Two-Wire Current PWM Output High Accuracy Speed Sensor IC

1. Features

- Two-wire current interface
- PWM protocol，detection of speed and rotation direction
- Airgap and Assembly position diagnosis
- Dynamic self-calibration principle
- High sensitivity
- South and North pole pre-induction possible
- PCB-Less
- -40℃ to 150℃ operating temperature range
- 4.5V to 24V operating voltage range
- Over-molded capacitor for improved EMC performance
- AEC-Q100 Grade0 qualified.
- Package：TS-2

2. Product Application

- ABS wheel speed sensor
- General speed sensor

3. Description

SC9642 is a two-wire current output wheel speed sensor based on pulse width modulation (PWM) principle, which can provide speed, rotation direction and installation distance information. The chip adopts the high-pressure BiCMOS process, that can achieve high EMC protection ability, and the accuracy and sensitivity are relatively stable at full temperature, which is very suitable for the harsh automotive electronic environment.

The SC9642 contains three Hall induction plants, amplifiers, comparators, and signal processing circuits that can detect the magnetic ring directly or the ferric signal wheel with a backmagnetic application. When the magnetic ring or gear rotates, the differential magnetic field is alternately changed, and the chip converts the magnetic field into a voltage signal, which is output after signal processing. The SC9642 is a two-wire current output that uses different pulse widths to characterize the speed and direction of the magnetic ring or gear, as well as installation distance information.

The device is packaged in a TS-2. It is lead (Pb) free, with 100% matte tin-plated lead frame.

Not to scale

Fig.1 TS-2 Package Outline

CONTENTS

4. Terminal Configuration

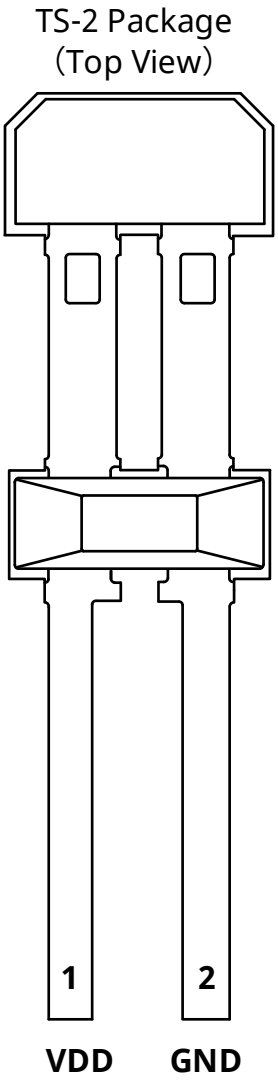


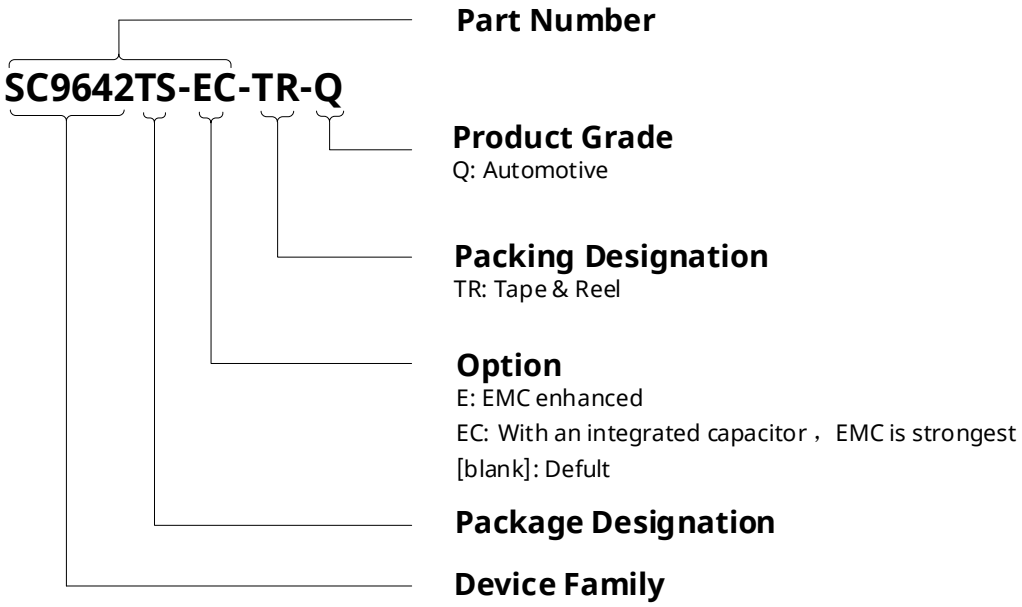
Fig.2 Pin Description

Terminal		Type	Description
Name	Number		
VDD	1	PWR	4.5V ~ 24 V power supply
GND	2	Ground	Ground

