STHV748

5-level, ±90 V, 2 A high-speed pulser with four independent channels

Preliminary data

Features

- High-density ultrasound transmitter
- 0 to ±90 V output voltage
- Up to 20 MHz operating frequency
- Low-power, high-voltage drivers
- 2 independently supplied half bridges for each channel in pulse wave (PW) mode
  - 5-level output waveform
  - ±2 A source and sink current
  - Down to 20 ps jitter
  - Anti-cross conduction function
  - Low 2nd harmonic distortion
  - Fine-tuning on propagation delay
- Fully integrated clamping-to-ground function
  - 6 Ω synchronous active clamp
  - Anti-leakage on output node
- Dedicated half bridge for continuous wave (CW) mode on each
  - Down to 0.1 W power consumption
  - ±0.6 A source and sink current
  - Down to 10 ps jitter
- Fully integrated HV receiver switch
  - 13.5 Ω on resistance
  - HV MOS topology to minimize current consumption
  - Up to 300 MHz BW
- 2.4 V to 3.6 V CMOS logic interface
- Auxiliary integrated circuits
  - Noise blocking diodes
  - Fully self-biasing architecture
  - Anti-memory effect for all internal HV nodes
  - Thermal protection
  - Stand by function
- Latch-up free due to HV SOI technology
- Very few external passive components needed

QFN64 9 x 9 x1.0 mm

Applications

- Medical ultrasound imaging
- Pulse waveform generator
- NDT ultrasound transmission
- Piezoelectric transducers driver

Description

This monolithic, high-voltage, high-speed pulser generator features four independent channels. It is designed for medical ultrasound applications, but can also be used for other piezoelectric, capacitive or MEMS transducers. The device comprises a controller logic interface circuit, level translators, MOSFET gate drivers, noise blocking diodes and high-power P-channel and N-channel MOSFETs as output stage for each channel, clamping-to-ground circuitry, anti-leakage, anti-memory effect block, thermal sensor and HV receiver switch (HVR_SW) which guarantees a strong decoupling during transmission phase. Moreover the STHV748 includes self biasing and thermal shutdown blocks (see *Figure 1*).

Each channel can support up to five active output levels with two half bridges. The output stage of each channel is able to provide ±2 A peak output current. In order to reduce power dissipation during continuous wave mode, the peak current is limited to 0.6 A (a dedicated half bridge is used).

