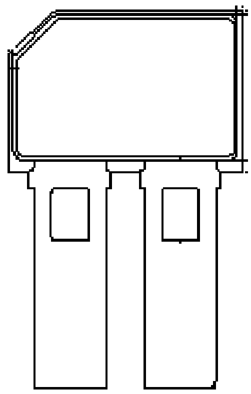
Data Sheet Supplement

Differential Two-Wire Hall Effect Sensor IC

TLE4941-2
TLE4941-2C

For all parameters not specified in this document the TLE4941 data sheet is valid.



PSSO2-1

Type	Marking	Ordering Code	Package
TLE4941-2	4102E	Q62705-K629	PSSO2-1
TLE4941-2C	41C2E	Q62705-K631	PSSO2-2

1 Functional description

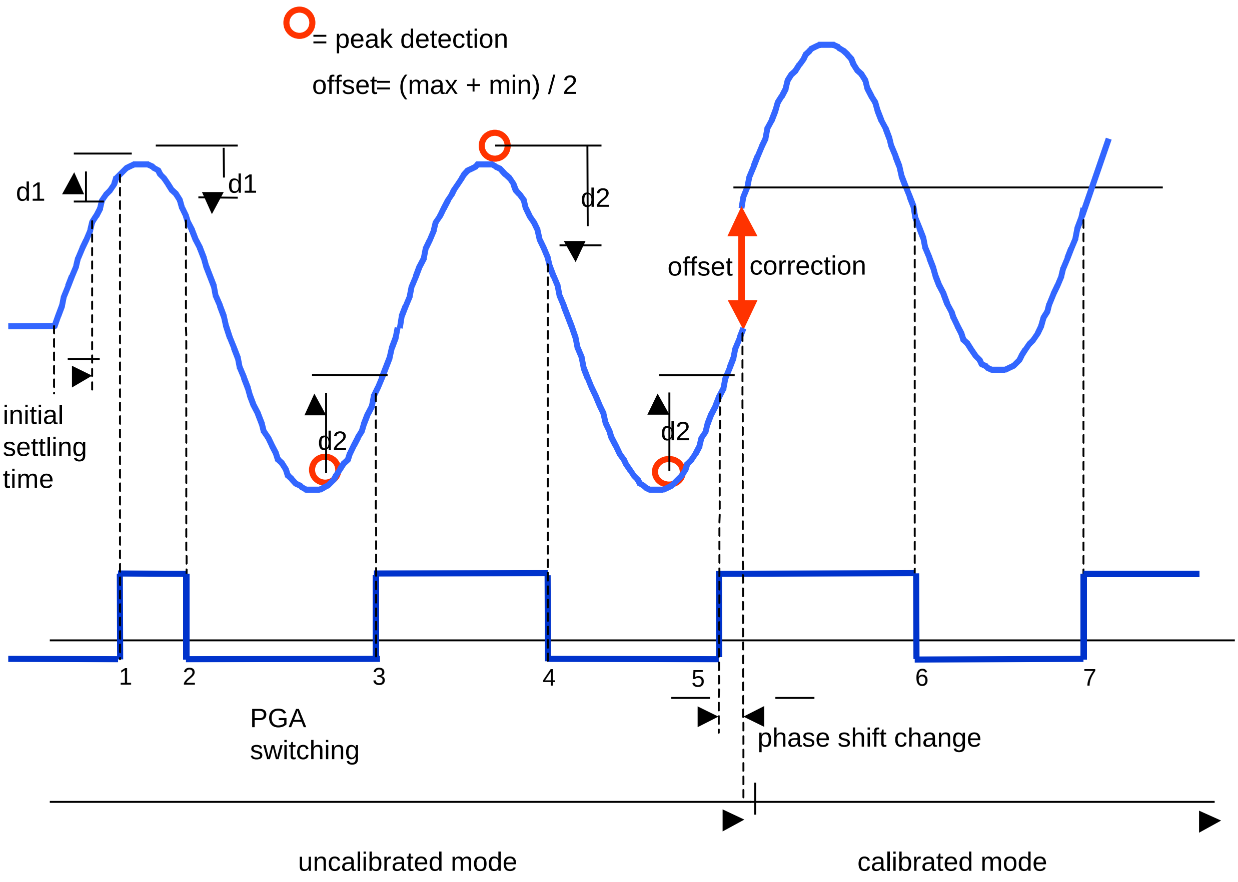


Fig. 1: example for startup behaviour

<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 trigger pulse is issued to a comparator. A second trigger pulse is issued 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 start-up 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, related to the corresponding PGA states), leading to a change in phase shift between magnetic input signal and output signal. After that consecutive output edges should have a nominal delay of about 180°. In rare cases one further switching of PGA can occur (see appendix B).

