3-Phase Bridge Driver IC

Features

- Compatible to very low ohmic normal level input N-Channel Mosfets
- Separate input for each MOSFET
- PWM frequency up to 30kHz
- Fulfills specification down to 9V supply voltage
- Low EMC sensitivity and emission
- Separate Source connection for each MOSFET
- Adjustable dead time
- Adjustable dI/dt limitation
- Short circuit protection with adjustable current limitation
- Driver undervoltage warning
- Reverse polarity protection
- Disable function
- Input with TTL characteristics
- Error flag
- Thermal overload warning for driver IC
- Shoot through protection
- Shoot through option
- Integrated bootstrap diodes

Product Summary

Turn on current	$I_{Oxx(on)}$	0.9	A
Turn off current	$I_{Oxx(off)}$	0.85	A
Supply voltage range	V_{Vs}	8...20	V
Gate Voltage	V_{GS}	10	V
Temperature range	T_J	-40...+150	°C

P-DSO36-12

Ordering Code

Q67007-A9406

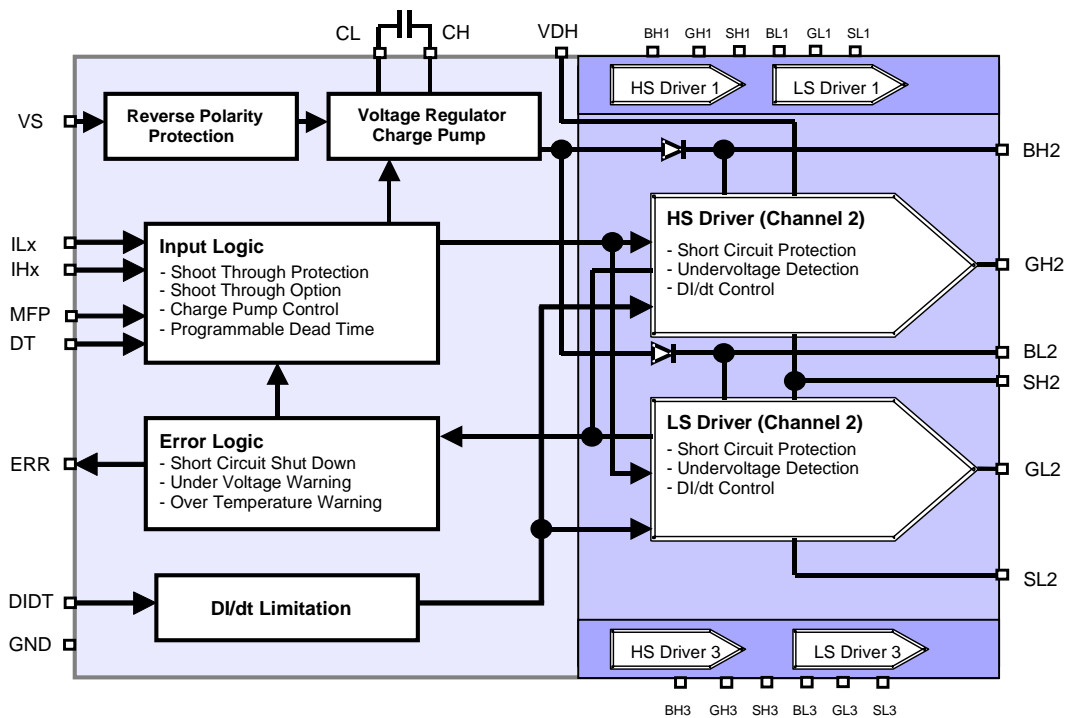## Application

- Dedicated for 3-phase high current motor bridges in PWM control mode. This device fulfills requirements in 12V automotive applications

General Description

3-phase bridge driver IC for MOSFET power stages with multiple protection functions.

Block Diagram
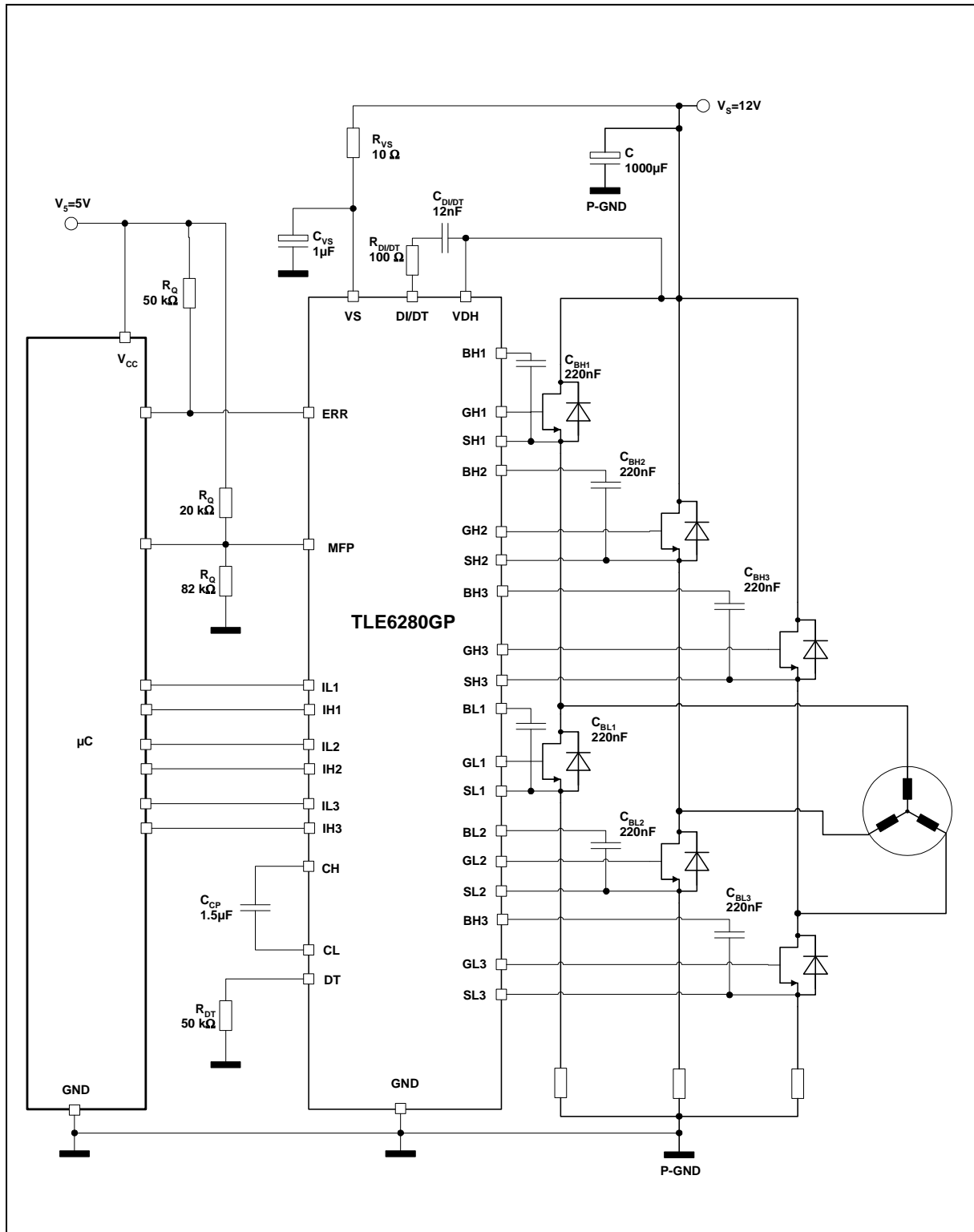
Application Block Diagram

Fig. 1 : Application circuit

Remark: This application diagram is one possible implementation of this driver IC. There is, e.g., the possibility to link all three BLx pins and use only one capacitor.