5. Ordering Information

Ordering Information	Marking	Option	Class	Ambient, T_A(℃)	Package	Packing	Quantity
SC9642TS-TR-Q	9642	-	Q	-40 ~ 150	TS-2	Tape & reel	1500/reel
SC9642TS-E-TR	9642	E	-	-40 ~ 150	TS-2	Tape & reel	1500/reel
SC9642TS-E-TR-Q	9642	E	Q	-40 ~ 150	TS-2	Tape & reel	1500/reel
SC9642TS-EC-TR-Q	9642	EC	Q	-40 ~ 150	TS-2	Tape & reel	1500/reel

Ordering Information Format



6. Absolute Maximum Ratings

over operating free-air temperature range

Symbol	Parameter	Test conditions	Min.	Max.	Units
V_{DDR}	Power supply reverse Voltage	Tj＜80℃	-0.5	-	V
V_{DD}	Power supply voltage	t=400ms，R_M≥100Ω	-	30	V
I_{rev}	Reverse current	t＜4h，external current limitation required	-	200	mA
T_A	Operating ambient temperature		-40	150	℃
T_J	Maximum junction temperature	5000h，V_{DD}＜16.5V	-55	150	℃
T_J	Maximum junction temperature	2500h，V_{DD}＜16.5V	-55	160	℃
T_J	Maximum junction temperature	500h，V_{DD}＜16.5V	-55	175	℃
T_{STG}	Storage Temperature		-65	175	℃
R_{thJA}	Thermal resistance			190	K/W

Note：
Stresses above those listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

7. ESD Protection

Symbol	Parameter	Test conditions	Min.	Max.	Units
V_{ESD_HBM}	HBM	Refer to AEC-Q100-002E HBM standard, R=1.5kΩ, C=100pF	-5	+5	KV
V_{ESD_CDM}	CDM	Refer to AEC-Q100-011C CDM standard	-750	750	V

8. Operating Characteristics

over operating free-air temperature range (V_{DD}=12V, unless otherwise noted)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Units
Electrical parameters						
V_{DD}	Operating voltage	$T_J<T_{J(max)}$	4.5	12	24	V
V_{AC}	Supply voltage ripple	f＜50Hz	-	-	8	Vpp
B_0	Pre-induction		-500	-	500	mT(1)
$\triangle B_{stat,l/r}$(2)	Pre-induction offset between outer probes	B_{left}-B_{right} when the gear is stationary	-20	-	20	mT
$\triangle B_{stat,m/r}$(3)	Pre-induction offset between Mean of outer probes and center probe	B_{center}-B_{right} when the gear is stationary	-20	-	20	mT
$\triangle B$(4)	Differential induction	B_{left}-B_{right} when the gear is rotating	-120	-	120	mT
$I_{DD(Low)}$	Operating supply current	V_{DD}=4.5V to 24 V	5.9	7.0	8.4	mA
$I_{DD(High)}$	Operating supply current	V_{DD}=4.5V to 24 V	11.8	14.1	16.8	mA
Ratio	Supply current ratio	$I_{DD(High)}$ / $I_{DD(Low)}$	1.9	-	-	-
t_r，t_f	Output rise/fall slew rate	R_M≤750Ω，T＜170℃	8	-	26	mA/us
I_X(5)	Current ripple	dI_X/dV_{DD}	-	-	90	uA/V
$\triangle B_{limit}$	Limit threshold	f_{mag}=1Hz~2.5KHz	-	0.77	-	mT
$\triangle B_{warning}$	Airgap warning threshold	f_{mag}=1Hz~2.5KHz	-	1.15	-	mT
$\triangle B_{warning}/\triangle B_{limit}$	Limit-Airgap warning threshold ratio	$\triangle B_{warning}/\triangle B_{limit}$	1.3	2.0	2.7	
$\triangle B_{EL}$	Assembly position threshold		5.2	7.2	9.6	mT
T_d	Initial calibration delay time		-	-	300	us
n_{DZ-cal}	Magnetic edges required for offset calibration		-	-	6	magn. edges
f_{mag}	Frequency		1	-	5000	Hz
Duty(6)	Duty cycle	Measured@△B=2mT sine wave	40	50	60	%
$S_{jit-close}$	Jitter,airgap is close	△B＞2mT,1Hz＜f_{mag}＜2500Hz	-3	-	3	%
$S_{jit-far}$	Jitter,airgap is far	$\triangle B_{limit}$＜△B＜2mT	-6	-	6	%
S_{jit-AC}	Jitter at board net ripple	V_{DD}=13V±6Vpp，0＜f＜50KHz，△B=15mT	-3	-	3	%
C	Integrated capacitance value		2.09	2.2	2.31	nF