During the uncalibrated mode the offset value is calculated by the peak detection algorithm as described in the TLE 4941 data sheet.

Transition to calibrated mode:
In the calibrated mode the output will switch at zero-crossing of the input signal. 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 TLE4941 data sheet.

Additional notes:
Unlike the TLE 4941 the first output edge 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 TLE4941-2. However, referring to the input signal the delay between star-up of the signal and first calibrated output signal is identical with TLE4941.

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

The summed up change in phase error from the first output edge issued to the output edges in calibrated mode will not exceed +/- 90°.

1	1	2	3	4	5	6	7	8	9	10
2	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	38µs ...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	38µs ...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	38µs ...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	38µs ...180° (uncal)	180° (uncal)	180° (uncal)	180° (uncal)	180° (uncal)	90...270°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	
7	135°..300° (PGA, uncal)	180...220°	180° (uncal)	180° (uncal)	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	180° (cal)	180° (cal)	
8	135°..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	135°..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	135°..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	135°..300° (PGA, uncal)	180° (uncal)	180° (uncal)	180° (uncal)	180° (uncal)	90...270°	150°..200° (cal/uncal)	150°..200° (cal/uncal)	180° (cal)	
12	38µs ...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	38µs ...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	38µs ...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	38µs ...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 start-up behaviour.
In the first row the edge number is given. The following rows show different possibilities for the nominal delays between the edges. 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: $\Delta B = 10mT \sin(\omega t + \varphi)$. $\varphi = 30°$
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 TLE4941 data sheet

2 Additions/Changes for TLE4941–2 versus TLE 4941

(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}	$n_{DZ\text{-}Start}$					Magnetic edge amplitude according to $\Delta\hat{B}_{Limit, early startup}$ Edges that occur before $n_{DZ\text{-}Start}$ can be suppressed
				2	edges	$1Hz \leq f \leq 2000Hz$
				3	edges	f > 2000Hz $t_{d,input}$ has to be taken into account
Systematic phase error of output edges during **start-up and uncalibrated mode**		38			µs	Shortest time delay between input signal edge 1 and 2 $t_{d,input}$ has to be taken into account
		-88		+88	°	*Systematical* phase error of "uncal" edge; nth vs. n+1th edge (does not include random phase error)
Phase shift change during PGA switching		0		80	°	after the 2nd edge
Phase shift change during **transition** from uncalibrated to calibrated mode	$\Delta\Phi_{switch}$	-90		+90	°	
Number of edges in uncalibrated mode	$n_{DZ\text{-}Startup}$			6	edges	
in rare cases (see appendix B)	$n_{DZ\text{-}Startup}$			8	edges	

Parameter	Symbol	min.	typ.	max.	Unit	Conditions
Jitter during uncalibrated mode	$S_{JitClose}$ (1σ-value)			± 3 ± 4	% %	$-40°C \leq T_{amb} \leq 150°C$ $150°C \leq T_{amb} \leq 170°C$
	S_{JitFar} (1σ-value)			± 5 ± 7	% %	$-40°C \leq T_{amb} \leq 150°C$ $150°C \leq T_{amb} \leq 170°C$
	S_{JitAC} (1σ-value)			± 3	%	see TLE 4941 data sheet
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 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 TLE4941-2 are guaranteed by design, based on lab characterizations. For series production additional to the parameters of TLE4941 (standard type) only $n_{DZ\text{-}start}$ is tested.

Appendix B Release 1.0

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

Identical to TLE4941, TLE4941C appendix B.

2. Magnetic input signal extremely close to a PGA switching threshold during signal start-up:

After signal start-up normally all PGA switching into the appropriate gain state happens 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 full range of the 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 polewheel, 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 start-up, comprised of $n_{DR\text{-}Startup}$ and $t_{d,input}$ is not affected by this behaviour for TLE4941-2.*