Pin	Symbol		Function
1;18;19:36	GND		Logic Ground
8	VS		Voltage supply
20	CL		Charge pump - capacitor
21	CH		
9	IH1		Control inputs for high-side switches 1 to 3
11	IH2		(low active)
13	IH3		
10	IL1		Control inputs for low-side switches 1 to 3
12	IL2		(high active)
14	IL3		
15	MFP		Multi function pin:
			a) Disable the complete device by $V_{MFP} < 1V$
			b) Program pin for output voltage level under short circuit condition ($V_{Gxx} - V_{Sxx} = 2 x V_{MFP}$)
			c) Enable shoot through option by $V_{MFP} > 4.5V$
17	DT		Program pin for dead time
35	DIDT		Program pin dI/dt limitation
34	VDH		Sense pin for drain voltage of the high-side Mosfets
16	ERR		Error flag for driver supply under voltage, over-temperature and short circuit (open drain output)
2	BH1		Bootstrap supply high-side switches 1 to 3
28	BH2		
22	BH3		
5	BL1		Backup capacitor connection low switches 1 to 3
31	BL2		
25	BL3		
3	GH1		Output to gate high-side switches 1 to 3
29	GH2		
23	GH3		
6	GL1		Output to gate low-side switches 1 to 3
32	GL2		
26	GL3		
4	SH1		Connection to source high-side switches 1 to 3
30	SH2		
24	SH3		
7	SL1		Connection to source low-side switches 1 to 3
33	SL2		
27	SL3		

Functional description

General

In the automotive sector there are more and more applications requiring high performance motor drives, such as electro-hydraulic or electric power steering. In these applications 3-phase motors, synchronous and asynchronous, are used, combining high output perform-ance, low space requirements and high reliability.
The TLE6280GP is a driver IC dedicated to control the 6 to 12 external Mosfets forming the converter for high current 3 phase motor drives in the automotive sector. It incorporates fea-tures like short circuit detection, diagnosis and high output performance and combines it with typical automotive specific requirements like full functionality even at low battery voltages. Its 3 high-side and 3 low-side output stages are powerful enough to drive Mosfets with 250nC gate charge with approx. 300ns fall and rise times.
Typical applications are cooling fan, water pump, electro-hydraulic and electric power steer-ing. The TLE6280GP is designed for a 12V power net.
Use in 24V application is possible as well. Limiting factor could be the power dissipation.
This datasheet describes all functionality of this device. Additional application tips are given in an application note available on the Internet.

Output stages

The 3 low-side and 3 high-side powerful push-pull output stages are all floating blocks, each with its own Source pin. This allows the direct connection of the output stage to the Source of each single Mosfet, allowing a perfect control of each Gate-Source voltage even when 200A are driven in the bridge with rise and fall times clearly below 1µs.
All 6 output stages have the same output power and, due to the use of the bootstrap princi-ple, they can be switched all up to 30kHz.
Its output stages are powerful enough to drive Mosfets with 250nC gate charge with approx. 300ns fall and rise times, or even to run 12 such Mosfets with fall and rise times of approx. 600ns.
Maximum allowed power dissipation and the need to refresh the bootstrap capacitors with a minimum refresh pulse limit the divice use for higher frequencies.
Fig. 2 shows the supply structure of TLE6280GP. The bootstrap capacitors are charged by the charge pump capacitor C_{CP} via the CH pin and diodes.
The exact value for this minimum refresh pulse is given by the RC time constant formed by the impedance between the CH pin and Bxx pin, and the capacitor formed by the external Mosfet ($C_{Mosfet}=Q_{Gate-total} / V_{GS}$). The size of the bootstrap capacitor has to be adapted to the external Mosfet that the driver IC has to drive. Usually the bootstrap capacitor is about 10-20 times bigger than C_{Mosfet}. External components, such as R-C networks, at the Vs Pin have to be considered, too.

Operation at Vs<12V – integrated charge pump

The TLE6280GP provides a feature tailored to the requirements of 12V automotive applica-tions. Often the operation of an application has to be assured even at 9V-supply voltage or lower. Normally bridge driver ICs provide in such conditions clearly less than 9V to the Gate of the external Mosfet, increasing its RDSon and associated the power dissipation.
The supply structure of the device is shown in fig.2. The TLE 6280GP has a built-in voltage regulator with charge pump control to generate an internal supply voltage of 13V within a supply voltage range of 8-40V. Operation below 8V is possible as well and will result in a re-duced Gate voltage. The charge pump works with an external capacitor C_{CP} connected be-tween the CL and CH pins. It provides more than 13V at the CH pin and guarantees high supply voltage for the bootstrap capacitors C_{Bx}.
The Input Low-side pins ILx (see Fig. 3) trigger the charge pump. As soon as the first exter-nal low-side Mosfet is switched on and the corresponding bootstrap capacitor is connected to GND, the C_{CP} is pushed to high and provides about 13V at the CH pin. C_{CP} can now di-
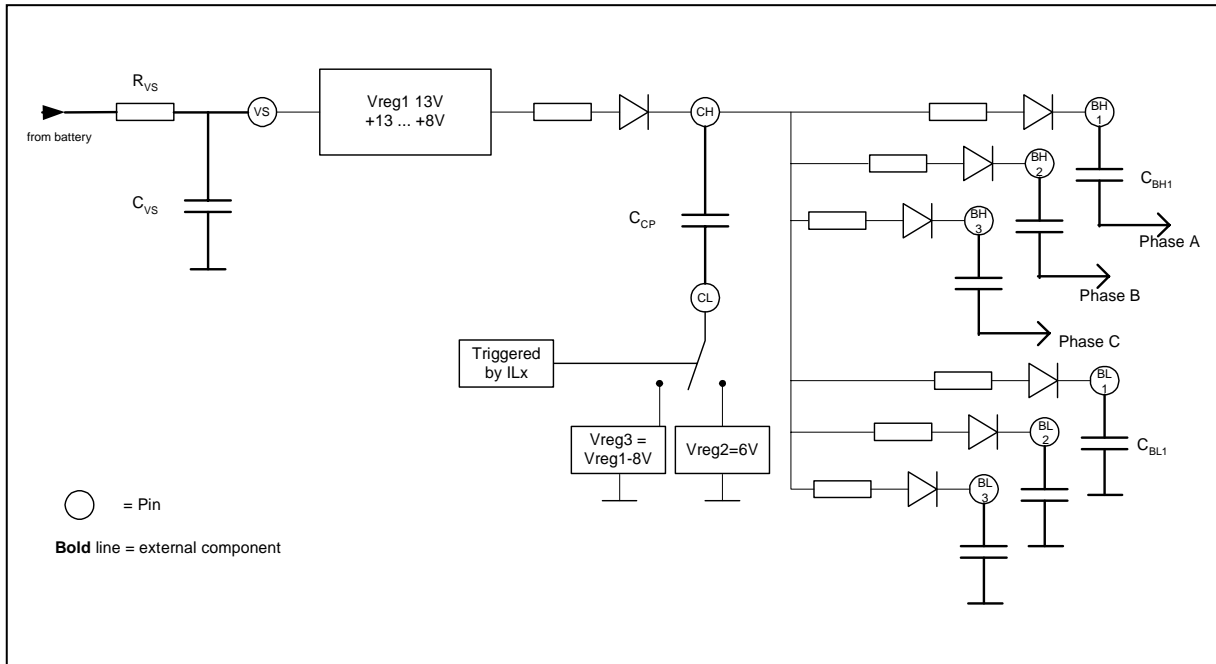
Fig. 2: Supply structure with external components (compare to Fig. 1)

rectly feed the low-side output stages and recharge the bootstrap capacitors connected to GND.

As soon as the first of the 3 external low-side Mosfets is switched off, the C_{CP} will be pulled down to be re-charged.

This synchronous operation with the output stages has the benefit that the electromagnetic emissions generated by the charge pump can be filtered by the same filter necessary to filter the EME of the converter itself. At the same time it is assured that the high voltage at the CH pin is available just in time to charge the high-side bootstrap.
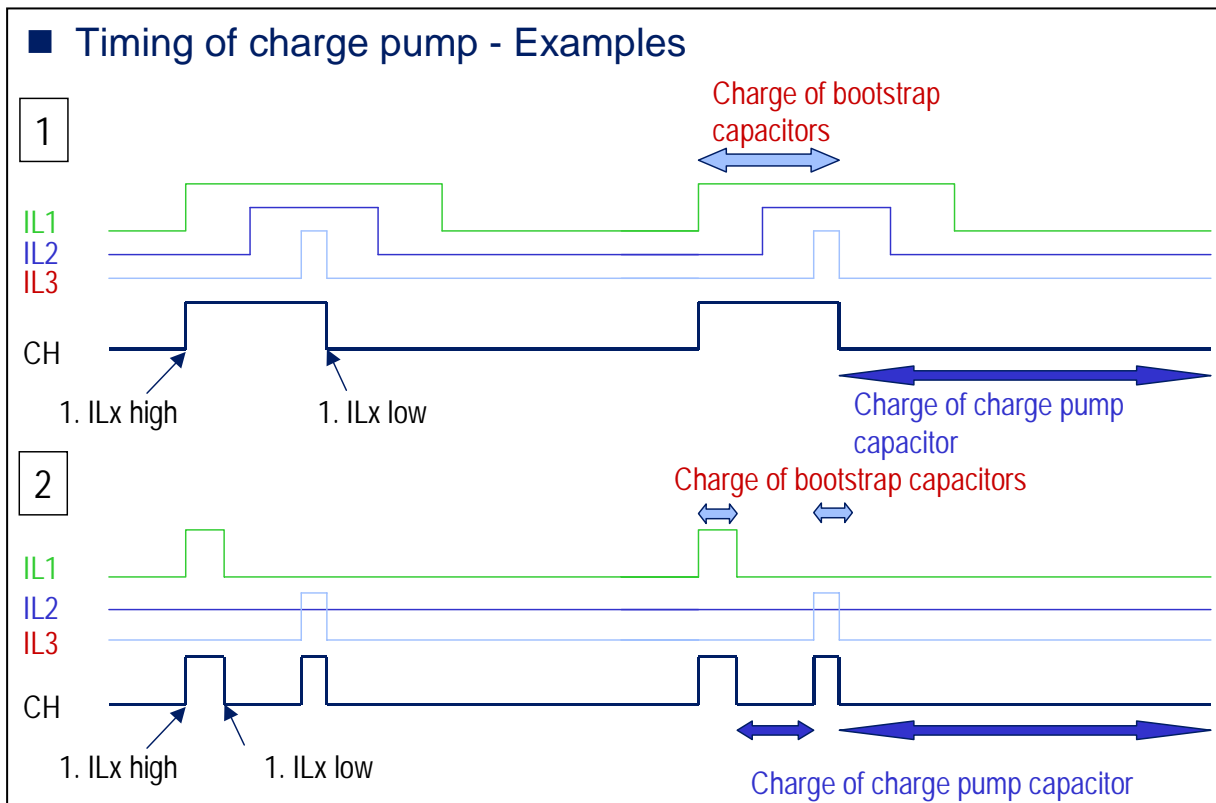