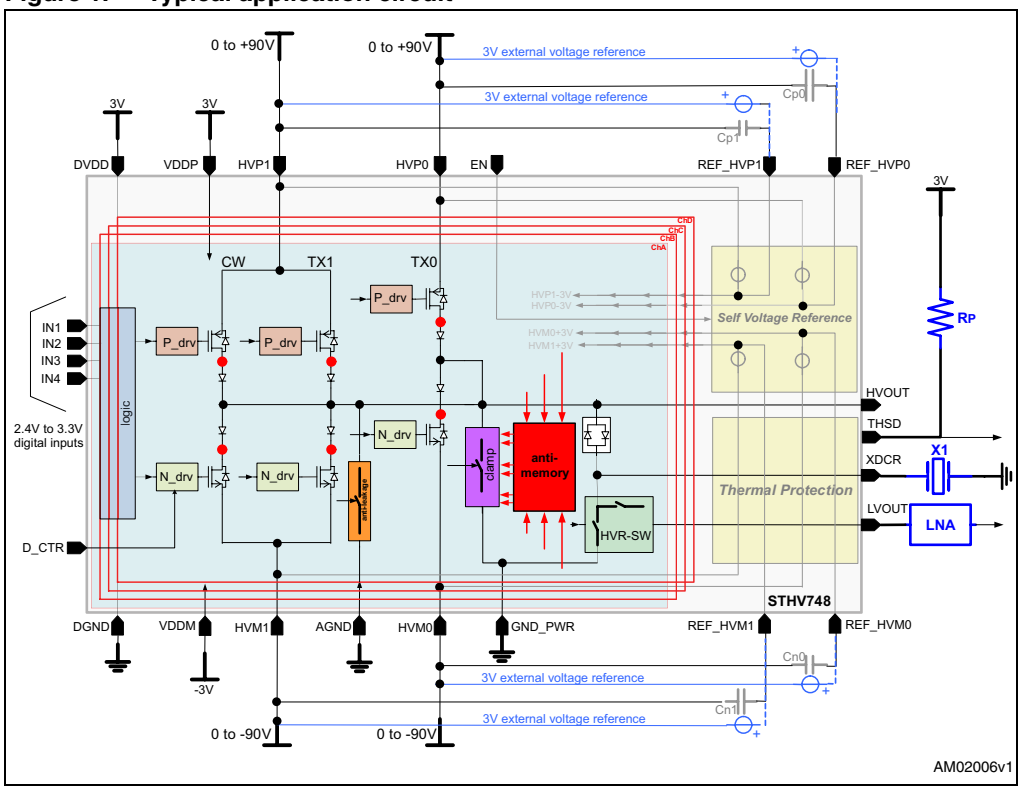
Table 1. Device summary

Order code	Package	Packaging
STHV748QTR	QFN64	Tape and reel

Contents

1 Typical application circuit

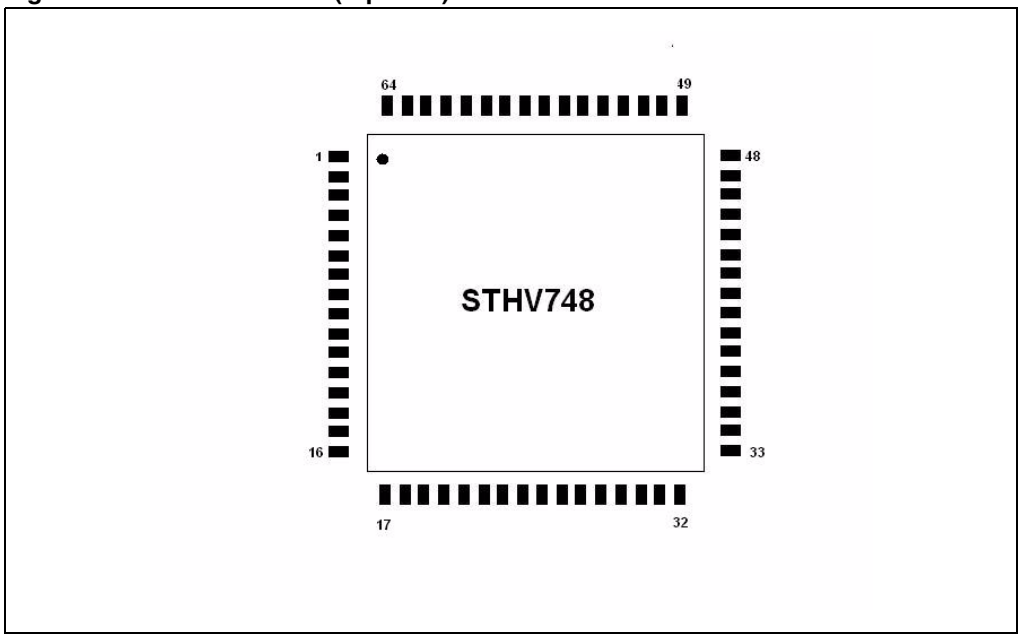
Figure 1. Typical application circuit



2 Pin settings

2.1 Connection

Figure 2. Pin connection (top view)



Note: 0.25 mm X 100 V maximum voltage between abutted pins

2.2 Description

Table 2. Pin description (P = power, A = analog, D = digital)

Pin N	Name	Function	IN/OUT	Type
1	AGND	Signal ground	I	A
2	REF_HVM1	Supply for low side 1 gate driver	I	P
3	HVM1_A	Negative high-voltage supply 1 channel A	I	P
4	HVM0_A	Negative high-voltage supply 0 channel A	I	P
5	HVOUT_A	Channel A, high-voltage output before noise blocking diodes	O	P
6	HVP0_A	Positive high-voltage supply 0 channel A	I	P
7	REF_HVP1	Supply for high side 1 gate driver	I	P
8	HVP1_A	Positive high-voltage supply 1 channel A	I	P
9	HVP1_B	Positive high-voltage supply 1 channel B	I	P
10	REF_HVP0	Supply for high side 0 gate driver	I	P
11	HVP0_B	Positive high-voltage supply 0 channel B	I	P

Table 2. Pin description (P = power, A = analog, D = digital) (continued)

Pin N	Name	Function	IN/OUT	Type
12	HVOUT_B	Channel B, high-voltage output before noise blocking diodes	O	P
13	HVM0_B	Negative high-voltage supply 0 channel B	I	P
14	HVM1_B	Negative high-voltage supply 1 channel B	I	P
15	REF_HVM0	Supply for low side 0 gate driver	I	P
16	D_CTR	Delay control	I	A
17	IN4	Input signal shared	I	D
18	IN1_B	Input signal channel B	I	D
19	IN2_B	Input signal channel B	I	D
20	IN3_B	Input signal channel B	I	D
21	VDDP	Positive low-voltage supply	I	A
22	GND_PWR	Power ground	I	P
23	XDCR_B	Channel B, high-voltage output	O	P
24	LVOUT_B	Channel B, low-voltage output	O	A
25	LVOUT_C	Channel C, low-voltage output	O	A
26	XDCR_C	Channel C, high-voltage output	O	P
27	GND_PWR	Power ground	I	P
28	VDDM	Negative low-voltage supply	I	A
29	IN3_C	Input signal channel C	I	D
30	IN2_C	Input signal channel C	I	D
31	IN1_C	Input signal channel C	I	D
32	THSD	Thermal shutdown pin	I/O	D
33	AGND	Signal ground	I	A
34	REF_HVM1	Supply for low side 1 gate driver	I	P
35	HVM1_C	Negative high-voltage supply 1 channel C	I	P
36	HVM0_C	Negative high-voltage supply 0 channel C	I	P
37	HVOUT_C	Channel C, high-voltage output before noise blocking diodes	O	P
38	HVP0_C	Positive high-voltage supply 0 channel C	I	P
39	REF_HVP1	Supply for high side 1 gate driver	I	P
40	HVP1_C	Positive high-voltage supply 1 channel C	I	P
41	HVP1_D	Positive high-voltage supply 1 channel D	I	P
42	REF_HVP0	Supply for high side 0 gate driver	I	P
43	HVP0_D	Positive high-voltage supply 0 channel D	I	P
44	HVOUT_D	Channel D, high-voltage output before noise blocking diodes	O	P

Table 2. Pin description (P = power, A = analog, D = digital) (continued)

Pin N	Name	Function	IN/OUT	Type
45	HVM0_D	Negative high-voltage supply 0 channel D	I	P
46	HVM1_D	Negative high-voltage supply 1 channel D	I	P
47	REF_HVM0	Supply for low side 0 gate driver	I	P
48	DGND	Logic ground	I	A
49	DVDD	Positive logic supply	I	A
50	IN1_D	Input signal channel D	I	D
51	IN2_D	Input signal channel D	I	D
52	IN3_D	Input signal channel D	I	D
53	VDDP	Positive low-voltage supply	I	A
54	GND_PWR	Power ground	I	P
55	XDCR_D	Channel D, high-voltage output	O	P
56	LVOUT_D	Channel D, low-voltage output	O	A
57	LVOUT_A	Channel A, low-voltage output	O	A
58	XDCR_A	Channel A, high-voltage output	O	P
59	GND_PWR	Power ground	I	P
60	VDDM	Negative low-voltage supply	I	A
61	IN3_A	Input signal channel A	I	D
62	IN2_A	Input signal channel A	I	D
63	IN1_A	Input signal channel A	I	D
64	EN	Enable internal supply generators	I	D
Exposed-Pad		Substrate	I	P

2.3 Additional pin description

EN allows minimizing the power consumption. If EN=0, the self voltage reference is not supplied. Supplying reference externally the total power consumption is reduced.

THSD is a thermal flag. The output stage of THSD pin is a Nch-MOS open-drain, so this necessary to connect external pull-up resistance (Rp≥10 kΩ) to positive low-voltage supply (see *Figure 1*).If the internal temperature overtakes 160 °C, THSD goes down and put all the channels in HZ state. Externally forcing THSD to positive low-voltage supply, the thermal protection will be disabled.

