

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	$I_{Oxx(on)}$	0.5	A
Turn off current	$I_{Oxx(off)}$	0.85	A
Supply voltage range	V_{Vs}	9...20	V
Max. Gatecharge @ 20kHz	Q_G	550	nC
Gate Voltage	V_{GS}	10	V
Temperature range	T_J	-40...+150	°C



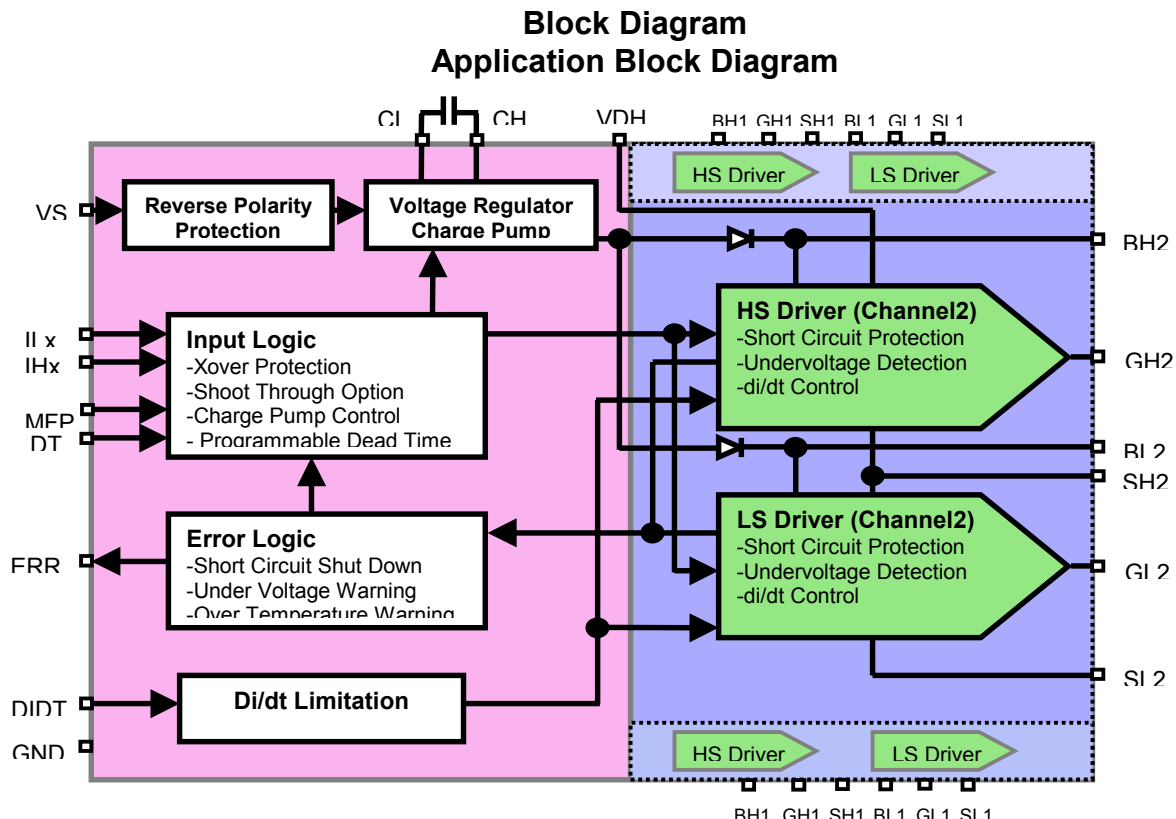
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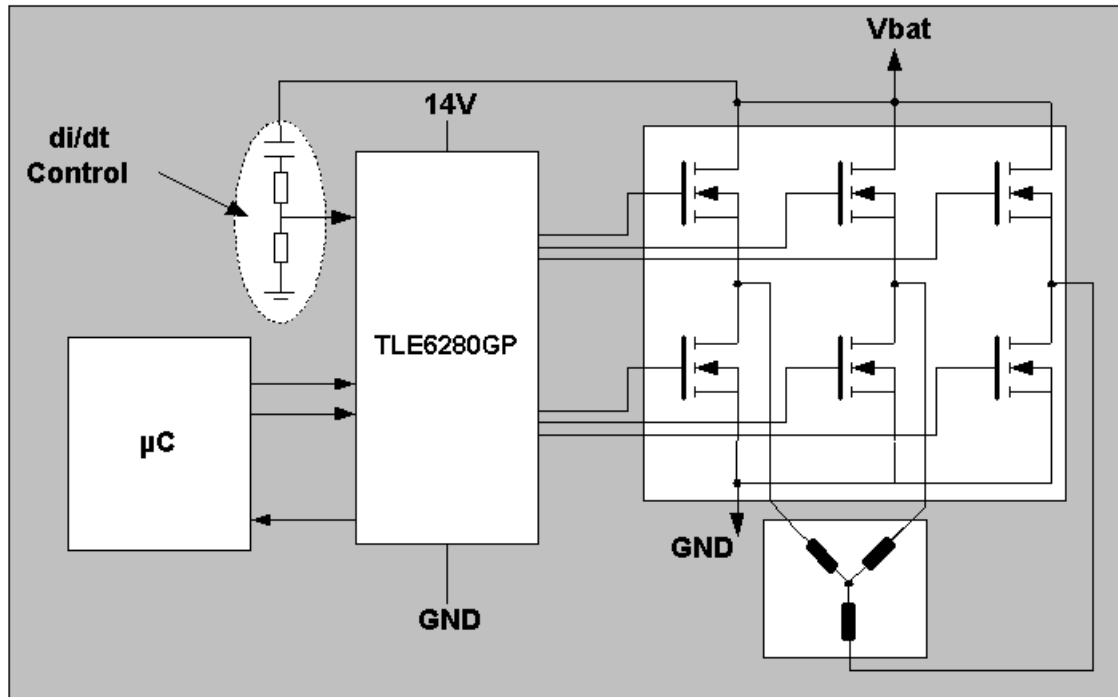
Application