Fig. 3: Trigger timing of charge pump caused by changing input signals

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The size of the C_{Bxx} and C_{CP} capacitors depends upon the gate charge of the Mosfet.
(See "output stages"). C_{CP} is usually 6 times larger then C_{Bxx}.

Dead Time and Shoot through option.

In bridge applications it has to be assured that the external high-side and low-side Mosfets
are not "on" at the same time, such that the battery voltage is directly connected to GND.
This is usually assured by the integration of delays in a driver IC, generating a so-called
dead time between switching off the external Mosfet and switching on the other Mosfet of the
same half-bridge.
The dead times generated in the TLE6280GP are adjustable. The dead time generated by
the TLE6280GP can be varied from 100ns to 4µs by connecting an external resistor from the
DT pin to GND. The dead time has to be long enough to avoid a short between battery and
GND, while the dead time should be as short as possible to reduce extra power dissipation
in the external Mosfets.
In addition to this adjustable delay, the TLE6280GP provides a locking mechanism, prevent-
ing both external Mosfets of one half-bridge from being switched on at the same time. This
functionality is called shoot through protection.
If the command to switch on both high and low-side switches in the same half-bridge is given
at the input pins, the command will be ignored. (See dead time diagrams, fig. 6-8)
This shoot through protection can be deactivated by setting the MFP-pin to 5V.

Short circuit protection / current limitation

The TLE6280GP provides a short circuit protection for the external Mosfets, by monitoring
the Drain-Source voltage of the external Mosfets. As soon as this voltage is higher than the
short circuit detection limit, the Gate-Source voltage of this Mosfet will be limited to twice the
voltage at the MFP-Pin, providing a current limitation.
The short circuit detection level is dependent upon the voltage of the MFP pin as well (see
diagrams).
After a delay of about 11µs all external Mosfets will be switched off until the driver is reset by
the MFP pin. The error flag is set.
The Drain-Source voltage monitoring of the short circuit detection for certain external Mos-
fets is active as soon as the corresponding input is set to "on" and the dead time is expired.
This feature provides a 2-step switch-on behavior for each regular switching-on of a Mosfet.

Description of MFP pin (Multi functional pin)

The MFP pin has multiple tasks:
1) Reset the device.
2) Adjust the short circuit detection level of the external Mosfet and define the gate voltage
   limitation for current limitation in case of short circuit
3) Deactivate the shoot-through protection

Fig 4. shows the internal structure of the MFP pin.

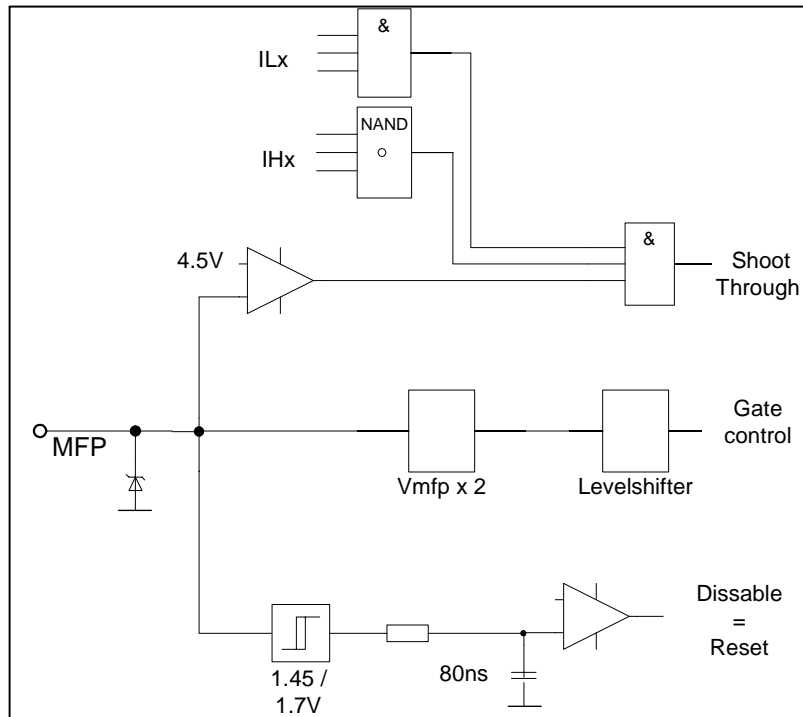| Condition of MFP pin	Function
0 – 1.1V	Disable the driver. All external Mosfets will be actively switched off
2.5 – 4.0 V	Adjustable short circuit detection level combined with adjustable gate voltage limitation for current limitation. Shoot-through protection is active.
> 4.5V	Shoot-through protection deactivated.

Fig. 4: Block diagram of internal structure of MFP pin

Shoot through protection / option

As already mentioned, the device has a built-in shoot-through protection, to avoid a simultaneous activation of high- and low-side switch in one half-bridge.
In case there is a short circuit in the bridge, the driver will switch off all external Mosfets. If there is still current flowing in the motor, it is possible for the user to override this shoot through protection.
By setting the ILx to "high", the IHx to "low" and MFP to a level above 4.5V, all external Mosfets will be turned on simultaneously to blow a well-dimensioned fuse. The application will be finally disconnected in this way from battery, and thus guarantee that the motor does not apply any uncontrolled torque.

Undervoltage warning:

If the voltage of a bootstrap capacitor C_{Bxx} reaches the undervoltage warning level the error flag is set and will remain set until the voltage of the bootstrap capacitor has recovered.
The error signal can be seen as awarning that an undervoltage shut-down could occur soon, and the user can take appropriate measures to avoid this. Such measures could be the change of the duty cycle to a range of 10-90% or the ramp down of the motor.

Undervoltage shut down:

The TLE6280GP has an integrated undervoltage shut-down, to guarantee that the behavior of the device is predictable in all voltage ranges.
If the voltage of a bootstrap capacitor C_{Bxx} reaches the undervoltage shut-down level, the Gate-Source voltage of the affected external Mosfet will be actively pulled to low. In this situation the short circuit detection of this output stage is deactivated to avoid a complete shut down of the driver. This allows continued operation of the motor in case of undervoltage shut-down for a short period of time.

As soon as the bootstrap voltage recovers, the output stage condition will be aligned to the input patterns by the next changing input signal at the corresponding input pin.

