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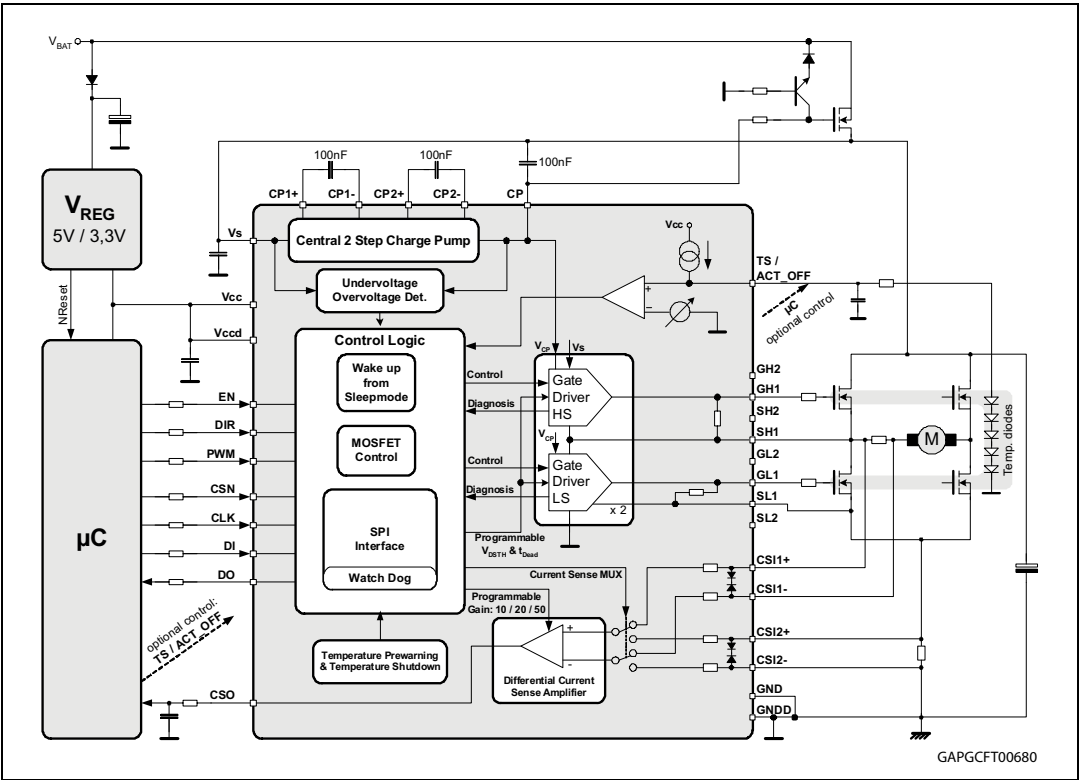
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# 1 Block diagram and pin description

Figure 1. Block diagram



## 1.1 Pinout PowerSSO-36

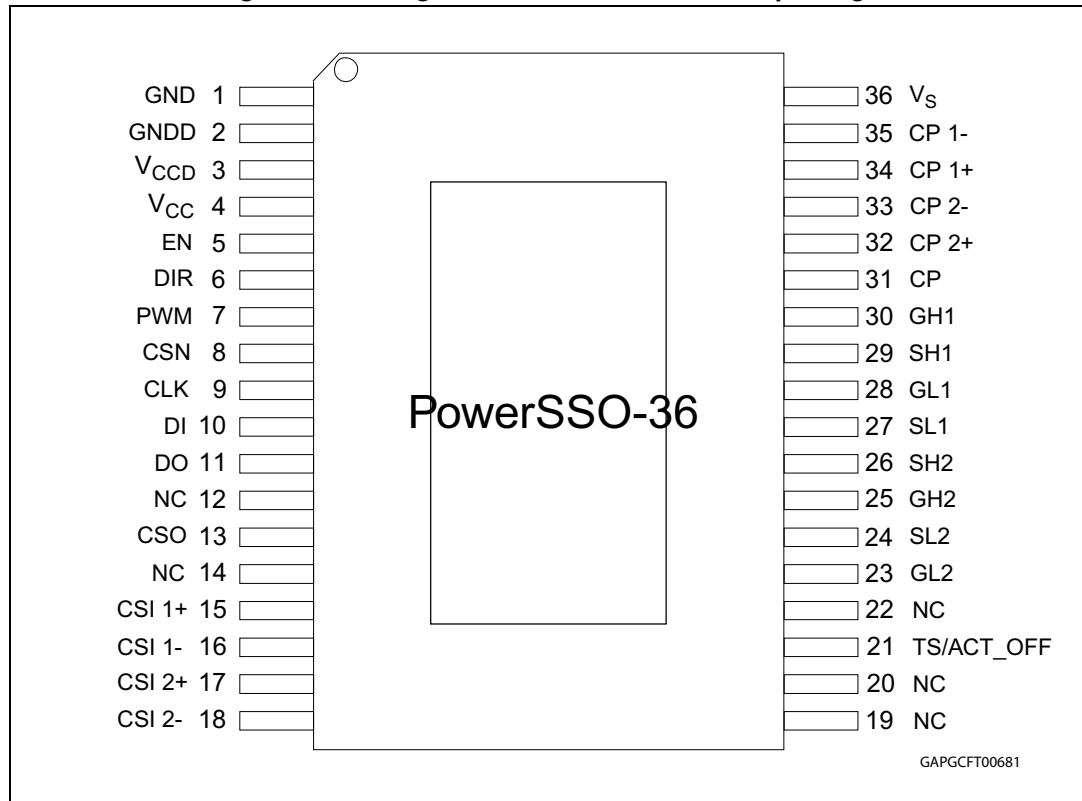
Table 2. Pin definitions and functions

| Pin | Symbol           | Function                                                                                                                                                                                                                        |
|-----|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | GND              | Ground. Reference potential, connected to slug.                                                                                                                                                                                 |
| 2   | GNDD             | Digital ground. Reference potential.                                                                                                                                                                                            |
| 3   | V <sub>CCD</sub> | Logic voltage supply 3.3 V/5 V: for this input a ceramic capacitor as close as possible to GND is recommended.                                                                                                                  |
| 4   | V <sub>CC</sub>  | Analog voltage supply 3.3 V/5 V: for this input a ceramic capacitor as close as possible to GND is recommended.                                                                                                                 |
| 5   | EN               | Enable input. The enable input has a pull-down resistor.                                                                                                                                                                        |
| 6   | DIR              | Direction select input for H-bridge control. This input has a pull-down current.                                                                                                                                                |
| 7   | PWM              | PWM input for H-bridge control. This input has a pull-down current.                                                                                                                                                             |
| 8   | CSN              | Chip select not input: this input is low active and requires CMOS logic levels. The serial data transfer between L99H01 and microcontroller is enabled by pulling the input CSN to low-level. This input has a pull-up current. |

Table 2. Pin definitions and functions (continued)

| Pin                   | Symbol      | Function                                                                                                                                                                                                                                      |
|-----------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 9                     | CLK         | Serial clock input: this input controls the internal shift register of the SPI and requires CMOS logic levels. This input has a pull-down current.                                                                                            |
| 10                    | DI          | Serial data in: the input requires CMOS logic levels and receives serial data from the microcontroller. The data is an 8-bit control word and the most significant bit (MSB, bit 7) is transferred first. This input has a pull-down current. |
| 11                    | DO          | Serial data out: the diagnosis data is available via the SPI and this tristate-output. The output remains in tristate, if the chip is not selected by the input CSN (CSN = high).                                                             |
| 12, 14, 19,<br>20, 22 | NC          | Not connected.                                                                                                                                                                                                                                |
| 13                    | CSO         | Current sense amplifier output: $V_{CC}$ compatible.                                                                                                                                                                                          |
| 15                    | CSI1+       | Current sense amplifier input: positive input 1, multiplexible.                                                                                                                                                                               |
| 16                    | CSI1-       | Current sense amplifier input: negative input 1, multiplexible.                                                                                                                                                                               |
| 17                    | CSI2+       | Current sense amplifier input: positive input 2, multiplexible.                                                                                                                                                                               |
| 18                    | CSI2-       | Current sense amplifier input: negative input 2, multiplexible.                                                                                                                                                                               |
| 21                    | TS/ ACT_OFF | Thermal sensor interface or input to switch all driver active off.                                                                                                                                                                            |
| 23                    | GL2         | Gate driver for PowerMOS low-side switch in halfbridge 2.                                                                                                                                                                                     |
| 24                    | SL2         | Source of low-side switch in halfbridge 2.                                                                                                                                                                                                    |
| 25                    | GH2         | Gate driver for PowerMOS high-side switch in halfbridge 2.                                                                                                                                                                                    |
| 26                    | SH2         | Source/drain of halfbridge 2.                                                                                                                                                                                                                 |
| 27                    | SL1         | Source of low-side switch in halfbridge 1.                                                                                                                                                                                                    |
| 28                    | GL1         | Gate driver for PowerMOS low-side switch in halfbridge 1.                                                                                                                                                                                     |
| 29                    | SH1         | Source/drain of halfbridge 1.                                                                                                                                                                                                                 |
| 30                    | GH1         | Gate driver for PowerMOS high-side switch in halfbridge 1.                                                                                                                                                                                    |
| 31                    | CP          | Charge pump output.                                                                                                                                                                                                                           |
| 32                    | CP2+        | Charge pump pin for capacitor 2, positive side.                                                                                                                                                                                               |
| 33                    | CP2-        | Charge pump pin for capacitor 2, negative side.                                                                                                                                                                                               |
| 34                    | CP1+        | Charge pump pin for capacitor 1, positive side.                                                                                                                                                                                               |
| 35                    | CP1-        | Charge pump pin for capacitor 1, negative side.                                                                                                                                                                                               |
| 36                    | $V_S$       | Power supply voltage (external reverse protection required).<br>For EMI reason a ceramic capacitor as close as possible to GND is recommended.                                                                                                |

Figure 2. Pinning of device in PowerSSO-36 package



## 1.2 Pinout LQFP32

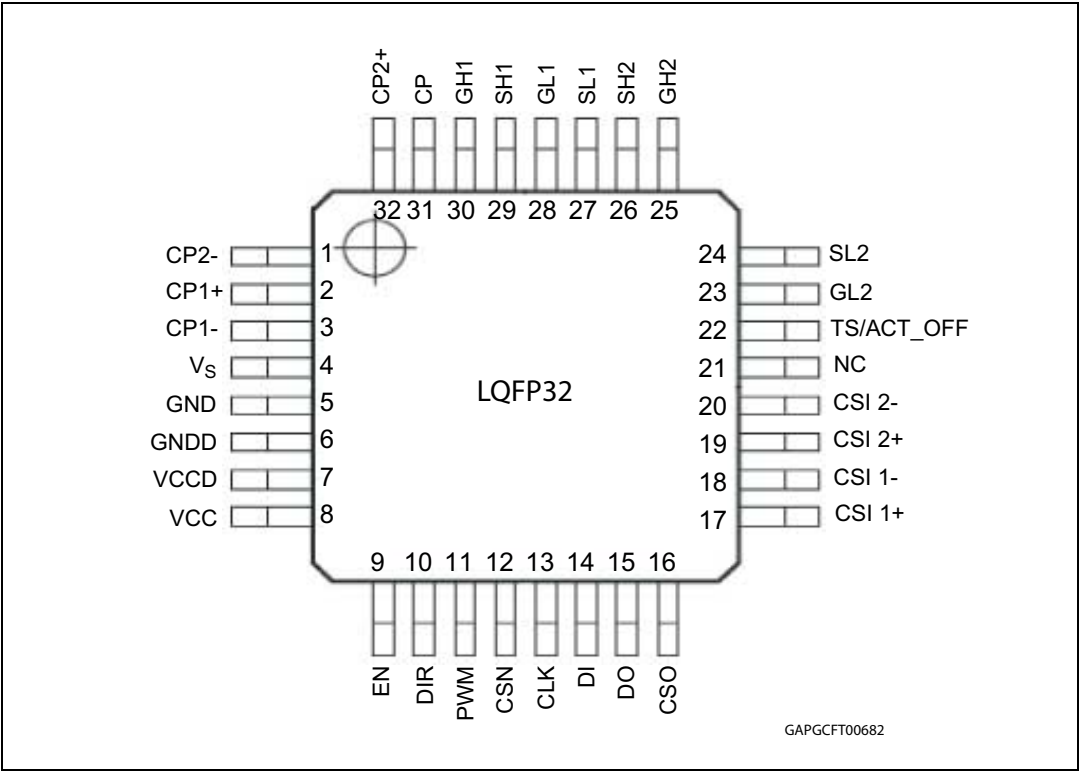
Table 3. Pin definitions and functions

| Pin | Symbol           | Function                                                                                                                                    |
|-----|------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | CP2-             | Charge pump pin for capacitor 2, negative side.                                                                                             |
| 2   | CP1+             | Charge pump pin for capacitor 1, positive side.                                                                                             |
| 3   | CP1-             | Charge pump pin for capacitor 1, negative side.                                                                                             |
| 4   | V <sub>S</sub>   | Power supply voltage (external reverse protection required). For EMI reason a ceramic capacitor as close as possible to GND is recommended. |
| 5   | GND              | Ground. Reference potential, connected to slug.                                                                                             |
| 6   | GNDD             | Digital ground. Reference potential.                                                                                                        |
| 7   | V <sub>CCD</sub> | Logic voltage supply 3.3 V/5 V: for this input a ceramic capacitor as close as possible to GND is recommended.                              |
| 8   | V <sub>CC</sub>  | Analog voltage supply 3.3 V/5 V: for this input a ceramic capacitor as close as possible to GND is recommended.                             |
| 9   | EN               | Enable input. The enable input has a pull-down resistor.                                                                                    |

Table 3. Pin definitions and functions (continued)

| Pin | Symbol      | Function                                                                                                                                                                                                                                      |
|-----|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10  | DIR         | Direction select input for H-bridge control. This input has a pull-down current.                                                                                                                                                              |
| 11  | PWM         | PWM input for H-bridge control. This input has a pull-down current.                                                                                                                                                                           |
| 12  | CSN         | Chip select not input: this input is low active and requires CMOS logic levels. The serial data transfer between L99H01 and microcontroller is enabled by pulling the input CSN to low-level. This input has a pull-up current.               |
| 13  | CLK         | Serial clock input: this input controls the internal shift register of the SPI and requires CMOS logic levels. This input has a pull-down current.                                                                                            |
| 14  | DI          | Serial data in: the input requires CMOS logic levels and receives serial data from the microcontroller. The data is an 8-bit control word and the most significant bit (MSB, bit 7) is transferred first. This input has a pull-down current. |
| 15  | DO          | Serial data out: the diagnosis data is available via the SPI and this tristate-output. The output remains in tristate, if the chip is not selected by the input CSN (CSN = high).                                                             |
| 16  | CSO         | Current sense amplifier output: $V_{CC}$ compatible.                                                                                                                                                                                          |
| 17  | CSI1+       | Current sense amplifier input: positive input 1, multiplexible.                                                                                                                                                                               |
| 18  | CSI1-       | Current sense amplifier input: negative input 1, multiplexible.                                                                                                                                                                               |
| 19  | CSI2+       | Current sense amplifier input: positive input 2, multiplexible.                                                                                                                                                                               |
| 20  | CSI2-       | Current sense amplifier input: negative input 2, multiplexible.                                                                                                                                                                               |
| 21  | NC          | Not connected.                                                                                                                                                                                                                                |
| 22  | TS/ ACT_OFF | Thermal sensor interface or external off for all gate drivers.                                                                                                                                                                                |
| 23  | GL2         | Gate driver for PowerMOS low-side switch in halfbridge 2.                                                                                                                                                                                     |
| 24  | SL2         | Source of low-side switch in halfbridge 2.                                                                                                                                                                                                    |
| 25  | GH2         | Gate driver for PowerMOS high-side switch in halfbridge 2.                                                                                                                                                                                    |
| 26  | SH2         | Source/drain of halfbridge 2.                                                                                                                                                                                                                 |
| 27  | SL1         | Source of low-side switch in halfbridge 1.                                                                                                                                                                                                    |
| 28  | GL1         | Gate driver for PowerMOS low-side switch in halfbridge 1.                                                                                                                                                                                     |
| 29  | SH1         | Source/drain of halfbridge 1.                                                                                                                                                                                                                 |
| 30  | GH1         | Gate driver for PowerMOS high-side switch in halfbridge 1.                                                                                                                                                                                    |
| 31  | CP          | Charge pump output.                                                                                                                                                                                                                           |
| 32  | CP2+        | Charge pump pin for capacitor 2, positive side.                                                                                                                                                                                               |