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

General Description

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





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 highside switches 1 to 3 (low active)
11	IH2	
13	IH3	
10	IL1	Control inputs for lowside switches 1 to 3 (high active)
12	IL2	
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 ($V_{Gxx} - V_{Sxx} = 2 \times V_{MFP}$) 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 highside MOS-FETs
16	ERR	Error flag for driver supply under voltage, overtemperature 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	

Maximum Ratings at $T_j=25^\circ\text{C}$ unless specified otherwise

Parameter	Symbol	Values	Unit
Supply voltage ¹	V_S	-4 ... 45V	V
Max. Gate charge @ 20kHz	Q_G	550	nC
Operating temperature range	T_j	-40 ... +150	$^\circ\text{C}$
Storage temperature range	T_{stg}	-55 ... +150	
Max. voltage range at lxx, MFP, DT; ERR		-0.3 ... +7	V
Max. voltage range at SLx	V_{SLx}	-7 ... +7	V
Max. voltage range at SHx	V_{SHx}	-7 ... +45	V
Max. voltage range at VDH, GHx $T_j=-40 \dots 150^\circ\text{C}$		-6 ... +55	V
Max. voltage range at BHx $T_j=-40 \dots 150^\circ\text{C}$	V_{BHx}	-0.3 ... +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) @ $T_c=125^\circ\text{C}$	P_{tot}	1.2	W
Electrostatic discharge voltage (Human Body Model) according to MIL STD 883D, method 3015.7 and EOS/ESD assn. standard S5.1 - 1993	V_{ESD}^2	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

Functional range

Parameter and Conditions at $T_j = 25^\circ\text{C}$, unless otherwise specified	Symbol	Values			Unit
		min	typ	max	

Parameter	Symbol	Values	Unit
Supply voltage	V_S	9 ... 20	V
Operating temperature range	T_j	-40 ... +150	$^\circ\text{C}$
Duty Cycle @ 20kHz ^{3 4}		0...96	%
Max. Gate charge @ 20kHz ; 0...98% duty cycle @ 20kHz ; 2...96% duty cycle	Q_G	275 550	nC
Max. voltage range at lxx,ERR		-0.3 ... +7	V

¹ With external resistor ($\geq 10 \Omega$) and capacitor

² All test involving Bxx pins $V_{ESD}=1\text{kV}$!

