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ASL2500SHN

Two phase boost converter

Rev. 3 — 26 October 2017

Product data sheet

1. Introduction

The ASL2500SHN is a highly integrated and flexible two-phase DC-to-DC boost converter IC. It has an SPI interface allowing control and diagnostic communication with an external microcontroller.

It is designed primarily for use in automotive LED lighting applications and provides an optimized supply voltage for ASLx415SHN Multi-channel LED Buck Driver.

2. General description

The ASL2500SHN has a fixed frequency peak current mode control with parabolic/non-linear slope compensation. It can operate with input voltages from 5.5 V to 40 V. It can be configured via SPI for output voltages of up to 80 V, to power the LED buck driver IC.

The ASL2500SHN is a two-phase converter which can have two independent outputs. The flexible driver can be configured, via the SPI interface, as a single output converter, or with multiple combinations of number of outputs and phases.

The ASL2500SHN boost converter can drive up to two external low-side N channel MOSFETs from an internally regulated adjustable supply. It can drive either logic or standard level MOSFETs.

The integrated SPI interface also allows for programming the supply under/over voltage range, output voltage range and DC-to-DC switching frequency. It enables the optimization of external components and flexibility for EMC design. This interface can also be used to provide diagnostic information such as the driver temperature.

Additional features include input under-voltage lockout and thermal shutdown when the junction temperature of the ASL2500SHN exceeds +175 °C.

The device is housed in a very small HVQFN32 pin package with an exposed thermal pad. It is designed to meet the stringent requirements of automotive applications. It is fully AEC Q100 grade 1 qualified. It operates over the -40 °C to +125 °C ambient automotive temperature range.



3. Features and benefits

- The ASL2500SHN is an automotive grade product that is AEC-Q100 grade 1 qualified.
- Operating ambient temperature range of $-40\text{ }^{\circ}\text{C}$ to $+125\text{ }^{\circ}\text{C}$
- Wide operating input voltage range from $+5.5\text{ V}$ to $+40\text{ V}$
- Output voltage programmable via SPI interface
- Multi-phase operation for higher power
- Up to two phases per output
- Up to two flexible output voltages with 3 % accuracy programmable via SPI
- Both output voltages can be controlled independently
- Fixed Frequency Operation via built-in oscillator
- Slope compensation to track the frequency and output voltage
- Programmable control loop compensation
- Fast high efficiency FET switching
- Programmable internal gate driver voltage regulator
- Gate switching is halted when overvoltage on output is detected
- Support both Logic Level and Standard Level FETs
- Low Electro Magnetic Emission (EME) and high Electro Magnetic Immunity (EMI)
- Output voltage monitoring
- Supply voltage measurement
- Control signal to enable the device
- Read-back programmed voltage and frequency range via SPI
- Junction temperature monitoring via SPI
- Small package outline HVQFN32
- Low quiescent current $<5\text{ }\mu\text{A}$ at $25\text{ }^{\circ}\text{C}$ when $\text{EN} = 0$

4. Applications

- Automotive LED lighting
 - ◆ Daytime running lights
 - ◆ Position or park light
 - ◆ Low beam
 - ◆ High beam
 - ◆ Turn indicator
 - ◆ Fog light
 - ◆ Cornering light

5. Ordering information

Table 1. Ordering information

Type number	Package		
	Name	Description	Version
ASL2500SHN	HVQFN32	plastic thermal enhanced very thin quad flat package; no leads; 32 terminals; body $5 \times 5 \times 0.85\text{ mm}$	SOT617-12