Figure 3. Pinning of device in LQFP-32 package



## 2 Electrical specifications

### 2.1 Absolute maximum ratings

Stressing the device above the rating listed in [Table 4](#) may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**Table 4. Absolute maximum ratings**

| Item  | Symbol                         | Parameter                       | Value                                          | Unit |
|-------|--------------------------------|---------------------------------|------------------------------------------------|------|
| 4.1.1 | $V_S$                          | Power supply voltage            | -0,3 to 35                                     | V    |
| 4.1.2 |                                | Single pulse $t_{max} < 400$ ms | 40                                             | V    |
| 4.2   | $V_{CC}$                       | Stabilished supply voltage      | -0.3 to 5.5                                    | V    |
| 4.3   | DI, DO, CLK, CSN, EN, DIR, PWM | Digital input / output voltage  | -0.3 to $V_{CC} + 0.3$                         | V    |
| 4.4   | CSO, TS                        | Analog input / output voltage   | -0.3 to $V_{CC} + 0.3$                         | V    |
| 4.5   | CSI1+, CSI1-, CSI2+, CSI2-     | HV signal pins                  | -4 to $V_S + 5V$                               | V    |
| 4.6   | GL2, GH2, GL1, GH1 (Gxy)       | HV signal pins                  | $S_{xy} - 1$ to $S_{xy} + 10$ ; $V_{CP} + 0.3$ | V    |
| 4.7   | SL2, SH2, SL1, SH1             | HV signal pins                  | -6 to 40                                       | V    |
| 4.8   | CP2- CP1-                      | HV signal pins                  | -0.3 to $V_S + 0.3$                            | V    |
| 4.9   | CP1+                           | HV signal pins                  | $V_S - 0.3$ to $V_S + 10$                      | V    |
| 4.10  | CP2+                           | HV signal pins                  | $V_S - 0.6$ to $V_S + 10$                      | V    |
| 4.11  | CP                             | Power pin                       | $V_S - 0.3$ to $V_S + 10$                      | V    |

### 2.2 ESD protection

**Table 5. ESD protection**

| Item | Parameter        | Value                  | Unit |
|------|------------------|------------------------|------|
| 5.1  | All pins         | $\pm 2$ <sup>(1)</sup> | kV   |
| 5.2  | $V_S$ versus GND | $\pm 4$ <sup>(1)</sup> | kV   |

1. - HBM according to MIL 883C, Method 3015.7 or EIA/JESD22-A114-A.  
 - HBM with all unzapped pins grounded.

## 2.3 Thermal data

**Table 6. Operating junction temperature**

| Item | Symbol | Parameter                      | Value      | Unit |
|------|--------|--------------------------------|------------|------|
| 6.1  | $T_j$  | Operating junction temperature | -40 to 150 | °C   |

**Table 7. Temperature warning and thermal shutdown**

| Item | Symbol         | Parameter                                          | Min. | Typ. | Max. | Unit |
|------|----------------|----------------------------------------------------|------|------|------|------|
| 7.1  | $T_{jTW\ ON}$  | Temperature warning threshold junction temperature | 135  | —    | 165  | °C   |
| 7.2  | $T_{jSD\ ON}$  | Thermal shutdown threshold junction temperature    | 155  | —    | 185  | °C   |
| 7.3  | $T_{jSD\ OFF}$ | Thermal shutdown threshold junction temperature    | 150  | —    | 180  | °C   |

**Table 8. Packages thermal resistance**

| Item | Symbol        | Parameter                                  | Value             |                   | Unit |
|------|---------------|--------------------------------------------|-------------------|-------------------|------|
|      |               |                                            | PowerSSO-36       | LQFP32            |      |
| 8.1  | $R_{thj-amb}$ | Thermal resistance junction-ambient (max.) | 58 <sup>(1)</sup> | 80 <sup>(1)</sup> | °C/W |

1. Minimum footprint.

## 2.4 Electrical characteristics

$V_S = 6\text{ V to }28\text{ V}$ ,  $V_{CC} = 3\text{ V to }5.3\text{ V}$ ,  $T_j = -40^\circ\text{C to }150^\circ\text{C}$ , unless otherwise specified.

The voltages are referred to GND and currents are assumed positive, when the current flows into the pin.

**Table 9. Supply**

| Item | Symbol         | Parameter                            | Test condition | Min. | Typ. | Max. | Unit |
|------|----------------|--------------------------------------|----------------|------|------|------|------|
| 9.1  | $V_S$          | Operating supply voltage range       |                | 6    |      | 28   | V    |
| 9.2  | $V_{VS\_OV1}$  | Overvoltage disable high threshold 1 | SPI: OVT = 1   | 28   | 30.5 | 32   | V    |
| 9.3  | $V_{VS\_OV1H}$ | Overvoltage threshold 1 hysteresis   |                | 0.57 | 0.77 | 1.07 | V    |
| 9.4  | $V_{VS\_OV2}$  | Overvoltage disable high threshold 2 | SPI: OVT = 0   | 18   | 20   | 22   | V    |
| 9.5  | $V_{VS\_OV2H}$ | Overvoltage threshold 2 hysteresis   |                | 0.42 | 0.62 | 0.82 | V    |

Table 9. Supply (continued)

| Item  | Symbol        | Parameter                          | Test condition                                                                                                                         | Min. | Typ. | Max. | Unit          |
|-------|---------------|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| 9.6   | $V_{VS\_UV}$  | Undervoltage disable low threshold |                                                                                                                                        | 4.7  | 4.9  | 5.1  | V             |
| 9.7   | $V_{VS\_UVH}$ | Undervoltage threshold hysteresis  |                                                                                                                                        | 0.2  | 0.3  | 0.4  | V             |
| 9.8.1 | $I_S$         | $V_S$ DC supply current            | $V_S = 13\text{ V}$ ; $V_{CC} = 5\text{ V}$ ; Active mode; Outputs floating                                                            | 4.5  | 5.5  | 6.5  | mA            |
| 9.8.2 |               |                                    | $V_S = 6\text{ V to }28\text{ V}$ ; $V_{CC} = 5.0\text{ V}$ ; Active mode; Outputs floating                                            | 2.5  |      | 18   | mA            |
| 9.9   | $I_{SL}$      | $V_S$ quiescent supply current     | $V_S = 13\text{ V}$ ; $V_{CC} = 0\text{ V}$ ; Standby mode; $T_{\text{Test}} = -40^\circ\text{C}, 25^\circ\text{C}$ ; Outputs floating |      |      | 5    | $\mu\text{A}$ |
| 9.10  | $I_{CC}$      | $V_{CC}$ DC supply current         | $V_S = 13\text{ V}$ ; $V_{CC} = 5\text{ V}$ ; active mode                                                                              | 1.5  | 1.8  | 2.5  | mA            |
| 9.11  | $I_{CC}$      | $V_{CC}$ quiescent supply current  | $V_{CC} = 5\text{ V}$ ; standby mode                                                                                                   | 30   | 70   | 150  | $\mu\text{A}$ |
| 9.12  | $I_{CCd}$     | $V_{CCd}$ supply current           | $V_S = 13\text{ V}$ ; $V_{CC} = V_{CCd} = 5\text{ V}$ ; active mode                                                                    | 250  | 500  | 750  | $\mu\text{A}$ |

Table 10. Undervoltage detection

| Item | Symbol                | Parameter                 | Test condition                           | Min. | Typ. | Max. | Unit |
|------|-----------------------|---------------------------|------------------------------------------|------|------|------|------|
| 10.1 | $V_{\text{POR OFF}}$  | Power-on reset threshold  | $V_{CC}$ increasing                      | 2.2  | 2.55 | 2.8  | V    |
| 10.2 | $V_{\text{POR ON}}$   | Power-on reset threshold  | $V_{CC}$ decreasing                      | 2.0  | 2.25 | 2.6  | V    |
| 10.3 | $V_{\text{POR hyst}}$ | Power-on reset hysteresis | $V_{\text{POR OFF}} - V_{\text{POR ON}}$ | 0.2  | 0.3  | 0.4  | V    |

Table 11. Watchdog

| Item | Symbol            | Parameter         | Test condition | Min. | Typ. | Max. | Unit |
|------|-------------------|-------------------|----------------|------|------|------|------|
| 11.1 | $T_{\text{WDTO}}$ | Watchdog time out | —              | 50   | 60   | 100  | ms   |

Table 12. Inputs: CSN, CLK, PWM, DIR, EN and DI

| Item  | Symbol         | Parameter                                            | Test condition              | Min.           | Typ.           | Max.           | Unit       |
|-------|----------------|------------------------------------------------------|-----------------------------|----------------|----------------|----------------|------------|
| 12.1  | $V_{in\ L}$    | Low-level input voltage                              |                             | $0.3 * V_{CC}$ | $0.4 * V_{CC}$ |                | V          |
| 12.2  | $V_{in\ H}$    | High-level input voltage                             |                             |                | $0.6 * V_{CC}$ | $0.7 * V_{CC}$ | V          |
| 12.3  | $V_{in\ Hyst}$ | Input voltage hysteresis                             |                             | $0.1 * V_{CC}$ |                |                | V          |
| 12.4  | $I_{CSN\ in}$  | Pull-up current at input CSN                         | $V_{CSN} = V_{CC} - 1.5\ V$ | -50            | -25            | -10            | $\mu A$    |
| 12.5  | $I_{CLK\ in}$  | Pull-down current at input CLK                       | $V_{CLK} = 1.5\ V$          | 10             | 35             | 50             | $\mu A$    |
| 12.6  | $I_{DI\ in}$   | Pull-down current at input DI                        | $V_{DI} = 1.5\ V$           | 10             | 35             | 50             | $\mu A$    |
| 12.7  | $I_{DIR\ in}$  | Pull-down current at input DIR                       | $V_{DIR} = 1.5\ V$          | 10             | 35             | 50             | $\mu A$    |
| 12.8  | $I_{PWM\ in}$  | Pull-down current at input PWM                       | $V_{PWM} = 1.5\ V$          | 10             | 35             | 50             | $\mu A$    |
| 12.9  | $R_{EN\ in}$   | Pull-down resistance at input EN                     | $V_{EN} = V_{CC}$           | 100            | 210            | 480            | k $\Omega$ |
| 12.10 | $C_{in}^{(1)}$ | Input capacitance at input CSN, CLK, DI, DIR and PWM | $0\ V < V_{CC} < 5.3\ V$    |                | 10             | 15             | pF         |

1. Value of input capacity is not measured in production test. Parameter guaranteed by design.

Table 13. Charge pump output

| Item   | Symbol         | Parameter                             | Test condition                                                       | Min.        | Typ.       | Max.         | Unit    |
|--------|----------------|---------------------------------------|----------------------------------------------------------------------|-------------|------------|--------------|---------|
| 13.1.1 | $V_{CP}$       | Charge pump output voltage            | $V_S = 6\ V; I_{CP} = 15\ mA$                                        | $V_S + 6$   | $V_S + 7$  | $V_S + 7.5$  | V       |
| 13.1.2 |                |                                       | $V_S = 10\ V; I_{CP} = 15\ mA$                                       | $V_S + 11$  | $V_S + 12$ | $V_S + 13.5$ | V       |
| 13.1.3 |                |                                       | $V_S > 12\ V; I_{CP} = 15\ mA$                                       | $V_S + 11$  | $V_S + 12$ | $V_S + 13.5$ | V       |
| 13.2   | $I_{CP}$       | Charge pump output current            | $f_{CP} = f_{SYS\_CLK} / 32;$<br>$V_S = 14\ V; V_{CP} = V_S + 10\ V$ | 26          | 38         | 48           | mA      |
| 13.3   | $V_{CP\_LOW}$  | Charge pump low threshold voltage     |                                                                      | $V_S + 4.5$ | $V_S + 5$  | $V_S + 5.5$  | V       |
| 13.4.1 | $f_{SYS\_CLK}$ | Clock frequency (internal oscillator) | $V_{CC} = 5\ V$                                                      | 3           | 4          | 4.5          | MHz     |
| 13.4.2 |                |                                       | $V_{CC} = 3\ V$                                                      | 2.4         | 3.3        | 3.5          | MHz     |
| 13.5   | $T_{CP}$       | Charge pump low filter time           |                                                                      |             | 64         |              | $\mu s$ |

Table 14. Gate drivers for external PowerMOS

| Item                                    | Symbol        | Parameter                          | Test condition                                                                     | Min.                   | Typ.                    | Max.                    | Unit          |
|-----------------------------------------|---------------|------------------------------------|------------------------------------------------------------------------------------|------------------------|-------------------------|-------------------------|---------------|
| Drivers for external high-side PowerMOS |               |                                    |                                                                                    |                        |                         |                         |               |
| 14.1                                    | $I_{GHx(on)}$ | Turn on current (SOURCE stage)     | $T_j = 25^\circ\text{C}$ <sup>(1)</sup>                                            | 0.3                    | 0.5 <sup>(2)</sup>      | 0.8                     | A             |
| 14.2.1                                  | $R_{GHx}$     | On-resistance of SINK stage        | $V_{SHx} = 0\text{ V}; I_{GHx} = 50\text{ mA}; T_j = 25^\circ\text{C}$             | 3                      | 4                       | 5                       | W             |
| 14.2.2                                  |               |                                    | $V_{SHx} = 0\text{ V}; I_{GHx} = 50\text{ mA}; T_j = 125^\circ\text{C}$            | 4.5                    | 5.3                     | 7                       | W             |
| 14.3                                    | $V_{GHxH}$    | Gate on voltage                    | Outputs floating                                                                   | $V_{SHx} + 8\text{ V}$ | $V_{SHx} + 10\text{ V}$ | $V_{SHx} + 12\text{ V}$ | V             |
| 14.4                                    | $R_{GSHx}$    | Passive Gate clamp resistance      |                                                                                    | 11                     | 13                      | 15                      | k $\Omega$    |
| Drivers for external low-side PowerMOS  |               |                                    |                                                                                    |                        |                         |                         |               |
| 14.5                                    | $I_{GLx(on)}$ | Turn on current (SOURCE stage)     | $T_j = 25^\circ\text{C}$ <sup>(1)</sup>                                            | 0.3                    | 0.5 <sup>(2)</sup>      | 0.8                     | A             |
| 14.6.1                                  | $R_{GLx}$     | On-resistance of SINK stage        | $V_{SLx} = 0\text{ V}; I_{GHx} = 50\text{ mA}; T_j = 25^\circ\text{C}$             | 3                      | 4                       | 5                       | W             |
| 14.6.2                                  |               |                                    | $V_{SLx} = 0\text{ V}; I_{GHx} = 50\text{ mA}; T_j = 125^\circ\text{C}$            | 4.5                    | 5.3                     | 7                       | W             |
| 14.7                                    | $V_{GLxH}$    | Gate on voltage                    |                                                                                    | $V_{SLx} + 8\text{ V}$ | $V_{SLx} + 10\text{ V}$ | $V_{SLx} + 12\text{ V}$ | V             |
| 14.8                                    | $R_{GSLx}$    | Passive gate clamp resistance      |                                                                                    | 11                     | 13                      | 15                      | k $\Omega$    |
| Timing of the drivers                   |               |                                    |                                                                                    |                        |                         |                         |               |
| 14.9                                    | $t_{GHxHL}$   | Propagation delay time high to low | $V_{VS} = 13.5\text{ V}; V_{SHx} = 0; R_G = 30\text{ }\Omega; C_G = 4.7\text{ nF}$ | 0.8                    | 1.4                     | 1.9                     | $\mu\text{s}$ |
| 14.10                                   | $t_{GLxHL}$   | Propagation delay time low to high | $V_{VS} = 13.5\text{ V}; V_{SLx} = 0; R_G = 30\text{ }\Omega; C_G = 4.7\text{ nF}$ | 0.6                    | 1.2                     | 1.8                     | $\mu\text{s}$ |
| 14.11                                   | $t_{GHxf2}$   | Rise time                          | $V_{VS} = 13.5\text{ V}; V_{SHx} = 0; R_G = 0\text{ }\Omega; C_G = 4.7\text{ nF}$  | 45                     |                         | 170                     | ns            |
| 14.12                                   | $t_{GHxf2}$   | Fall time                          | $V_{VS} = 13.5\text{ V}; V_{SHx} = 0; R_G = 0\text{ }\Omega; C_G = 4.7\text{ nF}$  | 60                     |                         | 210                     | ns            |
| 14.13                                   | $t_{GLxf2}$   | Rise time                          | $V_{VS} = 13.5\text{ V}; V_{SLx} = 0; R_G = 0\text{ }\Omega; C_G = 4.7\text{ nF}$  | 45                     |                         | 170                     | ns            |
| 14.14                                   | $t_{GLxf2}$   | Fall time                          | $V_{VS} = 13.5\text{ V}; V_{SLx} = 0; R_G = 0\text{ }\Omega; C_G = 4.7\text{ nF}$  | 60                     |                         | 210                     | ns            |