Diagnosis

The ERR pin is an open collector output and has to be pulled up with external pull-up resistors to 5V. In normal conditions the ERR signal is high. In case of an error the ERR pin is pulled down. There are 3 different causes for an error signal:
1) Short circuit of an external Mosfet – all external Mosfets are switched off. The driver has to be reset to start again.
2) Undervoltage warning: at least one of the external capacitors connected to Bxx pins has a voltage below the warning level.
3) Over-temperature warning: The device works normally but is out of the maximum ratings. Immediate actions have to be taken to reduce the thermal load. The error flag will be removed when the driver reached temperatures below the over temperature warning level.
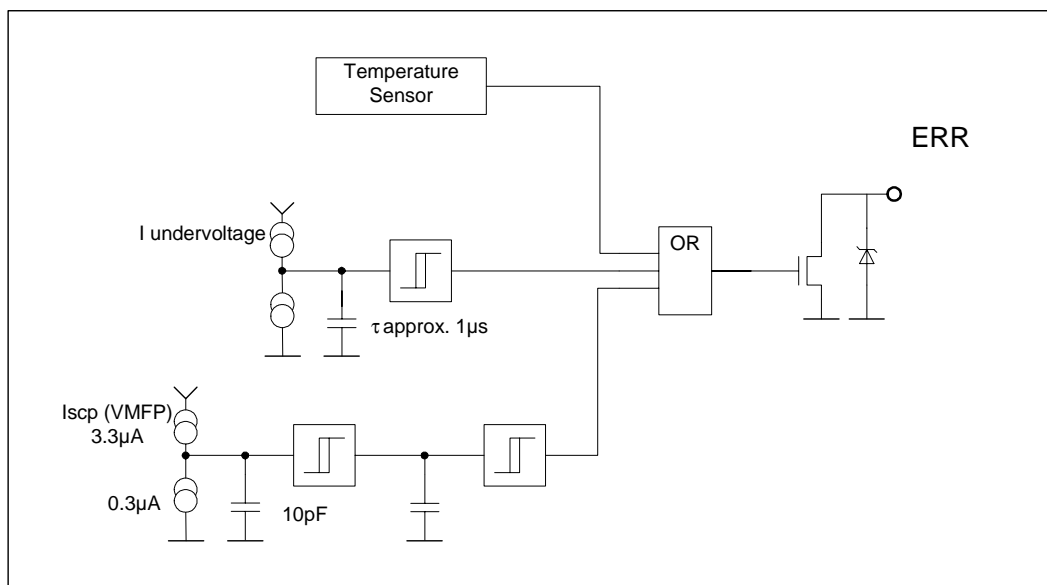

Fig. 5: Block diagram of ERR functionality

dI/dt control

In all high current PWM applications, transient overvoltages and electro-magnetic emmisions are critical items. The dI/dt regulation of the TLE6280GP helps to reduce transient overvoltage as well as electro-magnetic emissions.
Each real bridge configuration has stray inductance in each half-bridge. When the Mosfets in the bridge are switching and load current is flowing, the stray inductance together with the dI/dt in the halfbridge causies transient overvoltages. These transient overvoltages can be feed to the DIDT pin of the gate driver by a high pass filter. Voltages exceeding 2 to 5V or –2 to –5V at this pin will strongly reduce the gate current of the actually switched Mosfet, resulting in an increased switching time in the Miller plateau of the Mosfet, and reducing the switching speed exactly and only in the critical area of the switching process. Through this regulation over-voltages are reduced and a smoother dI/dt in the bridge is obtained.
For more detailed information please refer to application note.

Estimation of power dissipation within the driver IC

The power dissipation within the driver IC is strongly dependent upon the use of the driver and the external components. Nevertheless, a rough estimation of the worst case power dissipation is possible.
Worst case calculation is:

$$P_D = (Q_{gate}*n*const* f_{PWM} + I_{VS(open)}) * V_{Vs} - P_{RGate}$$

With:

P_D	= Power dissipation in the driver IC
f_{PWM}	= Switching frequency
Q_{gate}	= Total gate charge of used MOSFET at 10V V_{GS}
n	= number of switched Mosfets
const	= constant considering some leakage current in the driver and the power dissipation caused by the charge pump (nominally = 2)
$I_{VS(open)}$	= Current consumption of driver without connected Mosfets during switching
V_{VS}	= Voltage at Vs
P_{RGate}	= Power dissipation in the external gate resistors

This value can be reduced dramatically by the use of external gate resistors.

Recommended start up procedure

To assure the driver to be active and functional, a special initialization procedure is required whenever the gate drive is enabled (V_{MFP} is changed from LO to HI). Every time the driver is enabled, after 10µs or later, positive-going transition signals at all ILx pins are required in order to ensure proper start-up of the output driver. This procedure assures a proper wake up the device and allowes to fill the bootstrap capacitors. Not filling the bootstrap capacitors might lead to low Gate-Source voltages mainly in highside and can cause a short circuit detection when the highside switches are activated. Not changing the ILx input signal after enabling the device may cause the lowside outputs to stay in off conditions.

Maximum ratings

Parameter and Conditions at T_j = -40 … +150 °C, unless otherwise specified	Symbol	Values	Unit
Supply voltage [1]	V_S	-4 ... 45V	V
Operating temperature range	T_j	-40 ...+150	°C
Storage temperature range	T_{stg}	-55 ...+150	
Max. voltage range at Ixx, MFP, DT; ERR		-0.3 ...+7	V
Max. voltage range at SLx [2]	V_{SLx}	-7 ...+7	V
Max. voltage range at SHx [3]	V_{SHx}	-7 ...+45	V
Max. voltage range at GLx [2]	V_{GLx}	-7 ...+18	V
Max. voltage range at GHx [3]	V_{GHx}	-7 ...+55	V
Max. voltage range at BHx [3]	V_{BHx}	-0.3 ...+55	V
Max. voltage range at VDH [4]	V_{VDH}	-4 ...+55	V
Max. voltage difference Bxx - Sxx	V_{Bxx}-V_{Sxx}	-0.3 ...+15	V
Max. voltage difference Gxx - Sxx	V_{Gxx}-V_{Sxx}	-0.3...+11	V
Max. voltage range at CL	V_{CL}	-0.3 ...+10	V
Max. voltage range at CH	V_{CH}	-0.3 ...+18	V
Max. voltage range at DIDT	V_{DIDT}	-7 ...+7	V
Power dissipation (DC) @ T_C=125°C	P_{tot}	1.2	W
ESD voltage (Human Body Model) JESD22-A114-B @ all pins @ all pins excluding Gxx	V_{ESD}	 1 2	kV
DIN humidity category, DIN 40 040		E	
IEC climatic category, DIN IEC 68-1		40/150/56	
Jedec Level		3	
Thermal resistance junction-case	R_{thJC}	≤5	K/W

[1] With external resistor (≥10 Ω) and capacitor – see fig.1
[2] The min value -7V is reduced to –(Vs - 0.5V) if Vs<7.5V
[3] The min value -7V is reduced to –(V_{BHx}-V_{SHx}-1V) if bootstrap voltages <8V
[4] The min value -4V is increased to –(V_{BHx} - V_{SHx}) if bootstrap voltages <4V

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Functional range

Parameter and Conditions at T_j = -40 … +150 °C, unless otherwise specified	Symbol	Values	Unit
Supply voltage[567]	V_S	8 ... 20	V
Operating temperature range	T_j	-40 ...+150	°C
Duty Cycle @ 20kHz[678] Vs>8V	dc	0...95	%
Max. voltage range at Ixx, ERR	V_{Ixx}; V_{ERR}	-0.3 ...+7	V
Max. voltage range at MFP, DT[9]	V_{MFP}	-0.3 ...+5	V
Max. voltage range at SLx[2]	V_{SLx}	-7 ...+7	V
Max. voltage range at SHx[3]	V_{SHx}	-7 ...+45	V
Max. voltage range at GLx[2]	V_{GLx}	-7 ...+18	V
Max. voltage range at GHx[3]	V_{GHx}	-7 ...+55	V
Max. voltage range at BHx[3]	V_{BHx}	-0.3 ...+55	V
Max. voltage range at VDH[4]	V_{VDH}	-4 ...+55	V
Max. voltage difference Bxx - Sxx	V_{Bxx}-V_{Sxx}	-0.3 ...+15	V
Max. voltage difference Gxx - Sxx	V_{Gxx}-V_{Sxx}	-0.3...+11	V
Max. voltage range at DIDT	V_{DIDT}	-7 ...+7	V
PWM frequency[10]	F_{PWM}	2...50	kHz
Min. dead time resistor	R_{DT}	0	kΩ

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[5] operation above 20V limited by max allowed power dissipation and max. ratings

[6] If all 3 half-bridges are switched with f_{PWM} and a duty cycle <10%, undervoltage shut down can occur below Vs=9.5V

[7] Total gate charge of the attached Mosfet < 250nC

[8] If the bootstrap capacitor is charged to V_{BHx}-V_{SHx}=12V, the maximum duty cycle is 100% for 500 µs

[9] V_{MFP} up to 7V allowed up to 500ms

[10] Limited only by the minimum bootstrap voltage (undervoltage logout of output stage) and the max allowed power dissipation

Electrical Characteristics

Parameter and Conditions	Symbol	Values			Unit
at T_j = –40 … +150 °C, unless otherwise specified and supply voltage range V_S = 8 ... 20V; f_{PWM} = 20kHz		min	typ	max	