Operating Characteristics (continue)

Timming Characteristics						
$t_{pre-low}$	Pre- Low length	Refer to Figure 7	38	45	52	μs
$t_{Warning}$	Length of Warning pulse	Refer to Figure 7	38	45	52	μs
t_{DR-L}	Length of DR-L pulse	Refer to Figure 7	76	90	104	μs
t_{DR-R}	Length of DR-R pulse	Refer to Figure 7	153	180	207	μs
$t_{DR-L\&EL}$	Length of DR-L & EL pulse	Refer to Figure 7	306	360	414	μs
$t_{DR-R\&EL}$	Length of DR-R & EL pulse	Refer to Figure 7	616	720	828	μs
f_{ELmax}	Output of EL pulse, Maximum frequency		-	117	-	Hz
t_{Stop}	Length of stand still pulse	Refer to Figure 8	1.232	1.44	1.656	mS
T_{Stop}	Stand still period	Refer to Figure 8	590	737	848	mS

Note:

(1) 1mT=10GS

(2) The magnetic field difference between the two Hall induction points on the outside of the back magnetic field only, without gears or at rest of the gears

(3) The difference between the magnetic field value of the middle Hall induction point and the average magnetic field value of the outer two Hall induction points when the back magnetic field is only, no gear, or the gear is stationary

(4) After eliminating the back magnetic deviation, the magnetic field difference between the two outside Hall induction points is passed in the case of gear or magnetic ring rotatio

(5) The ratio of the change in current to the increase in power supply as the operating voltage increases

(6) The duty cycle of 3 output pulses is calculated. Refer to Figure 9 for specific definition