1. Indirect measurement, parameter measured dynamically using 100 nF load capacitor and evaluating the slew rate.

2. Average value.

Table 15. Cross current protection time<sup>(1)</sup>

| Item | Symbol     | Parameter                     | Test condition | Min. | Typ.               | Max. | Unit |
|------|------------|-------------------------------|----------------|------|--------------------|------|------|
| 15.1 | $t_{CCP0}$ | Cross current protection time | —              | —    | 250 <sup>(2)</sup> | —    | ns   |
| 15.2 | $t_{CCP1}$ | Cross current protection time | —              | 250  | 500                | 750  |      |
| 15.3 | $t_{CCP2}$ | Cross current protection time | —              | 500  | 750                | 1000 |      |
| 15.4 | $t_{CCP3}$ | Cross current protection time | —              | 700  | 1000               | 1300 |      |
| 15.5 | $t_{CCP4}$ | Cross current protection time | —              | 950  | 1250               | 1570 |      |
| 15.6 | $t_{CCP5}$ | Cross current protection time | —              | 1160 | 1500               | 1880 |      |
| 15.7 | $t_{CCP6}$ | Cross current protection time | —              | 1360 | 1750               | 2180 |      |
| 15.8 | $t_{CCP7}$ | Cross current protection time | —              | 1560 | 2000               | 2480 |      |

1. Test conditions:  $V_{CC} = 5\text{ V}$ ,  $V_S = 13.5\text{ V}$ 

2. Not tested

Table 16. Drain source monitoring

| Item | Symbol     | Parameter                        | Test condition | Min. | Typ. | Max. | Unit          |
|------|------------|----------------------------------|----------------|------|------|------|---------------|
| 16.1 | $V_{SCd1}$ | Drain - source threshold voltage | —              | 0.15 | 0.5  | 0.7  | V             |
| 16.2 | $V_{SCd2}$ | Drain - source threshold voltage | —              | 0.45 | 1    | 1.25 | V             |
| 16.3 | $V_{SCd3}$ | Drain - source threshold voltage | —              | 0.9  | 1.5  | 1.8  | V             |
| 16.4 | $V_{SCd4}$ | Drain - source threshold voltage | —              | 1.4  | 2    | 2.35 | V             |
| 16.5 | $t_{SCd}$  | Drain - source filtertime        | —              |      | 6    |      | $\mu\text{s}$ |

Table 17. Thermal sense interface ( $4.5\text{ V} < V_{CC} < 5.3\text{ V}$ )

| Item | Symbol         | Parameter            |                                                                                                           | Min. | Typ.                    | Max. | Unit          |
|------|----------------|----------------------|-----------------------------------------------------------------------------------------------------------|------|-------------------------|------|---------------|
| 17.1 | $I_{TS\_bias}$ | Output bias current  |                                                                                                           | 200  | 250                     | 300  | $\mu\text{A}$ |
| 17.2 | $V_{th\_TS}$   | TS threshold voltage | $V_{TS} < V_{CC} - 1\text{ V}$<br>$n = \text{number of diodes}$<br>$m = \text{programmed level (0 to 7)}$ |      | $n * (0.31 + m * 0.03)$ |      | V             |

Table 18. Current sense amplifier<sup>(1)</sup>

| Item          | Symbol                  | Parameter                                  | Test condition | Min. | Typ.               | Max.                  | Unit                         |
|---------------|-------------------------|--------------------------------------------|----------------|------|--------------------|-----------------------|------------------------------|
| DC parameters |                         |                                            |                |      |                    |                       |                              |
| 18.1          | $V_{ICM}$               | Input voltage range – common mode          |                | -4   |                    | $V_{CP} - 8\text{ V}$ | V                            |
| 18.2          | $V_{IOFF50}$            | Input offset voltage                       | Gain = 50      | -11  | -4                 | 3                     | mV                           |
| 18.3          | $V_{IOFF20}$            | Input offset voltage                       | Gain = 20      | -23  | -8                 | 7                     | mV                           |
| 18.4          | $V_{IOFF10}$            | Input offset voltage                       | Gain = 10      | -30  | -10                | 10                    | mV                           |
| 18.5          | $V_{IOFF-T50}/\Delta T$ | Input offset voltage drift vs. temperature | Gain = 50      |      | -10 <sup>(2)</sup> |                       | $\mu\text{V}/^\circ\text{K}$ |

Table 18. Current sense amplifier<sup>(1)</sup> (continued)

| Item               | Symbol                    | Parameter                                     | Test condition                      | Min.                     | Typ.                    | Max.  | Unit  |
|--------------------|---------------------------|-----------------------------------------------|-------------------------------------|--------------------------|-------------------------|-------|-------|
| 18.6               | V <sub>IOFF-T20</sub> /ΔT | Input offset voltage drift vs. temperature    | Gain = 20                           |                          | -18 <sup>(2)</sup>      |       | μV/°K |
| 18.7               | V <sub>IOFF-T10</sub> /ΔT | Input offset voltage drift vs. temperature    | Gain = 10                           |                          | -27 <sup>(2)</sup>      |       | μV/°K |
| 18.8               | V <sub>IOFF-O_50</sub>    | Input offset voltage with offset compensation | Gain = 50                           | -3.5                     | -1                      | 1.5   | mV    |
| 18.9               | V <sub>IOFF-O_20</sub>    | Input offset voltage with offset compensation | Gain = 20                           | -6                       | -2                      | 4     | mV    |
| 18.10              | V <sub>IOFF-O_10</sub>    | Input offset voltage with offset compensation | Gain = 10                           | -10                      | -3                      | 6     | mV    |
| 18.11              | P <sub>SRR_50</sub>       | Power supply rejection ratio                  | Gain = 50                           | 39                       |                         |       | dB    |
| 18.12              | P <sub>SRR_20</sub>       | Power supply rejection ratio                  | Gain = 20                           | 31                       |                         |       | dB    |
| 18.13              | P <sub>SRR_10</sub>       | Power supply rejection ratio                  | Gain = 10                           | 25                       |                         |       | dB    |
| 18.14              | CMRR                      | Input common mode rejection                   | T <sub>j</sub> = 25°C, DC           | 60                       |                         |       | dB    |
| 18.15              | Gain <sub>50</sub>        | Gain                                          |                                     | 46.75                    | 50                      | 53.25 |       |
| 18.16              | Gain <sub>20</sub>        | Gain                                          |                                     | 19                       | 20                      | 21    |       |
| 18.17              | Gain <sub>10</sub>        | Gain                                          |                                     | 9.5                      | 10                      | 10.5  |       |
| 18.18.1            | V <sub>CSOh</sub>         | High-level output voltage                     | I <sub>OUT</sub> = 2 mA             | V <sub>CC</sub> - 250 mV |                         |       | V     |
| 18.18.2            |                           |                                               | I <sub>OUT</sub> = 200 μA           | V <sub>CC</sub> - 50 mV  | V <sub>CC</sub> - 20 mV |       | V     |
| 18.19.1            | V <sub>CSOl</sub>         | Low-level output voltage                      | I <sub>OUT</sub> = -2 mA            |                          | 100                     | 250   | mV    |
| 18.19.2            |                           |                                               | I <sub>OUT</sub> = -200 μA          |                          | 15                      | 50    | mV    |
| Dynamic parameters |                           |                                               |                                     |                          |                         |       |       |
| 18.20              | SRcso_10                  | CSO slew rate                                 | Gain = 10; RL = 1 kΩ;<br>CL = 22 pF |                          | 2.8                     | 4     | V/μs  |
| 18.21              | SRcso_20                  | CSO slew rate                                 | Gain = 20; RL = 1 kΩ;<br>CL = 22 pF |                          | 3                       | 4.5   | V/μs  |
| 18.22              | SRcso_50                  | CSO slew rate                                 | Gain = 50; RL = 1 kΩ;<br>CL = 22 pF |                          | 4.4                     | 6     | V/μs  |
| 18.23              | I <sub>CSI_10</sub>       | CSI input current                             | Gain = 10                           | -114                     | -102                    | -90   | μA    |
| 18.24              | I <sub>CSI_20</sub>       | CSI input current                             | Gain = 20                           | -80                      | -72                     | -64   | μA    |
| 18.25              | I <sub>CSI_50</sub>       | CSI input current                             | Gain = 50                           | -39                      | -33                     | -27   | μA    |

1. Test conditions:  $V_S = 13 \text{ V}$ ,  $V_{\text{CC}} = 5 \text{ V}$ 

2. Not tested, guaranteed by design.

Figure 4. Output timing diagram (active free wheeling)

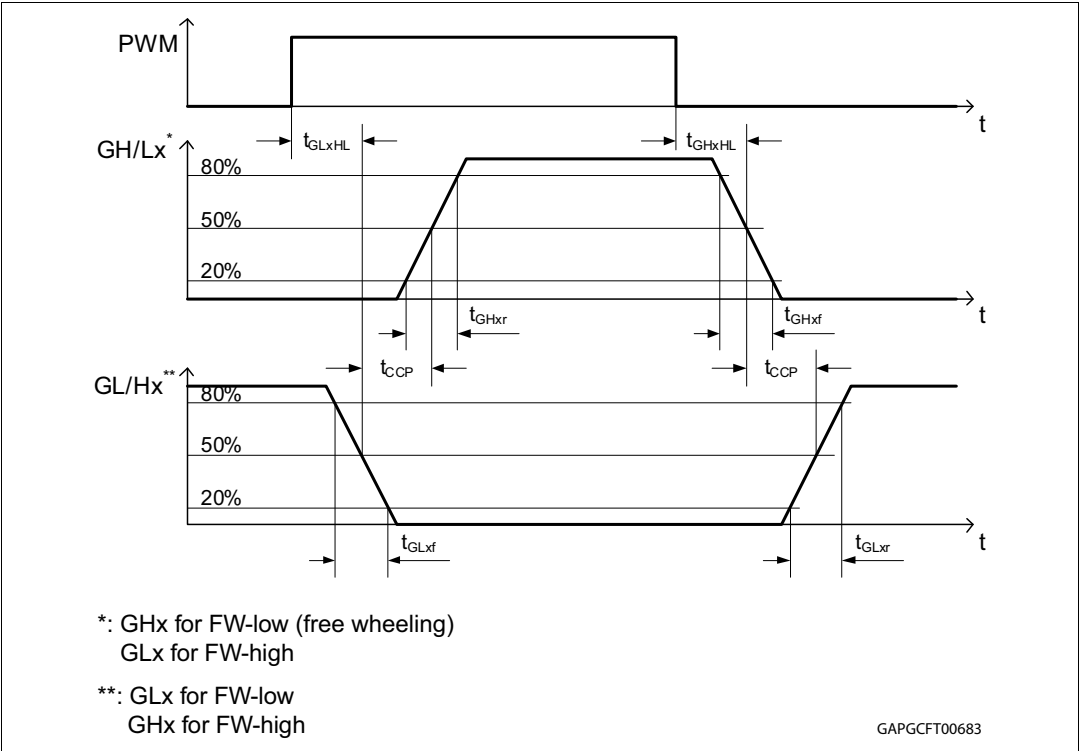
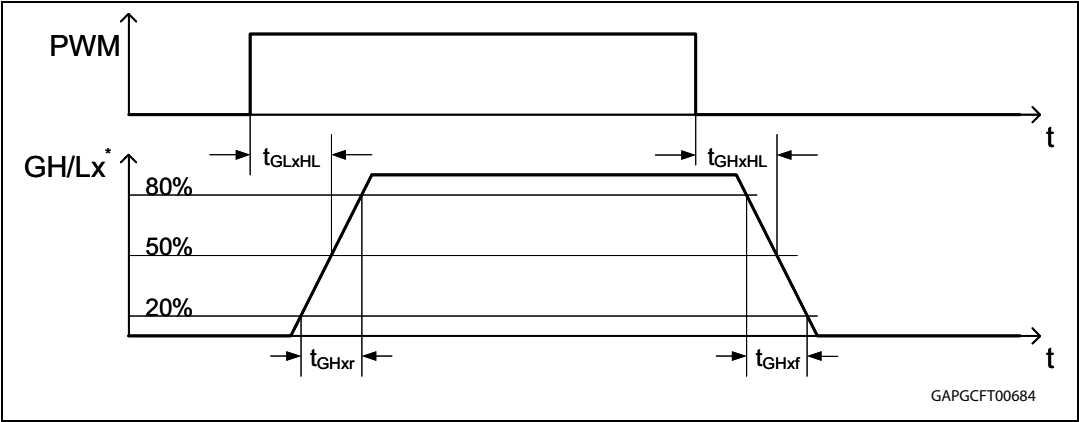


Figure 5. Output timing diagram (passive free wheeling)



## 2.5 SPI - electrical characteristics

$V_S = 6\text{ V}$  to  $28\text{ V}$ ,  $V_{CC} = 3\text{ V}$  to  $5.3\text{ V}$ ,  $T_j = -40^\circ\text{C}$  to  $150^\circ\text{C}$ , unless otherwise specified. The voltages are referred to GND and currents are assumed positive, when the current flows into the pin.

Table 19. DI timing<sup>(1)</sup>

| Item | Symbol         | Parameter                                          | Test condition | Min. | Typ. | Max. | Unit |
|------|----------------|----------------------------------------------------|----------------|------|------|------|------|
| 19.1 | $t_{CLK}$      | Clock period                                       | —              | 1000 | —    |      | ns   |
| 19.2 | $t_{CLKH}$     | Clock high time                                    | —              | 400  | —    |      | ns   |
| 19.3 | $t_{CLKL}$     | Clock low time                                     | —              | 400  | —    |      | ns   |
| 19.4 | $t_{set\ CSN}$ | CSN setup time, CSN low before rising edge of CLK  | —              | 400  | —    |      | ns   |
| 19.5 | $t_{set\ CLK}$ | CLK setup time, CLK high before rising edge of CSN | —              | 400  | —    |      | ns   |
| 19.6 | $t_{set\ DI}$  | DI setup time                                      | —              | 200  | —    |      | ns   |
| 19.7 | $t_{hold\ DI}$ | DI hold time                                       | —              | 200  | —    |      | ns   |
| 19.8 | $t_{r\ in}$    | Rise time of input signal DI, CLK, CSN             | —              |      | —    | 100  | ns   |
| 19.9 | $t_{f\ in}$    | Fall time of input signal DI, CLK, CSN             | —              |      | —    | 100  | ns   |

1. DI timing parameters tested in production by a passed / failed test:  
 $T_j = -40^\circ\text{C}$  /  $+25^\circ\text{C}$ : SPI communication @ 2 MHz.  
 $T_j = +125^\circ\text{C}$ : SPI communication @ 1.25 MHz.

