

---

## 4-Ch. 5-Level $\pm 80V$ High-Voltage Ultrasound Pulser with T/R Switches

---

### Features

- Power Sequencing Free 5 Output Levels including RTZ (Return-to-Zero)
- -44 dB Single-Cycle Pulse-Inversion Second Harmonic Distortion (HD2) at 5 MHz
- Output Voltage up to  $\pm 80V$
- $\pm 2.5A$  Peak Output Current
- $\pm 300$  mA Current from  $V_{PP1}/V_{NN1}$  in CW Mode-0
- Integrated T/R Switch & RX Damper Switch
- Bleeder Switches Achieve True Zero during RTZ
- Supports Both Transparent and Re-Timing Mode
- Re-Timing Clock Frequency Supports up to 220 MHz
- Built-In Output Protection Diodes and Clamp Diodes
- +2.5/+3.3V Input Logic
- Built-In CW Switches to Pair with External CW Transmitters (CW Mode-1)
- 9 mm x 9 mm 64-Lead VQFN Package

### Applications

- Medical Ultrasound Imaging Systems
- NDT Ultrasound
- Piezoelectric or Capacitive Transducer Drivers

### General Description

The HV7321 is a 4-channel, 5-level, ultrasound transmitter with built-in T/R switches, output protection diodes and clamp diodes. The HV7321 can provide up to  $\pm 2.5A$  and the output voltage swing can be up to  $\pm 80V$ . The HV7321 supports both Transparent and Re-Timing mode. The re-timing clock frequency can support up to 220 MHz. The re-timing feature helps reduce the output jitter introduced by the driving the field-programmable gate array (FPGA).

The HV7321 has two different modes for CW transmission, CW-Mode 0 and CW-Mode 1.

In CW-Mode 0 (Mode = 0, PWS = 0), the  $V_{PP1}$  and  $V_{NN1}$  rails are used for CW transmission. The output current is reduced in CW Mode-0.

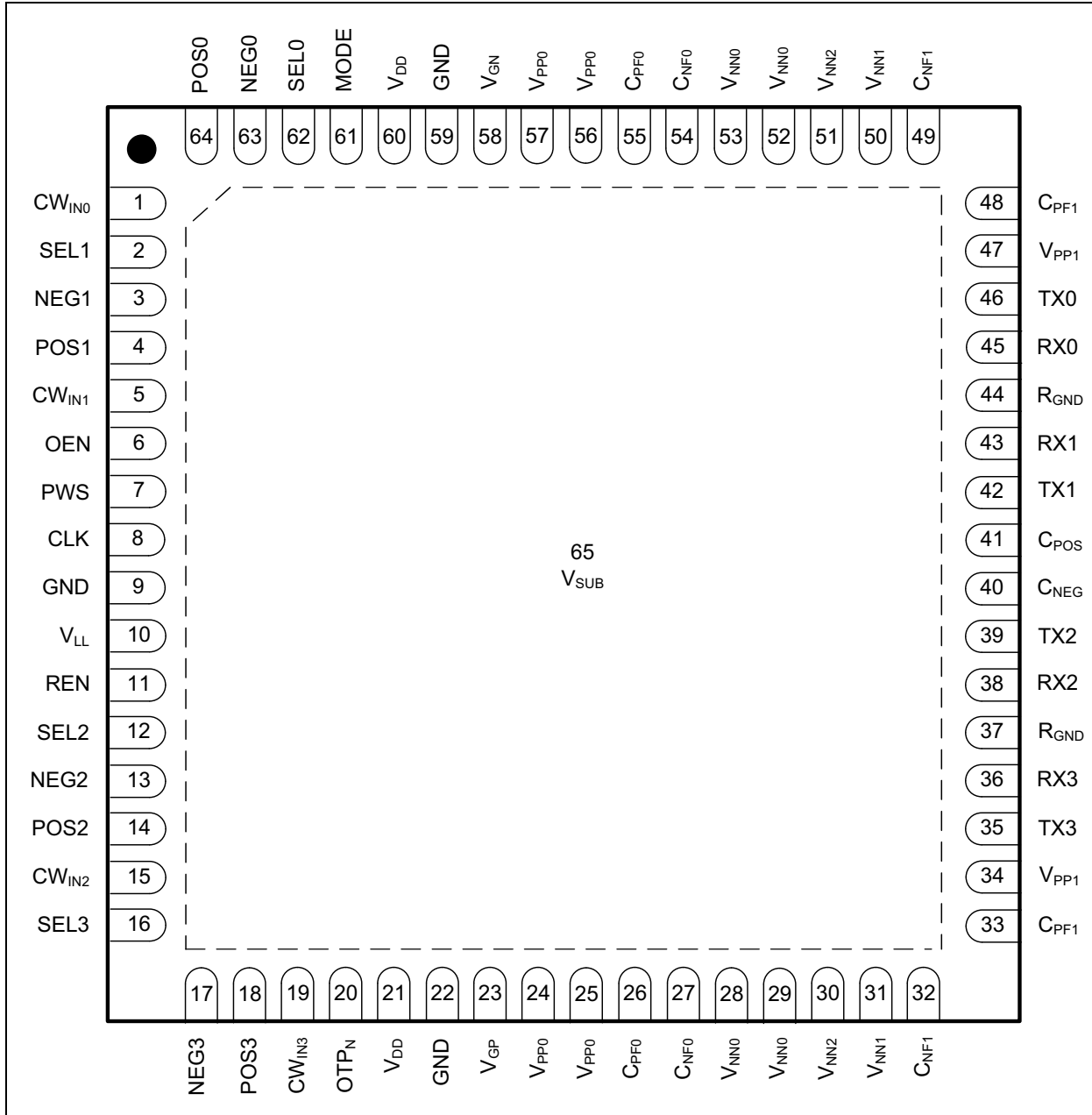
In CW-Mode 1, the HV7321 accepts the output of an external CW beamformer as CW source.