9. Block Diagram

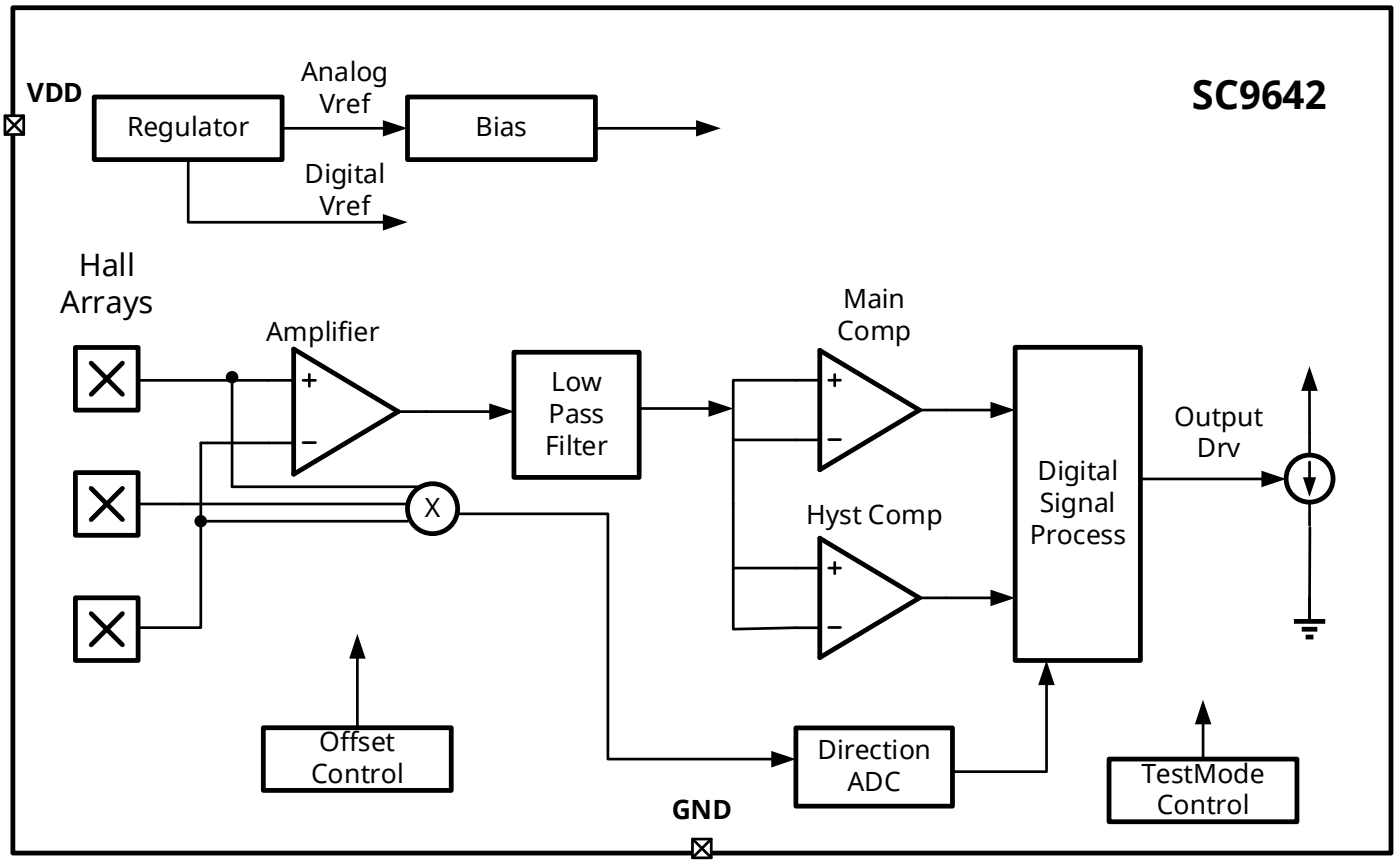


Fig.3 Block Diagram

10. Function Description

SC9642 is an optimized Hall-effect sensing integrated circuit. The chip contains 3 Hall induction points to detect the motion of permanent magnets or ferromagnetic objects by detecting their differential magnetic flux density. The differential magnetic fields of 2 Hall induction points outside are used for speed detection, and the magnetic fields of 3 Hall induction points are used for direction detection together.

In order to detect the motion of a ferromagnetic object, a permanent magnet must be affixed to the back of the chip (no mark surface), and the magnetic flux offset of up to ±20mT can be eliminated through the internal self-calibration algorithm of the chip, which can be completed within 6 edges.

The switching state of the chip is indicated by the level of current, and the input magnetic field signal will trigger an output pulse every time it crosses zero, as shown in Figure 4. A number of magnetic field thresholds are set inside, as shown in Figure 5; When the actual input magnetic field is in different areas, the pulse width of the output pulse will be different, as shown in Figure 7.