Table 20. DO

| Item | Symbol         | Parameter                  | Test condition                                               | Min.           | Typ.           | Max. | Unit          |
|------|----------------|----------------------------|--------------------------------------------------------------|----------------|----------------|------|---------------|
| 20.1 | $V_{DOL}$      | Low-level output voltage   | $I_D = -4\text{ mA}$                                         |                | 0.2            | 0.4  | V             |
| 20.2 | $V_{DOH}$      | High-level output voltage  | $I_D = 4\text{ mA}$                                          | $V_{CC} - 0.4$ | $V_{CC} - 0.2$ |      | V             |
| 20.3 | $I_{DOLK}$     | Tristate leakage current   | $V_{CSN} = V_{CC}$ ;<br>$0\text{ V} < V_{DO} < V_{CC}$       | -10            |                | 10   | $\mu\text{A}$ |
| 20.4 | $C_{DO}^{(1)}$ | Tristate input capacitance | $V_{CSN} = V_{CC}$ ;<br>$0\text{ V} < V_{CC} < 5.3\text{ V}$ |                | 10             | 15   | pF            |

1. Value of input capacity is not measured in production test. Parameter guaranteed by design.

Table 21. DO timing

| Item | Symbol                | Parameter                                   | Test condition                                                                   | Min. | Typ. | Max. | Unit |
|------|-----------------------|---------------------------------------------|----------------------------------------------------------------------------------|------|------|------|------|
| 21.1 | $t_{r\ DO}$           | DO rise time                                | $C_L = 100\ \text{pF}$ ;<br>$I_{load} = -1\ \text{mA}$                           | —    | 80   | 140  | ns   |
| 21.2 | $t_{f\ DO}$           | DO fall time                                | $C_L = 100\ \text{pF}$ ; $I_{load} = 1\ \text{mA}$                               | —    | 50   | 100  | ns   |
| 21.3 | $t_{en\ DO\ tri\ L}$  | DO enable time from tristate to low-level   | $C_L = 100\ \text{pF}$ ; $I_{load} = 1\ \text{mA}$ ;<br>pull-up load to $V_{CC}$ | —    | 100  | 250  | ns   |
| 21.4 | $t_{dis\ DO\ L\ tri}$ | DO disable time from low-level to tristate  | $C_L = 100\ \text{pF}$ ; $I_{load} = 4\ \text{mA}$ ;<br>pull-up load to $V_{CC}$ | —    | 380  | 450  | ns   |
| 21.5 | $t_{en\ DO\ tri\ H}$  | DO enable time from tristate to high-level  | $C_L = 100\ \text{pF}$ ;<br>$I_{load} = -1\ \text{mA}$ ; pull-down load to GND   | —    | 100  | 250  | ns   |
| 21.6 | $t_{dis\ DO\ H\ tri}$ | DO disable time from high-level to tristate | $C_L = 100\ \text{pF}$ ;<br>$I_{load} = -4\ \text{mA}$ ; pull-down load to GND   | —    | 380  | 450  | ns   |
| 21.7 | $t_{d\ DO}$           | DO delay time                               | $V_{DO} < 0.3\ V_{CC}$ ;<br>$V_{DO} > 0.7\ V_{CC}$ ; $C_L = 100\ \text{pF}$      | —    | 50   | 250  | ns   |

Table 22. EN, CSN timing

| Item | Symbol            | Parameter                                                                         | Test condition                                         | Min. | Typ. | Max. | Unit          |
|------|-------------------|-----------------------------------------------------------------------------------|--------------------------------------------------------|------|------|------|---------------|
| 22.1 | $t_{r\ DO}$       | DO rise time                                                                      | $C_L = 100\ \text{pF}$ ;<br>$I_{load} = -1\ \text{mA}$ |      | 80   | 140  | ns            |
| 22.2 | $t_{f\ DO}$       | DO fall time                                                                      | $C_L = 100\ \text{pF}$ ;<br>$I_{load} = 1\ \text{mA}$  |      | 50   | 100  | ns            |
| 22.3 | $t_{CSN\_HI,min}$ | CSN HI time, active mode: the min high time between two independent SPI commands. | Transfer of SPI-command to input register              | 2    |      |      | $\mu\text{s}$ |

Figure 6. SPI - transfer timing diagram

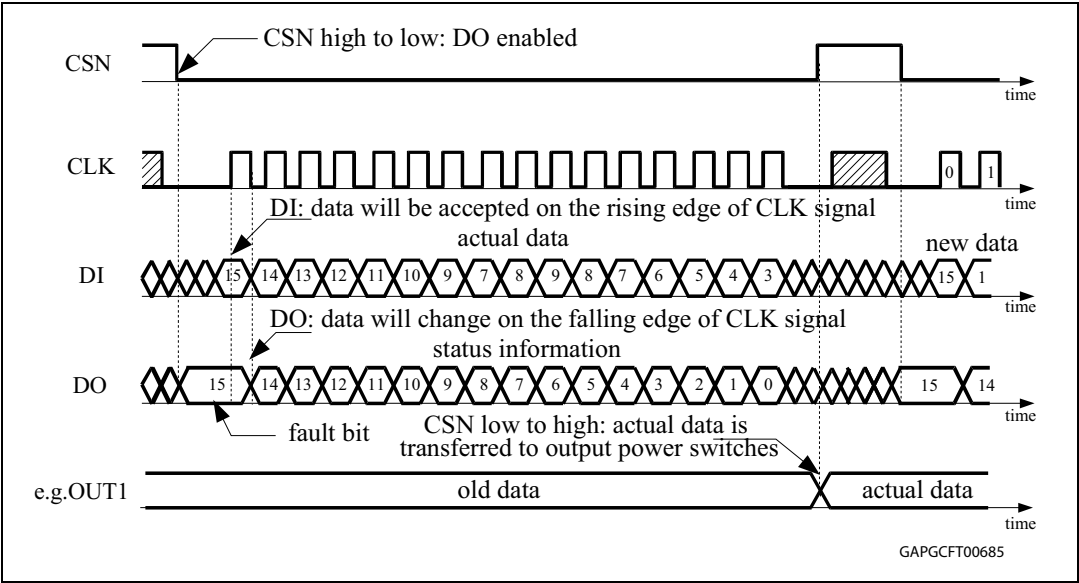


Figure 7. SPI - input timing

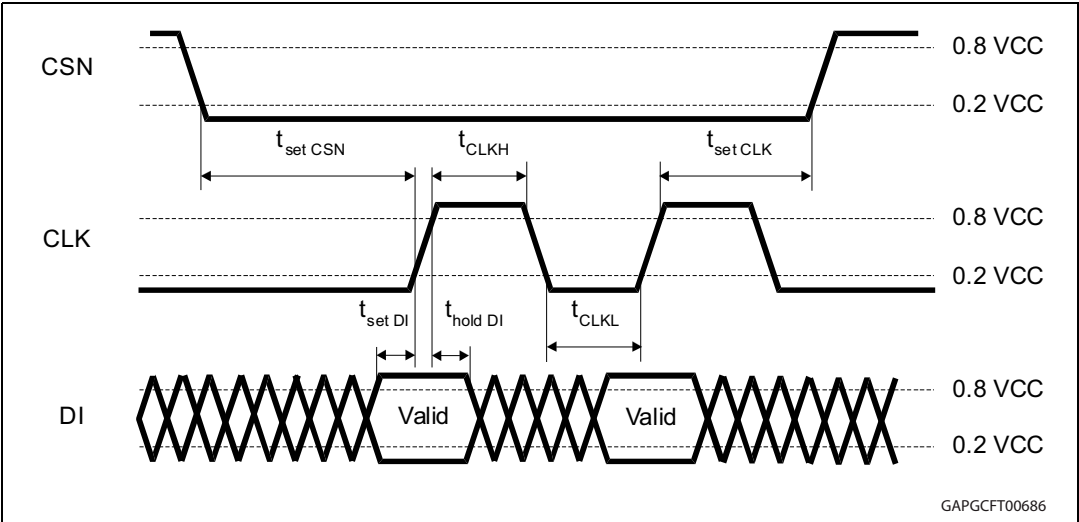


Figure 8. SPI - DO valid data delay time and valid time

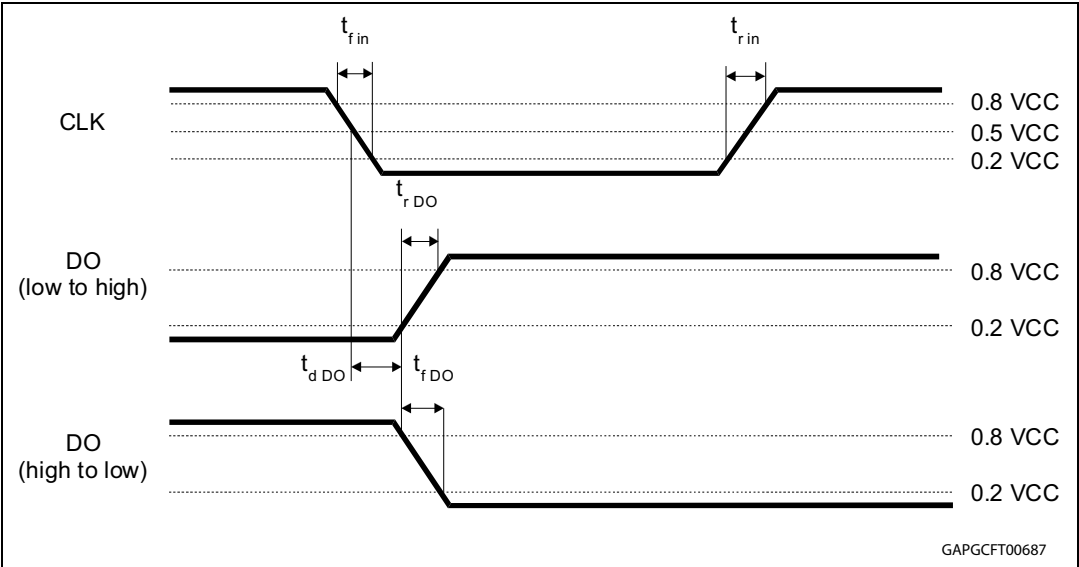


Figure 9. SPI - DO enable and disable time

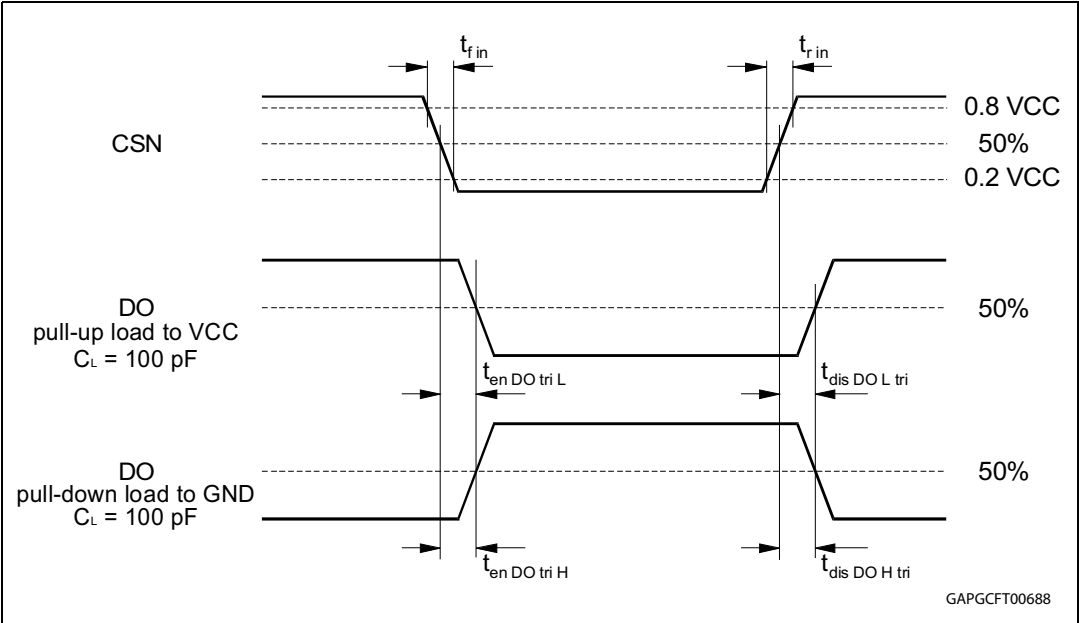
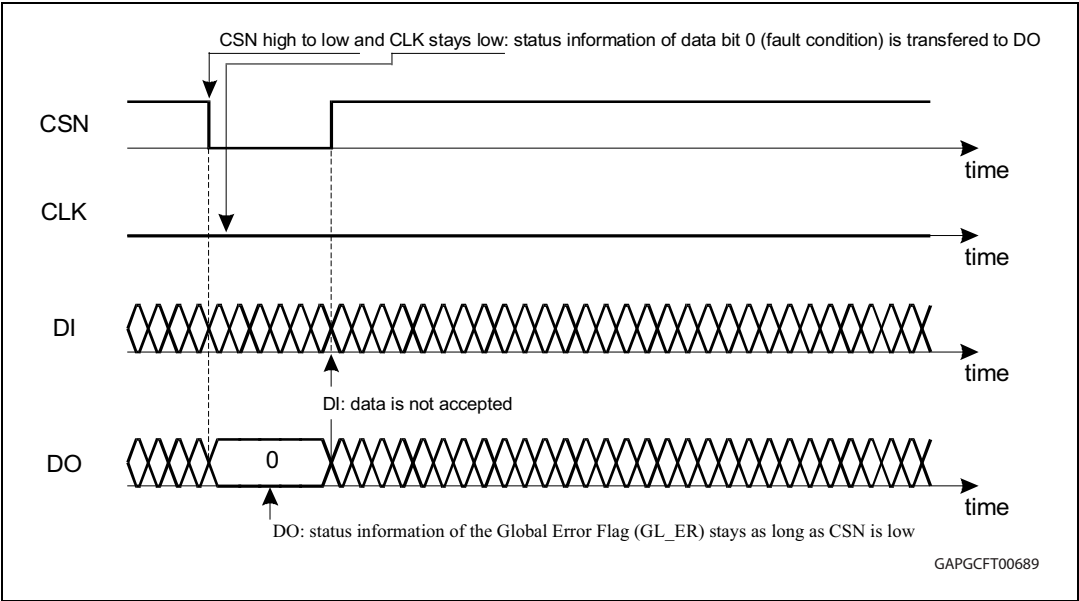


Figure 10. SPI - timing of status bit 0 (fault condition)



## 3 Device description

### 3.1 Dual power supply: $V_S$ and $V_{CC}$

The power supply voltage  $V_S$  supplies the charge-pump. An internal charge-pump is used to drive the high-side switches and the low-side switches. The logic supply voltage  $V_{CC}$  (3.3 V / 5 V) is used for the logic part and the SPI of the device. Due to the independent logic supply voltage the control and status information is not lost, even if the supply voltage  $V_S$  is switched-off. In case of power-on ( $V_{CC}$  increases from undervoltage to  $V_{POR\ OFF} = 2.5\text{ V}$ , typical) the circuit is initialized by an internally generated power-on reset (POR). If the voltage  $V_{CC}$  decreases under the minimum threshold ( $V_{POR\ ON} = 2.2\text{ V}$ , typical), the outputs are switched-off and the status registers are cleared.

### 3.2 Standby mode (EN)

The L99H01 is activated with enable input high signal. For enable input floating (not connected) or  $V_{EN} = 0\text{ V}$  the device is in standby mode. All latched data are cleared and the inputs and outputs are switched-off. In the standby mode the current at  $V_S$  is less than  $5\text{ }\mu\text{A}$  ( $1\text{ }\mu\text{A}$ ) for  $CSN = \text{high}$  (DO in tristate). If  $V_{CC} > V_{POR\ OFF}$  and  $EN = \text{high}$  the device enters the active mode. In the active mode the charge-pump and the diagnostic functions are active.

### 3.3 H-bridge control (DIR, PWM, bit FW)

The DIR and PWM inputs control the drivers of the external H-bridge transistors. The motor direction can be chosen with the DIR input, the duty cycle and frequency with the PWM input. With the SPI registers FW and FW-PAS 4 different free wheeling modes (2 active and 2 passive) can be selected using the high-side transistors or the low-side transistors. Unconnected inputs are defined by internal pull-down current.