³ As long as one switch is switched with the PWM frequency

⁴ If the Bootstrap Capacitor is pumped up to $V_{BHx}-V_{SHx}=12\text{V}$, the maximum duty cycle is 100% for 500 μs

Max. voltage range at MFP ⁵	V_{MFP}	-0.3 ...+5	V
Max. voltage range at SLx	V_{SLx}	-7 ...+7	V
Max. voltage range at SHx	V_{SHx}	-7 ...+45	V
Max. voltage range at VDH, GHx $T_j = -40 \dots 150^\circ\text{C}$		-6 ...+55	V
Max. voltage range at BHx $T_j = -40 \dots 150^\circ\text{C}$	V_{BHx}	-0.3 ...+55	V
Max. voltage range at DIDT	V_{DIDT}	-7 ...+7	V
PWM frequency	F_{PWM}	2...30	kHz
Min. dead time resistor ⁶	R_{DT}	10	k Ω

Electrical Characteristics

Parameter and Conditions at $T_j = 25^\circ\text{C}$, unless otherwise specified and supply voltage range $V_S = 9 \dots 18\text{V}$; $f_{PWM} = 20\text{kHz}$	Symbol	Values			Unit
		min	typ	max	

Static Characteristics

Low level output voltage ($V_{Oxx}-V_{Sxx}$) @ $I=10\text{mA}$	ΔV_{LL}	--	50	100	mV
High level output voltage ($V_{Oxx}-V_{Sxx}$) @ $I=-10\text{mA}$	ΔV_{HL}	8	10	11	V
Supply current at VS (device disabled) @ $V_{bat} = V_S = 14\text{V}$ $R_{DT}=400\text{k}\Omega$ $V_{MFP}=3\text{V}$	$I_{VS(dis)}$	--	--	12	mA
Supply current at VS @ 20kHz $V_{MFP} \leq 4\text{V}$ (Outputs open)	$I_{VS(open)}$	--	20	--	mA
Low level input voltage $T = -40 + 150^\circ\text{C}$	$V_{IN(LL)}$	--	--	1.0	V
High level input voltage $T = -40 + 150^\circ\text{C}$	$V_{IN(HL)}$	2.0	--	--	V
Input hysteresis	ΔV_{IN}	100	200		mV

⁵ V_{MFP} up to 7V allowed up to 500ms

⁶ Otherwise the supply current level $I_{VS(DIS)}$ will be increased

Dynamic characteristics

Turn on current @ $V_{GXX} - V_{SXX} = 0V$; $T_j = 25^\circ C$ @ $V_{GXX} - V_{SXX} = 4V$; $T_j = 125^\circ C$	$I_{GXX(on)}$	--	0.5 0.8	--	A
Turn off current @ $V_{GXX} - V_{SXX} = 10V$; $T_j = 25^\circ C$ @ $V_{GXX} - V_{SXX} = 4V$; $T_j = 125^\circ C$	$I_{OXX(off)}$	--	0.85 0.6	--	A
Dead time (adjustable) @ $R_{DT} = 1\text{ k}\Omega$ ⁷ @ $R_{DT} = 10\text{ k}\Omega$ @ $R_{DT} = 50\text{ k}\Omega$ @ $R_{DT} = 200\text{ k}\Omega$ @ $R_{DT} = 400\text{ k}\Omega$ @ $R_{DT} > 1\text{ M}\Omega$	t_{DT}	--	0.1 0.24 0.9 2.6 3.8 1.9	--	μs
Rise time @ $C = 22\text{ nF}$	t_{rise}	--	300	880	ns
Fall time @ $C = 22\text{ nF}$	t_{fall}	--	300	440	ns
Disable propagation time	$t_{P(DIS)}$	--	tbd	1000	ns
Input propagation time (low on)	$t_{P(ILN)}$	--	300	500	ns
Input propagation time (low off)	$t_{P(ILF)}$	--	350	500	ns
Input propagation time (high on)	$t_{P(IHN)}$	--	330	500	ns
Input propagation time (high off)	$t_{P(IHF)}$	--	300	500	ns
Input propagation time difference	$t_{P(Diff)}$	--	tbd	50	ns