Static Characteristics

Parameter and Conditions	Symbol	min	typ	max	Unit
Low level output voltage (V_{Gxx}-V_{Sxx}) @ I=10mA	ΔV_{LL}	--	50	100	mV
High level output voltage (V_{Gxx}-V_{Sxx}) [7] @ I=-10mA	ΔV_{HL}	8	10	11	V
Supply current at VS (device disabled) @ V_{bat}=V_S=14V R_{DT}=400kΩ V_{MFP}=0V	$I_{VS(dis)}$	--	--	12	mA
Supply current at VS @ 20kHz V_{MFP}≤4V (Outputs open)	$I_{VS(open)}$	--	19	28	mA
Low level input voltage	$V_{IN(LL)}$	--	--	1.0	V
High level input voltage	$V_{IN(HL)}$	2.0	--	--	V
Input hysteresis	ΔV_{IN}		200		mV

Dynamic characteristics

Parameter and Conditions	Symbol	min	typ	max	Unit
Turn on current @ V_{Gxx} -V_{Sxx} = 0V; T_j=25°C	$I_{Gxx(on)}$	--	0.93	--	A
@ V_{Gxx} -V_{Sxx} = 4V; T_j=125°C		--	0.95	--	
Turn off current @ V_{Gxx} -V_{Sxx} = 10V; T_j=25°C	$I_{Oxx(off)}$	--	0.85	--	A
@ V_{Gxx} -V_{Sxx} = 4V; T_j=125°C		--	0.55	--	
Dead time (adjustable) @ R_{DT} = 10 kΩ	t_{DT}	0.16	0.25	0.35	µs
@ R_{DT} = 50 kΩ		--	1.2	--	
@ R_{DT} = 200 kΩ		--	3.9	--	
@ R_{DT} = 400 kΩ		--	4.1	--	
@ R_{DT} > 1 MΩ		--	2.2	--	
Dead time @ R_{DT} = 0 kΩ	t_{DT}				ns
@ T_J = -40°C		20	55	125	
@ T_J = +25°C		25	70	130	
@ T_J = +150°C		45	110	200	
Rise time @ C_{Load}=22nF; R_{Load}=1Ω; 20…80% V_{CLoad}	t_{rise}				ns
@ T_J = -40°C		--	310	700	
@ T_J = +25°C		--	250	600	
@ T_J = +150°C		--	170	600	
Fall time @ C_{Load}=22nF; R_{Load}=1Ω; 20…80% V_{CLoad} @ T_J = -40°C	t_{fall}				ns
		--	220	400	
@ T_J = +25°C		--	250	350	
@ T_J = +150°C		--	200	350	

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Electrical Characteristics (continued)

Parameter and Conditions	Symbol	Values			Unit
at T_j = –40 … +150 °C, unless otherwise specified and supply voltage range V_S = 8 ... 20V; f_{PWM} = 20kHz		min	typ	max	

Dynamic characteristics (continued)

Disable propagation time	$t_{P(DIS)}$	--	350	700	ns
Wake up time after enabling the device	t_{WU}			10	µs
Input propagation time (low on)	$t_{P(ILN)}$	--	220	500	ns
Input propagation time (low off)	$t_{P(ILF)}$	--	180	500	ns
Input propagation time (high on)	$t_{P(IHN)}$	--	250	500	ns
Input propagation time (high off)	$t_{P(IHF)}$	--	185	500	ns
Input propagation time difference (all channels turn on)	$t_{PD(an)}$	20	55	70	ns
Input propagation time difference (all channels turn off)	$t_{PD(af)}$	--	11	50	ns
Input propagation time difference (one channel; high off – low on)	$t_{PD(1hfln)}$	--	60	150	ns
Input propagation time difference (one channel; low off – high on)	$t_{PD(1lfhn)}$	--	80	150	ns
Input propagation time difference (all channels; high off – low on)	$t_{PD(ahfln)}$	--	60	150	ns
Input propagation time difference (all channels; low off – high on)	$t_{PD(alfhn)}$	--	80	150	ns
DC-Resistance between CH and Bxx pin I_{CH-Bxx} = 50mA; V_{VS} = V_{Bxx} = GND = 0V @ T_J = -40°C @ T_J = +25°C @ T_J = +150°C	R_{CH-Bxx}	--	3.3 4.2 6.0	6.3 7.3 8.3	Ω
Boostrap diode forward voltage I_{CH-Bxx} = 50mA @ T_J = -40°C @ T_J = +25°C @ T_J = +150°C	V_{BSD}	--	0.84 0.73 0.52	1.2 1.0 0.76	V

Electrical Characteristics (continued)

Parameter and Conditions	Symbol	Values			Unit
at T_j = –40 … +150 °C, unless otherwise specified and supply voltage range V_S = 8 ... 20V; f_{PWM} = 20kHz; V_{Bxx}>7.5V		min	typ	max	

Diagnosis and Protection Functions

Undervoltage warning at ERR	V_{Bxx}-V_{Sxx}				V
@ T_J = -40°C		8	9.4	10	
@ T_J = +25°C		8	9.3	10	
@ T_J = +150°C		8	9.0	10	
Undervoltage shut down of output stage	V_{Bxx}-V_{Sxx}				V
@ T_J = -40°C		5.5	7.2	7.5	
@ T_J = +25°C		5.0	6.6	7.2	
@ T_J = +150°C		4.0	5.6	7.2	
Over-temperature warning[11]	$T_{J(OV)}$	150	170	190	°C
Hysteresis for over-temperature warning	$\Delta T_{J(OV)}$		20		°C
Short circuit protection shut down time delay	$t_{SCP(off)}$	7	11	15	µs
Short circuit criteria (V_{DS} of Mosfets) @ V_{MFP}=3V[12]	$V_{DS(SCP)}$				V
@ T_J = -40°C		1.4	1.85	--	
@ T_J = +25°C		--	1.90	--	
@ T_J = +150°C		--	1.95	2.3	
Factor between V_{MFP} and max. V_{GXX} @ 2V < V_{MFP} < 4V	V_{GxxMax}/V_{MFP}	1.67	2	2.27	
Disable input level	$V_{MFP(DIS)}$	--	--	1.1	V
Enable input level [13]	$V_{MFP(EN)}$	2.5	--	--	V
Disable input hysteresis	$\Delta V_{MFP(DIS)}$	--	500	--	mV
Error level @ 1.6mA I_{ERR}	V_{ERR}	--	--	1.0	V

Shoot through option

Shoot through protection activated	V_{MFP}			4	V
Shoot through option activated	V_{MFP}	4.5	--	--	V

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[11] specified by design
[12] Periodic short circuit condition will be detected within several cycles, if the duty cycle is more than 10%
[13] If the device is enabled, the slope of $dU_{(VMFP)}$/dt has to be higher than 3.5V/50µs

Electrical Characteristics (continued)

Parameter and Conditions	Symbol	Values			Unit
at T_j = –40 … +150 °C, unless otherwise specified and supply voltage range V_S = 8 ... 20V; f_{PWM} = 20kHz; V_{Bxx}>7.5V		min	typ	max	

dI /dt limitation

Non reaction level for dI/dt limitation (100% gate driver capability) @ V_{DIDT}>0V	V_{DIDT}	2	--	--	V
Non reaction level for dI/dt limitation (100% gate driver capability) @ V_{DIDT}<0V	V_{DIDT}	--	--	-2	V
Max. V_{Gxx} at full reaction level for dI/dt limitation @ V_{DIDT} = -5V	$V_{Gxx(DIDT)}$				V
@ T_J = -40°C		--	1.9	3.0	
@ T_J = +25°C		--	2.3	3.0	
@ T_J = +150°C		--	3.4	4.2	
Min. falltime at full reaction level for dI/dt limitation @ V_{DIDT} = +5V	$t_{fall (DIDT)}$				µs
@ T_J = -40°C		20	65	--	
@ T_J = +25°C		20	68	--	
@ T_J = +150°C		20	70	--	
Impedance of DIDT Pin to GND 10kHz<f<10MHz; V_{DIDT} = 5V	Z_{DIDT}		60		Ω

Default status of input pins:

To assure a defined status of all input pins in case of disconnection, these pins are internally secured by pull-up or pull-down current sources with approx. 10µA.
The following table shows the default status of each input pin.

