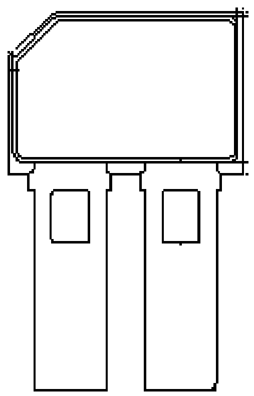
Data Sheet Supplement

Differential Two-Wire Hall Effect Sensor IC — TLE4942-2, TLE4942-2C

For all parameters not specified in this document the TLE4942 data sheet is valid.



P-SSO-2-1

Type	Marking	Ordering Code	Package
TLE4942-2	4202E4	Q62705-K633	PSSO2-1
TLE4942-2C	42C2E4	Q62705-K630	PSSO2-2

1 Functional description

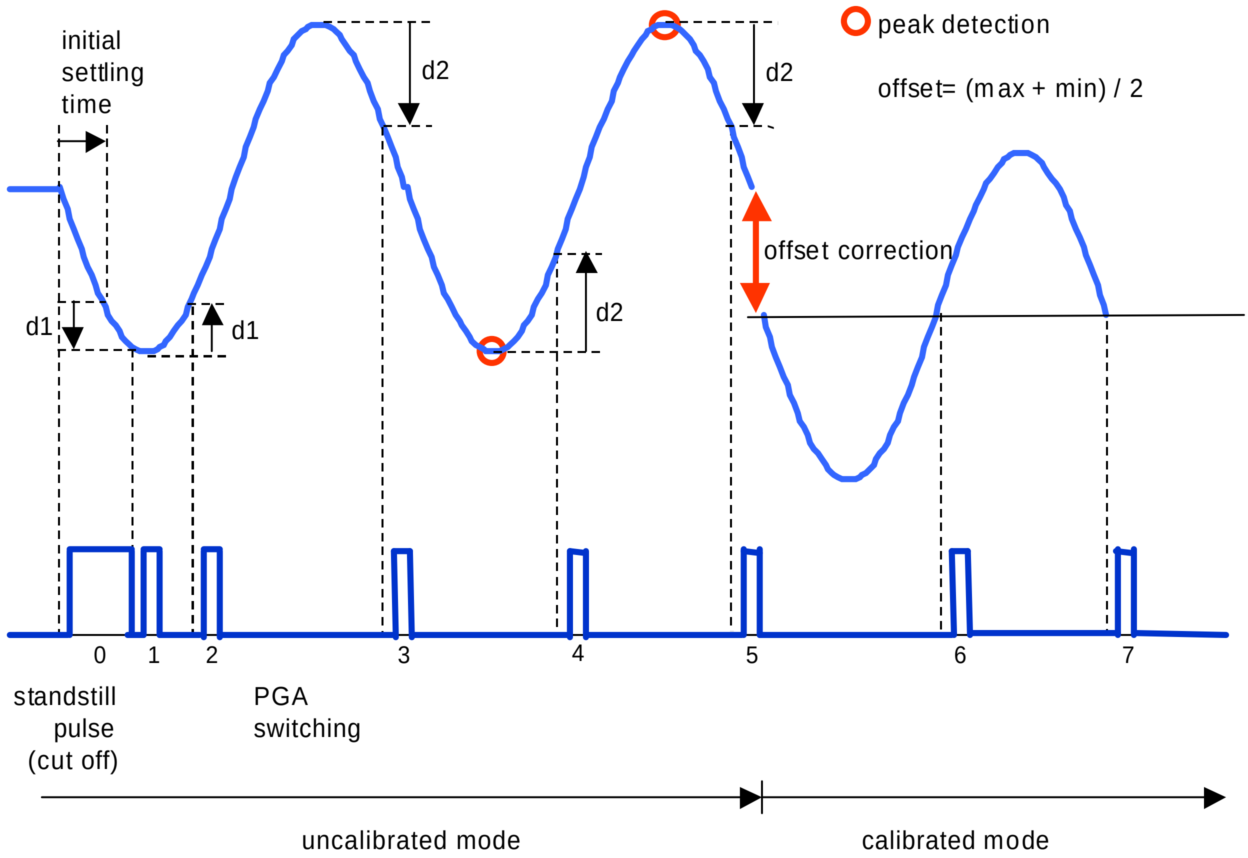


Fig. 1: example for start-up behaviour

<u>Uncalibrated mode:</u>

Occasionally a short initial offset settling time $t_{d,input}$ might delay the detection of the input signal. (The sensor is "blind").