D_CTR can be used to optimize 2nd HD performances by tuning the fall propagation delay (tdf - see table 9). If D_CTR is equal to ground tdf has the nominal value. If D_CTR is being varied from 2 V to 4.2 V tdf can be changed from -1ns to +600 ps respect to the nominal value.

EXPOSED-PAD is internally connected to the substrate. It can be floating or connected to a 100 V capacitance toward ground in order to reduce noise during the receiving phase.

3 Truth table and single channel block description

Figure 3. Single channel block description

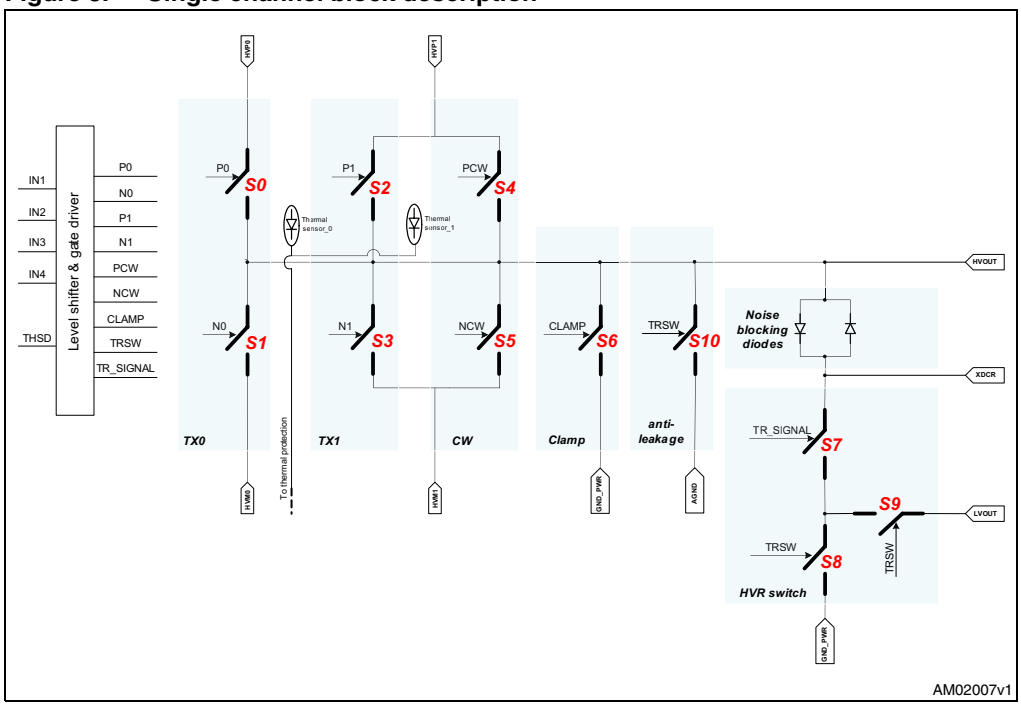


Table 3. Truth table for one channel

Global		Per channel			State	Switches internal state									
THSD	IN4	IN3	IN2	IN1		S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
1	x	x	0	0	Clamp	0	0	0	0	0	0	1	0	1	0
1	0	0	0	1	HVM0	0	1	0	0	0	0	0	0	1	0
1	0	0	1	0	HVP0	1	0	0	0	0	0	0	0	1	0
1	x	0	1	1	HVR_SW	0	0	0	0	0	0	1	1	0	1
1	0	1	0	1	HVM1	0	0	0	1	0	0	0	0	1	0
1	0	1	1	0	HVP1	0	0	1	0	0	0	0	0	1	0
1	0	1	1	1	HZ	0	0	0	0	0	0	0	0	1	0
1	1	1	1	1	HVR_SW	0	0	0	0	0	0	1	1	0	1
1	1	0	0	1	Max HVM0 and HVM1	0	1	0	1	0	0	0	0	1	0
1	1	0	1	0	Max HVP0 and HVP1	1	0	1	0	0	0	0	0	1	0
1	1	1	0	1	CW HVM1	0	0	0	0	0	1	0	0	1	0
1	1	1	1	0	CW HVP1	0	0	0	0	1	0	0	0	1	0
0	x	x	x	x	HZ	0	0	0	0	0	0	0	0	1	0

4 Typical supply reference setting

Table 4. Typical supply reference setting

Symbol	External supply mode	Self supply mode
EN	0	1
Cp0, Cp1	Not used	47 nF(1)
Cn0, Cn1	Not used	9 nF (1)
REF_HVP#	Has to be connected to HVP# -3 V	Not used
REF_HVM#	Has to be connected to HVM# +3 V	Not used

1. In Self supply mode 30 µs after EN edge to charge external capacitance are needed.

5 Electrical data

5.1 Absolute maximum ratings

Table 5. Absolute maximum ratings

Symbol	Parameter	Value	Unit
AGND	Analog ground reference (1)	0	V
DGND	Digital ground	-300 to 300	mV
GND_PWR	Power ground	-1.2 to 1.2	V
VDDP	Positive supply voltage	-0.3 to 3.9	V
VDDM	Negative supply voltage	0.3 to -3.9	V
DVDD	Positive logic voltage	-0.3 to 3.9	V
HVP0	TX0 high-voltage positive supply	0 to 95	V
HVP1	TX1 high-voltage positive supply	≤ HVP0	V
HVM0	TX0 high-voltage negative supply	0 to -95	V
HVM1	TX1 high-voltage negative supply	≥ HVM0	V
REF_HVP#	High-voltage positive gate supply	-0.3 < HVP - REF_HVP < 3.3	V
REF_HVM#	High-voltage negative gate supply	-0.3 < REF_HVM - HVM < 3.3	V
XDCR	High-voltage output	-95 to 95	V
HVOUT	High-voltage output before noise blocking diodes	-95 to 95	V
LVOUT	Low-voltage output	-1 to 1	V
DIG I/O	Digital input specified in tab1	-0.3 to DVDD + 0.3	V
D_CTR	Delay control	-0.3 to 4.6	V
T_{OP}	Operating temperature range	-40 to 125	°C
T_{STG}	Storage temperature range	-65 to 150	°C

1. AGND is considered like “ground reference” for all fallen voltages.

Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied.

Table 6.