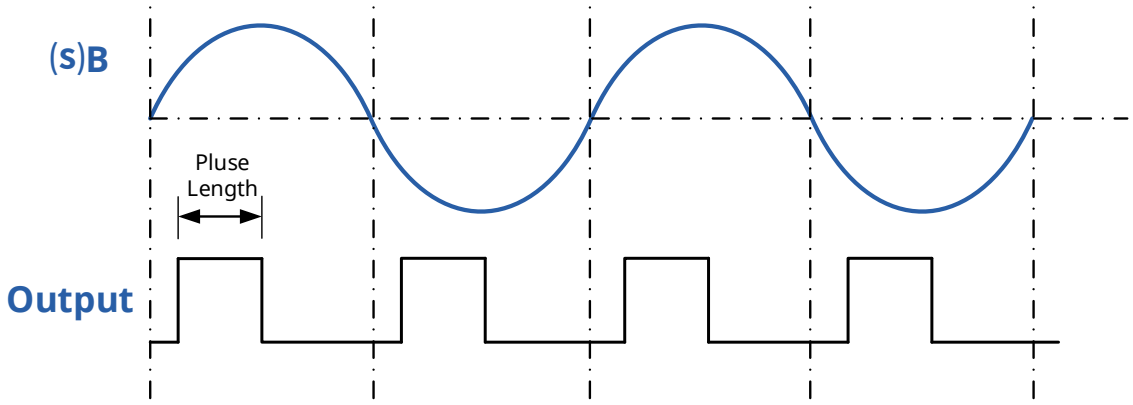


Fig.4 Zero crossing principle and corresponding output pulse

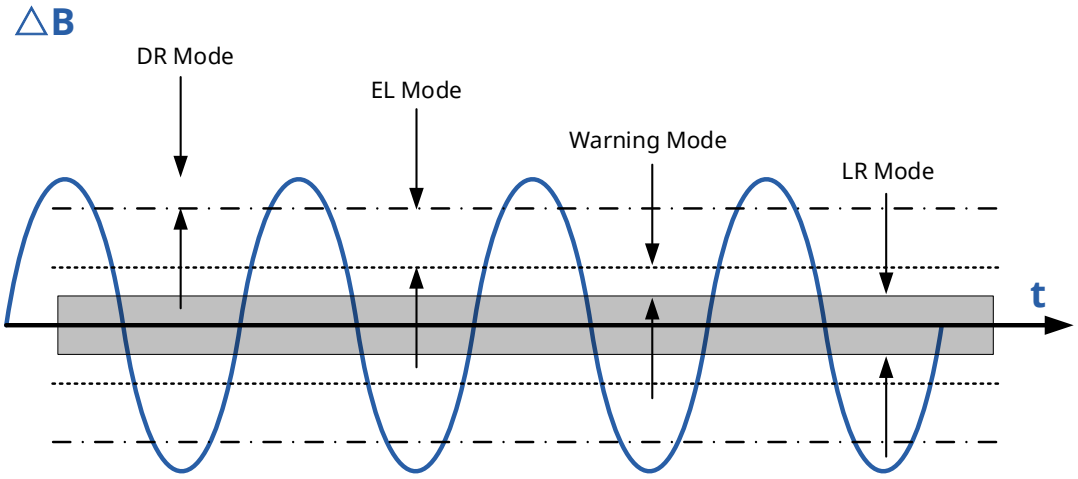


Fig.5 Differential magnetic field threshold and output mode definition

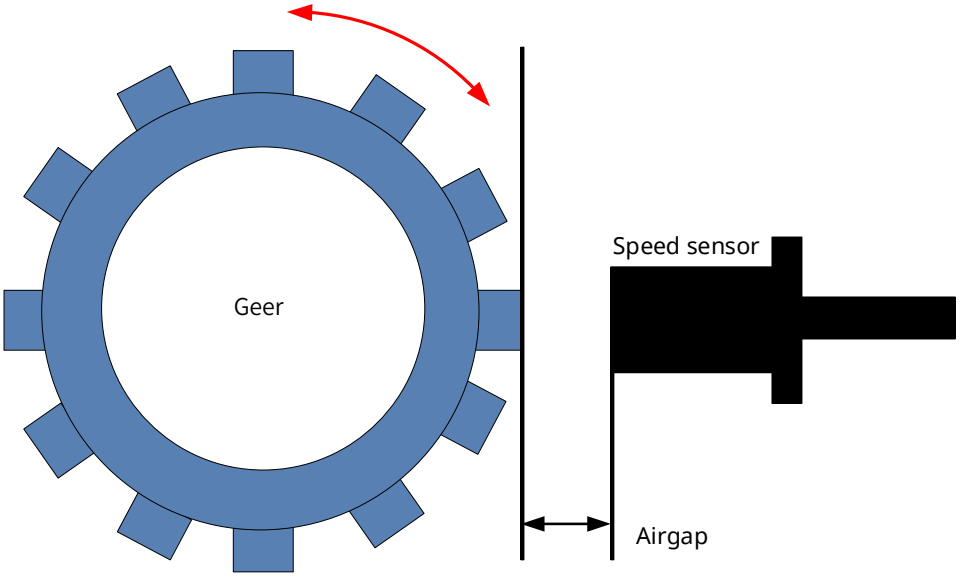


Fig.6 Sensor installation diagram

Stand Still： The installation distance is far or the gear does not rotate, △B is less than 7GS, the chip output pluse width is 1.44ms， period is 737ms.