6. Block diagram

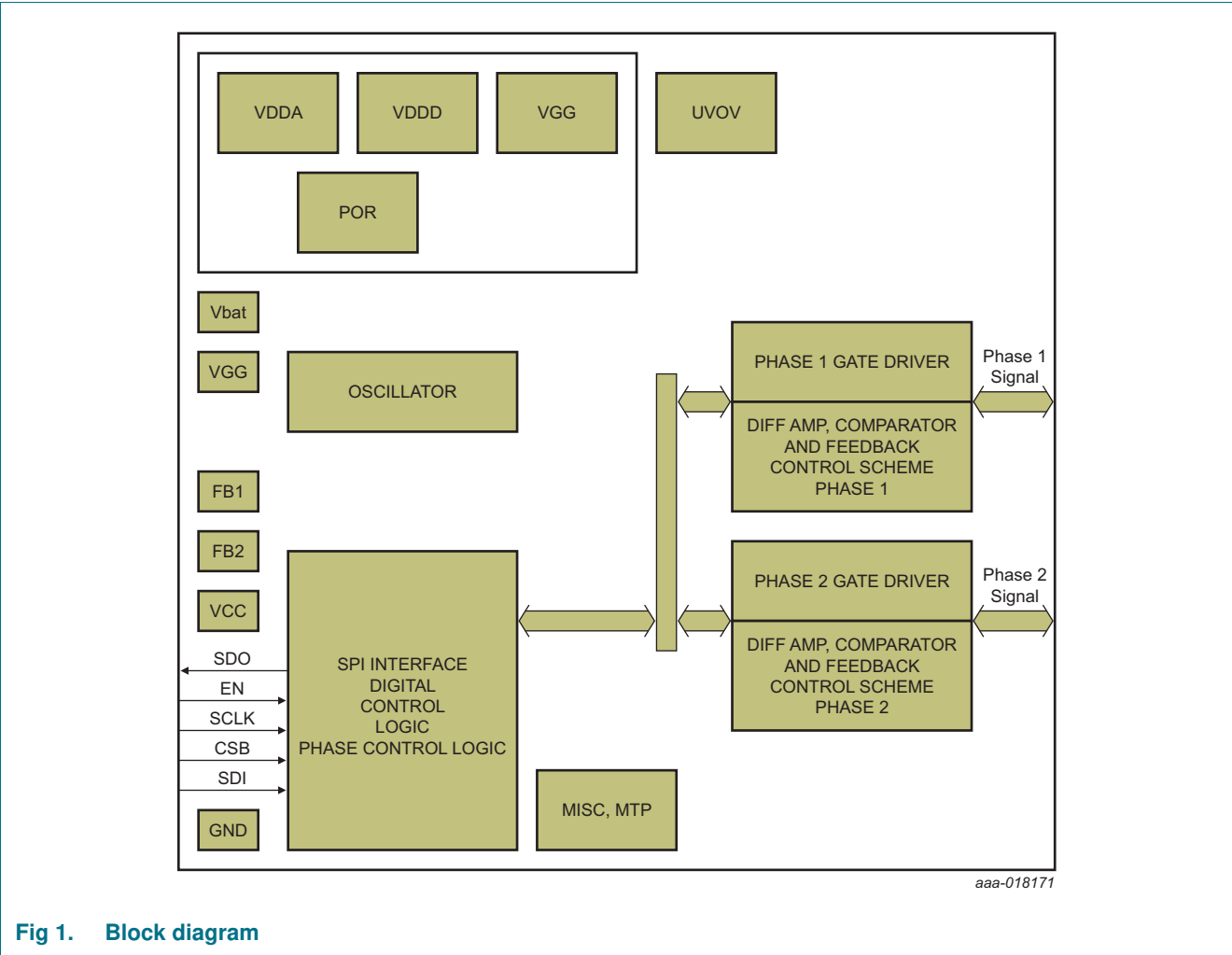


Fig 1. Block diagram

7. Pinning information

7.1 Pinning

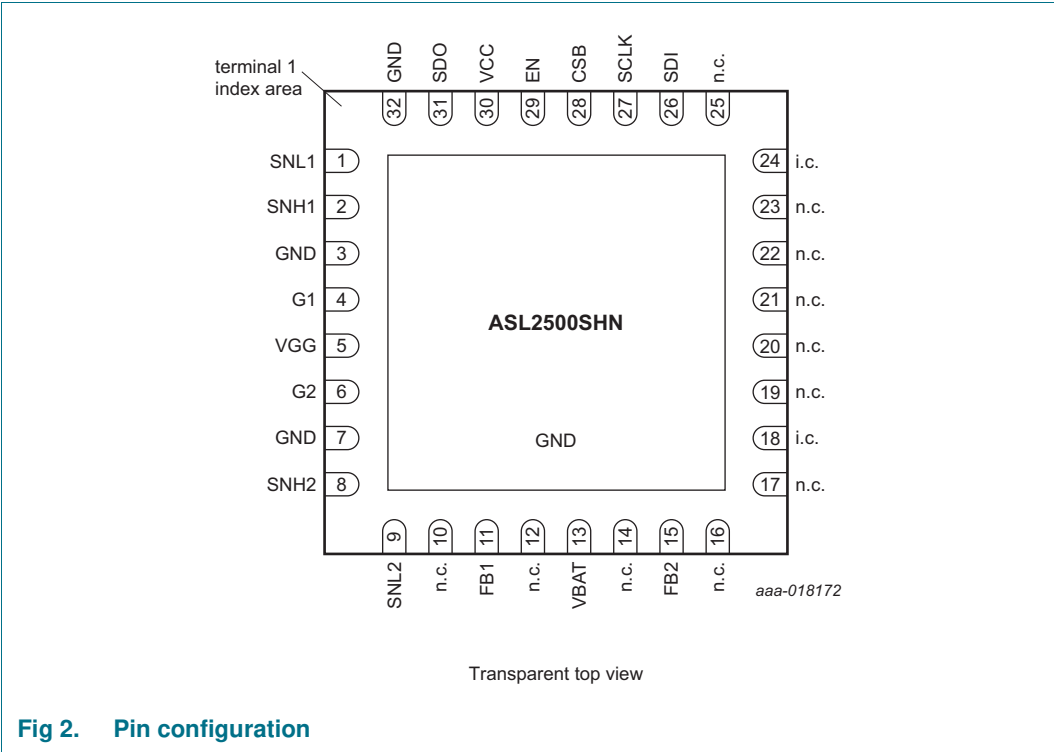


Fig 2. Pin configuration

7.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
SNL1	1	phase 1 sense low
SNH1	2	phase 1 sense high
GND	3	ground
G1	4	phase 1 gate driver
VGG	5	gate driver supply
G2	6	not connected
GND	7	ground
SNH2	8	phase 2 sense high
SNL2	9	phase 2 sense low
n.c.	10	not connected
FB1	11	feedback, output 1
n.c.	12	not connected
VBAT	13	battery supply
n.c.	14	not connected
FB2	15	feedback, output 2

Table 2. Pin description^[1] ...continued

Symbol	Pin	Description
n.c.	16	not connected
n.c.	17	not connected
i.c. ^[3]	18	internally connected
n.c.	19	not connected
n.c.	20	not connected
n.c.	21	not connected
n.c.	22	not connected
n.c.	23	not connected
i.c. ^[3]	24	internally connected
n.c.	25	not connected
SDI	26	SPI Data Input
SCLK	27	SPI Clock
CSB	28	SPI chip select
EN	29	enable signal
VCC	30	external 5 V supply
SDO	31	SPI Data Out
GND	32	chip ground

[1] n.c. pins are internally not connected and can be left floating or can be connected to any voltage level.

[2] See [Figure 4](#) and [Figure 14](#) for recommend connections for pin FB1 and pin FB2.

[3] Internally connected pins should be connected to GND.

For enhanced thermal and electrical performance, the exposed center pad of the package should be soldered to board ground (and not to any other voltage level).

8. Functional description

8.1 Operating modes

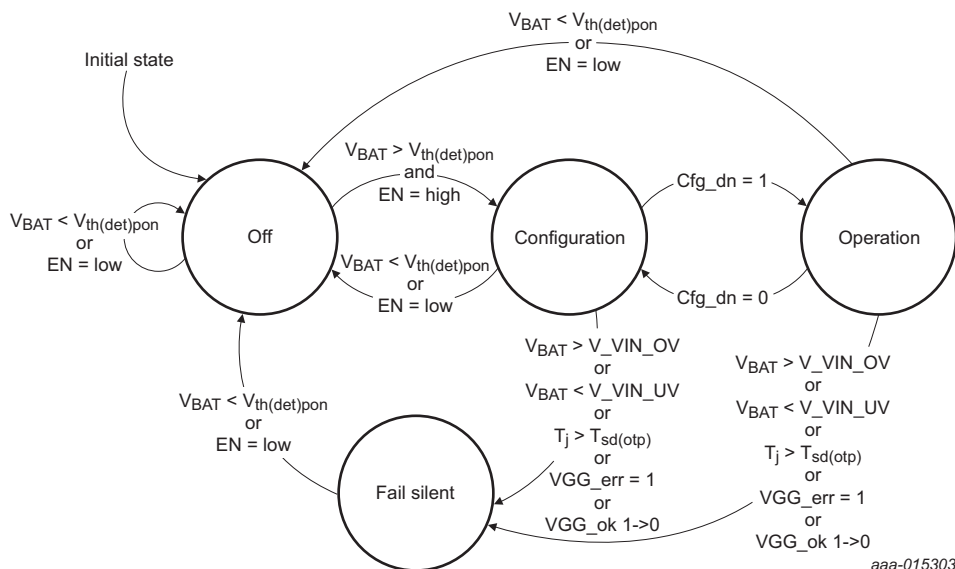


Fig 3. State diagram

Table 3. Operating modes

Mode	Control registers	Configuration registers	Diagnostic IC registers	VGG	Vout1	Remark
Off	n.a.	n.a.	n.a.	Off	Off	device is off, no communication possible
Configuration	Read/write	Read/write	Read	Off	Off	VGG is off if the output was not previously enabled
				According to register	Off	VGG stays on as soon as the output has been enabled
Operation	Read/write	Read	Read	Locked	According to register	configuration register is locked
Fail silent	Read/write	Read ^[1]	Read	Off	Off	communication possible, but the output is off; restart via EN possible.

[1] Setting the bit `cfg_dn` to 0 also grants write access to the configuration registers.

8.1.1 Off mode

The ASL2500SHN switches to off mode, if the input voltage drops below the power-on detection threshold ($V_{th(det)pon}$) or the EN pin is low.

The SPI interface and output are turned off when the ASL2500SHN is in the Off mode.

8.1.2 Configuration mode

The ASL2500SHN switches from off mode to configuration mode, as soon the input voltage is above the power-on detection threshold ($V_{th(det)pon}$) and pin EN is high.

The configuration registers can be set when the ASL2500SHN is in the Configuration mode.

8.1.3 Operation mode

The ASL2500SHN switches from configuration mode to operation mode, as soon as the configuration done bit is set. Once the bit is set, the configuration registers are locked and cannot be changed.

In operation mode, the output is available as configured via the SPI interface. Setting the bits Vout1en or Vout2en, starts up VGG. Once VGG is in regulation (signaled by bit VGG_ok), the output voltages Vout1 and Vout2 are turned on accordingly. When the converters are on, the battery monitoring functionality is available.

8.1.4 Fail silent mode

The ASL2500SHN switches from Operation mode to Fail silent mode, when the junction temperature exceeds the over temperature shutdown threshold or a VGG error is detected. It will also switch modes when the input voltage is below the under voltage detection threshold or above the over voltage detection threshold.

In Fail silent mode, all outputs are turned off and only the SPI interface remains operational.

8.2 Boost converter configuration

The ASL2500SHN is an automatic boost converter IC delivering constant DC-to-DC voltage to a load. It has a fixed frequency current-mode control for an enhanced stable operation.

The ASL2500SHN offers two phases. Each phase consists of a coil, a resistor, a MOSFET and a diode as shown in [Figure 4](#).