Table 23. Truth table

| N° | Control pins |     |     |            | Control bits |        | Failure bits |    |    |    |     |      |                  | Output pins      |                  |                  |       | SPI DO                                 |  | Comment |
|----|--------------|-----|-----|------------|--------------|--------|--------------|----|----|----|-----|------|------------------|------------------|------------------|------------------|-------|----------------------------------------|--|---------|
|    | EN           | DIR | PWM | TS/ACT_OFF | FW           | FW_PAS | CP_LOW       | OV | UV | SC | TSD | WDTO | GH1              | GL1              | GH2              | GL2              | GL_ER |                                        |  |         |
| 1  | 0            | X   | X   | X          | X            | X      | X            | X  | X  | X  | X   | X    | RL               | RL               | RL               | RL               | T     | Standby mode                           |  |         |
| 2  | 1            | X   | X   | X          | X            | X      | X            | X  | X  | X  | X   | X    | RL               | RL               | RL               | RL               | 1     | Power-on reset                         |  |         |
| 3  | 1            | X   | X   | 0          | X            | 0      | 0            | 0  | 0  | 0  | 0   | 0    | L                | L                | L                | L                | 0     | EXT_TS = 1 (external thermal shutdown) |  |         |
| 4  | 1            | X   | X   | 0          | X            | 0      | 0            | 0  | 0  | 0  | 0   | 0    | L                | L                | L                | L                | 0     | EXT_TS = 0 (active Off)                |  |         |
| 5  | 1            | X   | X   | 1          | X            | X      | 1            | 0  | 0  | 0  | 0   | 0    | RL               | RL               | RL               | RL               | 1     | Charge pump voltage too low            |  |         |
| 6  | 1            | X   | X   | 1          | X            | X      | 0            | 0  | 0  | 0  | 1   | 0    | RL               | RL               | RL               | RL               | 1     | Internal thermal shutdown              |  |         |
| 7  | 1            | X   | X   | 1          | X            | X      | 0            | 1  | 0  | 0  | 0   | 0    | L                | L                | L                | L                | 1     | Overvoltage                            |  |         |
| 8  | 1            | X   | X   | 1          | X            | X      | 0            | 0  | 1  | 0  | 0   | 0    | L                | L                | L                | L                | 1     | Undervoltage                           |  |         |
| 9  | 1            | X   | X   | 1          | X            | X      | 0            | 0  | 0  | 1  | 0   | 0    | L <sup>(1)</sup> | L <sup>(1)</sup> | L <sup>(1)</sup> | L <sup>(1)</sup> | 0     | Short-circuit <sup>(1)</sup>           |  |         |
| 10 | 1            | X   | X   | 1          | X            | X      | 0            | 0  | 0  | 0  | 0   | 1    | L                | L                | L                | L                | 1     | Watchdog time out                      |  |         |
| 11 | 1            | 0   | 1   | 1          | X            | X      | 0            | 0  | 0  | 0  | 0   | 0    | L                | H                | H                | L                | 0     | -                                      |  |         |
| 12 | 1            | X   | 0   | 1          | 0            | 0      | 0            | 0  | 0  | 0  | 0   | 0    | L                | H                | L                | H                | 0     | Act. free wheeling mode LS             |  |         |
| 13 | 1            | 0   | 0   | 1          | 0            | 1      | 0            | 0  | 0  | 0  | 0   | 0    | L                | H                | L                | L                | 0     | Pass. free wheeling mode LS            |  |         |
| 14 | 1            | 1   | 0   | 1          | 0            | 1      | 0            | 0  | 0  | 0  | 0   | 0    | L                | L                | L                | H                | 0     | Pass. free wheeling mode LS            |  |         |
| 15 | 1            | 1   | 1   | 1          | X            | X      | 0            | 0  | 0  | 0  | 0   | 0    | H                | L                | L                | H                | 0     | -                                      |  |         |
| 16 | 1            | X   | 0   | 1          | 1            | 0      | 0            | 0  | 0  | 0  | 0   | 0    | H                | L                | H                | L                | 0     | Act. free wheeling mode HS             |  |         |
| 17 | 1            | 0   | 0   | 1          | 1            | 1      | 0            | 0  | 0  | 0  | 0   | 0    | L                | L                | H                | L                | 0     | Pass. free wheeling mode HS            |  |         |
| 18 | 1            | 1   | 0   | 1          | 1            | 1      | 0            | 0  | 0  | 0  | 0   | 0    | H                | L                | L                | L                | 0     | Pass. free wheeling mode HS            |  |         |

1. Only the halfbridge (low-side and high-side) where one MOSFET is in short-circuit condition is switched-off. Both MOSFETs of the other halfbridge remain active and driven by DIR and PWM.

Symbols:

- **x**: Don't care
- **1**: Logic high or active
- **0**: Logic low or not active
- **H**: Output in source condition
- **L**: Output in sink condition
- **RL**: Resistive low (see [Section 3.4](#))
- **T**: Tristate
- **FW**: Free wheeling
- **FW\_PAS**: Free wheeling passive
- **CP\_LOW**: Charge pump low
- **OV**: Overvoltage
- **UV**: Undervoltage
- **SC**: Short-circuit
- **TSD**: Thermal shutdown
- **GL\_ER**: Global error flag

### 3.4 Resistive low

The resistive output mode protects the L99H01 and the H-bridge in the standby mode and in some failure modes (internal and external thermal shutdown (TSD), charge pump low (CP\_LOW), stucked reset (STK\_RESET\_Q) and power-on reset (PORES)). When a gate driver changes into the resistive output mode due to a failure a sequence is started. In this sequence the concerning driver is switched in sink condition for 32  $\mu$ s to 64  $\mu$ s to ensure a fast switch-off of the H-bridge transistor. Afterwards the driver is switched in the resistive output mode (resistive path to source).

### 3.5 Diagnostic functions

The diagnostic functions (over load, power supply over- and undervoltage, charge pump low, watchdog, temperature warning and internal/external thermal shutdown) are internally filtered and the condition has to be valid for at least 64  $\mu$ s (6  $\mu$ s for a short-circuit) before the corresponding status bit in the status registers is set. The filters are used to improve the noise immunity of the device. The internal temperature warning function is intended for information purpose and does not change the state of the output drivers. On the contrary, the over load condition switches the corresponding halfbridge in sink condition. The internal thermal shutdown condition and charge pump low disable all drivers (resistive low). The external thermal shutdown, watchdog, over- and undervoltage condition switch all driver in sink condition. The microcontroller needs to clear the status bits to reactivate the drivers.

### 3.6 Overvoltage and undervoltage detection

If the power supply voltage  $V_S$  rises above the overvoltage threshold  $V_{VS\_OVH}$  (typical 20 V / 30 V), all gate driver stages are switched in sink condition to protect the H-bridge and the load, setting the OV bit. Two values for the overvoltage threshold can be selected with the SPI. When the voltage  $V_S$  drops below the undervoltage threshold

$V_{VS\_UV}$ , all gate driver stages are switched in the sink condition to avoid driving the power devices without sufficient gate driving voltage (increased power dissipation), setting the UV bit. In both cases, overvoltage and undervoltage detection, the charge pump is disabled. If the supply voltage  $V_S$  recovers from UV/OV to normal operating voltage range and if the OV\_UV\_RD is set to 0, then the charge pump is automatically enabled. In any case, regardless of the OV\_UV\_RD bit value, the microcontroller needs to clear the status register to reactivate the gate drivers.

### 3.7 Charge pump

The charge pump uses 2 external capacitors. The output of the charge pump has a current limitation. In standby mode and after overvoltage, undervoltage or a thermal shutdown has been triggered the charge pump is disabled. If the charge pump output voltage remains too low for longer than  $T_{CP}$ , all gate drivers are switched-off (resistive output, see [Section 3.4](#)). The CP\_LOW bit has to be cleared through a software reset to reactivate the gate drivers.

### 3.8 Temperature warning and thermal shutdown

If junction temperature rises above  $T_{JT\_WON}$  the temperature warning flag TW is set and is detectable via the SPI. If junction temperature increases above the second threshold  $T_{JSDON}$ , the thermal shutdown bit (TSD) is set. The gate drivers and the charge pump are switched-off to protect the device. The gates of the H-bridge are discharged by the resistive low mode (see [Section 3.4](#)). In order to reactivate the output stages the junction temperature must decrease below  $T_{JSDOFF}$  and the thermal shutdown bit has to be cleared by the microcontroller.

### 3.9 Short-circuit detection / drain source monitoring

The drain - source voltage of each activated external MOSFET of the H-bridge is monitored by comparators to detect shorts to ground or battery. If the voltage drop over the external MOSFET exceeds the threshold voltage  $V_{SCd}$  for longer than the short current detection time  $t_{SCd}$  the corresponding gate driver switches the external MOSFET off and the corresponding drain source monitoring flag (DS\_MON [3:0]) is set. Until this failure flag is reseted the corresponding half bridge is in sink condition. The DS\_MON bits have to be cleared through a software reset to reactivate the gate drivers. The drain source monitoring has a filter time of 6  $\mu$ s. This monitoring is only active when the corresponding gate driver is in source condition. The threshold voltage  $V_{SCd}$  can be programmed in 4 steps between 0.5 V and 2 V with the SPI.

### 3.10 Programmable cross current protection

The external Power MOSFET's transistors in H-bridge (two halfbridges) configuration are switched-on with an additional delay time  $t_{CCP}$  to prevent cross current in the halfbridge. The cross current protection time  $t_{CCP}$  can be programmed with the SPI.

### 3.11 Current sense amplifier (CSA)

The current sense amplifier (CSA) is specially designed for current shunt automotive applications. It is a bidirectional, single-supply difference amplifier for amplifying small differential voltages in a wide common mode voltage range (-4 V to ( $V_{CP} - 8$ ) V). It supports the current measurement at two shunts. The result of respective shunt can be multiplexed to the microcontroller compatible output voltage by a SPI command.

A gain of 50, 20 or 10 is SPI programmable. The inputs (CSI1+ / CSI1- and CSI2+ / CSI2-) are build as a transconductance stage. Therefore a series resistor (for filtering etc.) should not exceed 50  $\Omega$  to keep the additional gain error below 1%.

The output works at half scale:  $V_{CSO0} = (0,5 * V_{CC})$  V for  $V_{IDIFF} = 0$  V. An internal offset measurement is in normal mode available with the "OFF\_CAL" SPI-bit. If this bit is set to logic "1" the input pins are disconnected from the amplifier and a virtual zero input differential voltage is selected.

### 3.12 Thermal sensor interface / H-bridge switch-off input

The TS/ACT\_OFF pin is configurable by SPI with the EXT\_TS bit. This pin could be used as temperature sensor interface for the H-bridge or external off for all gate drivers. The output bias current ITS\_bias is on for EN = high.

#### 3.12.1 EXT\_TS-bit = low (active off)

The TS/ACT\_OFF input is used as a logic driver control input, without filter delay and without latching the information.

Pulling the TS/ACT\_OFF pin below the programmed threshold all gate drivers are switched-off and the OT\_EXT bit is set.

Increasing the voltage at TS/ACT\_OFF pin above the programmed threshold the device remains to the status set by DIR and PWM-pins and the OT\_EXT bit is reseted.

The threshold is programmable by SPI with the registers EXTTH\_5:0.

#### 3.12.2 EXT\_TS-bit = high (thermal sensor interface)

With the thermal sensor interface external diodes can be used to control the temperature of the external H-bridge. When the diode forward voltage decreases below the reference voltage for longer than the internal filter time (64  $\mu$ s) the OT\_EXT bit is set and the driver switches in resistive low (see [Section 3.4: Resistive low](#)).

In this mode the OT\_EXT-status-bit has to be cleared to reactivate the gate drivers.

The threshold is programmable by SPI with the registers EXTTH\_5:0.

### 3.13 Watchdog

The tasks of the watchdog is to monitor the microcontroller during normal operation within a nominal trigger cycle of 60 ms. The microcontroller has to restart the watchdog timer by sending the watchdog restart bit via SPI repeatedly within the watchdog time  $T_{WDTO}$ . If no correct watchdog service is sent from the microcontroller, all gate drivers switch in sink

condition and the watchdog time out bit (WDTO) is set. Once the watchdog times out, the gate drivers can only be reactivated by sending a software reset.

## 4 Functional description of the SPI

### 4.1 Signal description

#### 4.1.1 Serial clock (CLK)

This input signal provides the timing of the serial interface. Data present at serial data input (DI) is latched on the rising edge of serial clock (CLK). Data on Serial Data Out (DO) is shifted out at the falling edge of serial clock (CLK).

The serial clock CLK must be active only during a frame (CSN low phase). Any other switching of CLK close to any CSN edge could generate setup/hold violations in the SPI logic of the device.

#### 4.1.2 Serial data input (DI)

This input is used to transfer data serially into the device. Values are latched on the rising edge of serial clock (CLK).

#### 4.1.3 Serial data output (DO)

This output signal is used to transfer data serially out of the device. Data is shifted out on the falling edge of serial clock (CLK).

DO also reflects the status of the *<Global Error Flag>* (*<Global Status Byte>*[7]) while CSN is low and no clock signal is present.

#### 4.1.4 Chip select not (CSN)

When this input signal is high, the communication interface of the device is deselected and serial data output (DO) is high impedance. Driving this input low enables the communication. The communication must start and stop on a low-level of serial clock (CLK).

The SPI can be driven by a microcontroller with its SPI peripheral running in following mode: CPOL = 0 and CPHA = 0.

For timing details and figures refer to [Section 2.5](#).

### 4.2 General data description

The SPI communication is based on a SPI interface structure using CSN (chip select not), DI (serial data in), DO (serial data out/error) and CLK (serial clock) signal lines.

Each DI communication frame consists of a *<Command Byte>* which is followed by 1 *<Data Byte>*.

The data returned on DO within the same frame always starts with the *<Global Status Byte>*, which provides general status information about the device. This byte is followed by 1 *<Data Byte>* (*'In-frame-response'*).

Table 24. DI

| Command byte |     |    |    |    |    |    |    | DI - data byte |    |    |    |    |    |    |    |
|--------------|-----|----|----|----|----|----|----|----------------|----|----|----|----|----|----|----|
| 15           | 14  | 13 | 12 | 11 | 10 | 9  | 8  | 7              | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| OC1          | OC0 | A5 | A4 | A3 | A2 | A1 | A0 | D7             | D6 | D5 | D4 | D3 | D2 | D1 | D0 |

Table 25. DO

| Global Status byte |    |             |  |     |    |    |    | DO - data byte |    |    |    |    |    |    |    |    |
|--------------------|----|-------------|--|-----|----|----|----|----------------|----|----|----|----|----|----|----|----|
| 15                 | 14 | 13          |  | 12  | 11 | 10 | 9  | 8              | 7  | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| GL_ER              | FE | STK_RESET_Q |  | TSD | TW | UV | OV | WDTO           | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |

#### 4.2.1 Command byte

Each communication frame starts with a command byte. It consists of an operating code which specifies the type of operation (<Read>, <Write>, <Fault Reset>, <Read Device Information>) and a 6-bit address.

Table 26. Command byte

| Command byte |     |         |    |     |    |    |    |
|--------------|-----|---------|----|-----|----|----|----|
| MSB          |     |         |    | LSB |    |    |    |
| Op code      |     | Address |    |     |    |    |    |
| OC1          | OC0 | A5      | A4 | A3  | A2 | A1 | A0 |

Comments:

- **OCx**: Operating code
- **Ax**: Address

#### 4.2.2 OpCode definition

Table 27. Operating code definition

| OC1 | OC0 | Meaning                   |
|-----|-----|---------------------------|
| 0   | 0   | <Write Mode>              |
| 0   | 1   | <Read Mode>               |
| 1   | 0   | <Clear Status>            |
| 1   | 1   | <Read Device Information> |

The <Write Mode> and <Read Mode> operations allow access to the RAM of the device.

The <Clear Status> operation is used to read a status register and subsequently clear its content.

<Read Device Information> allows access to the ROM area which contains device related information such as <ID-Header>, <Product Code>, <Silicon Version and Category> and <SPI-frame-ID>.

More detailed descriptions of the *device information* are available in [Section 4.7](#).

## 4.3 Device memory map

### 4.3.1 Control and status (RAM) address map

Table 28. Control and status (RAM) address map

| Name      | Access      | Address |    |    |    |    |    |          |          | Content  |            |         |              |         |         |  |  |
|-----------|-------------|---------|----|----|----|----|----|----------|----------|----------|------------|---------|--------------|---------|---------|--|--|
|           |             | A5      | A4 | A3 | A2 | A1 | A0 | D7       | D6       | D5       | D4         | D3      | D2           | D1      | D0      |  |  |
| Stat Reg0 | Read/ Clear | 0       | 0  | 0  | 0  | 0  | 0  | DS_MON_3 | DS_MON_2 | DS_MON_1 | DS_MON_0   | 0       | 0            | OT_EXT  | CP_LOW  |  |  |
| Appl Reg1 | Read/ Write | 0       | 0  | 0  | 0  | 0  | 1  | RWD      | FW_PAS   | OFF_CAL  | CLK_SPECTR | OVT     | OV_UV_R<br>D | DIAG_1  | DIAG_0  |  |  |
| Appl Reg2 | Read/ Write | 0       | 0  | 0  | 0  | 1  | 0  | RWD      | COPT_2   | COPT_1   | COPT_0     | FW      | MCSA         | GCSA_1  | GCSA_0  |  |  |
| Appl Reg3 | Read/ Write | 0       | 0  | 0  | 0  | 1  | 1  | RWD      | EXT_TS   | EXTTH_5  | EXTTH_4    | EXTTH_3 | EXTTH_2      | EXTTH_1 | EXTTH_0 |  |  |

### 4.3.2 Device (ROM) address map (access with OC0 and OC1 set to '1')

Table 29. Device (ROM) address map (access with OC0 and OC1 set to '1')

| Name           | Access      | Address |    |    |    |    |    | Content                                                                                                                                        |          |          |          |          |          |         |         |
|----------------|-------------|---------|----|----|----|----|----|------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------|----------|----------|----------|---------|---------|
|                |             | A5      | A4 | A3 | A2 | A1 | A0 | D7                                                                                                                                             | D6       | D5       | D4       | D3       | D2       | D1      | D0      |
| ID-Header      | Read device | 0       | 0  | 0  | 0  | 0  | 0  | FAM_1                                                                                                                                          | FAM_0    | NR_PI_5  | NR_PI_4  | NR_PI_3  | NR_PI_2  | NR_PI_1 | NR_PI_0 |
| Product Code 1 | Read device | 0       | 0  | 0  | 0  | 0  | 1  | PR_ID_7                                                                                                                                        | PR_ID_6  | PR_ID_5  | PR_ID_4  | PR_ID_3  | PR_ID_2  | PR_ID_1 | PR_ID_0 |
| Product Code 2 | Read device | 0       | 0  | 0  | 0  | 1  | 0  | PR_ID_15                                                                                                                                       | PR_ID_14 | PR_ID_13 | PR_ID_12 | PR_ID_11 | PR_ID_10 | PR_ID_9 | PR_ID_8 |
| SPI-Frame-ID   | Read device | 0       | 0  | 0  | 0  | 1  | 1  | BR                                                                                                                                             | AR5      | AR4      | AR3      | 32 bits  | 24 bits  | 16 bits | 8 bits  |
| Reserved       | Read device | 1       | 1  | 1  | 1  | 1  | 1  | Reserved, accessing this address is recognized as a failure, the device enters a fail-safe state (see <a href="#">Table 30: STK_RESET_Q</a> ). |          |          |          |          |          |         |         |

## 4.4 Global status byte

This byte is shifted out first at DO at every SPI access.

