that the expected output is achieved. It is also necessary to calculate the minimum supply current according to the load. Compare the driving capacity of the battery or voltage to ensure sufficient power to drive the load in the driver data sheet.

2.1.2 power supply selection

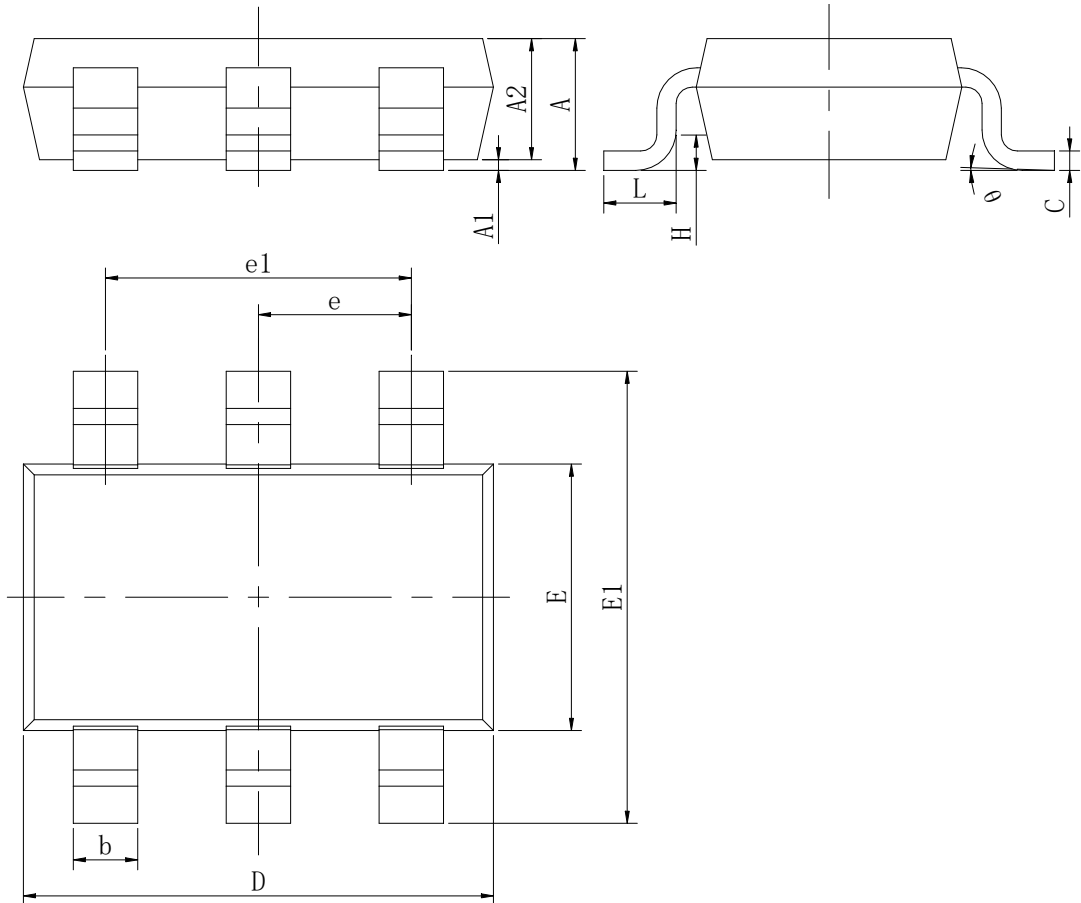
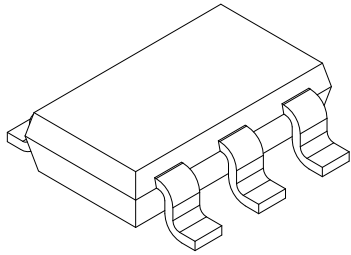
Tm6603 supports power supply voltage from 2.7V to 5.2v. Tm6603 can be directly connected to various types of batteries, including ordinary batteries, such as lithium ion and lithium polymer. The power suppression feature eliminates the need for a voltage regulator between the battery and VDD for the tm6603.

2.1.3 send tactile effect

Sending tactile effects with tm6603 is very simple. The best performance is achieved through the following steps.