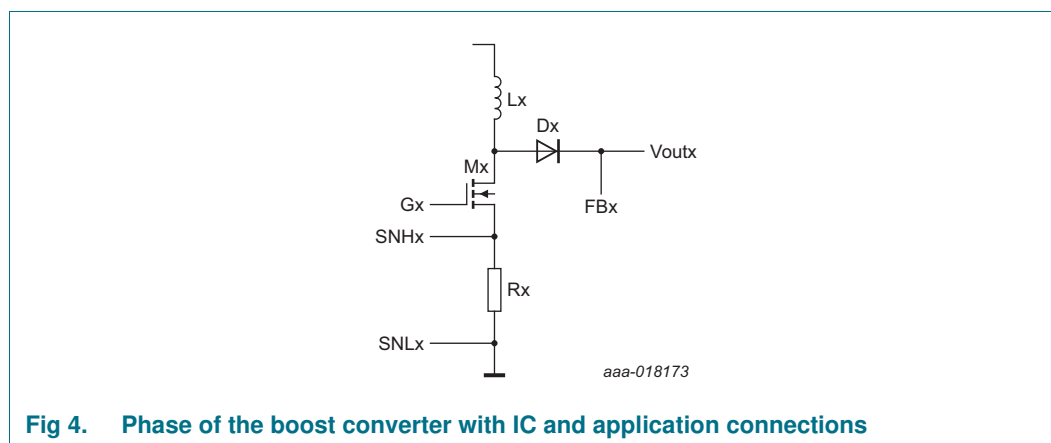
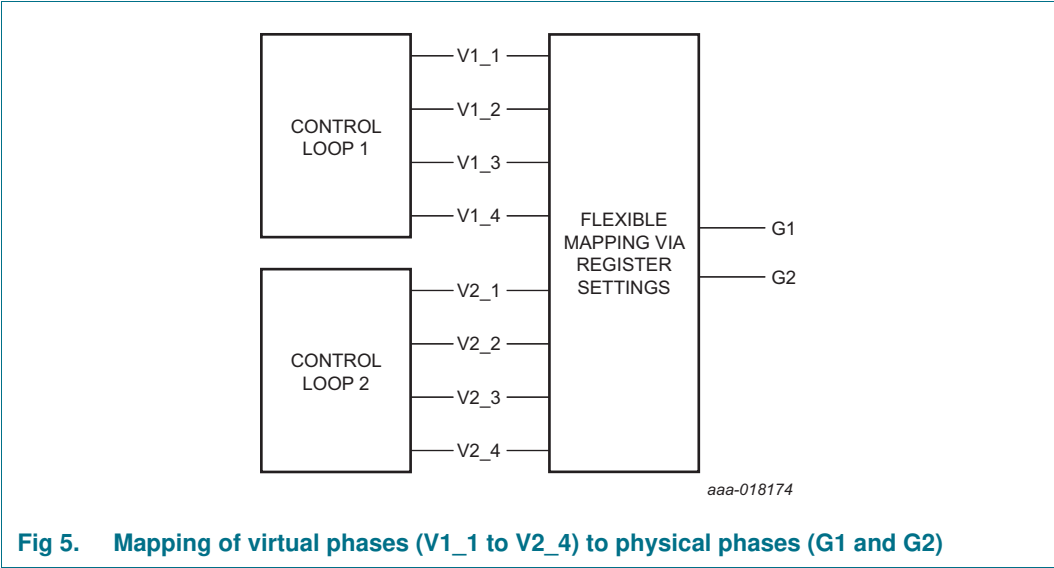


Fig 4. Phase of the boost converter with IC and application connections

To allow a flexible use of the ASL2500SHN, the configuration is based on virtual phases. These phases are then mapped to a real, physical phase according to the physical connections and conditions of the circuitry around the ASL2500SHN as shown in [Figure 5](#).



8.2.1 Configuration of the virtual phases

The ASL2500SHN can generate up to four internal phases for up to two virtual outputs. With the internal phase control enable registers, it can be selected, how many virtual phases are generated for the individual virtual outputs.

Table 4. Internal phase control enable for output 1, address 0x0Bh

Bit	Symbol	Description	Value	Function
7:4		reserved	0000	reserved; should remain cleared for future use
3	EN_P4_1	phase 4 enabled	0	phase 4 is off
			1	phase 4 is enabled
2	EN_P3_1	phase 3 enabled	0	phase 3 is off
			1	phase 3 is enabled
1	EN_P2_1	phase 2 enabled	0	phase 2 is off
			1	phase 2 is enabled
0	EN_P1_1	phase 1 enabled	0	phase 1 is off
			1	phase 1 is enabled

Table 5. Internal phase control enable for output 2, address 0x0Ch

Bit	Symbol	Description	Value	Function
7:4		reserved	0000	reserved; should remain cleared for future use
3	EN_P4_2	phase 4 enabled	0	phase 4 is off
			1	phase 4 is enabled
2	EN_P3_2	phase 3 enabled	0	phase 3 is off
			1	phase 3 is enabled
1	EN_P2_2	phase 2 enabled	0	phase 2 is off
			1	phase 2 is enabled
0	EN_P1_2	phase 1 enabled	0	phase 1 is off
			1	phase 1 is enabled

8.2.2 Association of physical phases to the output voltages

Each phase that the ASL2500SHN offers, must be associated to one of the outputs. Multiple combinations are possible here, e.g. all phases to one of the outputs, or 1 phase to one output and 1 phase to another one.

Table 6. Gate driver output, address 0x02h

Bit	Symbol	Description	Value	Function
7:2		reserved	0000000	reserved; should remain clear for future use
1	O_G2	association phase 2	0	phase 2 is connected to Vout1
			1	phase 2 is connected to Vout2
0	O_G1	association phase 1	0	phase 1 is connected to Vout1
			1	phase 1 is connected to Vout2

8.2.3 Association of connected phases to the internal phase generation

The physical phase that the ASL2500SHN offers, must be associated to one of the virtual phases of one of the outputs. It is established with the gate driver phase and phase select configuration registers.

Table 7. Gate driver phase, address 0x0Fh

Bit	Symbol	Description	Value	Function
7:2		reserved	000000	reserved; should remain clear for future use
1	O_GP2	association phase 2	0	phase 2 is connected to Vout1
			1	phase 2 is connected to Vout2
0	O_GP1	association phase 1	0	phase 1 is connected to Vout1
			1	phase 1 is connected to Vout2

Table 8. Phase select configuration, address 0x10h

Bit	Symbol	Description	Value	Function
7:4		reserved	0000	reserved; should remain clear for future use
3:2	Phsel2[1:0]	phase select gate driver 2	0x0h	routing from phase 1
			0x1h	routing from phase 2
			0x2h	routing from phase 3
			0x3h	routing from phase 4
1:0	Phsel1[1:0]	phase select gate driver 1	0x0h	routing from phase 1
			0x1h	routing from phase 2
			0x2h	routing from phase 3
			0x3h	routing from phase 4

8.2.4 Enabling of connected phases

The gate driver enable register is used to configure which of the phases is active.

Table 9. Gate driver enable, address 0x01h

Bit	Symbol	Description	Value	Function
7:2		reserved	0000000	reserved; should remain clear for future use
1	EN_G2	phase 2 enabled	0	phase 2 is off
			1	phase 2 is enabled
0	EN_G1	phase 1 enabled	0	phase 1 is off
			1	phase 1 is enabled

8.2.5 Configuration of the boost converter frequencies

The operation frequency of the boost converters can be set with via several SPI registers. To ensure a stable phase delay between the different phases, all timings are derived from the same oscillator. An integer number downscales the internal oscillator frequency for each regulation loop. The slower clock controls the off-time of a phase and the delay from one phase of the regulation loop to the next internal phase. The number of phases determinates finally when the phase is turned on again and so defines the operation frequency of the boost converter.