The HV7321 is LVCMOS 2.5V/3.3V input compatible, which can be interfaced with the FPGA directly.

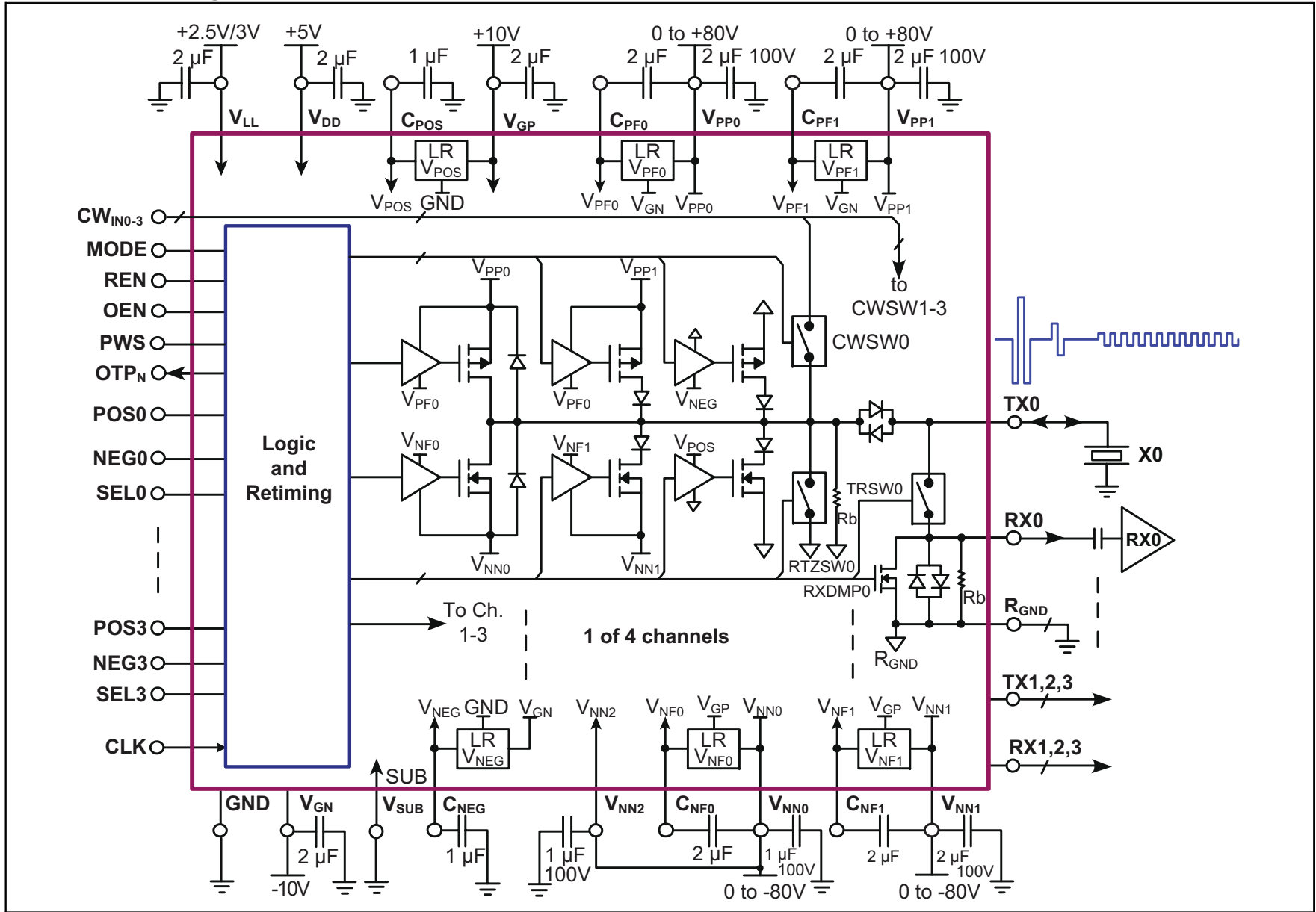
The HV7321 is available in a 9 mm x 9 mm 64-Lead VQFN package.