Symbol	Parameter	Value	Unit
$R_{th,JA}$	Thermal resistance junction-amb	30 (1)	°C/W

1. This value is given for a two layer PCB (252P) and it’s strongly sensitive to PCB layout. Increasing the number of PCB layer or adding heat singer vias this number degree (reduce)

6 Operating supply voltages and average currents [a]

Table 7. Supply voltages

Symbol	Parameter	Conditions	Min	Typ	Max	Units
VDDP	Positive supply voltage		2.7	3	3.6	V
I_{VDDP}	Positive supply current	PW mode [1]			3	mA
I_{VDDP_Q}		Stand-by mode [2]			1	µA
VDDM	Negative supply voltage		-2.7	-3	-3.6	V
I_{VDDM}	Negative supply current	PW mode			2	mA
I_{VDDM_Q}		Stand-by mode			1	µA
DVDD	Positive logic voltage		2.4	3	min(3.6,VDDP+0.3)	V
$I_{\_DVD}$	Logic supply current	PW mode			10	µA
$I_{\_DVD\_Q}$		Stand-by mode	55	65	80	µA
HVP	High-voltage positive supply		0		90	V
I_{HVP}	HV positive supply current	PW mode			50	mA
I_{HVP_Q}		Stand-by mode			1	µA
HVM	High-voltage negative supply		-90		0	V
I_{HVM}	HV negative supply current	PW mode			45	mA
I_{HVM_Q}		Stand-by mode			1	µA
HVP-REF_HVP	High-voltage positive gate supply		2.7	3	3.3	V
I_{REF_HVP}	HV positive REF current	PW mode			7	mA
$I_{REF\_HVP\_Q}$		Stand-by mode	200	300	400	µA
REF_HVM-HVM	High-voltage negative gate supply		2.7	3	3.3	V
I_{REF_HVM}	HV negative REF current	PW mode			3	mA
$I_{REF\_HVM\_Q}$		Stand-by mode	200	300	400	µA
AGND	Ground reference			0		V
I_{AGND}	Analog ground current	PW mode			700	µA
I_{AGND_Q}		Stand-by mode			1	µA
GND_PWR	Power ground reference			0		V
I_{GND_PWR}	PWR ground current	PC mode [3]			20	mA
$I_{GND\_PWR\_Q}$		Stand-by mode			1	µA
D_CTR	Delay control		0		4.2	V

1. In PW pulse wave mode the average current is measured over 5 periods (see Figure 5)
2. In Stand-by mode all channels are in HZ.
3. In PC pulse cancellation mode the average current is measured over 1 period (see Figure 6)

a. Operation conditions, unless otherwise specified, only A channel on, no load, HV=90V, TX0 and TX1 on, EN=0.

6.1 Digital inputs

Table 8. Digital inputs

Symbol	Parameter	Min.	Max.	Units
IN1_#, IN2_#, IN3_#, IN4, EN, THSD	Input logic high-voltage	0.8DVDD	DVDD	V
IN1_#, IN2_#, IN3_#, IN4, EN, THSD	Input logic low-voltage	0	0.2DVDD	V

6.2 Output signals

Table 9. Output signals

Symbol	Parameter	Min.	Max.	Units
HVOUT	High-voltage output before noise blocking diodes	-90	90	V
XDCR	High-voltage output	-90	90	V
LVOUT	Low-voltage output	-1	1	V
THSD	Thermal shutdown pin	0	3	V

7 Electrical characteristics

Table 10. Static electrical characteristics (1)

Symbol	Parameter	Condition	Min	Typ	Max	Units
I_N	Saturation current S1 – S3	HVP# =10V, HVM# =-10V, HVOUT=0V	1.18	1.28	1.40	A
		HVP# =25V, HVM# =-25V, HVOUT=0V		1.70		A
I_P	Saturation current S0 – S2	HVP# =10V, HVM# =-10V, HVOUT=0V	1.12	1.26	1.42	A
		HVP# =25V, HVM# =-25V, HVOUT=0V		1.70		A
I_{NCW}	Saturation current S5	HVP1=10V, HVM1=-10V, HVOUT=0V	315	350	400	mA
I_{PCW}	Saturation current S4	HVP1=10V, HVM1=-10V, HVOUT=0V	415	480	575	mA
I_{CL}	Positive saturation current S6 (Pch)	HVOUT=10V	1.25	1.54	2	A
		HVOUT=25V		TBD		A
	Negative saturation current S6 (Nch)	HVOUT=10V	1.32	1.59	2	
		HVOUT=25V		TBD		
I_L	Output leakage current, per channel	HVP# = 90V, HVM# = -90V, HVOUT=0V			1	µA
P_{SB}	Power dissipation in stand by mode	HVP# = 90V, HVM# = -90V, HVOUT=0V, EN=0		4	4.5	µW
		HVP# = 90V, HVM# = -90V, HVOUT=0V		126	150	mW
P_{RX}	Power dissipation in HVR_SW state	HVP# = 90V, HVM# = -90V, EN=0, all channels in receiving phase	25	30	40	mW
V_{REFP}	HVP# - REF_HVP#	HVP# = 90V, HVM# = -90V, HVOUT=0V	0.8VDDP		1.2VDDP	V
V_{REFN}	REF_HVM# - HVM#	HVP# = 90V, HVM# = -90V, HVOUT=0V	0.8VDDP		1.2VDDP	V
T_{OTP}	Over temperature threshold	HVP# =10V, HVM# =-10V	130	145	160	°C
T_{HYS}	OTP Hysteresis	HVP# =10V, HVM# =-10V		40		°C
C_{HVR_SW}	HVR_SW capacitance	LVOUT=0V		40		pF
$R_{HVR\_SW\_ON}$	R_{HVR_SW} on resistance	HVP# =10V, HVM# =-10V, XDCR=1V, LVOUT=0V	11.5	13.5	15.5	Ω
$R_{HVR\_SW\_OFF}$	R_{HVR_SW} off resistance	HVP# =10V, HVM# =-10V, XDCR=1V, LVOUT=0V	1			GΩ

Table 10. Static electrical characteristics (1) (continued)

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{DROP_CW}	Voltage drop between HVP1 and XDCR	HVP# =10V, HVM# =-10V, I_{SINK_XDCR}=50mA	2.62	2.79	2.96	V
	Voltage drop between XDCR and HVM1	HVP# =10V, HVM# =-10V, I_{SOURCE_XDCR}=50mA	2.69	2.86	3.03	V

1. Operating conditions, unless otherwise specified, EN = 1, HVP# = 90 V, HVM# = -90 V, VDDP = 3 V, VDDM = - 3 V, DVDD = 3 V, T_{ROOM} = 25 °C.