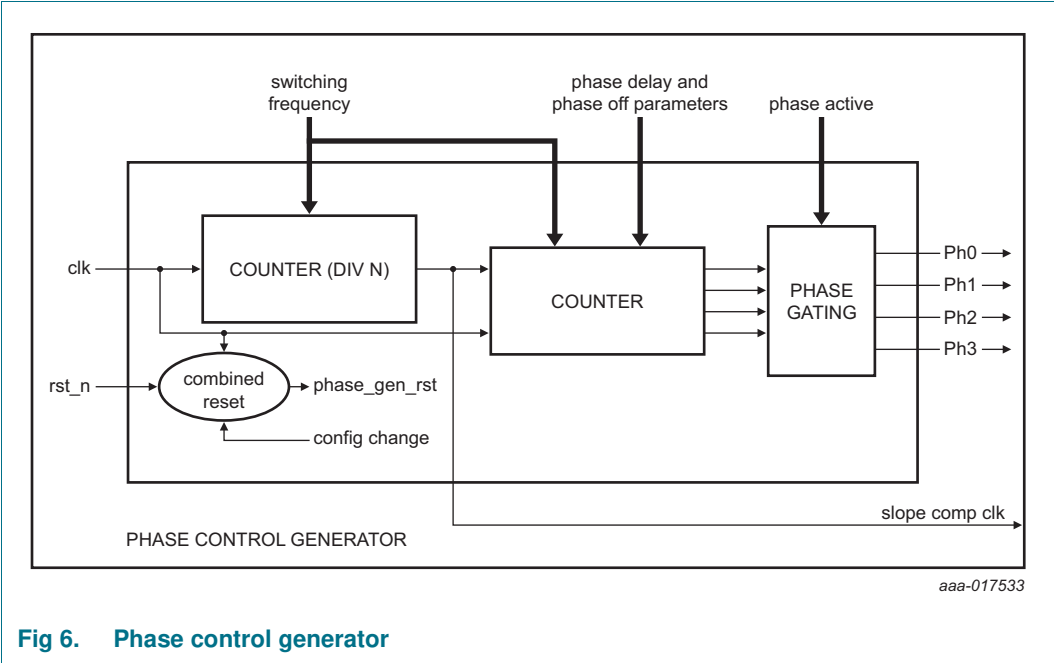


Table 10. Clock divider for Vout1, address 0x09h

Bit	Symbol	Description	Value	Function
7:0	Clkdiv1 [7:0]	clock divider for output voltage 1	0x00h	clock is not divided
			...	clock is divided by clkdiv1[7:0]+1
			0xFFh	clock is divided by 256

Table 11. Clock divider for Vout2, address 0x0Ah

Bit	Symbol	Description	Value	Function
7:0	Clkdiv1 [7:0]	clock divider for output voltage 2	0x00h	clock is not divided
			...	clock is divided by clkdiv2[7:0]+1
			0xFFh	clock is divided by 256

Table 12. Phase-off time and phase delay of output 1, address 0x0Dh

Bit	Symbol	Description	Value	Function
7:3	Phdel1 [4:0]	delay to next phase of output1	0x0h	phase delay is 1 clock period of the divided clock
			...	phase delay is Phdel1[4:0]+1 clock period of the divided clock
			0x1Fh	phase delay is 32 clock periods of the divided clock
2:0	Phoff1 [2:0]	phase-off time of output1	0x0h	phase-off time is 1 clock period of the divided clock
			...	phase-off time is Phoff1[2:0] clock period of the divided clock
			0x7h	phase-off time is 7 clock periods of the divided clock

Table 13. Phase-off time and phase delay of output 2, address 0x0Eh

Bit	Symbol	Description	Value	Function
7:3	Phdel2 [4:0]	delay to next phase of output2	0x0h	phase delay is 1 clock period of the divided clock
			...	phase delay is Phdel2[4:0]+1 clock period of the divided clock
			0x1Fh	phase delay is 32 clock periods of the divided clock
2:0	Phoff2 [2:0]	phase-off time of output2	0x0h	phase-off time is 1 clock period of the divided clock
			...	phase-off time is Phoff2[2:0] clock period of the divided clock
			0x7h	phase-off time is 7 clock periods of the divided clock

Note: To obtain the best performance of the internal slope compensation, keep the settings of the delay between the phases as close to 32 as possible.

8.2.6 Control loop parameter setting

The ASL2500SHN is able to operate with a wide range of external components and offers wide range of operating frequencies. To achieve the maximum performance for each set of operation conditions, set the control loop parameters according to the external components and the operating frequency.

Table 14. Loop filter proportional configuration, address 0x11h

Bit	Symbol	Description	Value	Function
7:4	Prop2[3:0]	proportional factor output 2	0x0h	proportional factor output 2 is 0.05
			...	proportional factor output 2 is Prop2[3:0]*0.05+0.05
			0xFh	proportional factor output 2 is 0.8
3:0	Prop1[3:0]	proportional factor output 1	0x0h	proportional factor output 1 is 0.05
			...	proportional factor output 1 is Prop1[3:0]*0.05+0.05
			0xFh	proportional factor output 1 is 0.8

Table 15. Loop filter integral configuration, address 0x12h

Bit	Symbol	Description	Value	Function
7:4	Integ2[3:0]	integral factor output 2	0x0h	integral factor output 2 is 0.005
			...	integral factor output 2 is Integ2[3:0]*0.005+0.005
			0xFh	integral factor output 2 is 0.08
3:0	Integ1[3:0]	integral factor output 1	0x0h	integral factor output 1 is 0.005
			...	integral factor output 1 is Integ1[3:0]*0.005+0.005
			0xFh	integral factor output 1 is 0.08

Table 16. Slope compensation configuration, address 0x13h

Bit	Symbol	Description	Value	Function
7:4	Slpcmp2[3:0]	slope compensation factor output 2	0x0h	slope compensation factor output 2 = 112 kΩ
			0x1h	slope compensation factor output 2 = 84 kΩ
			0x2h	slope compensation factor output 2 = 70 kΩ
			0x4h	slope compensation factor output 2 = 56 kΩ
			0x8h	slope compensation factor output 2 = 28 kΩ
3:0	Slpcmp1[3:0]	slope compensation factor output 1	0x0h	slope compensation factor output 1 = 112 kΩ
			0x1h	slope compensation factor output 1 = 84 kΩ
			0x2h	slope compensation factor output 1 = 70 kΩ
			0x4h	slope compensation factor output 1 = 56 kΩ
			0x8h	slope compensation factor output 1 = 28 kΩ

Table 17. Current sense slope resistor configuration, address 0x14h

Bit	Symbol	Description	Value	Function
7:4				
3:2	Slpr2[1:0]	slope resistor configuration for gate driver 2	0x0h	2'b00 - 250 Ω
			0x1h	2'b01 - 500 Ω
			0x2h	2'b10 - 1000 Ω
			0x3h	2'b11 - 1500 Ω
1:0	Slpr1[1:0]	slope resistor configuration for gate driver 1	0x0h	2'b00 - 250 Ω
			0x1h	2'b01 - 500 Ω
			0x2h	2'b10 - 1000 Ω
			0x3h	2'b11 - 1500 Ω

8.3 Output voltage programmability

The ASL2500SHN provides the possibility to program the output voltage and output overvoltage protection of the output via the SPI interface.

8.3.1 Output voltage target programming

The target output voltage can be programmed via the Output voltage registers. As the ASL2500SHN is a boost converter, the output voltage cannot be lower than the supply voltage minus the drop of the converter diode (Dx in [Figure 4](#)).

Table 18. Output voltage 1 register, address 0x03h

Bit	Symbol	Description	Value	Function
7:0	V_Vout_1[7:0]	target voltage output 1	0x00h	output 1 is turned off
			...	target voltage output 1 = $0.3606 * V_Vout_1[7:0]$
			0xFFh	maximum target output voltage = 90 V

Table 19. Output voltage 2 register, address 0x04h

Bit	Symbol	Description	Value	Function
7:0	V_Vout_2[7:0]	target voltage output 2	0x00h	output 2 is turned off
			...	target voltage output 2 = $0.3606 * V_Vout_2[7:0]$
			0xFFh	maximum target output voltage = 90 V

8.3.2 Output overvoltage protection programming

Due to fast changes in the supply or the output, it is possible that the output voltage is disturbed. To avoid high voltages that may result into damage of attached components, the ASL2500SHN offers a programmable overvoltage protection threshold. Once the output voltage is above this threshold, the gate pin of the output stops toggling. It results in a halt of the energy delivery to the output.

Once the output voltage recovers and is below the threshold again, the gate pin starts toggling again. The regulation loop regulates the output back to the target value.

For stable operation of the device, the limit voltage output register should be programmed around 5 V higher than the output voltage registers.

Table 20. Limit voltage output 1 register, address 0x05h

Bit	Symbol	Description	Value	Function
7:0	Vmax_Vout_1 [7:0]	limit voltage output 1	0x00h	output 1 is turned off
			...	target voltage output 1 = $0.3606 * Vmax_Vout_1[7:0]$
			0xFFh	maximum output over voltage protection output 1 = 90 V

Table 21. Limit voltage output 2 register, address 0x06h

Bit	Symbol	Description	Value	Function
7:0	Vmax_Vout_2 [7:0]	limit voltage output 2	0x00h	output 2 is turned off
			...	target voltage output 2 = $0.3606 * Vmax_Vout_2[7:0]$
			0xFFh	maximum output over voltage protection output 2 = 90 V

8.4 Coil peak current limitation

The ASL2500SHN offers a function to limit peak current inside the coil and therefore to limit the input current for the system. Furthermore this functionality can be used to avoid magnetic saturation of the coils. It also allows some soft start feature to be realized with this function.