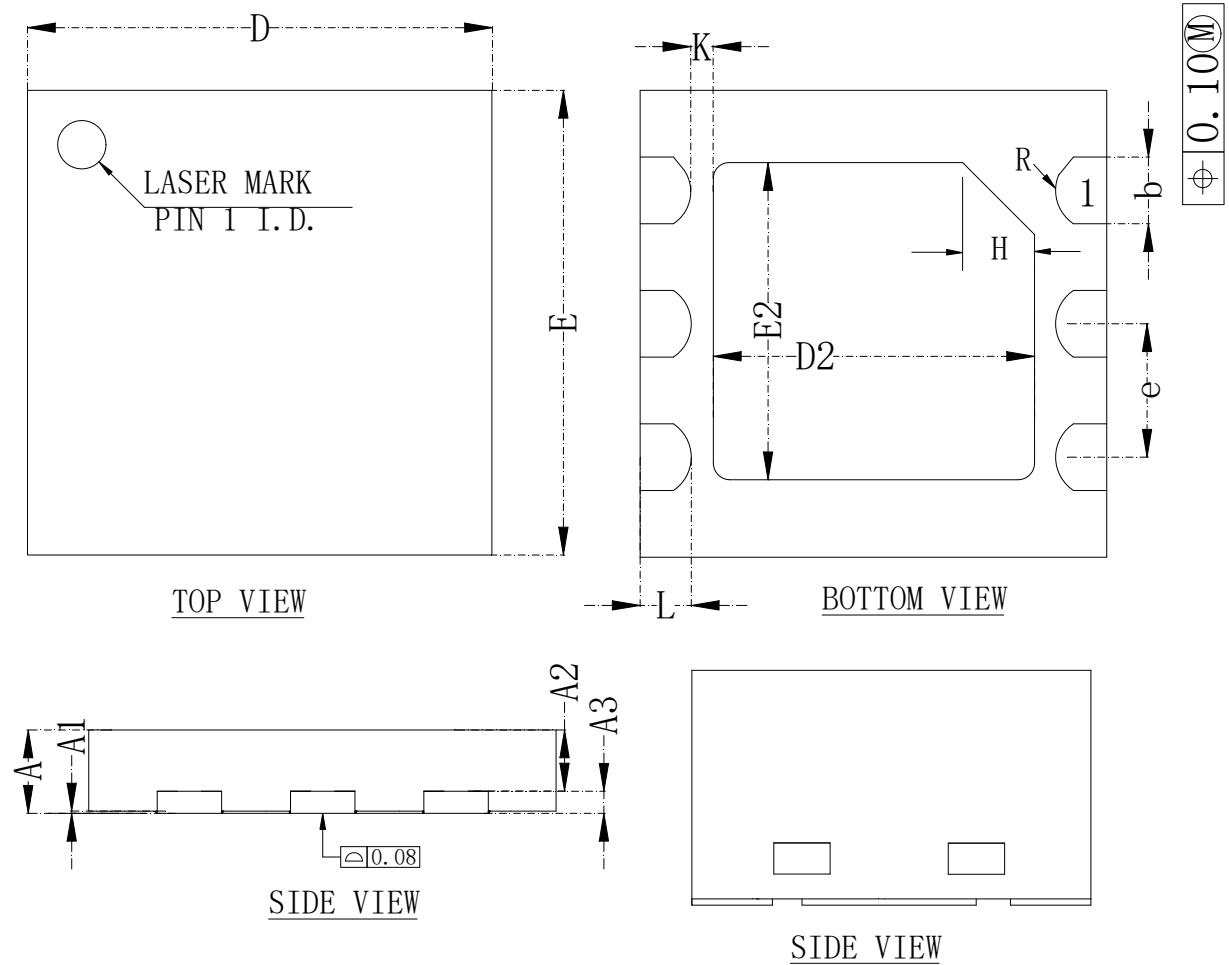
1. At or near the same time, the EN pin is pulled high and the PWM input waveform. Generally, the driver produces tactile effect within 20 ms to 50 ms of instantaneous driving. Refer to the specifications of the drive for the best overdrive characteristics.
2. When the tactile effect is completed, if braking is required, set the PWM duty cycle to 0%, and the EN pin must be kept high. When the braking is completed, set the EN pin to low to end the tactile effect. When braking ERM, users should be careful not to brake the driver too long, otherwise reverse rotation may occur.

Packaging diagram (SOT23-6)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	0.900	0.028	0.035
A1	0.000	0.100	0.000	0.004
A2	0.700	0.800	0.028	0.031
b	0.350	0.500	0.014	0.020
c	0.080	0.200	0.003	0.008
D	2.820	3.020	0.111	0.119
E	1.600	1.700	0.063	0.067
E1	2.650	2.950	0.104	0.116
e	0.95 (BSC)		0.037(BSC)	
e1	1.90 (BSC)		0.075(BSC)	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

(DFN6LE)



Symbol	Min	Max	Min
	Dimensions In Millimeters		
	Min	NOM	Max
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A2	0.50	0.55	0.60
A3	0.20REF		
b	0.20	0.25	0.30
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D2	0.70	0.80	0.90
E2	1.20	1.30	1.40
e	0.55	0.65	0.75
H	0.25REF		
K	0.20	--	--
L	0.30	0.35	0.40
R	0.11	--	--

All specs and applications shown above subject to change without prior notice.

Version revision history

edition	Issue date	Introduction to revision
V1.0	2018-5-25	First edition release
V1.1	2018-7-25	Modify the application circuit diagram to describe the error
V1.2	2018-11-21	Adjust and modify the circuit group
V1.3	2018-11-29	Correct the wrong unit and correct some descriptive words