The magnetic input signal is tracked by the speed ADC and monitored within the digital circuit. For detection the signal transient needs to exceed a threshold (digital noise constant d1). When the signal slope is identified as a rising edge (or falling edge), a comparator is triggered. The comparator is triggered again as soon as a falling edge (or rising edge respectively) is detected (and vice versa). Depending on the initial state of the comparator the IC output is first triggerd on the first or second detected edge.

Between the startup of the magnetic input signal and the time when its second extreme is reached, the PGA (programmable gain amplifier) will switch to its appropriate position. This value is determined by the signal amplitude and initial offset value. The digital noise constant value is changing accordingly (d1 $\rightarrow$ d2), leading to a change in phase shift between magnetic input signal and output signal. After that consecutive output pulses should have a nominal delay of about 180°.

During the uncalibrated mode the offset value is calculated by the peak detection algorithm as described in the TLE4942 data sheet.

<u>Transition to calibrated mode:</u>

In the calibrated mode the phase shift between input and output signal is no longer determined by the ratio between digital noise constant and signal amplitude. Therefore a sudden change in the phase shift may occur during the transition from uncalibrated to calibrated mode.

Calibrated mode:
See TLE4942 data sheet.

Additional notes:
Unlike the TLE4942 the first output pulse might occur before the first zero-crossing of the magnetic input signal. Therefore the maximum number of edges until the calibrated mode is active is increased by one for TLE4942-2. However, referring to the input signal the delay between startup of the signal and first calibrated output signal is identical with TLE 4942.

Typically the phase error due to PGA-transition (row 7 to 15) reduces the error caused by switching the mode from uncalibrated to calibrated.

In very rare cases a further PGA switching can occur during the calibration process. It can take place when the signal is extremely close to a PGA switching threshold. This additional switching might delay the transition to calibrated mode by two to three more pulses. The probability of this case is mainly depending on variations of magnetic amplitude under real automotive conditions. (See appendix B)

The direction detection feature is active in the calibrated mode only. Therefore identical to TLE4942 the correct direction information is available after the first three output pulses in calibrated mode. Regarding the rare case mentioned before combined with other initial conditions this may lead to a worst case of 11 pulses before correct direction information is guaranteed. The typical value is 5 pulses.

1	0	1	2	3	4	5	6	7	8	9	10
2	45µs...737 ms	180° (uncal)	90...270°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	180° (cal)	180° (cal)	180° (cal)	
3	45µs...737 ms	45µs ...180° (uncal)	180° (uncal)	90...270°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	180° (cal)	180° (cal)	
4	45µs...737 ms	45µs ...180° (uncal)	180° (uncal)	180° (uncal)	90...270°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	180° (cal)	
5	45µs...737 ms	45µs ...180° (uncal)	180° (uncal)	180° (uncal)	180° (uncal)	90...270°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	
6	45µs...737 ms	45µs ...180° (uncal)	180° (uncal)	180° (uncal)	180° (uncal)	180° (uncal)	90...270°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	
7	45µs...737 ms	180°...300° (PGA, uncal)	180...220°	180° (uncal)	180° (uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	180° (cal)	180° (cal)	
8	45µs...737 ms	180°...300° (PGA, uncal)	180° (uncal)	180...220°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	180° (cal)	
9	45µs...737 ms	180°...300° (PGA, uncal)	180° (uncal)	180° (uncal)	90...270°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	
10	45µs...737 ms	180°...300° (PGA, uncal)	180° (uncal)	180° (uncal)	180° (uncal)	90...270°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	
11	45µs...737 ms	180°...300° (PGA, uncal)	180° (uncal)	180° (uncal)	180° (uncal)	180° (uncal)	90...270°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	
12	45µs...737 ms	45µs ...180° (uncal)	180°...260° (PGA, uncal)	180...220°	180° (uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	180° (cal)	180° (cal)	
13	45µs...737 ms	45µs ...180° (uncal)	180°...260° (PGA, uncal)	180° (uncal)	180...220°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	180° (cal)	
14	45µs...737 ms	45µs ...180° (uncal)	180°...260° (PGA, uncal)	180° (uncal)	180° (uncal)	90...270°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	
15	45µs...737 ms	45µs ...180° (uncal)	180°...260° (PGA, uncal)	180° (uncal)	180° (uncal)	180° (uncal)	90...270°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	