# HV7321

## Package Types

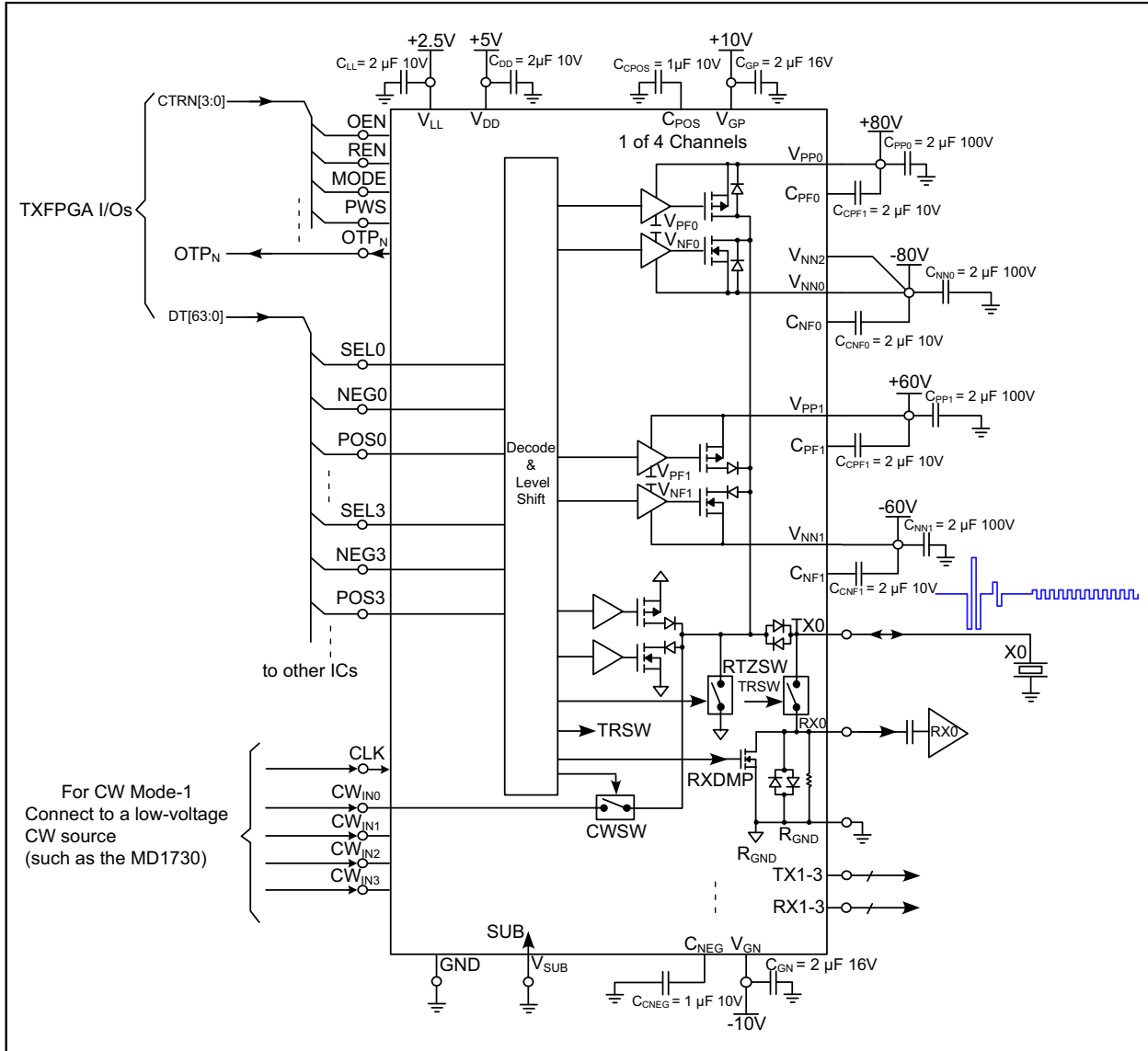


### HV7321 – Block Diagram



# HV7321

## HV7321 – Typical Application Circuit



## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

Positive logic supply ( $V_{LL}$ ).....	-0.5V to +5.5V
All I/O & CLK pin voltage ( $V_{IO}$ ).....	-0.5V to +5.5V
Positive voltage supply ( $V_{DD}$ ).....	-0.5V to +5.5V
Positive gate driver supply ( $V_{GP}$ ).....	-0.5V to +13.5V
Negative gate driver supply ( $V_{GN}$ ).....	-13.5V to +0.5V
High voltage positive supply ( $V_{PP0,1}$ ).....	-1.0V to +85V
High voltage negative supply ( $V_{NN0,1,2}$ ).....	-85V to +1.0V
CW input voltage ( $V_{CWIN}$ ).....	-7.5V to +7.5V
TX pin voltage ( $V_{TX}$ ).....	-85V to +85V
RX pin to GND voltage ( $V_{RX}$ ).....	$\pm 0.7$ to $\pm 1.4$ V
Operating temperature.....	0°C to +85°C
Storage temperature.....	-55°C to +150°C
Maximum junction temperature.....	+130°C
Maximum not-latch-up current.....	+100 mA
ESD Rating $CW_{IN,TX}$ , $V_{PP}$ , $V_{NN}$ pins.....	$\pm 500$ V
ESD Rating – all other pins.....	$\pm 2$ kV

† **Notice:** Stresses above those listed under “Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

### ELECTRICAL CHARACTERISTICS

**Electrical specifications:**  $V_{LL} = +2.5$ V,  $V_{DD} = +5.0$ V,  $V_{PP0,1} = +80$ V,  $V_{NN0,1,2} = -80$ V,  $V_{GP} = +10$ V,  $V_{GN} = -10$ V,  $V_{SUB} = 0$ V,  $PWS = OEN = REN = 1$ ,  $T_A = 25^\circ$ C, unless otherwise specified. Parameters in **Bold** apply over the operating temperature range of  $T_A = T_J = 0$  to **+85°C**.

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
<b>Operating Supply Voltages</b>						
Positive Logic Supply	$V_{LL}$	<b>2.25</b>	2.50	<b>3.60</b>	V	<b>Note 1</b>
Positive Voltage Supply	$V_{DD}$	<b>4.75</b>	5.0	<b>5.25</b>	V	<b>Note 1</b>
Positive Gate Driver Supply	$V_{GP}$	<b>8.0</b>	10	<b>12</b>	V	<b>Note 1</b> See <a href="#">Table 3-1</a> .
Negative Gate Driver Supply	$V_{GN}$	<b>-12</b>	-10	<b>-8.0</b>		
High Voltage Positive Supply	$V_{PP0}$	<b>0</b>	—	<b>80</b>	V	<b>Note 1</b> Must be $V_{PP0} \geq V_{PP1}$
	$V_{PP1}$	<b>0</b>	—	<b>80</b>		
High Voltage Negative Supply	$V_{NN0}$	<b>-80</b>	—	<b>0</b>	V	<b>Note 1</b> Must be $V_{NN0} \leq V_{NN1}$
	$V_{NN1}$	<b>-80</b>	—	<b>0</b>		
<b>Operating Supply Current</b>						
$V_{LL}$ Quiescent Current	$I_{LLQ}$	—	0.06	0.7	$\mu$ A	OEN = REN = 0
$V_{DD}$ Quiescent Current	$I_{DDQ}$	—	30	80	$\mu$ A	
$V_{PP0}$ Quiescent Current	$I_{PP0Q}$	—	0.37	6	$\mu$ A	
$V_{NN0}$ Quiescent Current	$I_{NN0Q}$	-9	-0.78	—	$\mu$ A	
$V_{PP1}$ Quiescent Current	$I_{PP1Q}$	—	0.44	10	$\mu$ A	
$V_{NN1}$ Quiescent Current	$I_{NN1Q}$	-10	-1.46	—	$\mu$ A	
$V_{NN2}$ Quiescent Current	$I_{NN2Q}$	-7	-3.84	—	$\mu$ A	