The GL\_ER bit is present at DO with the falling edge of CSN.

This byte could be reseted with the command <clear status>.

**Table 30. STK\_RESET\_Q**

| Bit       | 15    | 14 | 13          | 12  | 11 | 10 | 9  | 8    |
|-----------|-------|----|-------------|-----|----|----|----|------|
| Name      | GL_ER | FE | STK_RESET_Q | TSD | TW | UV | OV | WDTO |
| <default> | 0     | 0  | 1           | 0   | 0  | 0  | 0  | 0    |

Comments:

- **GL\_ER**: Global error flag. This signal is a logical OR among all the errors of all the channels of the device.
- **FE**: Frame error. If the number of clock pulses within the previous frame is not 16 the frame is ignored and this bit is set.
- **STK\_RESET\_Q**: If a stuck at '1' on SPI\_DI during any SPI frame occurs, or if a power-on reset occurs. STK\_RESET\_Q is reset ('1') with any SPI command. When STK\_RESET\_Q is active ('0'), the gate drivers are switched-off (see [Section 3.4: Resistive low](#)). After a startup of the circuit the STK\_RESET\_Q is active because of the POR pulse and the gate drivers are switched-off. The Gate drivers can only be activated after the STK\_RESET\_Q has been reset with a SPI command.
- **TSD**: Thermal shutdown due to an internal sensor. All the gate drivers and the charge pump must be switched-off (see [Section 3.4: Resistive low](#)). The gate drivers can only be activated after the TSD has been reset with a SPI command.
- **TW**: Thermal warning
- **UV**: Logical OR among the filtered undervoltage signals.
- **OV**: Logical OR among the filtered overvoltage signals.
- **WDTO**: Watchdog time out.

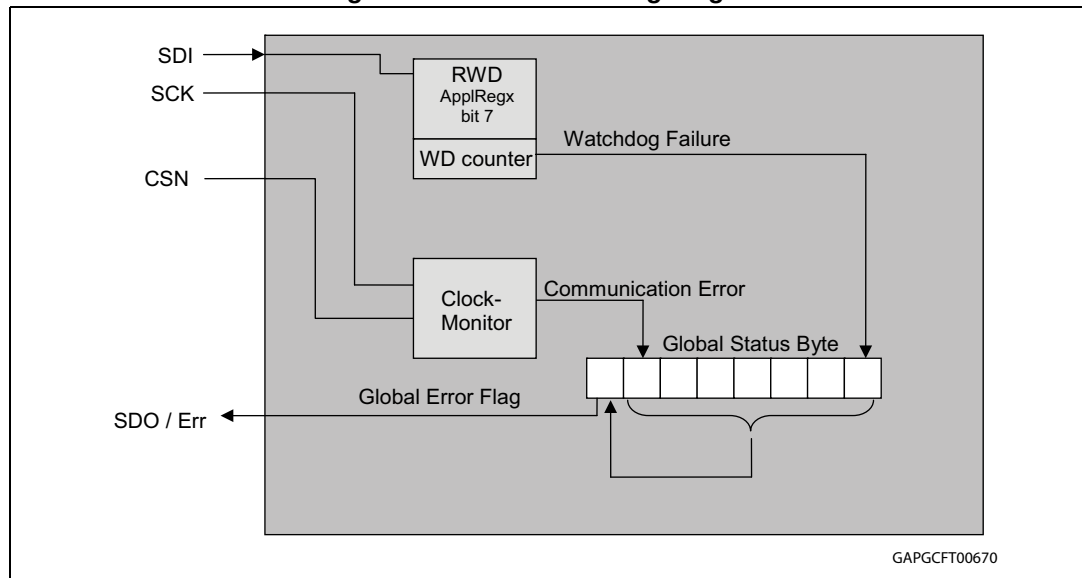
Failures of <Global Status Register>[8:14] are always linked to the <Global Error Flag>.

The <Global Error Flag> is generated by an OR combination of all failure events of the device (<Global Status Register>[8:14]).

The flag is reflected via the DO pin while CSN is held low and no clock signal is available. The flag remains as long as CSN is low. This operation does not cause the <communication error> bit in the <Global Status Byte> to be set.

#### 4.4.1 SPI clock monitor and watchdog

Figure 11. Global error flag diagram



1. Writing a "1" to RWD - bit in ApplRegx restarts the internal watchdog counter.

The clock monitor counts the number of clock pulses during a communication frame (while CSN is low). If the number of SCK pulses does not correspond with the frame width indicated in the <SPI-frame-ID> (ROM address 03hex) the frame is ignored and the bit <frame error> in the <Global Status Byte> is set.

**Note:** Due to this safety functionality, daisy chaining the SPI is not possible. Instead, a parallel operation of the SPI bus by controlling the CSN signal of the connected ICs is recommended.

## 4.5 Detailed byte description of status register (StatReg0)

The read operation starts always with the command byte followed by 1 data byte. The content of the send data byte has to be '0'. The content of the addressed register is shifted out at DO within the same frame ('in-frame response').

The device uses 1 status register to monitor the state of the device. [Table 31](#) shows the address and the content of the register.

**Table 31. Address 0<00(hex)>:StatReg 0 - read only<sup>(1)</sup>**

| Bit       | 7        | 6        | 5        | 4        | 3 | 2 | 1      | 0      |
|-----------|----------|----------|----------|----------|---|---|--------|--------|
| Name      | DS_MON_3 | DS_MON_2 | DS_MON_1 | DS_MON_0 | X | X | OT_EXT | CP_LOW |
| <default> | 0        | 0        | 0        | 0        | 0 | 0 | 0      | 0      |

1. The errors of the status register are not linked to the <Global Error Flag>.

Comments:

- **DS\_MON[3:0]:** If max drain source voltage exceeds the defined thresholds, the DS\_MON are set and the corresponding drivers go to sink mode. The DS\_MON bits have to be cleared through a software reset to reactivate the drivers.

**Table 32. DS\_MON - drivers relations**

| Register | Deactivated driver |
|----------|--------------------|
| DS_MON_3 | High-side 2        |
| DS_MON_2 | High-side 1        |
| DS_MON_1 | Low-side 2         |
| DS_MON_0 | Low-side 1         |

- **OT\_EXT:** Depending on EXT\_TS bit following two meanings exist:
  - EXT\_TS = low (active off):  
TS/ACT\_OFF pin is used as input to switch the H-bridge in tristate and back. Details are described in [Section 3.12.1](#).
  - EXT\_TS = high (thermal sensor interface):  
TS/ACT\_OFF pin is used as thermal sensor interface for external temperature diodes. Details are described in [Section 3.12.2](#).
- **CP\_LOW:** If a charge pump output voltage low occurs, all gate drivers must be switched-off (resistive low). The CP\_LOW bit has to be cleared through a software reset to reactivate the gate driver.

## 4.6 Detailed byte description of application registers (ApplRegX)

The write/read operation starts always with a command byte followed by 1 data byte.

### 4.6.1 Description of the data byte

The device uses 3 application registers to configure the device. Note that the last row shows the logic levels during a reset phase.

**Table 33. Address 1 <01(hex)>:ApplReg1-read/write**

| Bit       | 7   | 6      | 5       | 4         | 3   | 2        | 1     | 0     |
|-----------|-----|--------|---------|-----------|-----|----------|-------|-------|
| Name      | RWD | FW_PAS | OFF_CAL | CLK_SPCTR | OVT | OV_UV_RD | DIAG1 | DIAG0 |
| <default> | 0   | 0      | 0       | 0         | 0   | 0        | 0     | 0     |

Comments:

- **RWD**: Restarts the watchdog counter
- **FW\_PAS**: Enables passive free wheeling according to [Table 23](#)
- **OFF\_CAL**: Offset calibration mode for CSA
- **OVT**: Overvoltage threshold
- **CLK\_SPCTR**: Switch the clock to the charge pump
  - **0**: 125 KHz (50% duty cycle)
  - **1**: pulses train (max = 8  $\mu$ s, min = 2  $\mu$ s) to optimize power spectrum

**Table 34. Overvoltage threshold of the Vs monitoring**

| OVT | Threshold |
|-----|-----------|
| 0   | 20 V      |
| 1   | 29 V      |

- **OV\_UV\_RD**: Over/undervoltage recovery disabled.
  - **0**: If  $V_S$  recovers from OV/UV condition to normal operating voltage range, the charge pump is automatically enabled;
  - **1**: If  $V_S$  recovers from OV/UV condition to normal operating voltage range, the charge pump remains disabled;

In both cases the microcontroller has to clear the status register to enable the gate drivers

- **DIAG[1:0]**: Drain source monitoring threshold voltage

**Table 35. DIAG monitoring of source voltages**

| DIAG[1] | DIAG[0] | Monitoring threshold voltage |
|---------|---------|------------------------------|
| 0       | 0       | $V_{SCD1} = 0.5 \text{ V}$   |
| 0       | 1       | $V_{SCD2} = 1 \text{ V}$     |
| 1       | 0       | $V_{SCD3} = 1.5 \text{ V}$   |
| 1       | 1       | $V_{SCD4} = 2 \text{ V}$     |

**Table 36. Address 2 <02(hex)>: ApplReg2 – read/write**

| Bit       | 7   | 6      | 5      | 4      | 3  | 2    | 1      | 0      |
|-----------|-----|--------|--------|--------|----|------|--------|--------|
| Name      | RWD | COPT_2 | COPT_1 | COPT_0 | FW | MCSA | GCSA_1 | GCSA_0 |
| <default> | 0   | 0      | 0      | 0      | 0  | 0    | 0      | 0      |

Comments:

- **RWD**: Restarts the watchdog counter
- **COPT[2:0]**: Filter time to protect the two external halfbridges against cross current.

**Table 37. Cross current protection time ( $t_{CCP}$ )**

| COPT_2 | COPT_1 | COPT_0 | Protection time |
|--------|--------|--------|-----------------|
| 0      | 0      | 0      | 250 ns          |
| 0      | 0      | 1      | 500 ns          |
| 0      | 1      | 0      | 750 ns          |
| 0      | 1      | 1      | 1000 ns         |
| 1      | 0      | 0      | 1250 ns         |
| 1      | 0      | 1      | 1500 ns         |
| 1      | 1      | 0      | 1750 ns         |
| 1      | 1      | 1      | 2000 ns         |

- **FW**: Selects high-side or low-side free wheeling
- **MCSA**: Multiplexer for current sense amplifier.

**Table 38. Multiplexer for current sense amplifier**

| MCSA | Selected amplifier   |
|------|----------------------|
| 0    | CSA2 (CSI2+ / CSI2-) |
| 1    | CSA1 (CSI1+ / CSI1-) |

- **GCSA[1:0]**: Gain of the current sense amplifier.

**Table 39. Gain of current sense amplifier**

| GCSA_1 | GCSA_0 | Gain           |
|--------|--------|----------------|
| 0      | 0      | 10             |
| 0      | 1      | 20             |
| 1      | 0      | 50             |
| 1      | 1      | Not applicable |

Table 40. Address 3 &lt;03(hex)&gt; : ApplReg3 – read/write

| Bit       | 7   | 6      | 5       | 4       | 3       | 2       | 1       | 0       |
|-----------|-----|--------|---------|---------|---------|---------|---------|---------|
| Name      | RWD | EXT_TS | EXTTH_5 | EXTTH_4 | EXTTH_3 | EXTTH_2 | EXTTH_1 | EXTTH_0 |
| <default> | 0   | 0      | 0       | 0       | 0       | 0       | 0       | 0       |

Comments:

- **RWD**: Restarts the watchdog counter
- **EXT\_TS**: The bit select the mode of the input pin TS/ACT\_OFF:
  - EXT\_TS = low (active off):  
TS/ACT\_OFF pin is used as input to switch the H-bridge in tristate and back.  
Details are described in [Section 3.12.1](#).
  - EXT\_TS = high (thermal sensor interface):  
TS/ACT\_OFF pin is used as thermal sensor interface for external temperature diodes. Details are described in [Section 3.12.2](#).
- **EXTTH[5:0]**: Determines the threshold of the external thermal shutdown/warning

Table 41. External threshold voltage, factor n

| EXTTH_5 | EXTTH_4 | EXTTH_3 | n |
|---------|---------|---------|---|
| 0       | 0       | 0       | 7 |
| 0       | 0       | 1       | 6 |
| 0       | 1       | 0       | 5 |
| 0       | 1       | 1       | 4 |
| 1       | 0       | 0       | 3 |
| 1       | 0       | 1       | 2 |
| 1       | 1       | 0       | 1 |
| 1       | 1       | 1       | 0 |

Table 42. External threshold voltage, factor m

| EXTTH_2 | EXTTH_1 | EXTTH_0 | m |
|---------|---------|---------|---|
| 0       | 0       | 0       | 7 |
| 0       | 0       | 1       | 6 |
| 0       | 1       | 0       | 5 |
| 0       | 1       | 1       | 4 |
| 1       | 0       | 0       | 3 |
| 1       | 0       | 1       | 2 |
| 1       | 1       | 0       | 1 |
| 1       | 1       | 1       | 0 |

**Equation 1**

$$V_{th} = n * (0.31 + m * 0.03) V$$

The purpose of factor n is to determine the number of external temperature sense diodes (in series). With factor m the level of the threshold voltage can be fine tuned.

## 4.7 Read device information (ROM)

The device information is stored at the ROM addresses defined below and is read using the respective operating code.

**Table 43. Read device information (ROM)**

| Op code |     | Address | Device information                                                                                                                             |
|---------|-----|---------|------------------------------------------------------------------------------------------------------------------------------------------------|
| OC1     | OC0 | Ax      |                                                                                                                                                |
| 1       | 1   | 00H     | <ID-Header>                                                                                                                                    |
| 1       | 1   | 01H     | <Product Code 1>                                                                                                                               |
| 1       | 1   | 02H     | <Product Code 2>                                                                                                                               |
| 1       | 1   | 03H     | <SPI-frame-ID>                                                                                                                                 |
| 1       | 1   | 3FH     | Reserved, accessing this address is recognized as a failure, the device enters a fail-safe state (see <a href="#">Table 30: STK_RESET_Q</a> ). |

The <ID-Header> indicates the product family and specifies how many bytes of device information are available.

**Table 44. Address 0 <00(hex)> : ID-header - read only<sup>(1)</sup>**

| Bit       | 7     | 6     | 5       | 4       | 3       | 2       | 1       | 0       |
|-----------|-------|-------|---------|---------|---------|---------|---------|---------|
| Name      | FAM_1 | FAM_0 | NR_PI_5 | NR_PI_4 | NR_PI_3 | NR_PI_2 | NR_PI_1 | NR_PI_0 |
| <default> | 0     | 1     | 0       | 0       | 0       | 0       | 1       | 0       |

1. Addressable only through a read device information command.

- **FAM[1:0]**: Family identifier, FAM[1:0] = [0:1] stands for ASSPs.
- **NR\_PI[5:0]**: Number of product information bytes.

The <Product Code 1 and 2> represents a unique identifier of the device and version.