With the Max phase current Vout1 register, the maximum peak current for the phase can be configured. Once the voltage between pins SNSLx and SNSHx reaches this level, the gate will be turned off until the next switching cycle. To avoid sub harmonic oscillations when the coil peak current limitation is becoming active, the slope compensation remains active. It reduces the coil peak current towards the end of the switching cycle to ensure stable operation of the system.

In order to avoid that this function interferes with the normal regulation, the limit should be placed well above the maximum expected current.

Table 22. Maximum phase current Vout1 register, address 0x07h

Bit	Symbol	Description	Value	Function
7:0	I_max[7:0]	coil current limitation for phases assigned to Vout1	0x00h	no current allowed
			...	maximum peak current = $(I_max_per_phase_Vout1 [7:0] * 1.8 V / 256 - 0.24 V) / R_{sense}$
			0x80	max allowed setting = $(128/255 * 1.8V - 0.24) V / R_{sense}$
			...	not allowed
			0xFFh	not allowed

Table 23. Maximum phase current Vout2 register, address 0x08h

Bit	Symbol	Description	Value	Function
7:0	I_max[7:0]	coil current limitation for phases assigned to Vout2	0x00h	no current allowed
			...	maximum peak current = $(I_max_per_phase_Vout2 [7:0] * 1.8 V / 256 - 0.24 V) / R_{sense}$
			0x80	max allowed setting = $(128/255 * 1.8V - 0.24) V / R_{sense}$
			...	not allowed
			0xFFh	not allowed

8.5 Enabling the output voltage

The ASL2500SHN provides two independent output voltages. In operation mode, the output voltages are turned on with the bit Vout1en and Vout2en.

As soon as one of the outputs is turned on, the VGG voltage regulator is turned on. After $t_{VGG_startup}$ the gate drivers start switching, provided the bit VGG_ok is set.

Table 24. Function control register, address 0x00h

Bit	Symbol	Description	Value	Function
7:4		reserved	0000	reserved; should remain cleared for future use
3	Cnt_CSB	count chip select time	0	chip select low count feature is disabled
			1	chip select low count feature is enabled
2	Vout2en	enable output 2	0	output 2 is turned off
			1	output 2 is turned on when the device is in operation mode
1	Vout1en	enable output 1	0	output 1 is turned off
			1	output 1 is turned on when the device is in operation mode
0	Cfg_dn	configuration done bit	0	device is in configuration mode - no configuration lock
			1	device is in operation mode - configuration lock is active

8.6 Frequency trimming

To ensure the ASL2500SHN operates inside the specified oscillator frequency range, it is mandatory to adjust the internal oscillator frequency of the device.

To measure the actual internal frequency, the device is measuring the time that the CSB pin is low during an SPI transfer. This time information can be used to adjust the oscillator frequency of the device. The recommended procedure for the time adjustment is shown in [Figure 7](#).

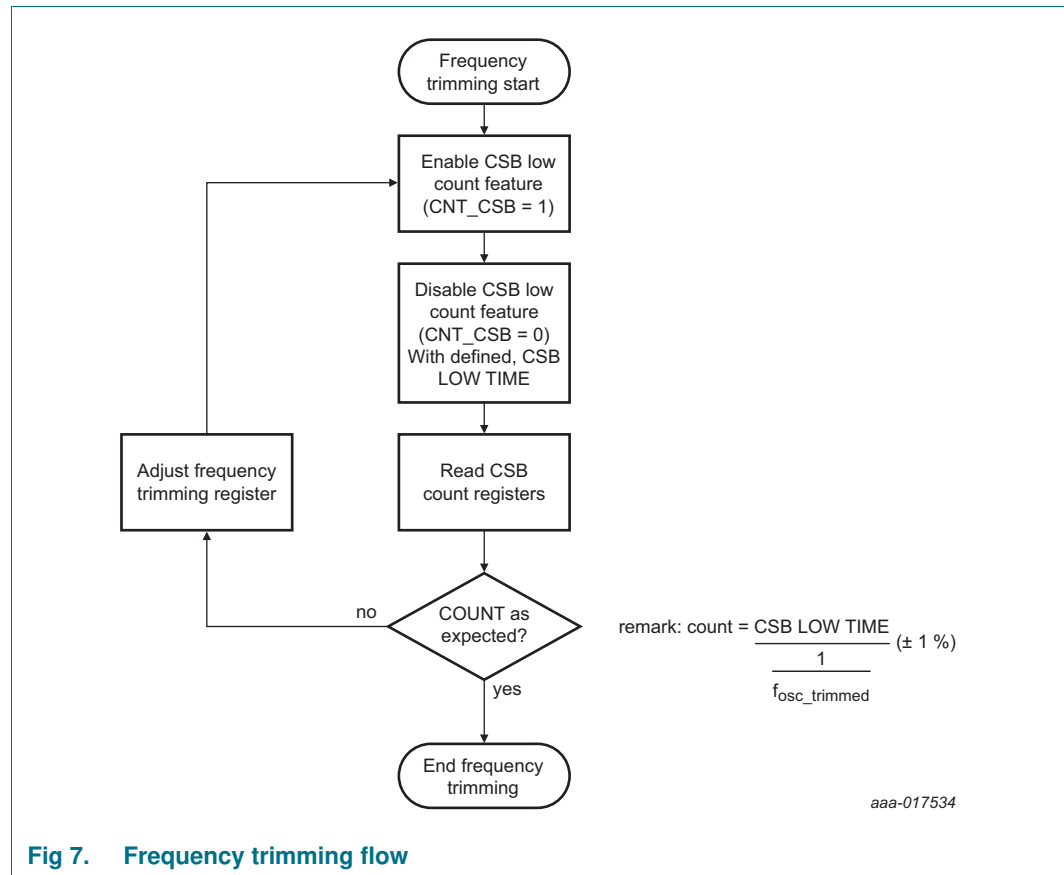


Fig 7. Frequency trimming flow

At the start of the sequence, the CSB low count feature is activated. It is done by setting the Cnt_CSB Bit high in the Frequency trimming control register (Bit 3; register 0x00h). The device now measures the time with its internal time domain each time the CSB pin is low. It makes this information available in the CSB count registers. To allow an exact stable reading, set the Cnt_CSB Bit low again with an accurately known CSB low time. Setting the bit low freezes the count registers. They store the last value, which in this case is the command that set the Cnt_CSB bit low.

The CSB count registers contain the count of the CSB low time of the last SPI command the CSB low count feature was enabled. CSB count register 1 contains the bits 7 to 0 of the counter, while the CSB count register 2 contains the bits 15:8.

Table 25. CSB count register 1, address 0x41h

Bit	Symbol	Description	Value	Function
7:0	CSB_cnt[7:0]	CSB count low	...	count value (bits 7:0)

Table 26. CSB count register 2, address 0x42h

Bit	Symbol	Description	Value	Function
7:0	CSB_cnt[15:8]	CSB count high	...	count value (bits 15:8)

The count, the CSB count register returns, should correspond to the real time of the CSB low time. 1 count should correspond with $1/f_{\text{osc_trimmed}}$ (see [Table 44](#)).

When the count that the CSB count registers return, deviates from the applied CSB low time, the device internal timing must be adjusted by modifying the frequency trimming register.

Table 27. Frequency trimming register, address 0x1Ch

Bit	Symbol	Description	Value	Function
7:6		reserved		not allowed
5:0	Freq_trim[5:0]	frequency trim bits	010001	default frequency –33.33 %
			010011	default frequency –30.56 %
			010101	default frequency –27.78 %
			010111	default frequency –25.00 %
			011001	default frequency –22.22 %
			011011	default frequency –19.44 %
			011101	default frequency –16.67 %
			011111	default frequency –13.89 %
			000001	default frequency –11.11 %
			000011	default frequency –8.33 %
			000101	default frequency –5.56 %
			000111	default frequency –2.78 %
			001001	default frequency
			001011	default frequency + 2.78 %
			001101	default frequency + 5.56 %
			001111	default frequency + 8.33 %
			110001	default frequency + 11.11 %
			110011	default frequency + 13.89 %
			110101	default frequency + 16.67 %
			110111	default frequency + 19.44 %
			111001	default frequency + 22.22 %
			111011	default frequency + 25.00 %
			111101	default frequency + 27.78 %
			111111	default frequency + 30.56 %
			100001	default frequency + 33.33 %
			100011	default frequency + 36.11 %
			others	not allowed

To ensure that the adjustment had the desired effect, restart the procedure and check the count with the new settings in the frequency trimming register.