**Note 1:** Characterized only; not 100% tested in production.

**2:** Design guidance only.

# HV7321

## ELECTRICAL CHARACTERISTICS (CONTINUED)

**Electrical specifications:**  $V_{LL} = +2.5V$ ,  $V_{DD} = +5.0V$ ,  $V_{PP0,1} = +80V$ ,  $V_{NN0,1,2} = -80V$ ,  $V_{GP} = +10V$ ,  $V_{GN} = -10V$ ,  $V_{SUB} = 0V$ ,  $PWS = OEN = REN = 1$ ,  $T_A = 25^\circ C$ , unless otherwise specified. Parameters in **Bold** apply over the operating temperature range of  $T_A = T_J = 0$  to  $+85^\circ C$ .

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions	
$V_{DD}$ Current	$I_{DDEEN}$	—	0.9	1.0	mA	$f = 0$ MHz $f_{CLK} = 0$ MHz MODE = 0 or 1	
$V_{PP0}$ Current	$I_{PP0EN}$	—	0.1	0.13	mA		
$V_{NN0}$ Current	$I_{NN0EN}$	-0.12	-0.1	—	mA		
$V_{PP1}$ Current	$I_{PP1EN}$	—	0.1	0.13	mA		
$V_{NN1}$ Current	$I_{NN1EN}$	-0.12	-0.1	—	mA		
$V_{NN2}$ Current	$I_{NN2EN}$	-0.05	-0.03	—	mA		
$V_{LL}$ Current with Re-Timing	$I_{LLRT}$	—	0.11	0.3	mA	$f_{CLK} = 80$ MHz	
$V_{DD}$ Current with Re-Timing	$I_{DDRT}$	—	7.08	8	mA	TX one-channel output, no load, continuous, <b>Note 1</b>	
$V_{LL}$ Max. Current of SEL = 0/1	$I_{LL5}$	—	23	40	$\mu A$	CLK = 0 PWS = 1 MODE = 0 $I_{PP05}/I_{NN05}$ and $I_{PP15}/I_{NN15}$ are calculated using TX one channel output continuous, no load, at 5 MHz.	
$V_{DD}$ Max. Current of SEL = 0/1	$I_{DD5}$	—	1.5	1.7	mA		
$V_{GP}$ Max. Current of SEL = 0/1	$I_{GP5}$	—	2.6	4	mA		
$V_{GN}$ Max. Current of SEL = 0/1	$I_{GN5}$	-14	-9	—	mA		
$V_{PP0}$ Current of SEL = 0 <sup>(1)</sup>	$I_{PP05}$	—	136	146	mA		
$V_{NN0}$ Current of SEL = 0 <sup>(1)</sup>	$I_{NN05}$	-132	-125	—	mA		
$V_{PP1}$ Current of SEL = 1 <sup>(1)</sup>	$I_{PP15}$	—	148	158	mA		
$V_{NN1}$ Current of SEL = 1 <sup>(1)</sup>	$I_{NN15}$	-150	-143	—	mA		
$V_{GP}$ Current of SEL = 1	$I_{GPCW}$	—	1.0	2.0	mA		TX one-channel output 5 MHz, continuous, no load
$V_{GN}$ Current of SEL = 1	$I_{GNCW}$	-8.0	-5.0	—	mA		$V_{PP1}/V_{NN1} = \pm 5V$ PWS = MODE = 0 CW Mode-0, <b>Note 1</b>
$V_{PP1}$ Current of SEL = 1	$I_{PP1CW}$	—	17	26	mA		
$V_{NN1}$ Current of SEL = 1	$I_{NN1CW}$	-20	-15	—	mA		
<b>CWSW High-Voltage Analog Switch</b>							
CWSW Switch Input Voltage	$V_{CWIN0-3}$	-7.0	—	+7.0	V		
CWSW Analog Switch On-Resistance <sup>(1)</sup>	$R_{CWSW}$	—	26.5	35	$\Omega$	$I_{CWSW} = \pm 100$ mA	
TRSW Off Withstand Voltage	$V_{CWSW}$	-80	—	+80	V	$I_{SW} = \pm 1.0$ $\mu A$	
CWSW Off Capacitance to GND	$C_{CWSW}$	—	5.0	—	pF	MODE = 1, 1 MHz, 0 dBm, DC 0V, <b>Note 1</b>	
CWSW On Capacitance to GND		—	60	—			
CWSW Switching On Time	$t_{CWSW}$	—	800	1100	ns	50% MODE rise to CWSW on/off <b>Note 1</b>	
CWSW Switching Off Time		—	66	90			
<b>TX Output P-Channel MOSFET on <math>V_{PP0}</math></b>							
On-Resistance	$R_{ON\_P0}$	—	8.5	19	$\Omega$	$I_{SD} = 100$ mA	
Peak Output Current	$I_{OUT\_P0}$	1	1.5	—	A	$V_{PP0} = +25V$ , $R_L = 1.0\Omega$ to GND <b>Note 1</b>	
		2.0	2.8	—	A	$V_{PP0} = +80V$ , $R_L = 1.0\Omega$ to GND <b>Note 1</b>	

**Note 1:** Characterized only; not 100% tested in production.

**Note 2:** Design guidance only.

## ELECTRICAL CHARACTERISTICS (CONTINUED)

**Electrical specifications:**  $V_{LL} = +2.5V$ ,  $V_{DD} = +5.0V$ ,  $V_{PP0,1} = +80V$ ,  $V_{NN0,1,2} = -80V$ ,  $V_{GP} = +10V$ ,  $V_{GN} = -10V$ ,  $V_{SUB} = 0V$ ,  $PWS = OEN = REN = 1$ ,  $T_A = 25^\circ C$ , unless otherwise specified. Parameters in **Bold** apply over the operating temperature range of  $T_A = T_J = 0$  to  $+85^\circ C$ .