Diagnosis and Protection Functions

Undervoltage warning at ERR	$V_{BXX} - V_{SXX}$	8	9.2	--	V
Overtemperature warning	$T_{J(OV)}$	150	170	tbd	$^\circ C$
Hysteresis for overtemperature warning	$\Delta T_{J(OV)}$		20		$^\circ C$
Short circuit protection shut down time delay	$t_{SCP(off)}$		12		μs
Short circuit criteria (V_{DS} of Mosfets) @ $V_{MFP} = 3V$ ⁸	$V_{DS(SCP)}$		1.5		V
Factor between V_{MFP} and max. V_{GXX} @ $2V < V_{MFP} < 4V$	V_{GXXMax}/V_{MFP}		2		
Disable input level ⁹	$V_{MFP(DIS)}$	1.1	tbd	1.7	V
Disable input hysteresis	$\Delta V_{MFP(DIS)}$	--	250	--	mV
Error level @ 1.6mA I_{ERR}	V_{ERR}	--	--	1.0	V

dl /dt limitation

Non reaction level for dl/dt limitation (100% gate driver capability)	V_{DIDT}	2	--	tbd	V
Full reaction level for dl/dt limitation (Gate output current < 5mA)	V_{DIDT}	tbd	5	tbd	V

⁷ With increased $I_{VS(DIS)}$

⁸ aperiodic short circuit condition will be detected within several cycles, if the duty cycle is more than 10%

⁹ If the device is reset after disable, the slope of $dU_{(VMFP)}/dt$ has to be higher than 3.5V/50 μs

Shoot through option

Enable level for shoot through option together with all Mosfets switched on	V_{MFP}	4	--	4.5	V
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Remarks:

Default status of input pins:

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

Input pin	Default status
ILx	Low
Ihx	High
DIDT	Pull down with approx. 150 Ω
DT	2 μ s dead time
MFP	Disable (pull down)

Shoot through option:

In order to avoid uncontrolled currents in the motor in short circuit case, it is possible to override the short circuit protection and by setting the ILx to "high", the IHx to "low" and MFP to a level above 4.5V.

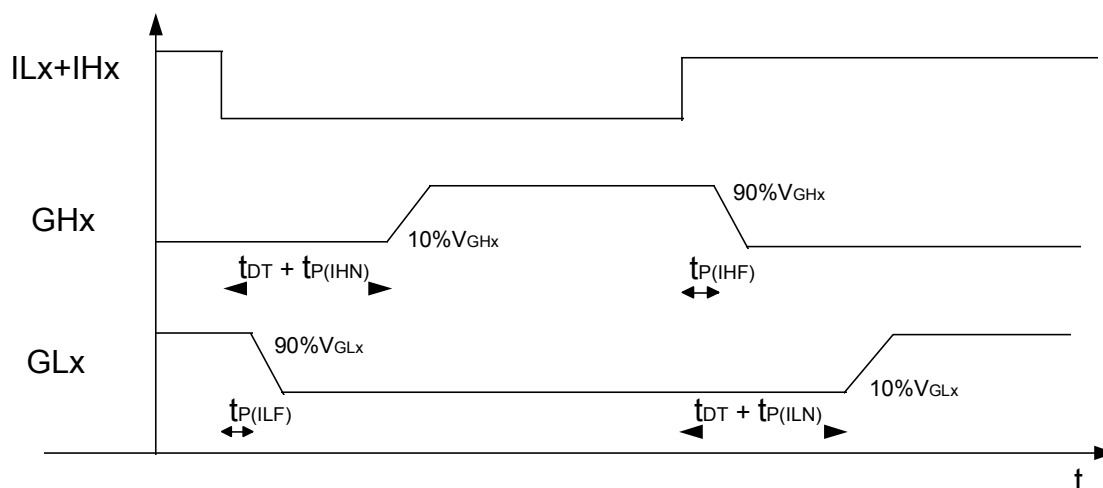
Reset:

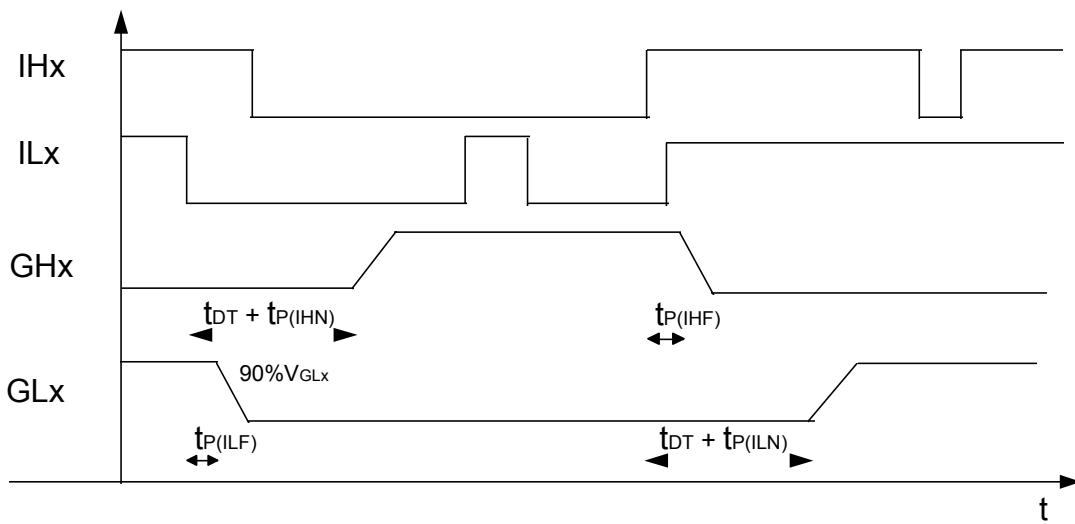
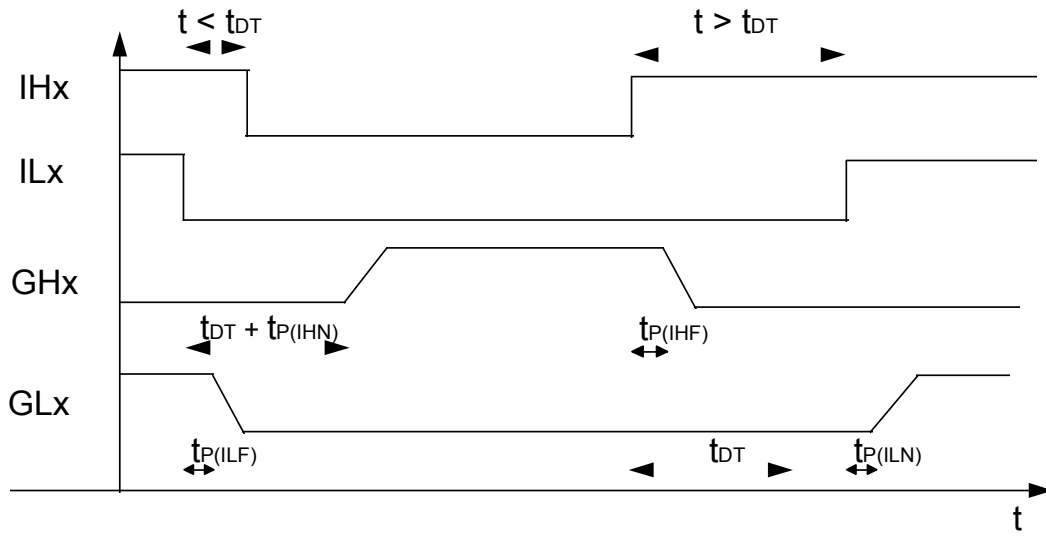
To reset the driver, the device has to be disabled for more than 1 μ s

External components:

It is recommended to dimension the bootstrap and bypass ceramic capacitors according the rule $C = \text{total gate charge of the mosfet} / 0.5V$. The charge pump capacitor should be 6 times higher than the bootstrap / bypass capacitors.