When the device internal time matches the applied CSB low time, no further adjustment is needed and the trimming procedure is finished.

8.7 Gate voltage supply

The ASL2500SHN has an integrated linear regulator to generate the supply voltage of the gate drivers, which is internally connected to the pin VGG. The voltage generated by the linear regulator can be set via the VGG control register.

Table 28. VGG control register, address 0x15h

Bit	Symbol	Description	Value	Function
7:0	VGG[7:0]	supply voltage for gate driver	0x00h	not allowed
			...	not allowed
			0x5Dh	maximum output voltage = 10.04 V
			...	(255- VGG[7:0]) * 62 mV
			0xB7h	minimum output voltage = 4.46 V
			...	not allowed
			0xFFh	not allowed

The actual value of VGG can deviate from the target setting due to the tolerances of the VGG regulation loop (see $V_{o(\text{reg})\text{acc}}$ in [Table 43](#)).

When a setting between 0x00h and 0x5Dh is used, the resulting gate driver target voltage exceeds the limiting values of the IC. The limiting values of the VGG pin can also be violated with target settings of 0xA6h to 0x5Dh due to these tolerances. A violation of the limiting values with the actual VGG voltage must be avoided. To ensure that only allowed settings are used for the gate driver target voltage, an immediate read back of the programmed value is required after setting the registers.

If a setting between 0xFFh and 0xB7h is used, the device may not start up VGG. If the device operates, parameters of VGG are not guaranteed.

8.7.1 Gate voltage supply diagnostics

The diagnostic options for the gate voltage supply are:

- VGG available. Details can be found in [Section 8.10](#)
- VGG protection active. Details can be found in [Section 8.10](#)

8.8 Supply voltage monitoring

The ASL2500SHN is continuously measuring the voltage at pin Vbat, when at least one of the outputs is enabled and bit VGG_ok is set. It allows the system to monitor the supply voltage without additional external components. It also offers the option to put an automatic under- and/or overvoltage protection in place.

Note: The VIN_UV and VIN_OV bits in the status register use the battery voltage measurement. Consequently the VIN_UV and VIN_OV bits are only reliable when at least one output is enabled.

8.8.1 Battery voltage measurement

The ASL2500SHN continuously measures the voltage at pin Vbat. The measurement result is available in the battery voltage register when the output is enabled.

Table 29. Battery voltage register, address 0x45h

Bit	Symbol	Description	Value	Function
7:0	V_VBAT[7:0]	Battery voltage	0x00h	battery voltage = 0 V
			...	battery voltage = $0.3606 * V_VBAT[7:0]$
			0xFFh	maximum measurable battery voltage = 90 V

8.8.2 Undervoltage detection

The ASL2500SHN offers a variable undervoltage detection threshold. When the supply voltage drops below this threshold, the undervoltage detect bit is set, and fail silent mode is entered. The gate pin stops toggling and no more power is delivered to the output.

Table 30. Undervoltage threshold register, address 0x1Bh

Bit	Symbol	Description	Value	Function
7:0	V_VIN_UV[7:0]	undervoltage detection threshold	0x00h	undervoltage detection threshold = 0 V
			...	under voltage detection threshold = $0.3606 * V_VIN_UV[7:0]$
			0xFFh	maximum undervoltage detection threshold = 90 V

8.8.3 Overvoltage detection

The ASL2500SHN offers a variable overvoltage detection threshold. When the supply voltage rises above this threshold, the overvoltage detect bit is set, and fail silent mode is entered. The gate pin stops toggling and no more power is delivered to the output.

Table 31. Overvoltage threshold register, address 0x1Ah

Bit	Symbol	Description	Value	Function
7:0	V_VIN_OV[7:0]	overvoltage detection threshold	0x00h	overvoltage detection threshold = 0 V
			...	overvoltage detection threshold = $0.3606 * V_VIN_OV[7:0]$
			0xFFh	maximum overvoltage detection threshold = 90 V

8.9 Junction temperature information

The ASL2500SHN provides a measurement of the IC junction temperature. The measurement information is available in the junction temperature register.

Table 32. Junction temperature register, address 0x46h

Bit	Symbol	Description	Value	Function
7:0	T_junction[7:0]	junction temperature	...	device junction temperature below $-40\text{ }^{\circ}\text{C}$
			0x18h	device junction temperature = $-40\text{ }^{\circ}\text{C}$
			...	device junction temperature = $T_junction[7:0] * (215/106)\text{ }^{\circ}\text{C} - 88\text{ }^{\circ}\text{C}$
			0x82h	device junction temperature $\geq 175\text{ }^{\circ}\text{C}$

8.10 Diagnostic information

The diagnostic register contains useful information for diagnostic purposes. Details for each bit can be found in the following subchapters.

Table 33. Diagnostic register, address 0x5Fh

Bit	Symbol	Description	Value	Function
7	Vout1_ok	Vout1 regulated	0	Vout1 is deviating from the target value
			1	Vout1 is regulated to the target value
6	Vout2_ok	Vout2 regulated	0	Vout2 is deviating from the target value
			1	Vout2 is regulated to the target value
5	VGG_ok	VGG regulation OK	0	VGG is not available
			1	VGG is available
4	Tj_err	device temperature is too high	0	device temperature below $T_{sd(otp)}$
			1	device temperature above $T_{sd(otp)}$
3	VIN_UV	VIN under voltage	0	no under voltage at VIN detected
			1	under voltage at VIN detected
2	VIN_OV	VIN over voltage	0	no over voltage at VIN detected
			1	over voltage at VIN detected
1	SPI_err	SPI error	0	last SPI command was executed correctly
			1	last SPI command was erroneous and has been discarded
0	VGG_err	VGG error	0	VGG overload protection not active
			1	VGG overload protection has turned on and VGG is deactivated

8.10.1 Bit VIN_OV

The bit VIN_OV depends on the battery monitoring functionality as described in [Section 8.8](#). It indicates that the device has detected an overvoltage condition and entered fail silent mode. A write access to the diagnostic register or when the Off mode has been entered, clears the bit. Independent of the clearing of the bit, the device stays in fail silent mode.

8.10.2 Bit VIN_UV

The bit VIN_UV depends on the battery monitoring functionality as described in [Section 8.8](#). It indicates that the device has detected an undervoltage condition and entered fail silent mode. A write access to the diagnostic register or when the Off mode has been entered, clears the bit. Independent of the clearing of the bit, the device stays in fail silent mode.

8.10.3 Bit SPI_err

The device is evaluating all SPI accesses to the device for the correctness of the commands. When the command is not allowed, the SPI_err bit is set.

A write access to the diagnostic register or when the Off mode is entered, clears the bit.

8.10.4 Bit Tj_err

The bit Tj_err indicates that the junction temperature has exceeded the maximum allowable temperature, and the device has entered Fail silent mode. A write access to the diagnostic register, or once Off mode has been entered, clears the bit. The device stays in Fail silent mode irrespective of the clearing of the bit. After leaving the OFF mode (at IC start-up), it is possible that bit Tj_err is set. To avoid wrong diagnostics, clear the diagnostic register before it is evaluated.

8.10.5 Bit VGG_err

Bit VGG_err is set when the gate driver does not reach the VGG_ok_window (when V_{VGG} is within range) within the regulator voltage start-up error time. Once bit VGG_err is set, it indicates that an error on the gate driver has been detected and the device has entered Fail silent mode. A write access to the diagnostic register, or once Off mode has been entered, clears the bit. The device stays in Fail silent mode irrespective of the clearing of the bit.

8.10.6 Bit VGG_ok

The bit VGG_ok indicates that the gate driver is regulated to the target voltage and allows the gate drivers to drive the gate driver pins. If the gate driver is outside the VGG_ok window after $t_{startup}$, and V_{VGG} is within range, the device clears VGG_ok bit and enters Fail silent mode.