Table 11. AC electrical characteristics (1)

Symbol	Parameter	Test condition	Min	Typ	Max	Units
f	Maximum output frequency		16			MHz
		50pF//200Ω		22		MHz
f_{CW}	Maximum output frequency CW	HVP1 =5V, HVM1 = -5V, continuous wave mode	20			MHz
f_{BW}	Output frequency BW	HVP1 = 50V, HVM1 = -50V, continuous wave mode, 50pF//200Ω		10		MHz
t_j	Output jitter			20		ps, rms
$t_{j\text{-}CW}$	CW output jitter	HVP1 =10V, HVM1 = -10V, continuous wave mode		5		ps, rms
t_f	Fall time			28	31	ns
t_r	Rise time			28	31	ns
t_{dr}	Rise propagation delay			24	27	ns
t_{df}	Fall propagation delay			24	27	ns
t_{HVR_SW}	HVR_SW turn-on / turn-off time			170		ns
HD2	2^{nd} harmonic distortion	1 pulse f = 1.7MHz		-40		dBc
		1 pulse f = 5MHz	-60		-40	dBc
		5 pulses f = 1.7MHz		-40		dBc
		5 pulses f = 5MHz	-60		-40	dBc
HD2PC	Pulse cancellation	f = 1.7MHz original and inverted pulse		-40		dBc
		f = 5MHz original and inverted pulse	-60		-40	dBc
BVD	Burst voltage drop	1^{st} to 128^{th} pulse HVP1 = 10V, HVM1 = -10V		2		%
P_{D_CW}	Power dissipation, per channel	CW mode, f = 5MHz, HVP1 = 5V, HVM1 = -5V, no load			70	mW
HVR_SW_{SPIKE}	HVR_SW spike on XDCR and LVOUT			100		mV_{pp}
X_{TALK}	Cross talk between channels.	Ampl(2ch)/Ampl(1ch), 50pF//200Ω		-40		db

1. Operating conditions, unless otherwise specified, HVP# = 90V, HVM# = -90V, VDDP = 3V, VDDM = -3V, DVDD = 3V, EN = 0, (HVP-REF_HVP) = 3V, (REF_HVM-HVM) = 3V, XDCR load C = 300pF//R = 100Ω, LVOUT load C = 20pF//200Ω T_{ROOM} = 25 °C.

8 Timings

Figure 4. t_r, t_f, t_{dr} and t_{df} descriptions

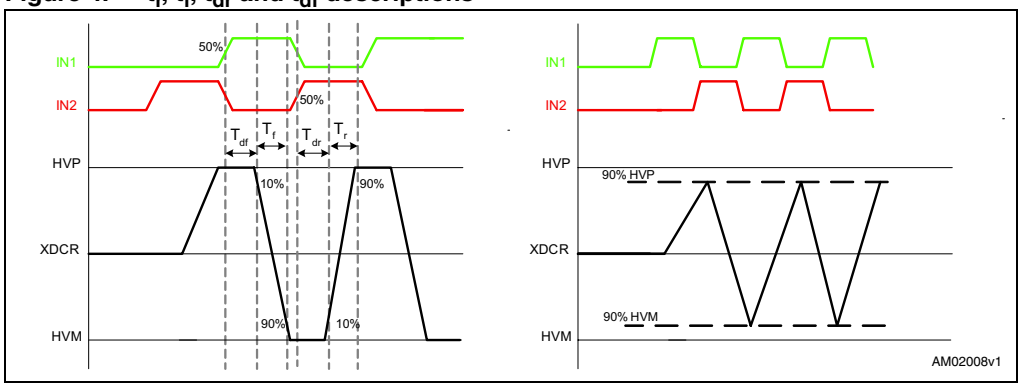


Figure 5. PW example 5 periods, HVP0 = 90 V HVM0 = -90 V, T=200 ns, T_tx=1.2 µs

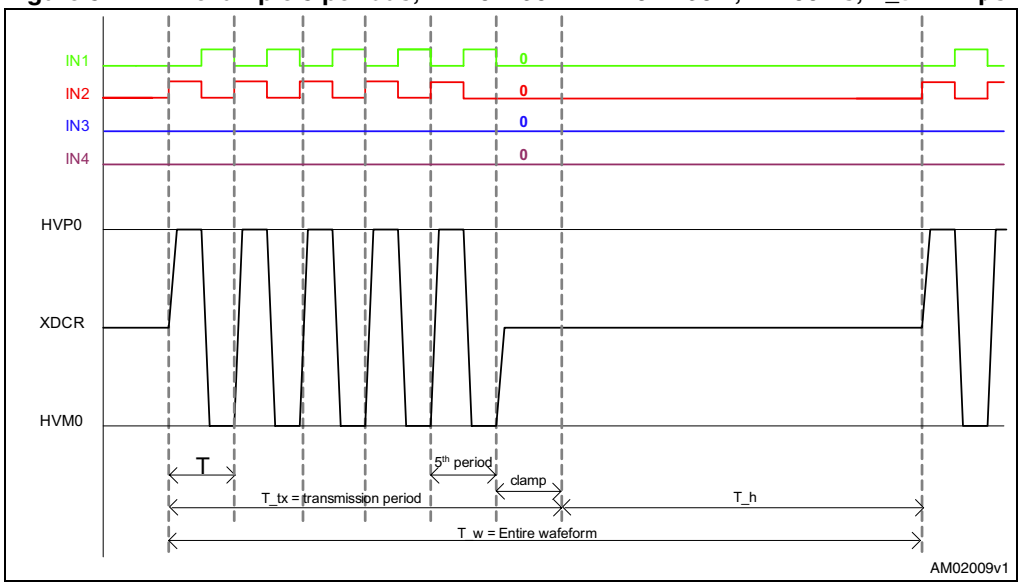


Figure 6. PW and HD2 example (HVP0=80V, HVM0=-80 V load 300 pF//100 Ω)