Table1: overview of the startup-behaviour.
In the first row the pulse number is given. Pulse number 0 is the last pulse before signal startup, e.g. the standstill (stopped) pulse. The following rows show different possibilities for the nominal delays between the pulses. Numbers are calculated for sinusoidal input signals. Additionally the specified tolerances have to be taken into account (e.g. Jitter)

Rows 2..6: behaviour at small input amplitudes (ΔB< approx. 3.5mT)
Rows 7..11: behaviour at initial phases of –90° .. 0°
Rows 12..15: behaviour at initial phases of 0°.. 90°

Remark: the additional PGA switching can only occur *once* per row. Therefore also the additional phase shift marked "150°..200° (cal/uncal)" will only occur once per row. (see example)

Example: The 14th row describes the behaviour shown in Fig. 1: The standstill pulse length can be cut by the first detected speed pulse, therefore the minimum distance between the rising edges will be 45µs. The distance between the first and second detected speed pulse is determined by the initial signal phase and amplitude and a possible first PGA switching. As the first pulse length also can theoretically be cut off by the following pulse, the minimum distance could be 45µs. The rising edge between the first signal minimum and the first signal maximum can cause the PGA switching into a lower gain range. As a result the digital noise constant value can increase in relation to the signal amplitude. That typically leads to an increased delay between the second and the third pulse, its maximum value is 260°. The following minimum and maximum are necessary for peak detection. After offset correction, the delay between the 5^{th} and the 6^{th} pulse can have a maximum value 270°. As this marks the transition from uncalibrated to calibrated mode, the following consecutive pulses (4, 5, 6 ...) will be spaced 180° nominally.

Same example with numbers: $\Delta B = 10mT \sin(\omega t + \varphi)$. $\varphi = 30°$
Typical startup-behaviour at a sinusoidal input signal of 10mT amplitude, initial phase= 30°.

	1	2	3	4	5	6	7	8	9	10
φ	43,6°	133,9°	333,2°	513,2°	693,2°	900°	1080°	1260°	1440°	...
Δφ	90,3° (PGA, uncal)	199,3° (PGA, uncal)	180° (uncal)	180° (uncal)	206,8° (Offset-correction)	180° (cal)	180° (cal)	180° (cal)	180° (cal)	

→ This corresponds to row 14 in the table, behaviour similar to Fig. 1

As a special (and rare) case instead of an offset correction after edge number 5, a further (extra) PGA switching could occur before edge number 5. PGA switching inhibits an immediate offset update. It *can* happen if one of the signal peaks is exactly at a PGA switching threshold (speed-ADC overflow). In this case the offset update (switching from uncalibrated mode to calibrated mode) would be delayed by two to three further edges. The referring phase shifts of the example would then be as follows:

	1	2	3	4	5	6	7	8	9	10
φ	43,6°	133,9°	333,2°	513,2°	727,5°	907,5°	1087,5°	1260°	1440°	...
Δφ	90,3° (PGA, uncal)	199,3° (PGA, uncal)	180° (uncal)	214,3° (extra PGA)	180° (uncal)	180° (uncal)	172,5° (Offset-correction)	180° (cal)	180° (cal)	

→ This corresponds to row 13 of the table.

Circuit Description

See TLE4942 data sheet

2 Additions/Changes for TLE4942–2 versus TLE4942

(All values are valid for constant amplitude and offset of input signal, f<2500Hz)