8.10.7 Bit Vout1_ok and Vout2_ok

The bits Vout1_ok and Vout2_ok indicate whether the output voltage is regulated to the target value or deviating from the target value. The bits are set as soon as the corresponding output is within the Vout_ok window (when V_O is within the range) for more than $t_{filtr(ov)}$. The bits are cleared when the corresponding output is outside the Vout_ok window for more than $t_{filtr(ov)}$.

8.11 SPI

The ASL2500SHN uses an SPI interface to communicate with an external microcontroller. The SPI interface can be used for setting the LEDs current, reading and writing the control register.

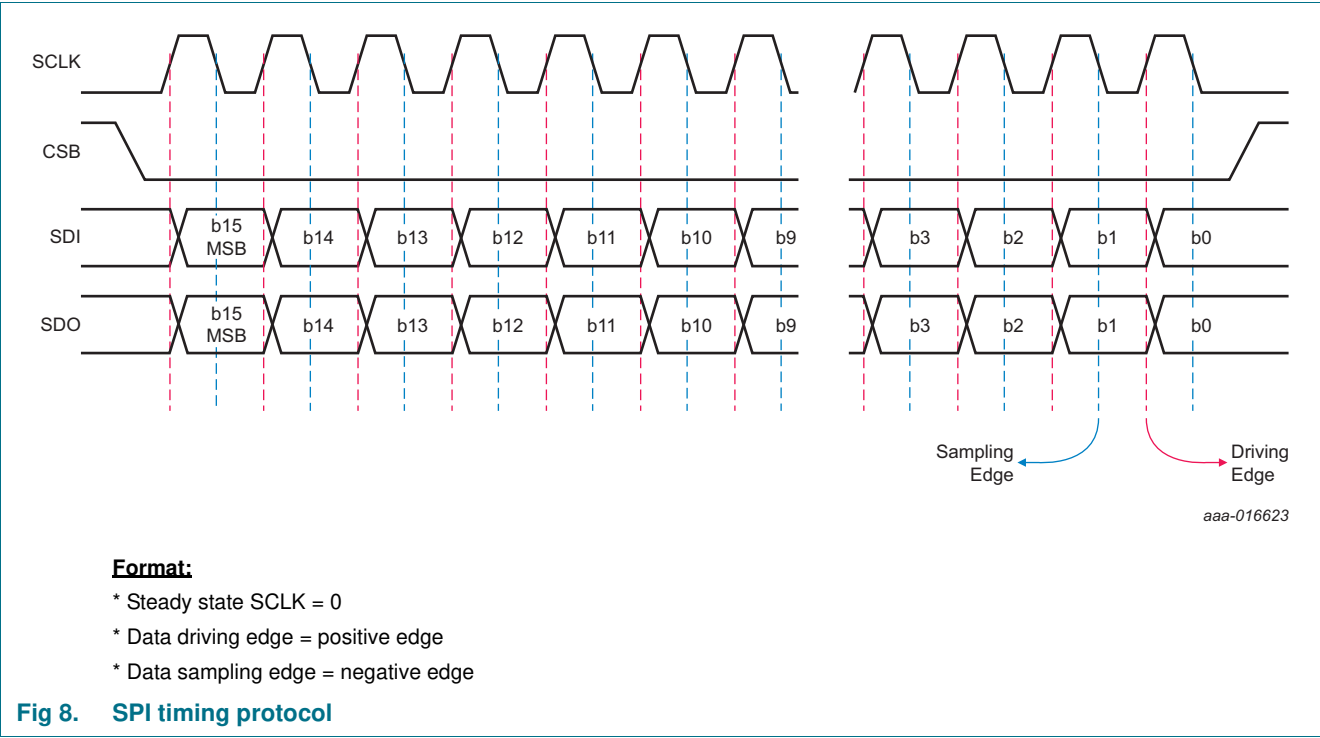
8.11.1 Introduction

The Serial Peripheral Interface (SPI) provides the communication link with the microcontroller, supporting multi-slave operations. The SPI is configured for full duplex data transfer, so status information is returned when new control data is shifted in. The interface also offers a read-only access option, allowing the application to read back the registers without changing the register content.

The SPI uses four interface signals for synchronization and data transfer:

- CSB - SPI chip select; active LOW
- SCLK - SPI clock - default level is LOW due to low-power concept
- SDI - SPI data input
- SDO - SPI data output - floating when pin CSB is HIGH

Bit sampling is performed on the falling clock edge and data is shifted on the rising clock edge as illustrated in [Figure 8](#).



The data bits of the ASL2500SHN are arranged in registers of one-byte length. Each register is assigned to a 7-bit address. For writing into a register, 2 bytes must be sent to the LED driver. The first byte is an identifier byte that consists of the 7-bit address and one read-only bit. For writing, the read-only bit must be set to 0. The second byte is the data that is written into the register. So an SPI access consists of at least 16 bit.

[Figure 9](#) together with [Table 34](#) and [Table 35](#) demonstrate the SPI frame format.

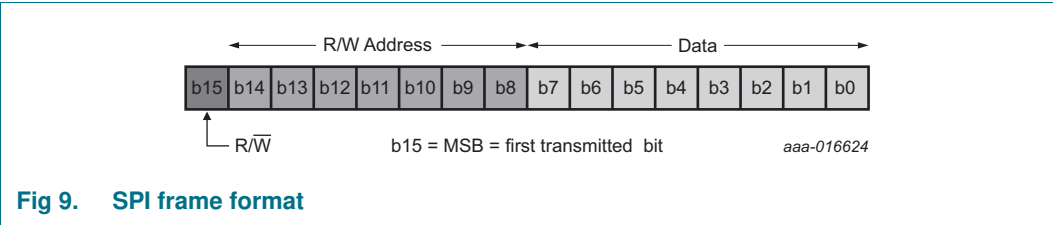


Table 34. SPI frame format for a transition to the device

Bit	Symbol	Description	Value	Function
15	b15	R/W bits	0	write access
			1	read access
14:8	b14:8	address bits	...	selected address
7:0	b7:0	data bits	...	transmitted data

Table 35. SPI frame format for a transition from the device

Bit	Symbol	Description	Value	Function ^[1]
8:15	b8:15	diagnostic register	...	content of diagnostic register
7:0	b7:0	data bits	...	when previous command was a valid read command, content of the register that is supposed to be read
			...	when previous command was a valid write command, new content of the register that was supposed to be written

[1] The first SPI command after leaving the Off mode, will return 0x00h.

The master initiates the command sequence. The sequence begins with CSB pin pulled low and lasts until it is asserted high.

The ASL2500SHN also tolerates SPI accesses with a multiple of 16 bits. It allows a daisy chain configuration of the SPI.