Input pin	Default status
ILx	Low (ext. Mosfet off)
IHx	High (ext. Mosfet off)
DIDT	Low (no dI/dt limitation)
DT	2µs dead time
MFP	Disable (pull-down)

Truth Table

ILx	IHx	DT	MFP	UV	OT	SC	GLx	GHx	ERR
	Input			Conditions			Output		
1	1	D	>2.5V	0	0	0	1	0	5V
0	0	D	>2.5V	0	0	0	0	1	5V
1	0	D	2.5-4.0V	0	0	0	A	A	5V
0	1	D	>2.5V	0	0	0	0	0	5V
0	0	D	>2.5V	1	0	0	0	1	0V
1	1	D	>2.5V	1	0	0	1	0	0V
1	0	D	2.5-4.0V	1	0	0	A	A	0V
0	1	D	>2.5V	1	0	0	0	0	0V
0	0	D	>2.5V	0	1	0	0	1	0V
1	1	D	>2.5V	0	1	0	1	0	0V
1	0	D	2.5-4.0V	0	1	0	A	A	0V
0	1	D	>2.5V	0	1	0	0	0	0V
X	X	D	>2.5V	0	0	1	0	0	B
X	X	D	<1.1V	0	0	X	0	0	5V
X	X	D	<1.1V	1	0	X	0	0	0V
X	X	D	<1.1V	0	1	X	0	0	0V
X	X	D	<1.1V	1	1	X	0	0	0V
C	C	D	>4.5V	X	X	X	1	1	0V

A) stays in the output condition prior to the shoot through input command (see also dead time diagrams)
B) ERR=0V and stays latched until reset
C) All 3 ILx=1 AND all 3 IHx=0 (shoot through command)
D) No influence on static results
X) Can be 0 or 1
Remark:
If 1.1V < VMFP < 2.5V the device is either working normally or is disabled.
If 4.0V < VMFP < 4.5V the device is either working normally or will allow shoot through.

Definition:

In this datasheet a duty cycle of 98% means that the GLx pin is 2% of the PWM period in high condition.
Remark: Please consider the influence of the dead time for your input duty cycle

Dead time diagrams:
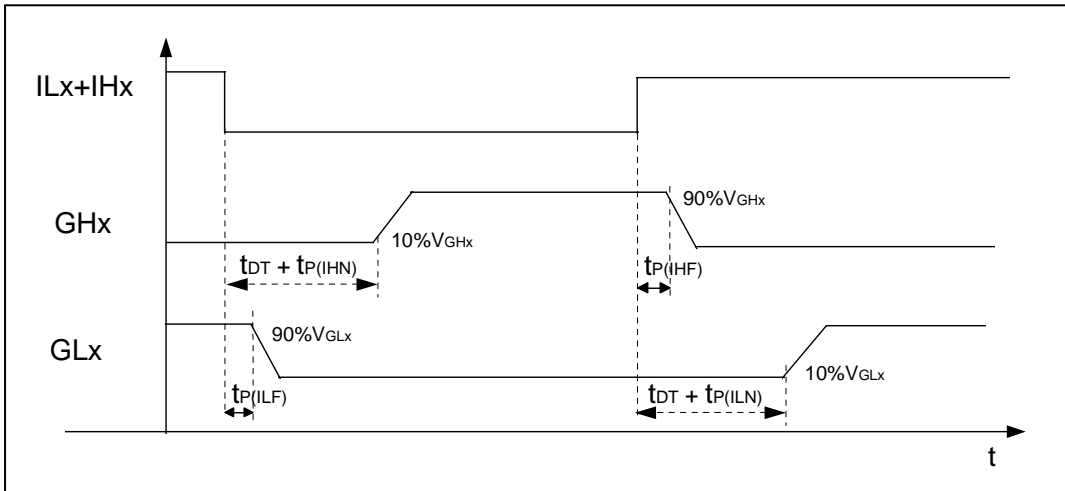
Fig. 6: Dead time generation when IHx and ILx are tied together
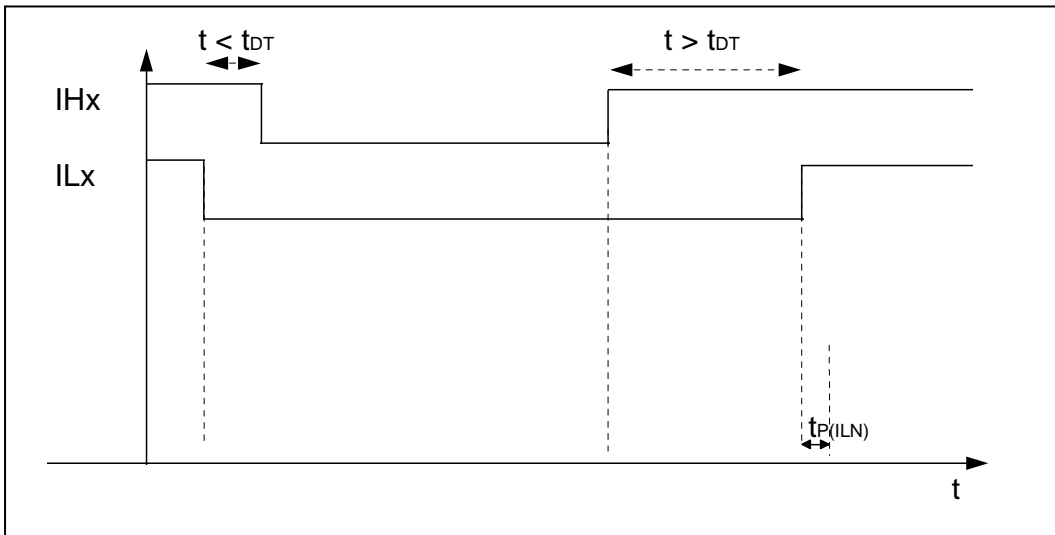
Fig. 7: Dead time generation when IHx and ILx are seperated

Fig. 8: Dead time gereration and shoot through protection

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Typ. dead time generation

Parameter: $T_{Junction}$
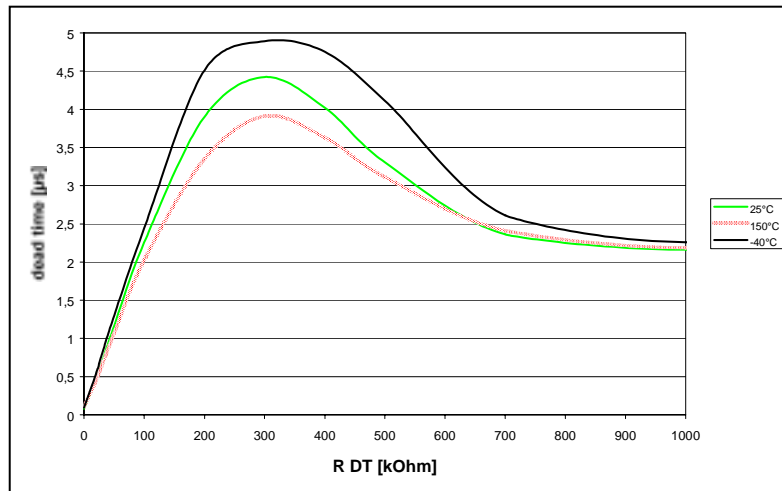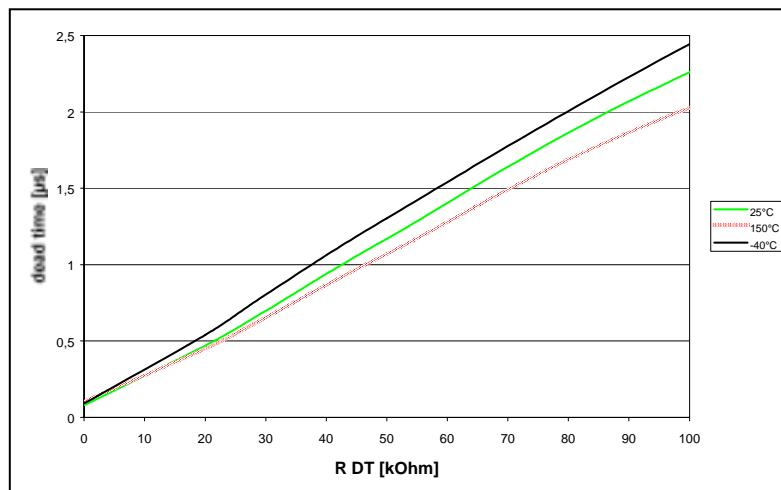

Fig. 9: Typ. dead time internal generated

Fig. 10: Typ. dead time internal generated - detail
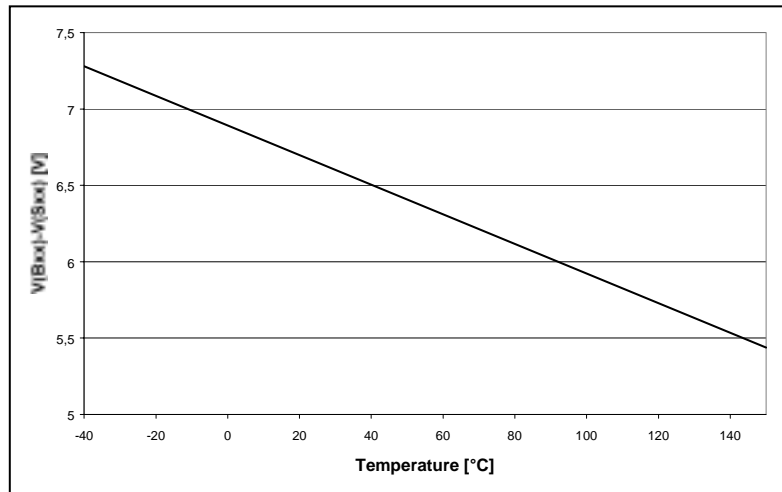
Typ. undervoltage shut down level