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
<b>TX Output P-Channel MOSFET on <math>V_{PP1}</math></b>						
On-Resistance at PWS = 1	$R_{ON\_P1}$	—	16	21	$\Omega$	$I_{SD} = 100$ mA
On-Resistance at PWS = 0		—	33	43		
Peak Output Current at PWS = 1 <sup>(1)</sup>	$I_{OUT\_P1}$	0.8	1.0	—	A	$V_{PP0,1} = +25V$ , $R_L = 1.0\Omega$ to GND
Peak Output Current at PWS = 0 <sup>(1)</sup>		1.5	1.75	—		$V_{PP0,1} = +80V$ , $R_L = 1.0\Omega$ to GND
		0.4	0.5	—		$V_{PP0,1} = +25V$ , $R_L = 1.0\Omega$ to GND
		0.8	0.95	—		$V_{PP0,1} = +80V$ , $R_L = 1.0\Omega$ to GND
<b>TX Output N-Channel MOSFET on <math>V_{NN0}</math></b>						
On-Resistance	$R_{ON\_N0}$	—	8	10	$\Omega$	$I_{SD} = 100$ mA
Peak Output Current <sup>(1)</sup>	$I_{OUT\_N0}$	-1.4	-1.7	—	A	$V_{NN0} = -25V$ , $R_L = 1.0\Omega$ to GND
		-2.0	-2.3	—	A	$V_{NN0} = -80V$ , $R_L = 1.0\Omega$ to GND
<b>TX Output N-Channel MOSFET on <math>V_{NN1}</math></b>						
On-Resistance at PWS = 1	$R_{ON\_N1}$	—	11	13	$\Omega$	$I_{SD} = 100$ mA
On-Resistance at PWS = 0		—	36	45		
Peak Output Current at PWS = 1 <sup>(1)</sup>	$I_{OUT\_N1}$	—	-1.2	-1.0	A	$V_{NN0,1} = -25V$ , $R_L = 1.0\Omega$ to GND
Peak Output Current at PWS = 0 <sup>(1)</sup>		—	-1.6	-1.3		$V_{NN0,1} = -80V$ , $R_L = 1.0\Omega$ to GND
		—	-0.4	-0.3		$V_{NN0,1} = -25V$ , $R_L = 1.0\Omega$ to GND
		—	-0.55	-0.4		$V_{NN0,1} = -80V$ , $R_L = 1.0\Omega$ to GND
<b>TX Damping P-Channel MOSFET on GND</b>						
On-Resistance	$R_{ON\_PDMP}$	—	7.0	16	$\Omega$	$I_{SD} = 100$ mA
Peak Output Current <sup>(1)</sup>	$I_{OUT\_PDMP}$	2.3	2.7	—	A	$R_L = 1.0\Omega$ from -25V to TX
		2.3	2.8	—	A	$R_L = 1.0\Omega$ from -80V to TX
<b>TX Damping N-Channel MOSFET on GND</b>						
On-Resistance	$R_{ON\_NDMP}$	—	7.0	16	$\Omega$	$I_{SD} = 100$ mA
Peak Output Current <sup>(1)</sup>	$I_{OUT\_NDMP}$	—	-2.0	-1.8	A	$R_L = 1.0\Omega$ from +25V to TX
		—	-2.3	-2.0	A	$R_L = 1.0\Omega$ from +80V to TX
<b>RTZSW Auto Bleed High-Voltage Analog Switch</b>						
RTZSW On-Resistance <sup>(1)</sup>	$R_{RTZSW}$	—	238	270	$\Omega$	$I_{SD} = \pm 1.0$ mA
RTZSW Off Withstand Voltage <sup>(1)</sup>	$V_{RTZSW}$	-80	—	+80	V	$I_{SW} = \pm 100$ $\mu$ A
<b>TX OUTPUT Isolation Diodes and Bleed Resistor</b>						
Diode Forward Voltage	$V_F$	—	0.96	1.9	V	$I_{FM} = 300$ mA, <b>Note 1</b>
Forward Continuous Current	$I_{FM}$	—	300	—	mA	<b>Note 2</b>
Peak Forward Pulse Current	$I_{FSM}$	—	3.0	—	A	PW = 50 ns, <b>Note 2</b>
Total Capacitance of 2-diode	$C_T$	—	3.5	—	pF	at 1 MHz, 1 dBm, 0V DC, <b>Note 2</b>
TX/RX Bleed Resistor to GND	$R_b$	11	15	20	k $\Omega$	<b>Note 1</b>

**Note 1:** Characterized only; not 100% tested in production.

**Note 2:** Design guidance only.

# HV7321

## ELECTRICAL CHARACTERISTICS (CONTINUED)

**Electrical specifications:**  $V_{LL} = +2.5V$ ,  $V_{DD} = +5.0V$ ,  $V_{PP0,1} = +80V$ ,  $V_{NN0,1,2} = -80V$ ,  $V_{GP} = +10V$ ,  $V_{GN} = -10V$ ,  $V_{SUB} = 0V$ ,  $PWS = OEN = REN = 1$ ,  $T_A = 25^\circ C$ , unless otherwise specified. Parameters in **Bold** apply over the operating temperature range of  $T_A = T_J = 0$  to  $+85^\circ C$ .