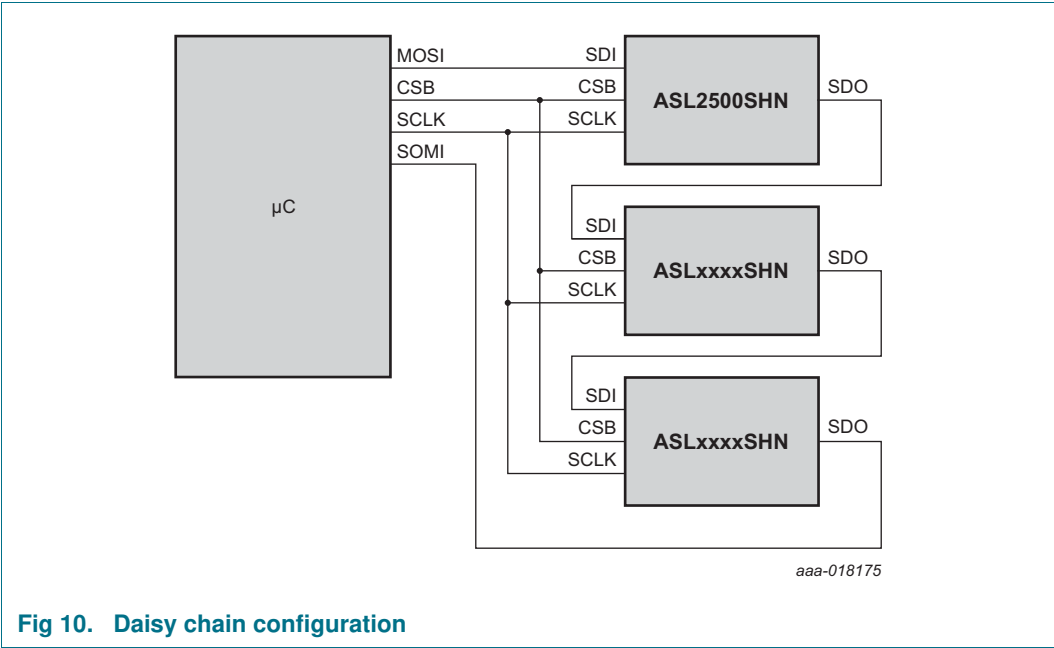


Fig 10. Daisy chain configuration

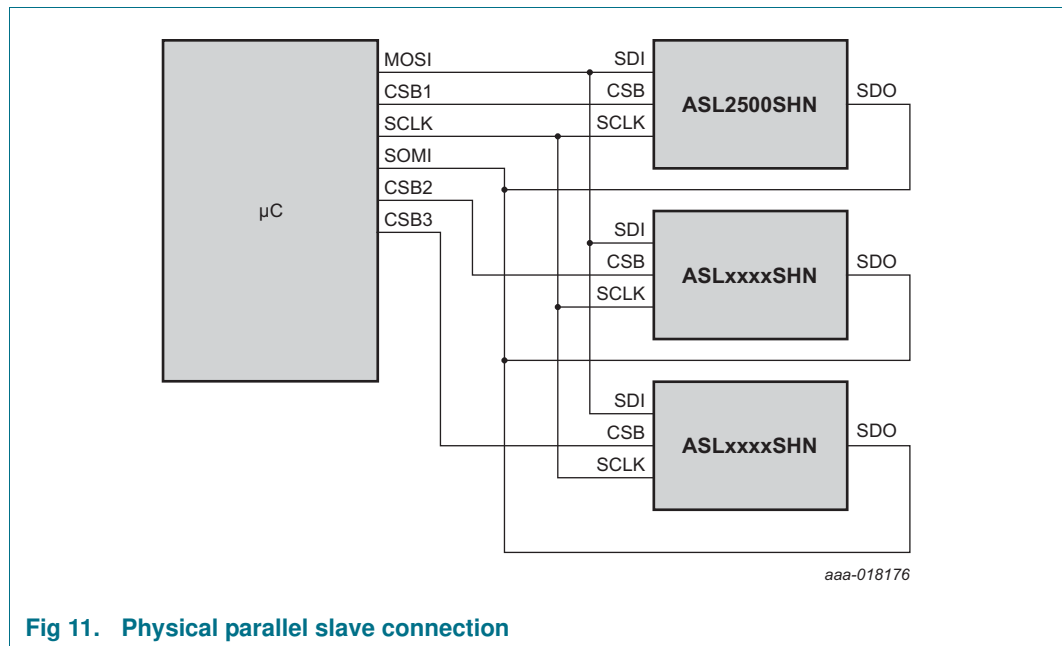


Fig 11. Physical parallel slave connection

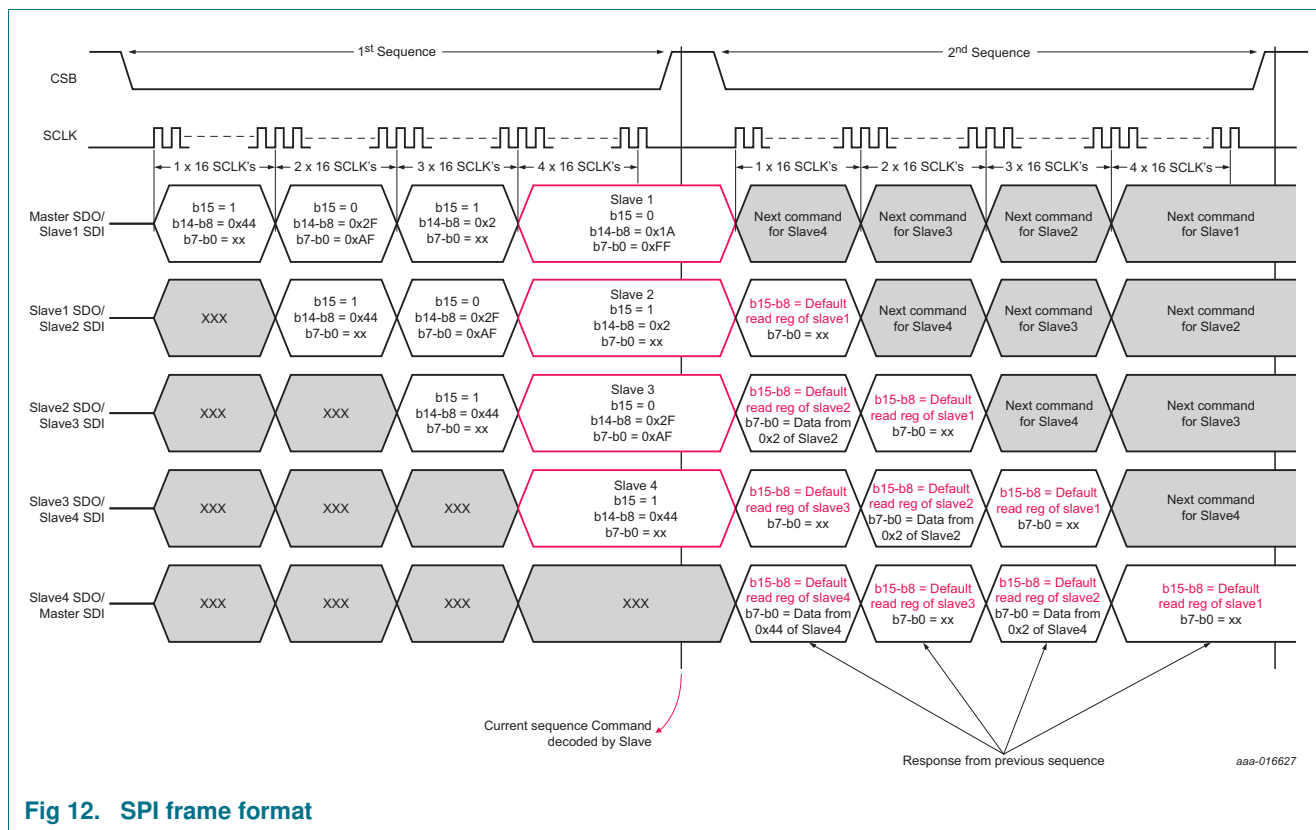
During the SPI data transfer, the identifier byte and the actual content of the addressed registers is returned via the SDO pin. The same happens for pure read accesses. Here the read-only bit must be set to 1. The content of the data bytes that are transmitted to the ASL2500SHN is ignored.

The ASL2500SHN monitors the number of data bits that are transmitted. If the number is not 16, or a multiple of 16, then a write access is ignored and the SPI error indication bit is set.

8.11.2 Typical use case illustration (Write/Read)

Consider a daisy chain scheme with one master connected to 4 slaves in Daisy chain fashion. The following commands are performed during one sequence (first sequence).

- Write data 0xFF to register 0x1A Slave 1
- Read from register 0x02 of Slave 2
- Write data 0xAF to register 0x2F of Slave 3
- Read from register 0x44 of Slave 4



8.11.3 Diagnostics for the SPI interface

The device is evaluating all SPI access to the device for the correctness of the commands. When the command is not allowed, the SPI_err bit is set. The conditions that are considered as erratic accesses are:

- SPI write is attempted to a read-only location or reserved location
- SPI write is attempted during operation to a configuration register
- SPI read is attempted from a reserved location
- SPI command does not consist of a multiple of 16 clock counts

If an SPI access is considered to be erratic, no modifications to a SPI register are made. The access after the erratic SPI command returns the diagnostic register and zero in the data field.

For details about the SPI_err bit, see [Section 8.10.3](#).

8.11.4 Register map

The addressable register space amounts to 128 registers from 0x00 to 0x7F. They are separated in two groups as shown in [Table 36](#). The register mapping is shown in [Table 37](#), [Table 38](#), [Table 39](#) and [Table 40](#). The functional description of each bit can be found in the dedicated chapter.