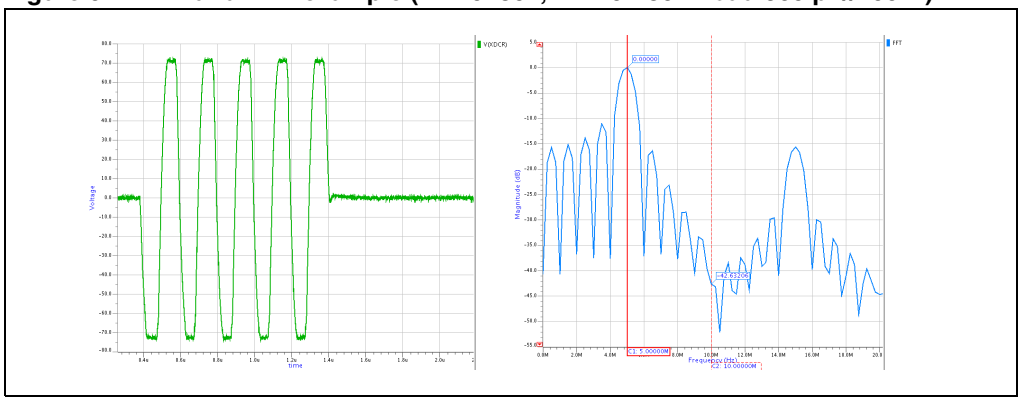


Figure 7. PC example, HVP0 = 90 V HVM0 = -90 V, T=200 ns, T_pos= T_neg=400 ns

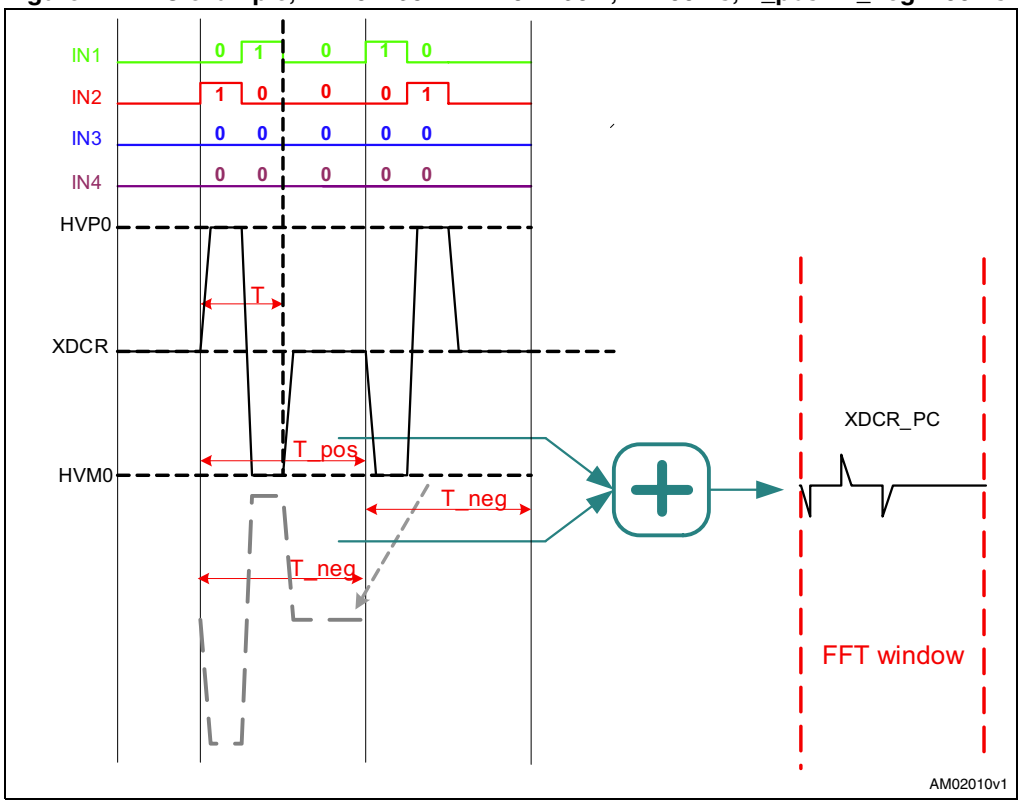


Figure 8. PC and HD2 example (HVP0=60 V, HVM0=-60 V load 300 pF//100 Ω)