Fig. 11: Typ. undervoltage shut down (Voltage of bootstrap capacitors)

Typ. Current consumption of output stage

Conditions: Vs=12V; measured with V(BHx=12V) and potentiometer between SHx and GND
Parameter: MFP voltage / $T_{Junction}$
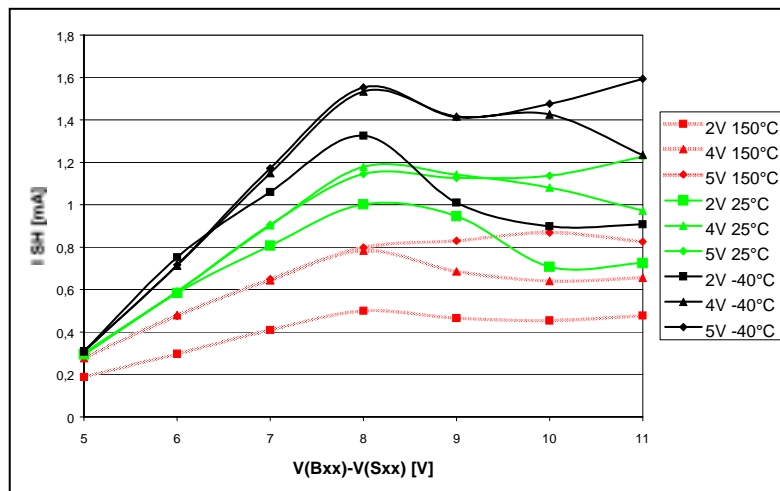
Fig. 12: Leakage current of driver output stages measured as current out of SH Pin to GND

Remark:
The leakage current of the driver output stage is taken from the bootstrap capacitors C_{BX}. When an external high-side Mosfet is switched on, it is impossible to replace this current. The capacitor will be discharged as long as this Mosfet stays on. The time until this output stage reaches the undervoltage shut-down can be determined by the size of the capacitor, the initial capacitor voltage, the leakage current taken out of this capacitor and the undervoltage lock-out level.

Typ. Boostrap voltage vs. Duty Cycle

Conditions: Mosfet: 6x SPB80N04S2-04; f_{PWM}=20kHz, Vs=9V
Parameter: Charge pump capacitor C_{CP} / Bootstrap capacitor C_{BX}
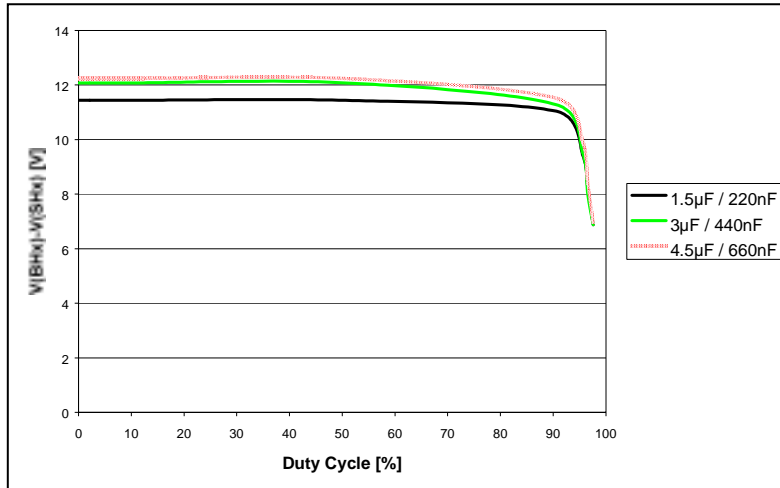
**Fig. 13: Typ. bootstrap voltage V(BHx)-V(SHx);
duty cycle of 1 half-bridge = 50%; duty cycle of the other
2 halfbridges variable**
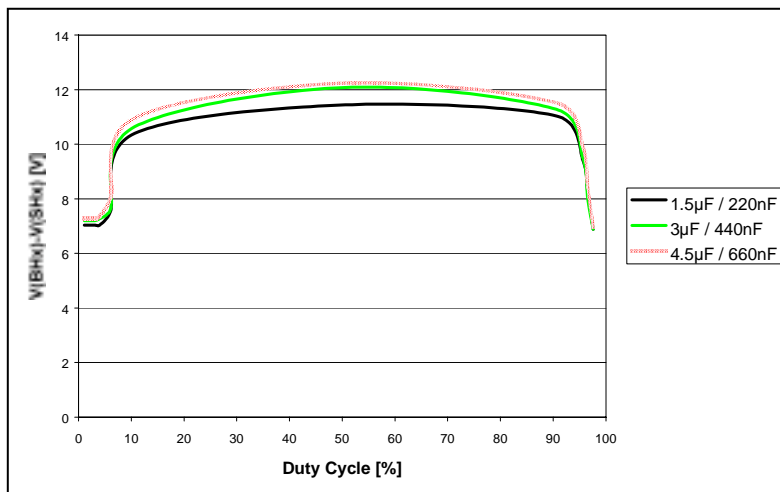
**Fig. 14: Typ. bootstrap voltage V(BHx)-V(SHx);
duty cycle of 1 half-bridge = 0%; duty cycle of the other 2
halfbridges variable**

Remark:
The reachable duty cycle depends on the used PWM patterns. To achieve an even higher duty cycle, run it for some periods and reduce the duty cycle only for 1 period down to 90% to recharge the bootstrap capacitors.

Typ. Short circuit detection level

Conditions: Vs=12V
Parameter: $T_{Junction}$
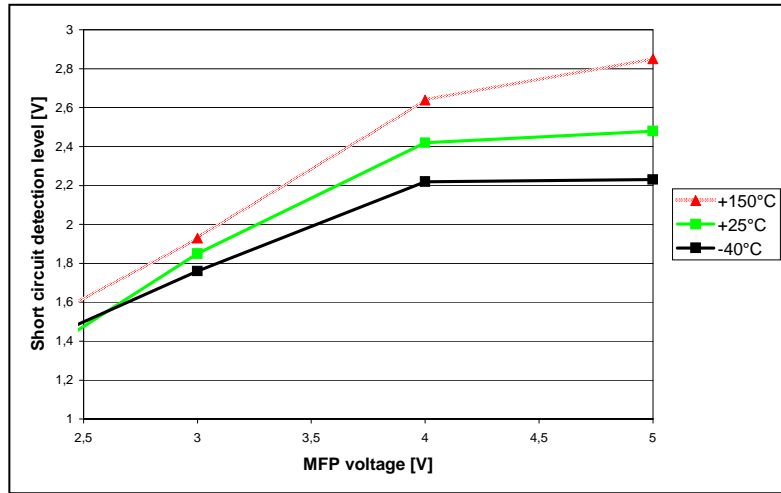
Fig. 15: Short circuit detection level

Typ. Gate voltage limitation during short circuit detection

Conditions: Vs=12V; Load at output: capacitor with 22nF; V(SHx) = GND; V(SLx) = GND;
                 For HS (high-side output); Short happens during on phase V(VDH)-V(SHx)=3V;
                 For LS (low-side output); Short happens during on phase V(SHx)-V(SLx)=3V;
Parameter: $T_{Junction}$; high-side (HS) or low-side (LS) output
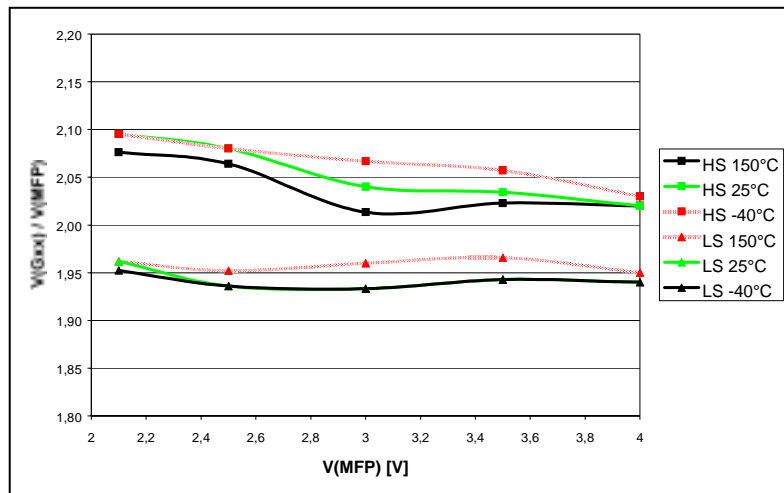
Fig. 16: Factor between reduced gate voltage V(Gxx) in case of short circuit and the voltage at the MFP pin