**Table 45. Address 1 <01(hex)>: product ID (LSB) - read only<sup>(1)</sup>**

| Bit       | 7       | 6       | 5       | 4       | 3       | 2       | 1       | 0       |
|-----------|---------|---------|---------|---------|---------|---------|---------|---------|
| Name      | PR_ID_7 | PR_ID_6 | PR_ID_5 | PR_ID_4 | PR_ID_3 | PR_ID_2 | PR_ID_1 | PR_ID_0 |
| <default> | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 1       |

1. Addressable only through a read device information command.

**Table 46. Address 2 <02(hex)>: product ID (MSB) - read only<sup>(1)</sup>**

| Bit       | 7        | 6        | 5        | 4        | 3        | 2        | 1       | 0       |
|-----------|----------|----------|----------|----------|----------|----------|---------|---------|
| Name      | PR_ID_15 | PR_ID_14 | PR_ID_13 | PR_ID_12 | PR_ID_11 | PR_ID_10 | PR_ID_9 | PR_ID_8 |
| <default> | 0        | 0        | 1        | 0        | 1        | X        | X       | X       |

1. Addressable only through a read device Information command.

The <SPI-frame-ID> (ROM address 03H) provides information about the register width (1, 2, 3 bytes) and the availability of 'burst mode read' option.

**Table 47. Address 3 <03(hex)>: SPI frame ID - read only<sup>(1)</sup>**

| Bit       | 7  | 6   | 5   | 4   | 3       | 2       | 1       | 0      |
|-----------|----|-----|-----|-----|---------|---------|---------|--------|
| Name      | BR | AR5 | AR4 | AR3 | 32 bits | 24 bits | 16 bits | 8 bits |
| <default> | 0  | 0   | 0   | 0   | 0       | 0       | 1       | 0      |

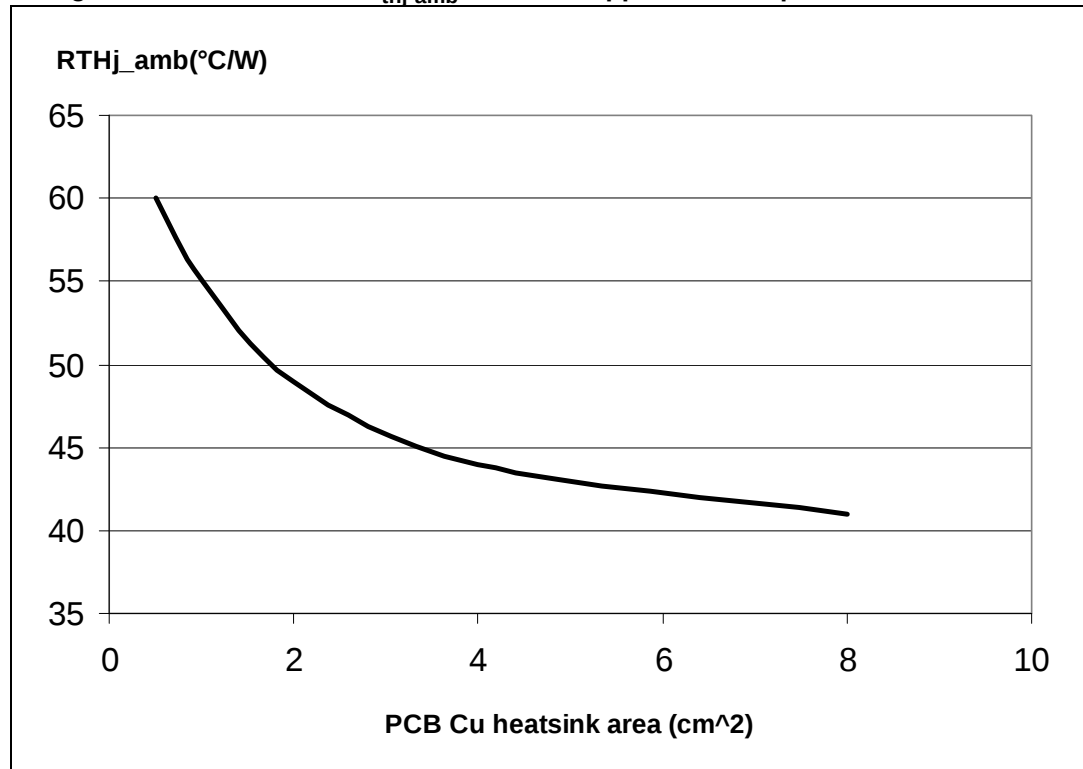
1. Addressable only through a Read Device Information command.

Comments:

- **BR:** Burst mode read. Not supported
- **AR5:** Address width reduction. Not supported
- **AR4:** Address width reduction. Not supported
- **AR3:** Address width reduction. Not supported
- **32 bits:** 32 bits frame width. Not supported
- **24 bits:** 24 bits frame width. Not supported
- **16 bits:** 16 bits frame width, 8 bits command and 8 bits data
- **8 bits:** 8 bits frame width. Not supported

## 5 Packages thermal data

Figure 12. PowerSSO-36  $R_{thj-amb}$  vs. PCB copper area in open free air condition



1. Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (PCB: double layer, thermal vias, FR4 area = 129 mm x 60 mm, PCB thickness = 1.6 mm, Cu thickness = 70  $\mu m$  (front and back side), Copper areas: from minimum pad layout to 8  $cm^2$ ).

## 6 Package and packing information

### 6.1 ECOPACK®

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

## 6.2 PowerSSO-36 package information

Figure 13. PowerSSO-36 package dimensions

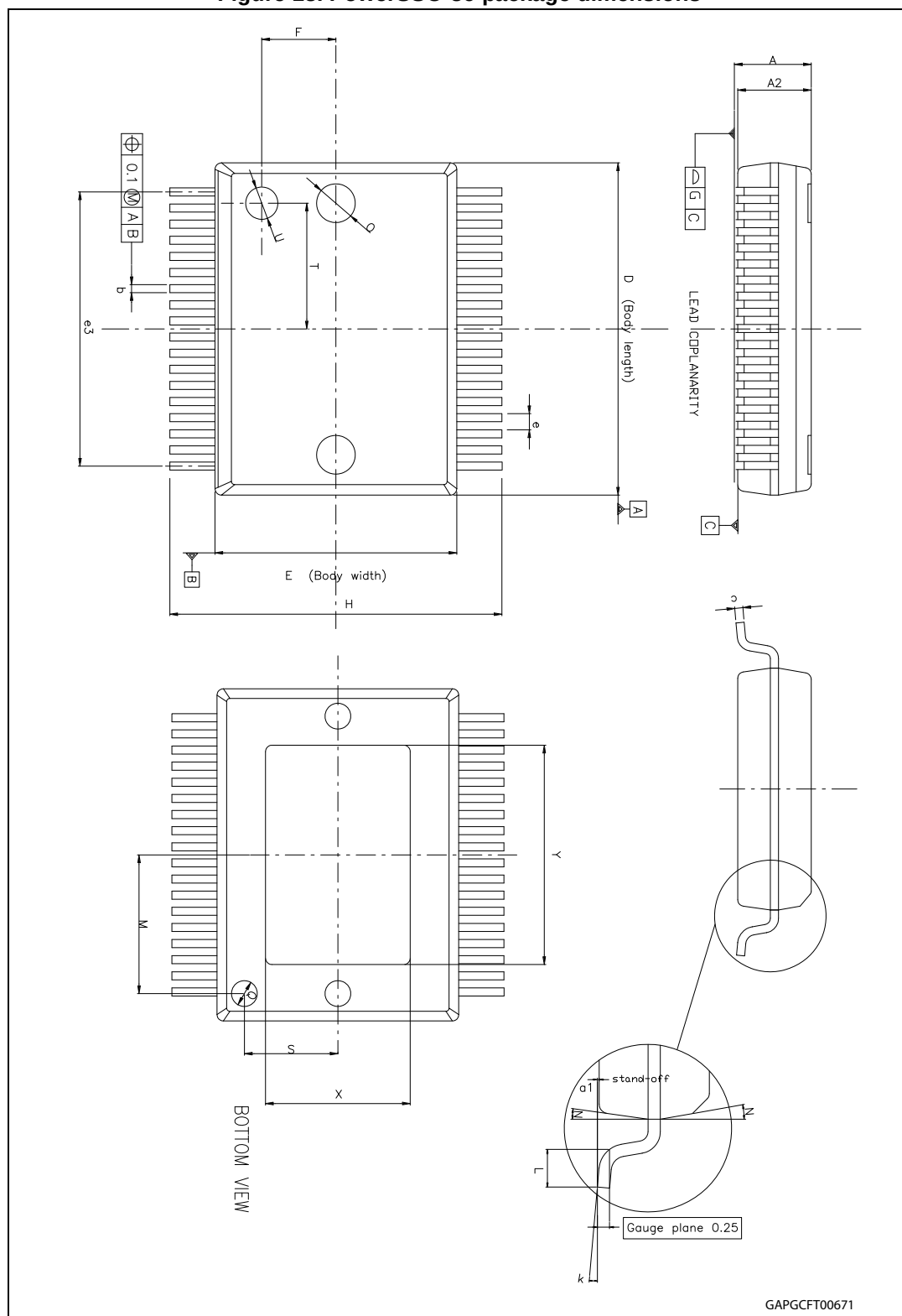


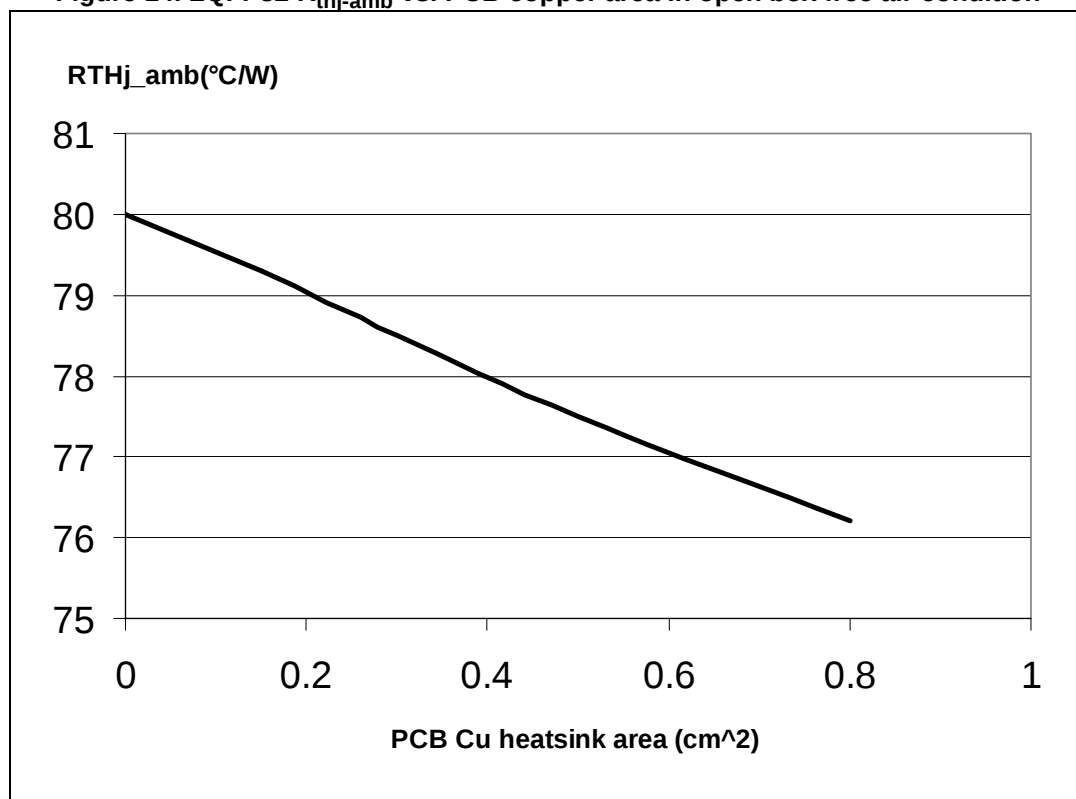
Table 48. PowerSSO-36 mechanical data

| Symbol           | Millimeters |      |       |
|------------------|-------------|------|-------|
|                  | Min.        | Typ. | Max.  |
| A                | 2.15        | -    | 2.45  |
| A2               | 2.15        | -    | 2.35  |
| a1               | 0           | -    | 0.1   |
| b                | 0.18        | -    | 0.36  |
| c                | 0.23        | -    | 0.32  |
| D <sup>(1)</sup> | 10.10       | -    | 10.50 |
| E <sup>(1)</sup> | 7.4         | -    | 7.6   |
| e                | -           | 0.5  | -     |
| e3               | -           | 8.5  | -     |
| F                | -           | 2.3  | -     |
| G                | -           | -    | 0.1   |
| H                | 10.1        | -    | 10.5  |
| h                | -           | -    | 0.4   |
| k                | 0°          | -    | 8°    |
| L                | 0.55        | -    | 0.85  |
| M                | -           | 4.3  | -     |
| N                | -           | -    | 10°   |
| O                | -           | 1.2  | -     |
| Q                | -           | 0.8  | -     |
| S                | -           | 2.9  | -     |
| T                | -           | 3.65 | -     |
| U                | -           | 1    | -     |
| X                | 4.1         | -    | 4.7   |
| Y                | 6.5         | -    | 7.1   |

1. "D" and "E" do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15 mm per side (0.006").

### 6.3 Packages thermal data

Figure 14. LQFP32  $R_{thj-amb}$  vs. PCB copper area in open box free air condition



1. Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (PCB: double layer, thermal vias, FR4 area = 78 mm x 86 mm, PCB thickness = 1.6 mm, Cu thickness = 70  $\mu m$  (front and back side), copper areas: from minimum pad layout to 8  $cm^2$ ).

6.4 LQFP32 package information

Figure 15. LQFP32 package dimensions

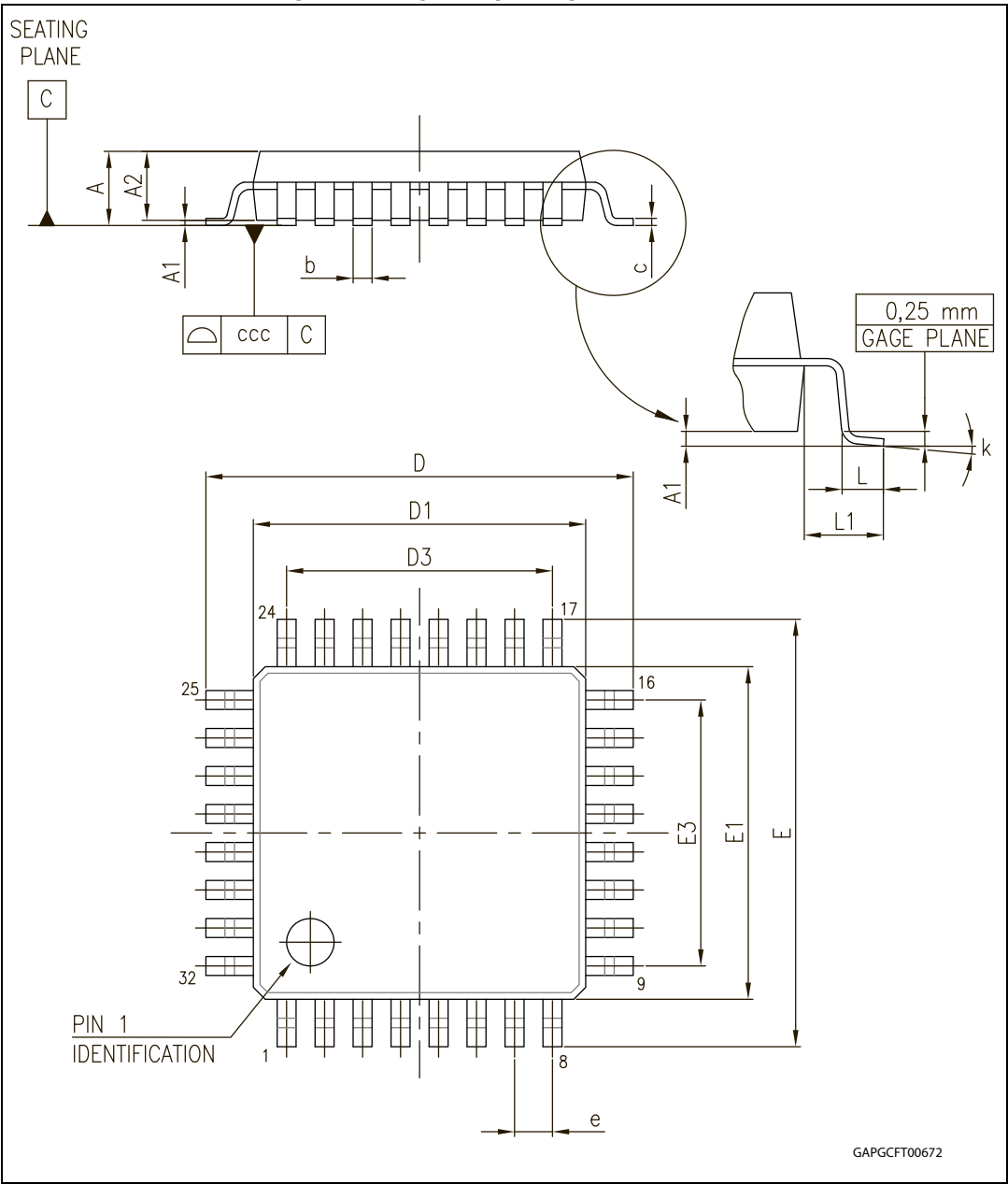


Table 49. LQFP32 mechanical data

| Dim.              | Millimeter |      |      |
|-------------------|------------|------|------|
|                   | Min.       | Typ. | Max. |
| A                 |            |      | 1.60 |
| A1                | 0.05       |      | 0.15 |
| A2 <sup>(1)</sup> | 1.35       | 1.40 | 1.45 |
| b                 | 0.30       | 0.37 | 0.45 |
| c                 | 0.09       |      | 0.20 |
| D                 | 8.80       | 9.00 | 9.20 |
| D1                | 6.80       | 7.00 | 7.20 |
| D3                |            | 5.60 |      |
| E                 | 8.80       | 9.00 | 9.20 |
| E1                | 6.80       | 7.00 | 7.20 |
| E3                |            | 5.60 |      |
| e                 |            | 0.80 |      |
| L                 | 0.45       | 0.60 | 0.75 |
| L1                |            | 1.00 |      |
| K                 | 0°         | 3.5° | 7°   |
| ccc               |            |      | 0.10 |