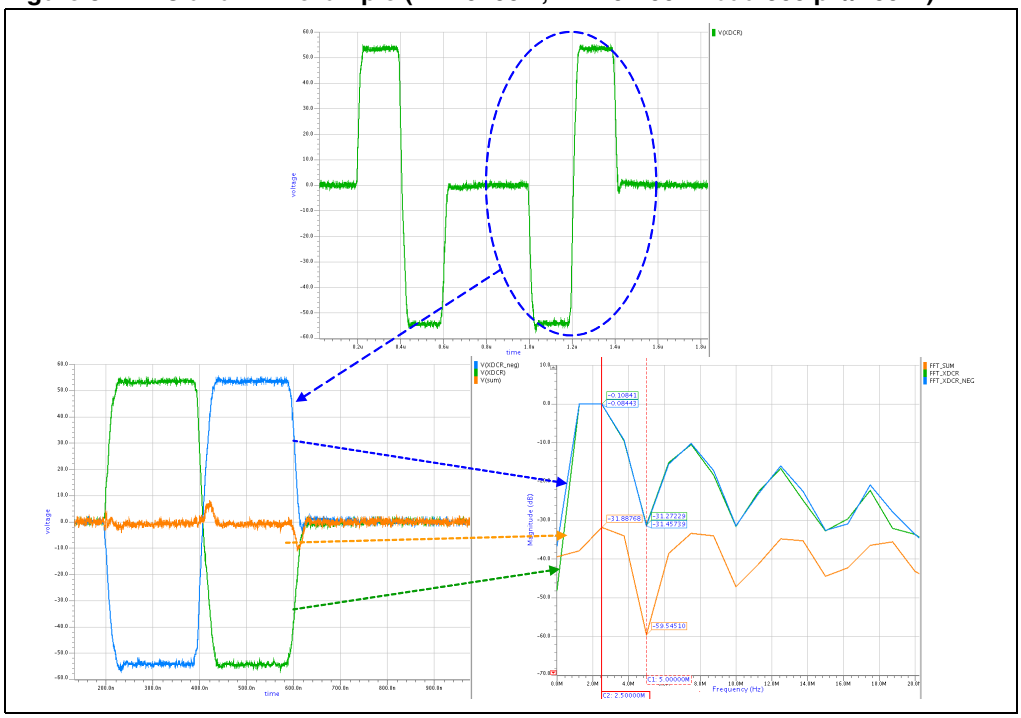


Figure 9. CW mode example, HVP1 = 5 V, HVM1 = 5 V, T = 200 ns, T_tx>1 ms

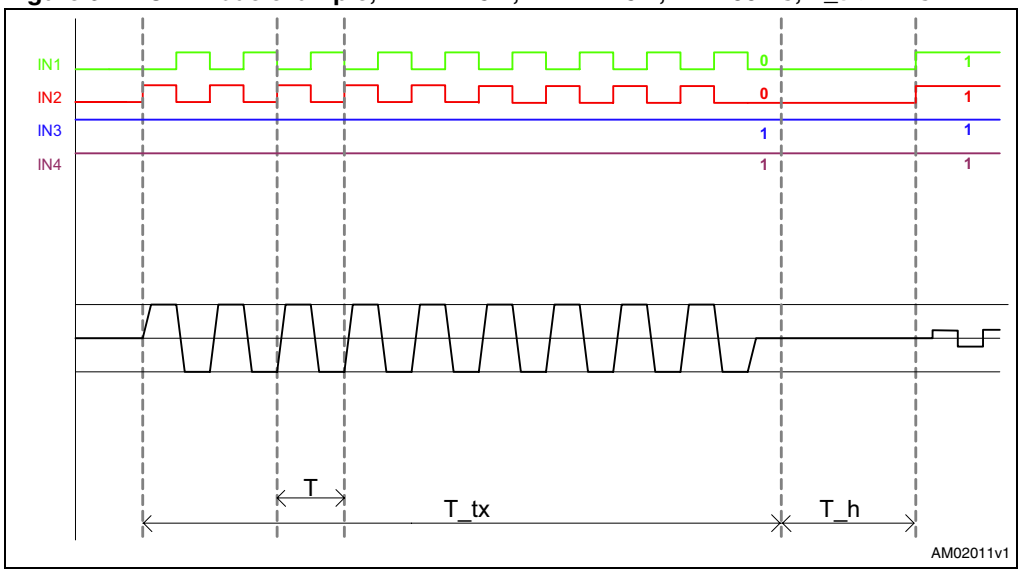
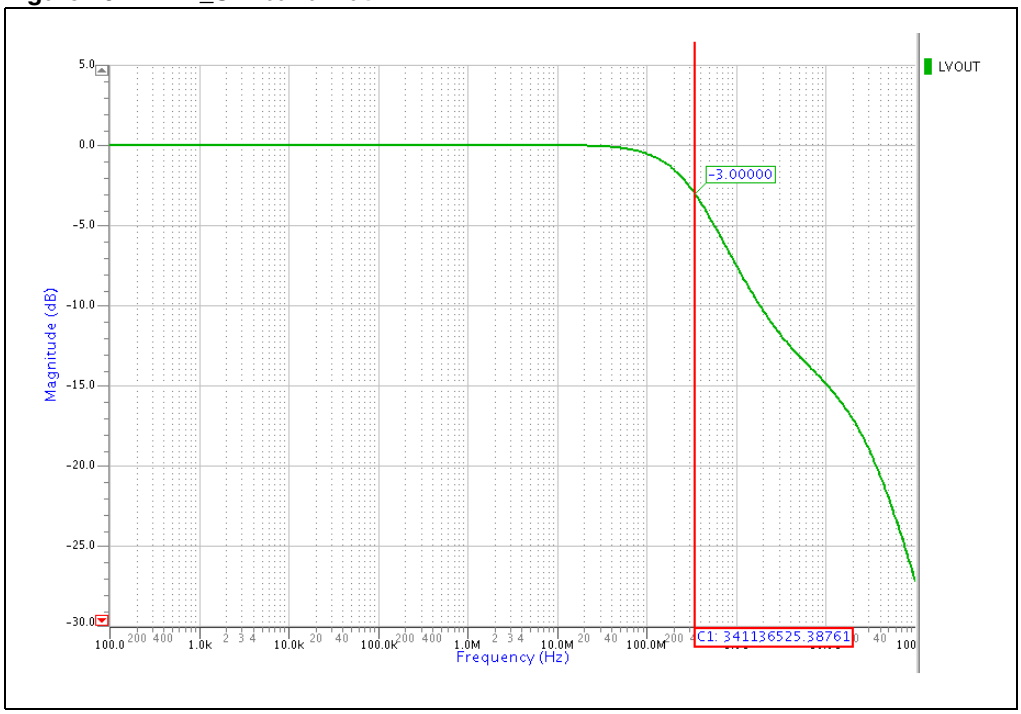


Figure 10. HVR_SW bandwidth



9 Package mechanical data

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. ECOPACK® is an ST trademark.

Table 12. QFN64 9 x 9 x 1.0 mm 64 pitch 0.50 mechanical data

Dim	Min.	Typ.	Max.
A	0.8	0.9	1
A1		0.02	0.05
A2		0.65	1
A3		0.2	
b	0.18	0.25	0.3
D	8.85	9	9.15
D1		8.75	
D2	See exposed pad variation		
E	8.85	9	9.15
E1		8.75	
E2	See exposed pad variation		
e		0.5	
L	0.35	0.4	0.45
P			0.6
K			12
ddd			0.08

Table 13. Exposed-pad variation

Variation	D2			E2		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	4.1	4.25	4.4	4.1	4.25	4.4
B	4.55	4.7	4.85	4.55	4.7	4.85
C	6.95	7.1	7.25	6.95	7.1	7.25
D	7.15	7.3	7.45	7.15	7.3	7.45