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
<b>TRSW and RXDMP Switches</b>						
TRSW Analog Switch On-Resistor	$R_{TRSW}$	—	18	22	$\Omega$	$I_{TRSW} = \pm 1.0$ mA <b>Note 1</b>
TRSW Off Withstand Voltage	$V_{TRSW}$	-80	—	+80	V	$I_{SW} = \pm 100$ $\mu$ A, <b>Note 1</b>
RX to GND Protection Diode	$V_F$	—	1.5	2.2	V	$I_F = \pm 100$ mA, <b>Note 1</b>
RXDMP Switch On-Resistance	$R_{RXDMP}$	—	17	21	$\Omega$	$I_{SD} = \pm 1.0$ mA, <b>Note 1</b>
RX Pin to GND Capacitance	$C_{RXG}$	—	—	7.0	pF	1 MHz, 1 dBm, 0V DC, <b>Note 2</b>
<b>Built-In Gate Drive Voltage Linear Regulators</b>						
Output P-Channel Gate Drive Voltage Referenced to $V_{PP0}$	$V_{PF0}$	-5.2	-4.6	-3.8	V	$V_{GN} - V_{PP0} < -10V$
Output P-Channel Gate Drive Voltage Referenced to $V_{PP1}$	$V_{PF1}$	-5.2	-4.6	-3.8	V	$V_{GN} - V_{PP1} < -10V$
Output N-Channel Gate Drive Voltage Referenced to $V_{NN0}$	$V_{NF0}$	3.3	4.2	5.2	V	$V_{GP} - V_{NN0} > 10V$
Output N-Channel Gate Drive Voltage Referenced to $V_{NN1}$	$V_{NF1}$	3.3	4.2	5.2	V	$V_{GP} - V_{NN1} > 10V$
Output N-Channel Gate Drive Voltage Referenced to GND	$V_{POS}$	3.2	4.2	5.2	V	
Output P-Channel Gate Drive Voltage Referenced to GND	$V_{NEG}$	-5.2	-4.5	-3.8	V	
Dropout Voltage of ( $V_{PP0} - V_{GN}$ )	$V_{DOPF0}$	-2.9	-2.6	-2.4	V	
Dropout Voltage of ( $V_{PP1} - V_{GN}$ )	$V_{DOPF1}$	-2.9	-2.6	-2.4	V	
Dropout Voltage of ( $V_{GP} - V_{NN0}$ )	$V_{DONF0}$	3.0	3.3	3.6	V	
Dropout Voltage of ( $V_{GP} - V_{NN1}$ )	$V_{DONF1}$	3.0	3.3	3.6	V	
Dropout Voltage of ( $V_{NEG} - V_{GN}$ )	$V_{DONEG}$	2.9	3.3	3.5	V	
Dropout Voltage of ( $V_{GP} - V_{POS}$ )	$V_{DOPOS}$	-2.8	-2.6	-2.4	V	
<b>Logic &amp; Clock Input Characteristics</b>						
Input Logic Low Voltage	$V_{IL}$	0	—	$0.2 V_{LL}$	V	
Input Logic High Voltage	$V_{IH}$	$0.8 V_{LL}$	—	$V_{LL}$	V	
Input Logic Low Current	$I_{IL}$	-1.0	—	—	$\mu$ A	<b>Note 1</b>
Input Logic High Current	$I_{IH}$	—	—	1.0	$\mu$ A	<b>Note 1</b>
Input Capacitance	$C_{IN}$	—	2.0	3.0	pF	<b>Note 2</b>
OEN Switching On Time	$t_{OEN}$	—	200	—	$\mu$ s	50% OEN rise to TX ready, <b>Note 2</b>
OEN Switching Off Time		—	20	—	ns	50% OEN fall to TX all output FETs on HV rails are off, <b>Note 1</b>
<b>Thermal protection <math>OTP_N</math> &amp; UVLO</b>						
$OTP_N$ Output Max. Pull-Up	$V_{OH}$	—	—	5.25	V	
$OTP_N$ Output Low Max. Voltage	$V_{OL}$	—	—	0.1	V	at 100 $\mu$ A
		—	—	0.4	V	at 4.0 mA
$OTP_N$ Output High Current	$I_{OFF}$	—	—	15	$\mu$ A	$25^\circ C$ , at 5.25V pull-up, <b>Note 1</b>

**Note 1:** Characterized only; not 100% tested in production.

**2:** Design guidance only.



## ELECTRICAL CHARACTERISTICS (CONTINUED)

**Electrical specifications:**  $V_{LL} = +2.5V$ ,  $V_{DD} = +5.0V$ ,  $V_{PP0,1} = +80V$ ,  $V_{NNO,1,2} = -80V$ ,  $V_{GP} = +10V$ ,  $V_{GN} = -10V$ ,  $V_{SUB} = 0V$ ,  $PWS = OEN = REN = 1$ ,  $T_A = 25^\circ C$ , unless otherwise specified. Parameters in **Bold** apply over the operating temperature range of  $T_A = T_J = 0$  to  $+85^\circ C$ .