Dead time diagrams:





Truth Table

Input				Conditions			Output		
ILx	IHx	DT	MFP	UV	OT	SC	GLx	GHx	ERR
1	1	D	>1.7V	0	0	0	1	0	5V
0	0	D	>1.7V	0	0	0	0	1	5V
1	0	D	1.7-4.5V	0	0	0	A	A	5V
0	1	D	>1.7V	0	0	0	0	0	5V
0	0	D	>1.7V	1	0	0	0	1	0V
1	1	D	>1.7V	1	0	0	1	0	0V
1	0	D	1.7-4.5V	1	0	0	A	A	0V
0	1	D	>1.7V	1	0	0	0	0	0V
0	0	D	>1.7V	0	1	0	0	1	0V
1	1	D	>1.7V	0	1	0	1	0	0V
1	0	D	1.7-4.5V	0	1	0	A	A	0V
0	1	D	>1.7V	0	1	0	0	0	0V
X	X	D	>1.7V	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 condition before the shoot through condition occurs (see also dead time diagrams)
 B) ERR=0V and stays latched until reset
 C) All 3 ILx=1 AND all 3 IHx=0
 D) No influence on static results
 X) Can be 0 or 1

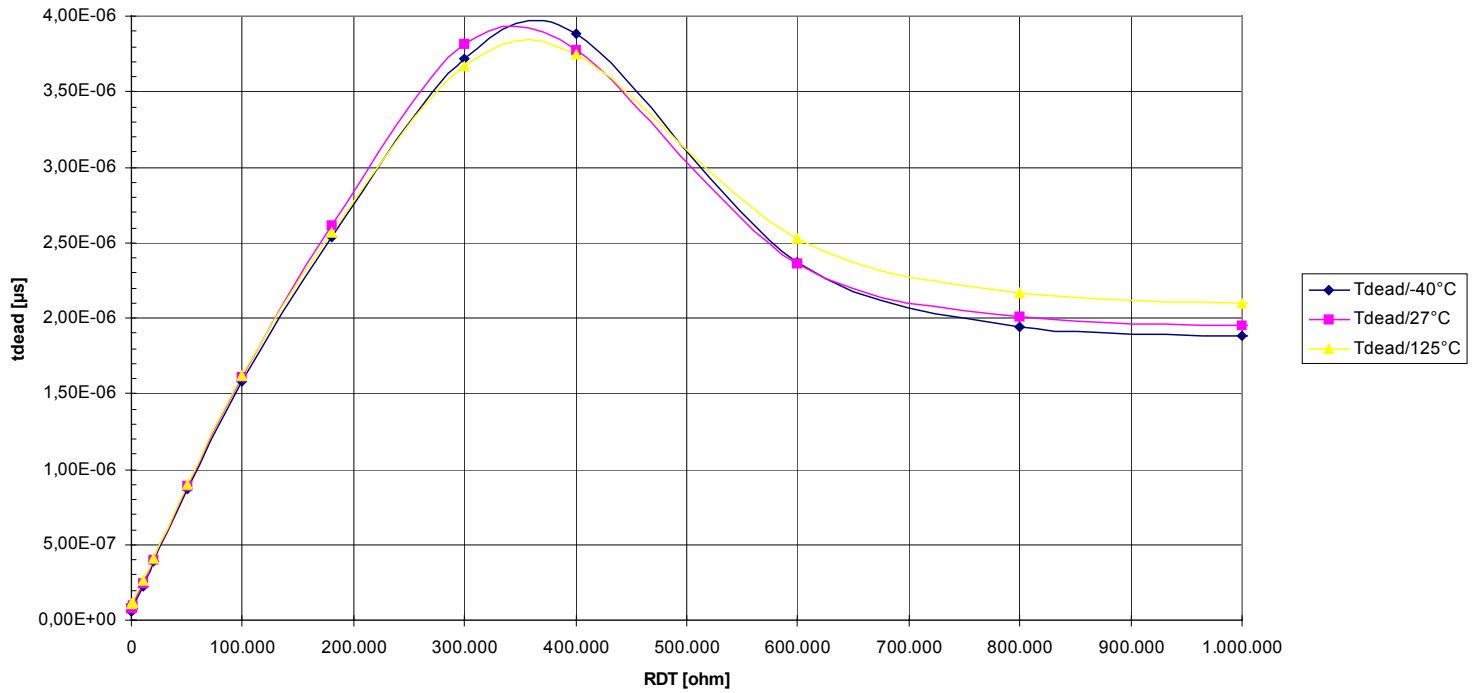
Definition:

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

Diagram “Deadtime vs. R_{DT} ”

Deadtime vs. RDT



Package and Ordering Code

(all dimensions in mm)

Package Code

Ordering Code

P-DSO 36-10

Q67007-A9406