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Typ. Switching behavior

Conditions: Vs=12V; Vbb=12V; I_{Load} = 10A; V_{MFP}=3.75V; R_{Gate} =1Ω; R_{DT}=10kΩ; C_{Bxx} =220nF; C_{CP}=1,5µF; one SPB80N04 S2-04 per output with $Q_{G(total)}$ = 135nC; Measured: V(DS)
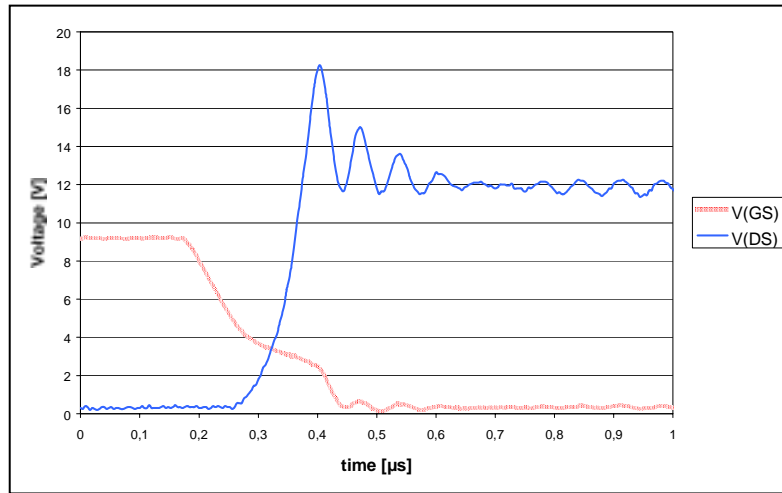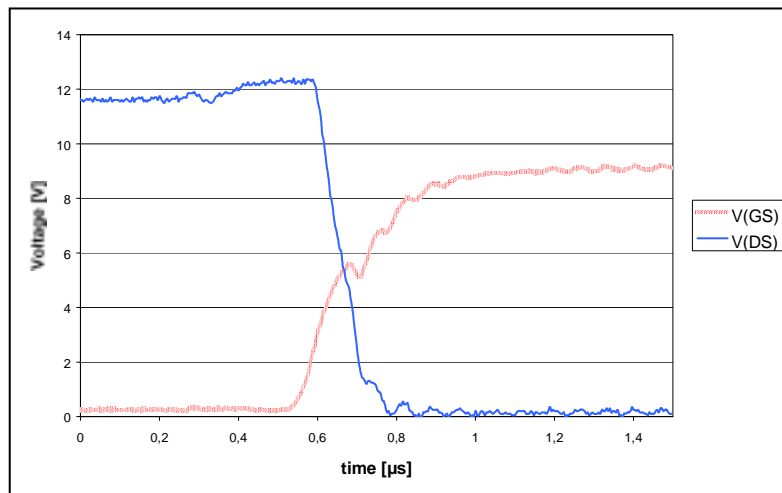

Fig. 17: typ. fall-time at 25°C
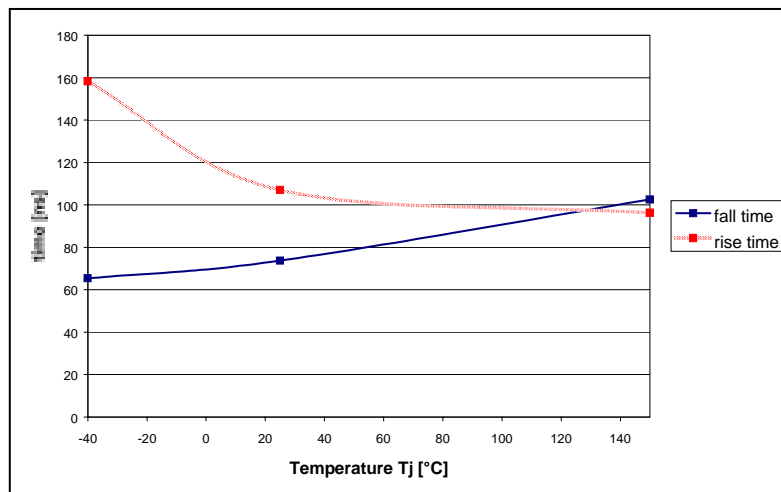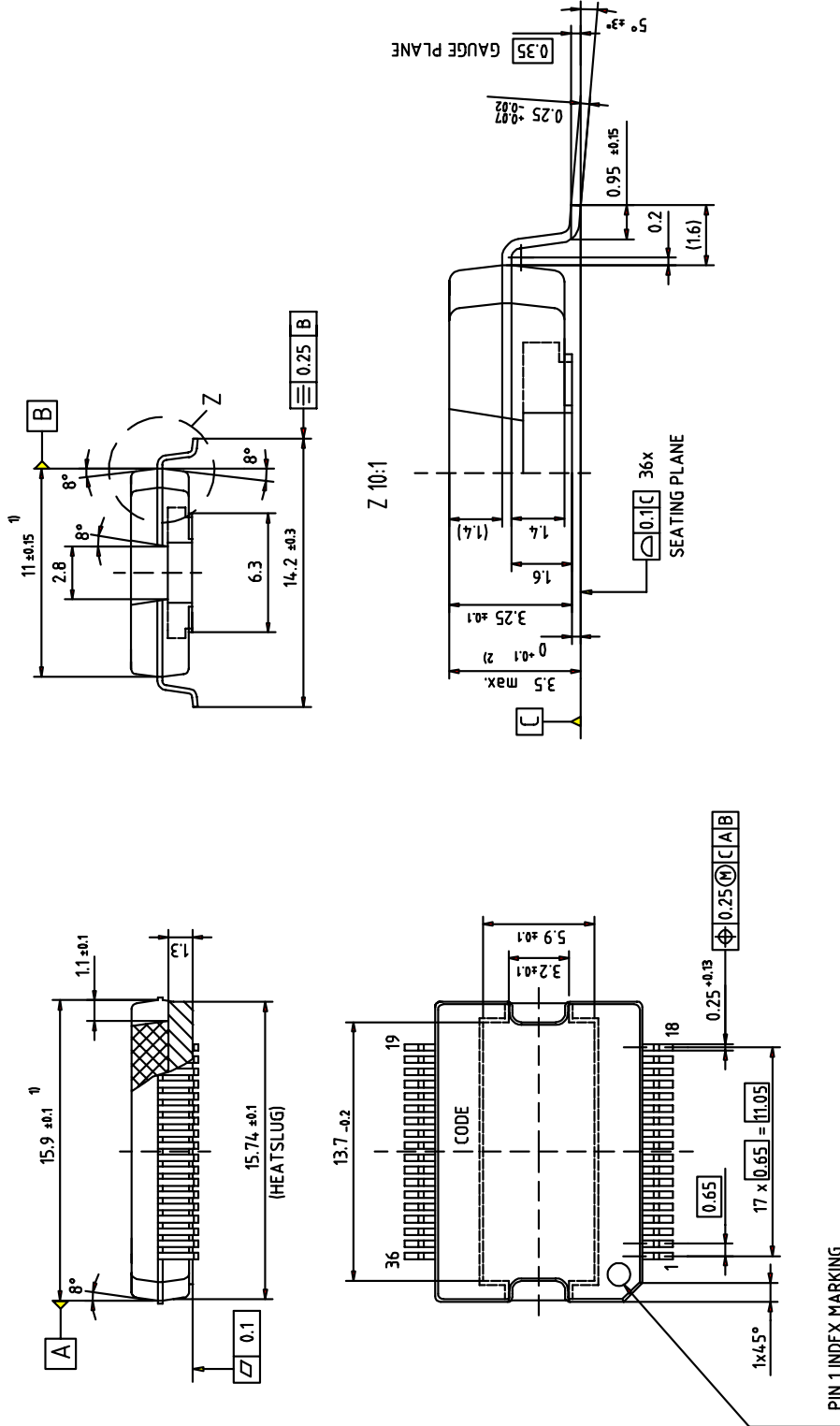

Fig. 18: typ. rise-time at 25°C

Fig. 19: Rise- and fall-times vs. temperature T_J

Package and Ordering Code

Package: P-DSO36-12

(all dimensions in mm)

Attention please!

Information

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