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions	
Thermal Shutdown Trip Point	$T_{TRIP}$	125	138	160	$^\circ C$	$OTP_N = LO$ when thermal shut-down occurs, <b>Note 1</b>	
Thermal Shutdown Hysteresis	$T_{HYS}$	—	38	—	$^\circ C$		
$V_{DD}$ OK On Voltage	$V_{DDUVON}$	3.45	3.7	4.05	V	<b>Note 1</b>	
$V_{DD}$ UVLO Trip Voltage	$V_{DDUVOFF}$	3.05	3.4	3.85			
$V_{LL}$ OK On Voltage	$V_{LLUVON}$	1.59	1.7	1.81			
$V_{LL}$ UVLO Trip Voltage	$V_{LLUVOFF}$	1.39	1.6	1.71			
<b>TX Output HD2 &amp; Timing Characteristics</b>							
Second Harmonic Distortion	HD2	—	-44	-40	dB	$V_{PP0}/V_{NNO} = \pm 70V$ launched in 100 $\mu s$ apart, with load of 220 pF//1k (Second Harmonic Distortion). HD2, single-cycle inverting 5.0 MHz <b>Note 1</b>	
Output Rise Time from 0V to $V_{PP0}$	$t_{r1}$	—	10	12	ns		
Output Fall Time from 0V to $V_{NNO}$	$t_{f1}$	—	10	12			
Output Rise Time from $V_{NNO}$ to $V_{PP0}$	$t_{r2}$	—	17	19			
Output Fall Time from $V_{PP0}$ to $V_{NNO}$	$t_{f2}$	—	17	19			
Output Rise Time from $V_{NNO}$ to 0V	$t_{r3}$	—	10	13.5			
Output Fall Time from $V_{PP0}$ to 0V	$t_{f3}$	—	10	13.5			
Propagation Delay Rise Time 1	$t_{dr1}$	—	16	18	ns		All these $t_r, t_f, t_d$ values, at $V_{PP0,1}/V_{NNO,1} = \pm 70V$ , 220 pF//1k <b>Note 1</b>
Propagation Delay Fall Time 1	$t_{df1}$	—	16	18			
Propagation Delay Rise Time 2	$t_{dr2}$	—	17.5	19			
Propagation Delay Fall Time 2	$t_{df2}$	—	17.5	19			
Propagation Delay Rise Time 3	$t_{dr3}$	—	14	16			
Propagation Delay Fall Time 3	$t_{df3}$	—	14	16			
Output Rise Time from 0V to $V_{PP1}$	$t_{r4}$	—	15	17	ns	All these $t_r, t_f, t_d$ values at $V_{PP0,1}/V_{NNO,1} = \pm 70V$ , 220 pF//1k <b>Note 1</b>	
Output Fall Time from 0V to $V_{NN1}$	$t_{f4}$	—	15	17			
Output Rise Time from $V_{NN1}$ to $V_{PP1}$	$t_{r5}$	—	24	27			
Output Fall Time from $V_{PP1}$ to $V_{NN1}$	$t_{f5}$	—	24	27			
Output Rise Time from $V_{NN1}$ to 0V	$t_{r6}$	—	10	13			
Output Fall Time from $V_{PP1}$ to 0V	$t_{f6}$	—	10	13			
Propagation Delay Rise Time 4	$t_{dr4}$	—	15	17	ns		
Propagation Delay Fall Time 4	$t_{df4}$	—	15	17			
Propagation Delay Rise Time 5	$t_{dr5}$	—	16	18			
Propagation Delay Fall Time 5	$t_{df5}$	—	16	18			
Propagation Delay Rise Time 6	$t_{dr6}$	—	15	17			
Propagation Delay Fall Time 6	$t_{df6}$	—	15	17			
Delay Time Matching with SEL = L	$\Delta t_{d1}$	—	1.5	2.0	ns	P to N, ch.-to-ch. matching in IC, typ. at $V_{PP0,1}/V_{NNO,1,2} = \pm 70V$ , 220 pF//1k, <b>Note 1</b>	
Delay Time Matching with SEL = H	$\Delta t_{d2}$	—	1.5	2.0	ns		

**Note 1:** Characterized only; not 100% tested in production.

**2:** Design guidance only.

# HV7321

## ELECTRICAL CHARACTERISTICS (CONTINUED)

**Electrical specifications:**  $V_{LL} = +2.5V$ ,  $V_{DD} = +5.0V$ ,  $V_{PP0,1} = +80V$ ,  $V_{NN0,1,2} = -80V$ ,  $V_{GP} = +10V$ ,  $V_{GN} = -10V$ ,  $V_{SUB} = 0V$ ,  $PWS = OEN = REN = 1$ ,  $T_A = 25^\circ C$ , unless otherwise specified. Parameters in **Bold** apply over the operating temperature range of  $T_A = T_J = 0$  to **+85°C**.

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
TRSW Switch On Delay Time	$t_{TRSW}$	130	180	230	ns	From POS = 0 & NEG = 0, <b>Note 1</b>
TRSW Switch Off Delay Time		8	12	16	ns	From POS = 1 or NEG = 1, <b>Note 1</b>
RTZSW Switch On Delay Time	$t_{RTZSW}$	130	180	240	ns	From POS = 0 & NEG = 0, <b>Note 1</b>
RTZSW Switch Off Delay Time		11	21	31	ns	From POS = 1 or NEG = 1, <b>Note 1</b>
RXDMP Damp Switch On Delay Time	$t_{RXDMP}$	3	10	15	ns	From POS = 1 or NEG = 1, <b>Note 1</b>
RXDMP Damp Switch Off Delay Time		0.55	1.4	2.35	us	From POS = 0 & NEG = 0, <b>Note 1</b>
PWS = 0 to 1 Mode Change Time	$t_{MC}$	—	220	—	ns	<b>Note 2</b>
Output Max. Frequency Range	$f_{OUT}$	—	20	—	MHz	100Ω resistor load, <b>Note 2</b>
Re-Timing Clock Frequency	$f_{CLK}$	10	—	220	MHz	<b>Note 2</b>
Re-Timing Clock Rise & Fall Times	$t_{RC}, t_{FC}$	—	0.5	5.0	ns	<b>Note 2</b>
Set-Up Time, POS/NEG to CLK	$t_{SU}$	2.0	—	—	ns	<b>Note 2</b>
Hold Time, CLK to POS/NEG	$t_H$	1.0	—	—	ns	<b>Note 2</b>
Clock Time Low <sup>(2)</sup>	$t_{CLK\_LO}$	2.0	—	100	ns	CLK input must be activated before POS and NEG inputs are high. CLK input must be deactivated after POS and NEG inputs are low.
Clock Time High <sup>(2)</sup>	$t_{CLK\_HI}$	2.0	—	100		
Clock Recognition Time <sup>(1)</sup>	$t_{CLK\_REC}$	—	2.0	—		
Clock Release Time <sup>(1)</sup>	$t_{CLK\_RLS}$	150	330	500		