1. LQFP stands for low profile quad flat package.  
Low profile: Body thickness (A2 = 1.40 mm)

## 6.5 PowerSSO-36 packing information

Figure 16. PowerSSO-36 tube shipment (no suffix)

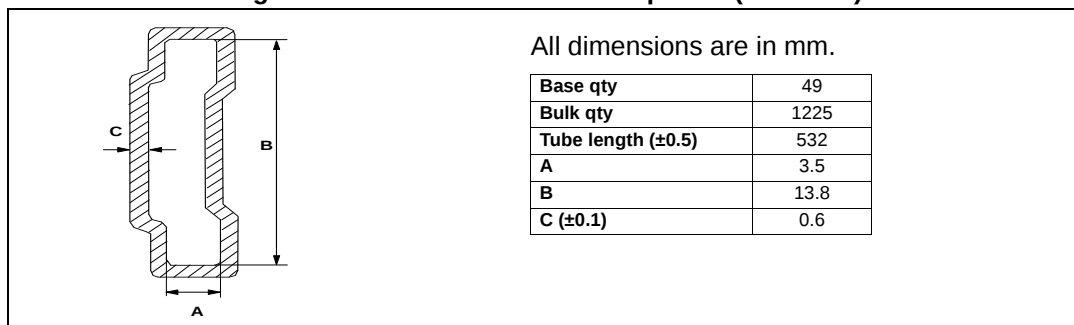
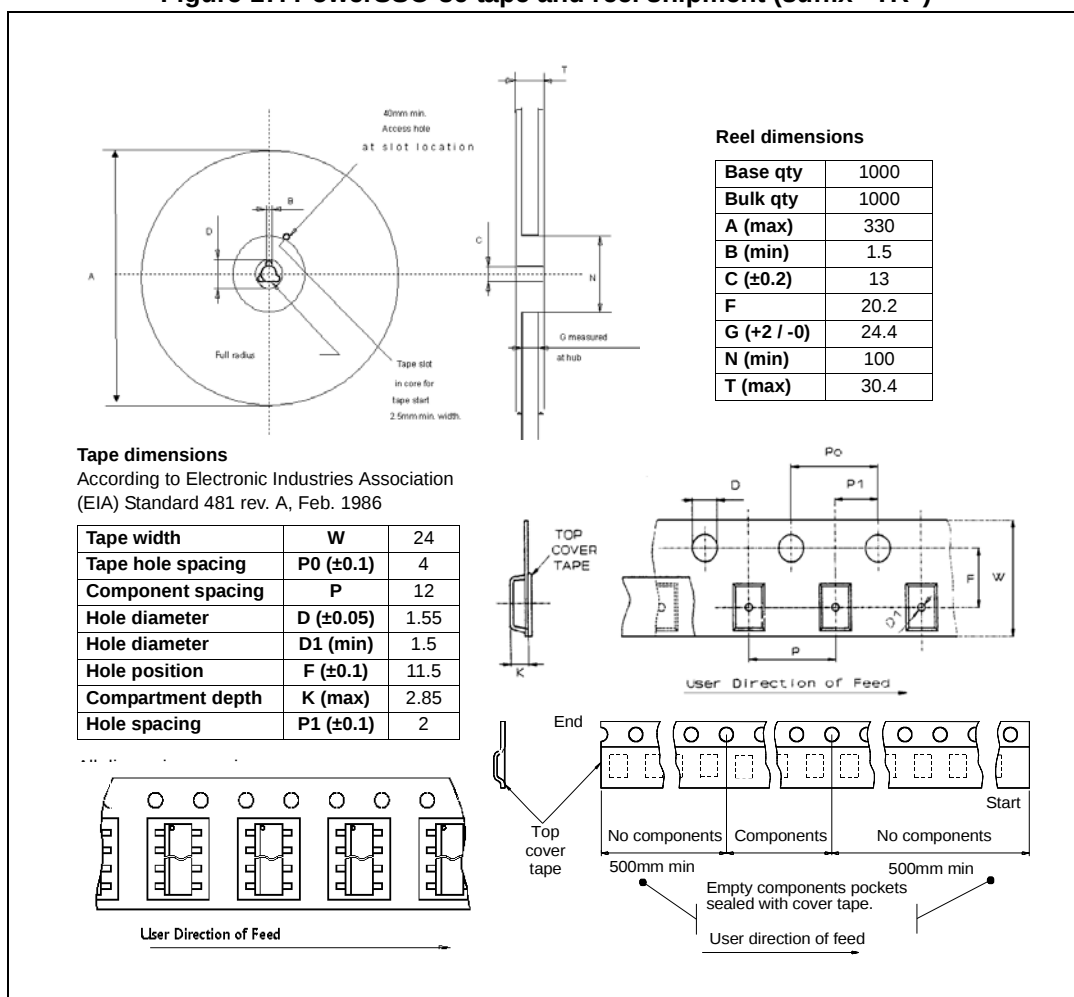
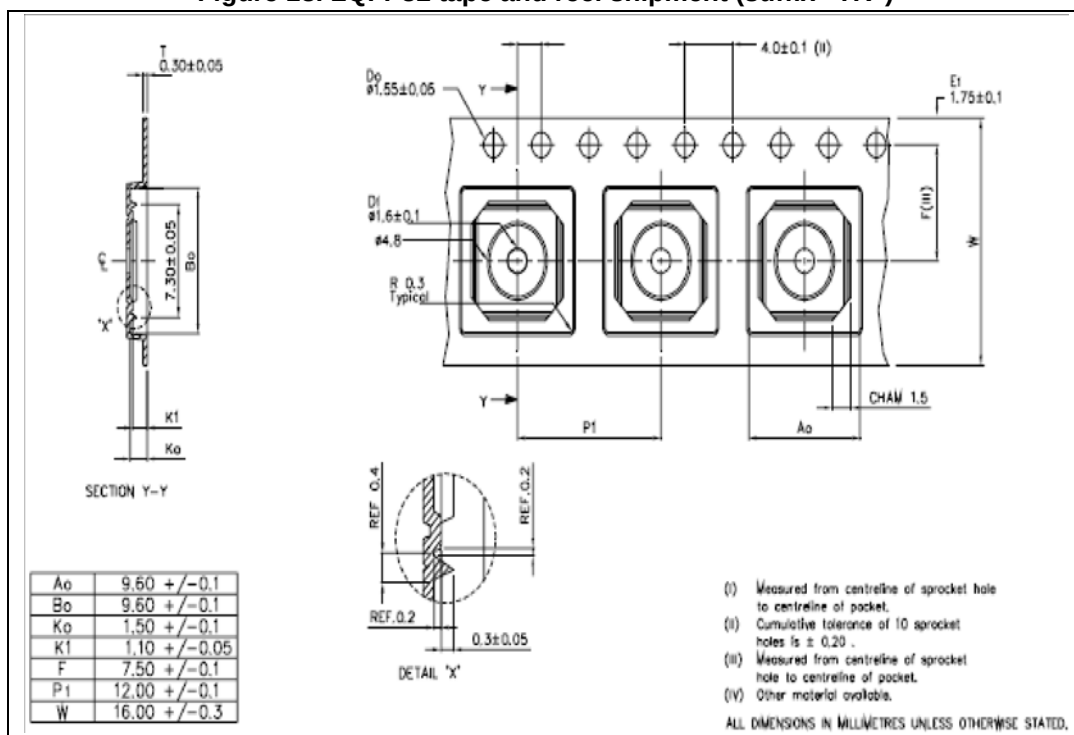


Figure 17. PowerSSO-36 tape and reel shipment (suffix "TR")

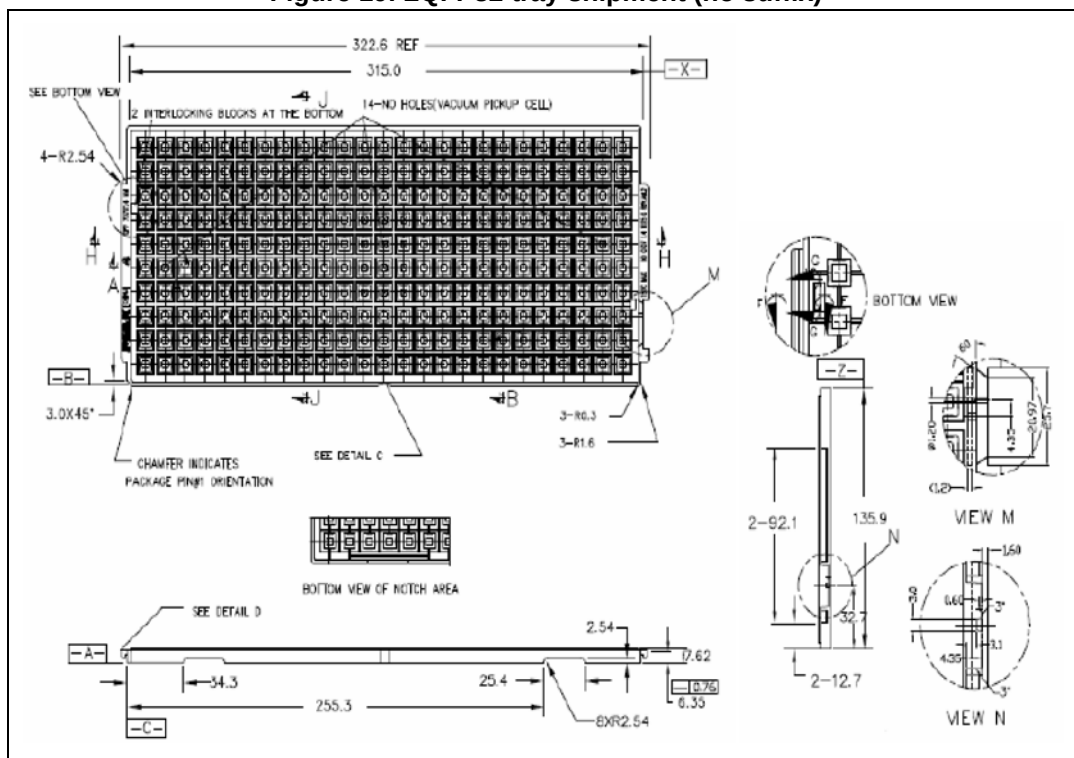


## 6.6 LQFP32 packing information

**Figure 18. LQFP32 tape and reel shipment (suffix “TR”)**



**Figure 19. LQFP32 tray shipment (no suffix)**



## 7 Revision history

Table 50. Document revision history

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 17-Apr-2009 | 1        | Initial release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 19-Aug-2009 | 2        | <p>Updated corporate template from V3 to V3.1</p> <p>Updated <a href="#">Figure 4</a>.</p> <p>Removed items 17.16, 17.18 and 17.20 of the <a href="#">Table 18: Current sense amplifier</a>.</p> <p>Added <a href="#">Table 15: Cross current protection time</a></p> <p><a href="#">Table 18: Current sense amplifier</a>.</p> <ul style="list-style-type: none"> <li>– <math>V_{\text{IOFF}50}</math>, <math>V_{\text{IOFF}20}</math>, <math>V_{\text{IOFF}10}</math>: added min/typ/max value, deleted "<math>T_j = 25\text{ }^{\circ}\text{C}</math>" for test condition</li> <li>– <math>V_{\text{IOFF-T}50}/\Delta T</math>: changed symbol (it was <math>V_{\text{IOFF-T}50}</math>), updated whole row.</li> <li>– <math>V_{\text{IOFF-T}20}/\Delta T</math>: changed symbol (it was <math>V_{\text{IOFF-T}20}</math>), updated whole row.</li> <li>– <math>V_{\text{IOFF-T}10}/\Delta T</math>: changed symbol (it was <math>V_{\text{IOFF-T}10}</math>), updated whole row.</li> <li>– <math>V_{\text{IOFF-}50}</math>, <math>V_{\text{IOFF-}20}</math>, <math>V_{\text{IOFF-}10}</math>: added min/typ/max value</li> <li>– Gain<sub>50</sub>, Gain<sub>20</sub>, Gain<sub>10</sub>: added min/typ/max value</li> <li>– Setting time: deleted row</li> </ul> <p>Added <a href="#">Figure 5: Output timing diagram (passive free wheeling)</a></p> <p>Updated <a href="#">Table 23: Truth table</a>.</p> <p>Updated <a href="#">Section 3.9</a>, <a href="#">Section 3.11</a>, <a href="#">Section 3.12.1</a> and <a href="#">Section 3.12.2</a>.</p> <p><a href="#">Table 30: STK_RESET_Q</a>: changed title (it was "Global status byte")</p> <p>Updated <a href="#">Section 4.4.1</a> and <a href="#">Section 4.6.1</a>.</p> <p>Updated <a href="#">Table 43</a>.</p> |
| 20-Apr-2010 | 3        | Updated the CP value in <a href="#">Table 4: Absolute maximum ratings</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 30-Apr-2012 | 4        | <p><a href="#">Table 9: Supply</a>:</p> <ul style="list-style-type: none"> <li>– <math>V_{\text{VS\_OV}1}</math>: : changed symbol (it was <math>V_{\text{VS\_OVH}1}</math>)</li> <li>– <math>V_{\text{VS\_OV}1\text{H}}</math>: : changed symbol (it was <math>V_{\text{VS\_OVH}1}</math>)</li> <li>– <math>V_{\text{VS\_OV}2}</math>: : changed symbol (it was <math>V_{\text{VS\_OVH}2}</math>)</li> <li>– <math>V_{\text{VS\_OV}2\text{H}}</math>: : changed symbol (it was <math>V_{\text{VS\_OVH}2}</math>)</li> <li>– <math>V_{\text{VS\_UV}}</math>: : changed symbol (it was <math>V_{\text{VS\_UVH}}</math>)</li> </ul> <p>Updated <a href="#">Section 3.6: Overvoltage and undervoltage detection</a> and <a href="#">Section 3.7: Charge pump</a></p> <p><a href="#">Section 4.6.1: Description of the data byte</a>:</p> <ul style="list-style-type: none"> <li>– updated OV_UV_RD bit description</li> </ul> <p><a href="#">Table 48: PowerSSO-36 mechanical data</a>:</p> <ul style="list-style-type: none"> <li>– L: updated values</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 21-Jun-2013 | 5        | Updated <a href="#">Table 17: Thermal sense interface (<math>4.5\text{ V} &lt; V_{\text{CC}} &lt; 5.3\text{ V}</math>)</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 19-Sep-2013 | 6        | Updated disclaimer.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

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