Warning : When the installation distance is at the critical position, △B between 7GS to 12GS, the chip output pluse width is 45μS.

EL： When the installation distance is moderate, △B between 12GS and 65GS, and the speed is slow,

When the frequency is below 117Hz, the forward rotation (VDD→GND) ,output pluse width is 360uS ,which is DR-L&EL, and the reverse rotation (GND→VDD) output pluse width is 720μS , which is DR-R&EL.

When the frequency is beyond 117HZ, the forward rotation (VDD→GND) ,output pluse width is 90uS, and the reverse rotation (GND→VDD) output pluse width is 180μS.

DR： When the installation distance is relatively close, △B is greater than 65GS, regardless of frequency, forward rotation (VDD→GND) output pluse width is 90uS ,which is DR-L, reverse (GND→VDD) output pluse width is 180μS, which is DR-R.

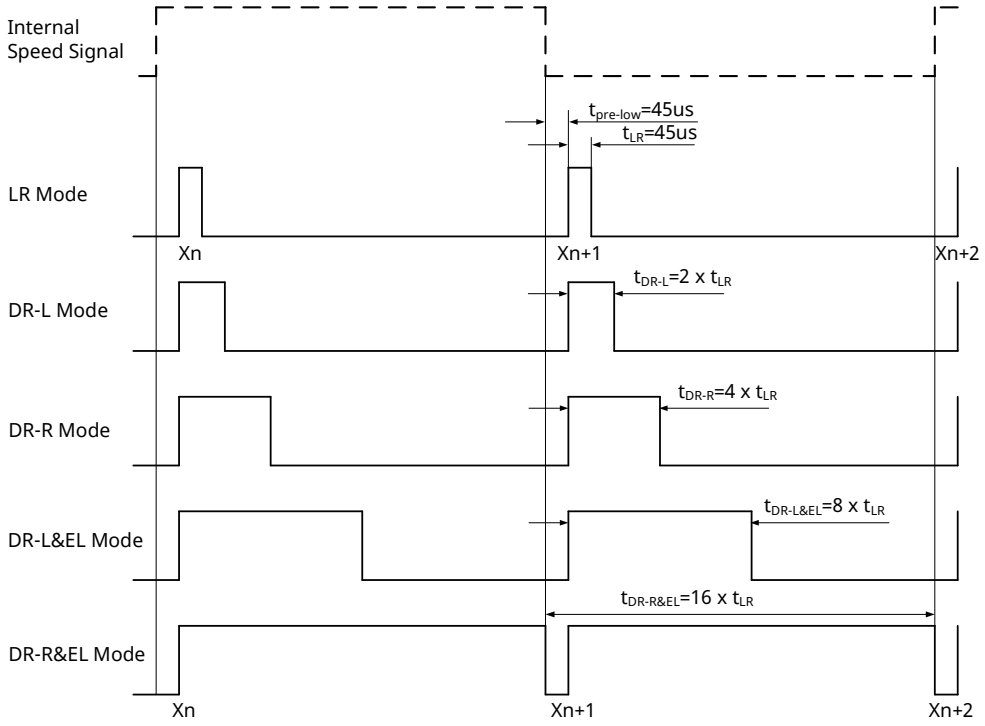


Fig.7 PWM timing definition

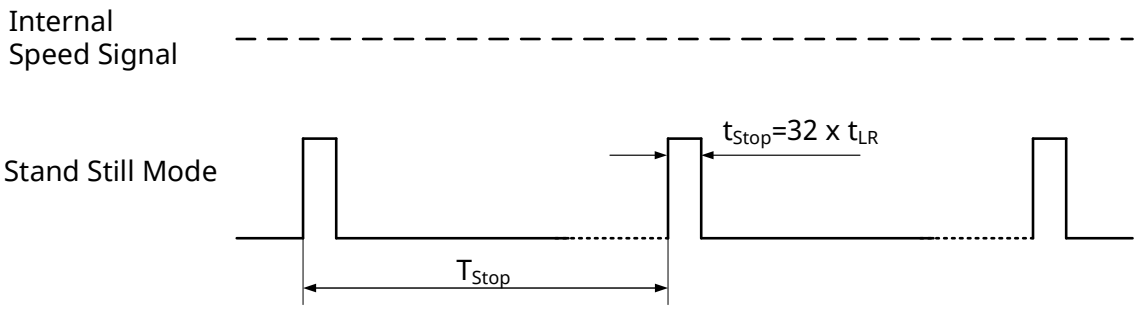


Fig.8 Stand Still Mode timing definition

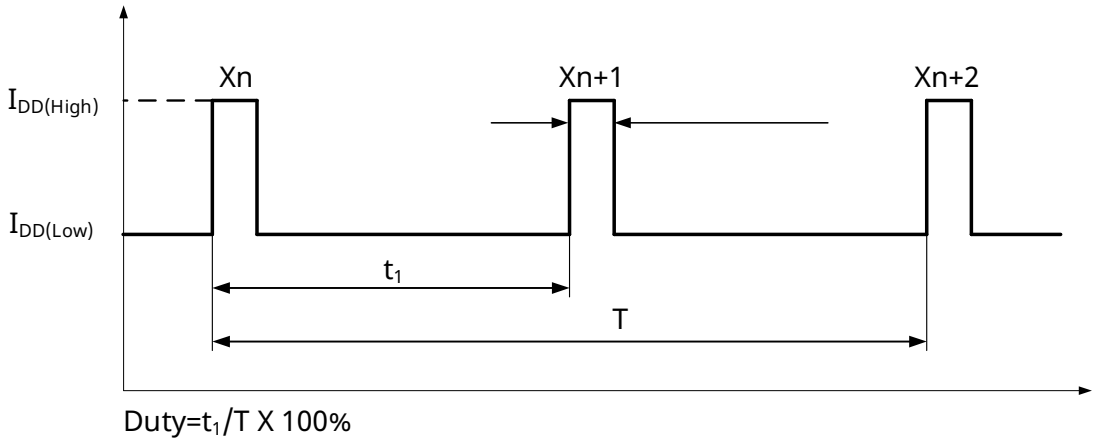


Fig.9 Duty cycle definition

11. Typical Application

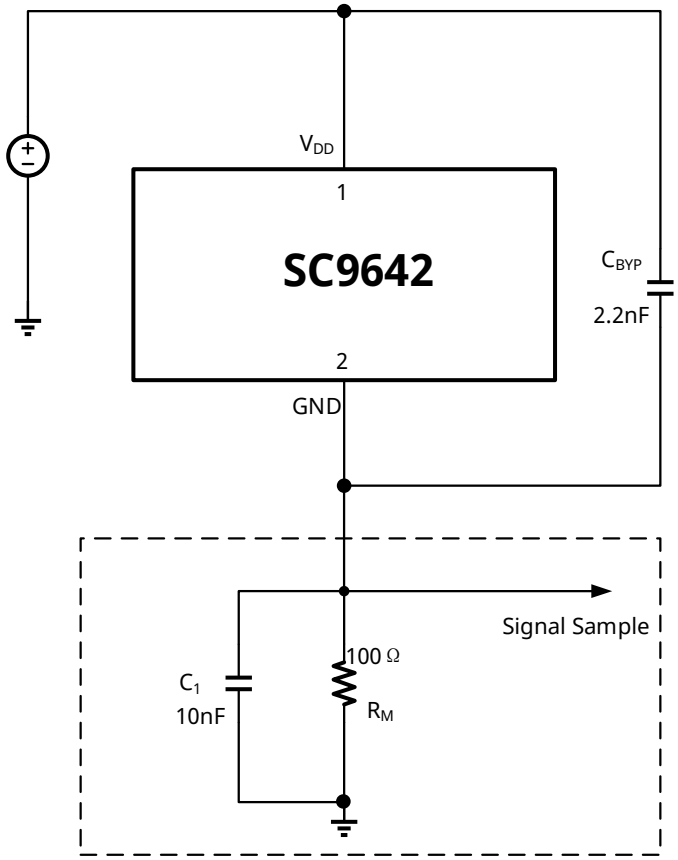
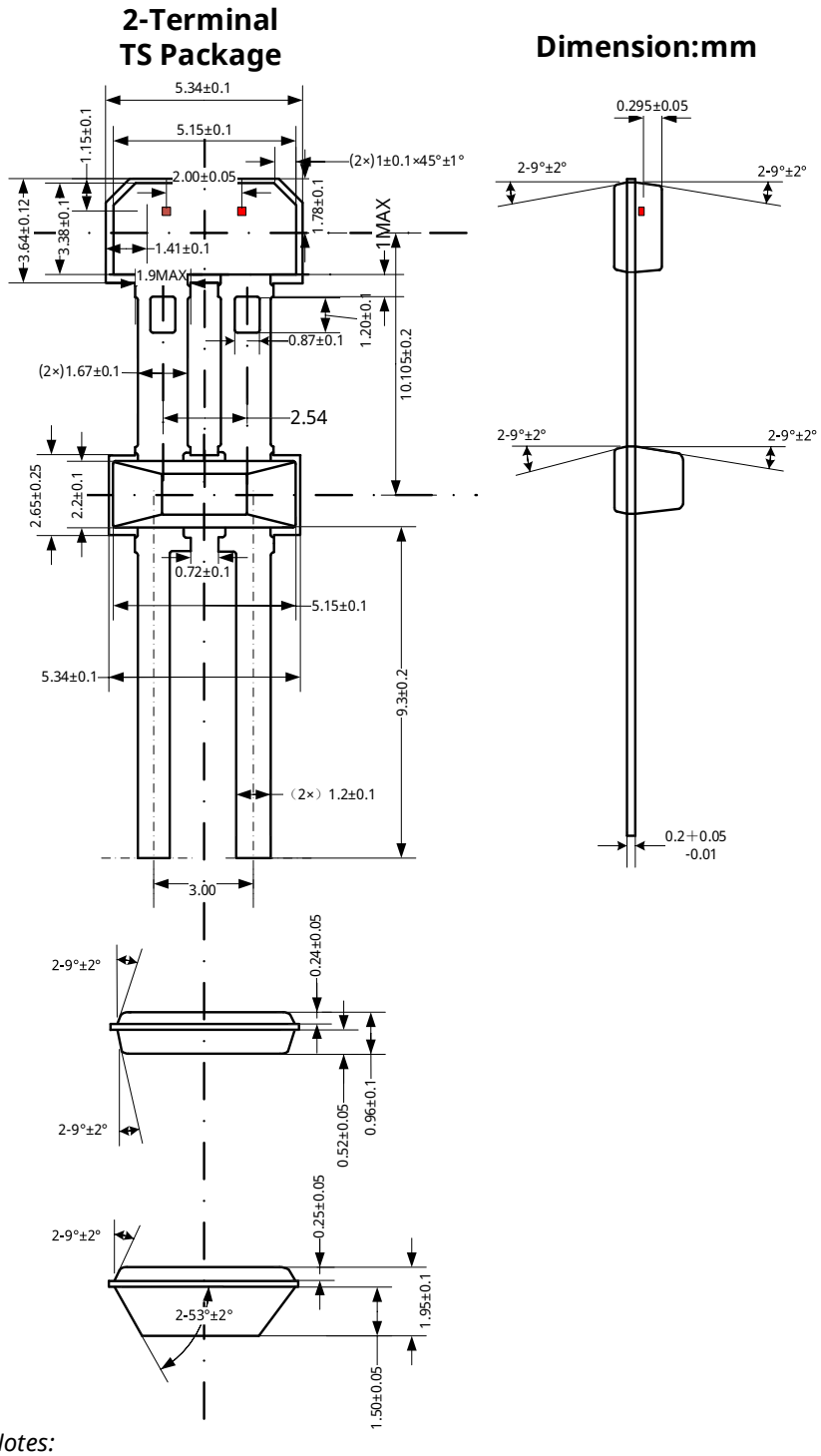


Fig.10 Typical Application

12. Package Information “TS-2”



Notes:

1. *Exact body and lead configuration at vendor’s option within limits shown.*
2. *Height does not include mold gate flash.*
3. *The spacing between two hall plates is 2.0mm*

Where no tolerance is specified, dimension is nominal.

Fig.11 Package Dimensions

13. Revision History

Revision	Date	Description
Rev.0.1	2017-09-23	The old revision
Rev.2.3	2018-11-07	The final revision of old datasheet
Rev.A1.0	2020-11-19	Unified datasheet format
Rev.A1.1	2025-01-22	Update ordering information