Figure 11. QFN64 9 x 9 x 1.0 mm 64 pitch 0.50 drawing

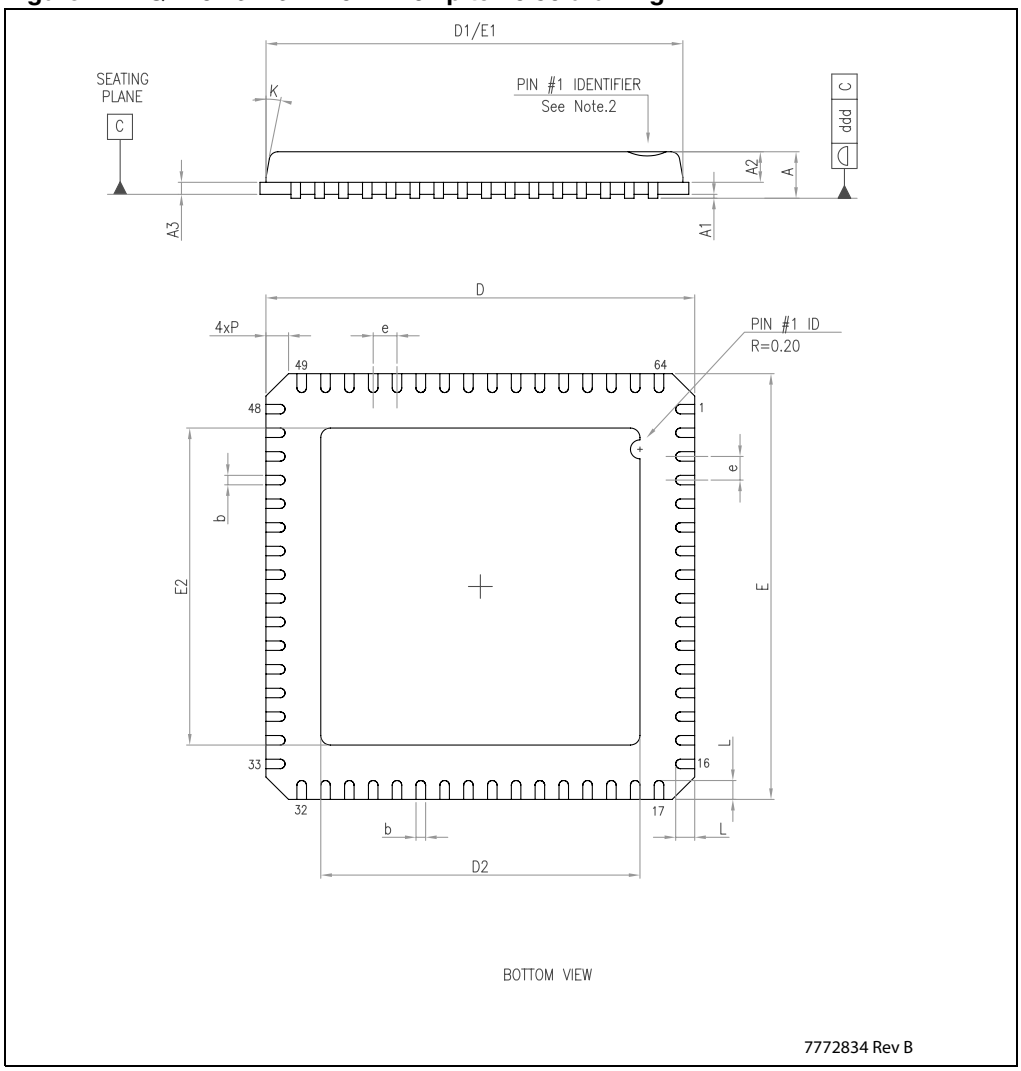
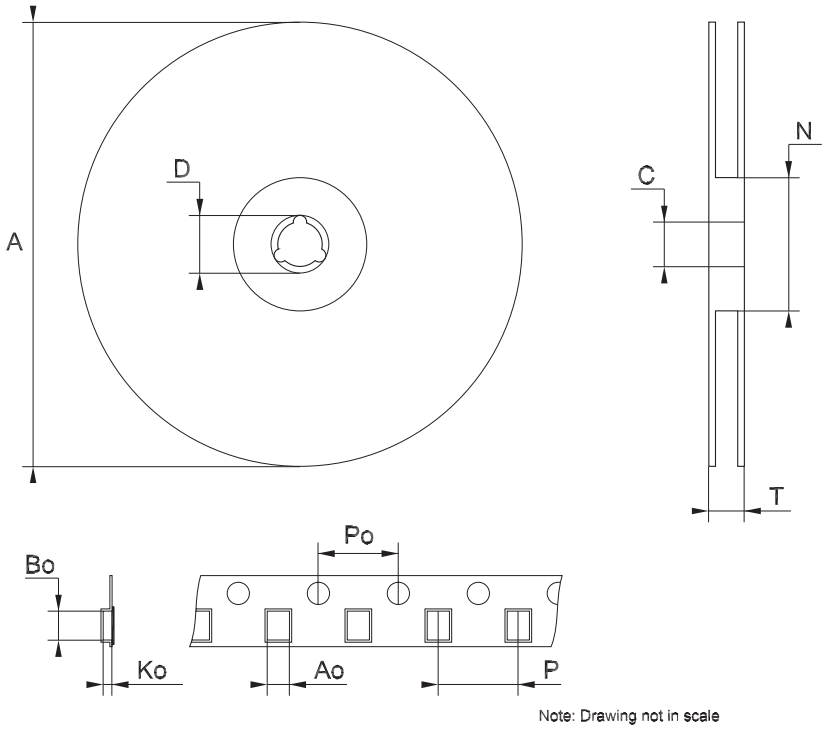


Figure 12. QFN64 9 x 9 x 1.0 mm 64 tape and reel information

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			330			12.992
C	12.8		13.2	0.504		0.519
D	20.2			0.795		
N	60			2.362		
T			30.4			1.196
Ao	12.25		12.45	0482		0.490
Bo	12.25		12.45	0482		0.490
Ko	2.1		2.3	0.083		0.091
Po	3.9		4.1	0.153		0.161
P	15.9		16.1	0.626		0.639



10 Revision history

Table 14. Document revision history

Date	Revision	Changes
20-Jan-2010	1	Initial release
17-Feb-2010	2	Updated typo on coverpage

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