Parameter	Symbol	min.	typ.	max.	Unit	Conditions
Signal behaviour after undervoltage or standstill>t_{Stop}	$n_{DZ-Start}$					Magnetic edge amplitude according to $\Delta\hat{B}_{Limit, early\ startup}$ Edges that occur before $n_{DZ-Start}$ can be suppressed
				2	pulses	1Hz ≤ f ≤ 2000Hz
				3	pulses	f > 2000Hz $t_{d,input}$ has to be taken into account
Systematic phase error of output pulses during **startup- and uncalibrated mode**		38	45	52	µs	Shortest time delay between pulse 0 (stop pulse) and pulse 1 $t_{d,input}$ has to be taken into account
		38	45	52	µs	Shortest time delay between wheel speed pulse 1 and 2
		-88		+88	°	*Systematical* phase error of "uncal" pulse; nth vs. n+1th pulse (does not include jitter)
Phase shift change during PGA switching		0		80	°	
Phase shift change during **transition** from uncalibrated to calibrated mode	$\Delta\Phi_{switch}$	-90		+90	°	
Number of pulses in uncalibrated mode	$n_{DZ-Startup}$			6	pulses	
in rare cases (see appendix B)	$n_{DZ-Startup}$			8	pulses	
Number of pulses with invalid supplementary information	$n_{DR-Startup}$			9	pulses	After $n_{DR-Startup}$ pulses the supplementary information is correct (starting with the $n_{DR-Startup}$+1-th pulse the pulse length is correct)
in rare cases (see application notes)	$n_{DR-Startup}$			11	pulses	

Parameter	Symbol	min.	typ.	max.	Unit	Conditions
Jitter during **startup and uncalibrated mode**	$S_{JitClose}$ (1σ-value)			± 3 ± 4	% %	-40°C ≤T_{amb} ≤ 150°C: 150°C ≤T_{amb} ≤ 170°C:
	S_{JitFar} (1σ-value)			± 5 ± 7	% %	-40°C ≤T_{amb} ≤ 150°C 150°C≤T_{amb} ≤170°C
	S_{JitAC} (1σ-value)			± 3	%	see TLE 4942 spec
Magnetic field amplitude change necessary for early startup of the –2 Versions $\Delta\hat{B}_{Limit, early startup}$ > 2 * ?$\hat{B}_{Limit}$ + X% (X = 10)	$\Delta\hat{B}_{Limit, early startup}$	0.7 **0.7**	1.6 +10% **1.76**	3.0 +10% **3.3**	mT mT	These magnetic field changes are necessary for startup with the second magnetic edge
Permitted time for edges to exceed $\Delta\hat{B}_{Limit, early startup}$	$\Delta t_{Limit, slow early startup}$			590	ms	necessary for startup with the second edge f < 1s

Behaviour at magnetic input signals slower than T_{stop} (self-calibration time period):

Unlike the TLE4941 magnetic changes exceeding $\Delta\hat{B}_{Limit, early startup}$ can cause output switching of the TLE4941-2, even at f significantly lower than 1Hz. Depending on their amplitude edges slower than $\Delta t_{Limit, slow early startup}$ might be detected. If the digital noise constant ($\Delta\hat{B}_{Limit,early startup}$) is not exceeded before a new initial self-calibration is started, the output of the corresponding edge will be inhibited. This depends on signal amplitude and initial phase.

3 Additional remarks

All additional parameters for TLE4942-2 are guaranteed by design, based on lab characterisations. For series production additional to the parameters of TLE4942 (standard type) only $n_{DZ\text{-}start}$ is tested.

Appendix B: TLE4942-2 Application Notes Release 1.0

1. Occurrence of initial calibration delay time $t_{d,input}$

Identical to TLE 4942, TLE 4942 C Application notes.

2. Magnetic input signal extremely close to a PGA switching threshold during signal startup:

After signal startup normally all PGA switching into the appropriate gain state occurs within less than one signal period. This is included in the calculation for $n_{DZ\text{-}Startup}$. For the very rare case that the signal amplitude is extremely close to a switching threshold of the PGA and the the full range of following speed ADC respectively, a slight change of the signal amplitude *can* cause one further PGA switching. It can be caused by non-perfect magnetic signal (amplitude modulation due to tolerances of pole-wheel, tooth wheel or air gap variation). This additional PGA switching *can* result in a further delay of the output signal ($n_{DZ\text{-}Startup}$) up to three magnetic edges leading to a worst case of $n_{DZ\text{-}Start}$=9 and $n_{DR\text{-}Startup}$=11.

However, the speed signal startup, comprised of $n_{DR\text{-}Startup}$ and $t_{d,input}$ is not affected by this behaviour for TLE 4942-2.

3. - 6. Identical to TLE4942, TLE4942C Application notes.