**Note 1:** Characterized only; not 100% tested in production.

**2:** Design guidance only.

## TEMPERATURE CHARACTERISTICS

Unless otherwise indicated, all parameters apply with  $V_{LL} = +2.5V$ ,  $V_{DD} = +5.0V$ ,  $V_{PP0,1} = +80V$ ,  $V_{NN0,1,2} = -80V$ ,  $V_{GP} = +10V$ ,  $V_{GN} = -10V$ ,  $V_{SUB} = 0V$ ,  $OEN = REN = 1$

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
<b>Temperature Ranges</b>						
Operating Ambient Temperature Range	$T_{OA}$	0	—	+85	°C	
Storage Temperature Range	$T_{ST}$	-55	—	+150	°C	
Maximum Junction Temperature	$T_J$	—	—	+130	°C	
Total Power Dissipation	PD	—	3.0	—	W	
<b>Thermal Package Resistances (64LD 9 mm x 9 mm VQFN)</b>						
Junction-to-Ambient Thermal Resistance	$\theta_{JA}$	—	16.3	—	°C/W	JEDEC (2S2P) 4L PCB 114.3 mm x 76.2 mm x 1.6 mm $T_A = 85^\circ C$
Junction-to-Board Thermal Resistance	$\theta_{JB}$	—	2.55	—	°C/W	JEDEC (2S2P) 4L PCB 114.3 mm x 76.2 mm x 1.6 mm $T_A = 85^\circ C$
Junction-to-Case Top Thermal Resistance	$\theta_{JC}$	—	0.2	—	°C/W	JEDEC (2S2P) 4L PCB 114.3 mm x 76.2 mm x 1.6 mm $T_A = 85^\circ C$

**TABLE 1-1: INPUT OUTPUT LOGIC TRUTH TABLE (TRANSPARENT, CLK = 0)**

Function	OTPN	Logic Inputs							TX Output	RTZSW & TRSW	CWSW	RXDMP
		OEN	MODE	PWS	CLK	SEL	NEG	POS				
Pulsed-Echo Mode <sup>(1)</sup>	1	1	0	1	0	0	0	0	RTZ	OFF	OFF	ON
	1	1	0	1	0	0	0	1	V <sub>PP0</sub>	OFF	OFF	ON
	1	1	0	1	0	0	1	0	V <sub>NN0</sub>	OFF	OFF	ON
	1	1	0	1	0	0	1	1	RTZ+ <sup>(4)</sup>	ON	OFF	OFF
	1	1	0	1	0	1	0	0	RTZ	OFF	OFF	ON
	1	1	0	1	0	1	0	1	V <sub>PP1</sub>	OFF	OFF	ON
	1	1	0	1	0	1	1	0	V <sub>NN1</sub>	OFF	OFF	ON
	1	1	0	1	0	1	1	1	high Z	OFF	OFF	ON
CW Mode-0 <sup>(2)</sup>	1	1	0	0	0	0	0	0	RTZ	OFF	OFF	ON
	1	1	0	0	0	0	0	1	V <sub>PP0</sub>	OFF	OFF	ON
	1	1	0	0	0	0	1	0	V <sub>NN0</sub>	OFF	OFF	ON
	1	1	0	0	0	0	1	1	RTZ+ <sup>(4)</sup>	ON	OFF	OFF
	1	1	0	0	0	1	0	0	RTZ	OFF	OFF	ON
	1	1	0	0	0	1	0	1	V <sub>PP1</sub>	OFF	OFF	ON
	1	1	0	0	0	1	1	0	V <sub>NN1</sub>	OFF	OFF	ON
	1	1	0	0	0	1	1	1	high Z	OFF	OFF	ON
CW Mode-1 <sup>(3)</sup>	1	1	1	x	x	other than 011			high Z	OFF	ON	ON
						0	1	1	RTZ+ <sup>(4)</sup>	ON	OFF	OFF
Device Disabled	x	0	x	x	x	x	x	x	high Z	OFF	OFF	ON
Thermal Protection Activated	0	x	x	x	x	x	x	x	high Z	OFF	OFF	ON

- Note**
- 1: In Pulsed-Echo mode, low duty cycle must be used due to the IC power dissipation limit.
  - 2: When PWS = 0, V<sub>PP1</sub>/V<sub>NN1</sub> output current is reduced for low-voltage CW mode-0. V<sub>PP0</sub>/V<sub>NN0</sub> output current is unaffected when PWS = 1, as in Pulsed-Echo mode.
  - 3: In CW MODE = 1, the CWSW is turned on to use external CW waveform at CW<sub>IN</sub>, if the channel SEL = NEG = POS = 0.
  - 4: When SEL = 0, NEG = 1, POS = 1, the channel is in Receiving mode (RTZ+).

# HV7321

**TABLE 1-2: INPUT OUTPUT LOGIC TRUTH TABLE (WITH CLK RE-TIMING, CLK ≥ 10MHZ)**

Function	OTP <sub>N</sub>	Logic Inputs							TX Output	RTZSW & TRSW	CWSW	RXDMP
		OEN	MODE	PWS	CLK	SEL	NEG	POS				
Pulsed-Echo Mode <sup>(1)</sup>	1	1	0	1	↑	0	0	0	RTZ	OFF	OFF	ON
	1	1	0	1	↑	0	0	1	V <sub>PP0</sub>	OFF	OFF	ON
	1	1	0	1	↑	0	1	0	V <sub>NN0</sub>	OFF	OFF	ON
	1	1	0	1	↑	0	1	1	RTZ+ <sup>(4)</sup>	ON	OFF	OFF
	1	1	0	1	↑	1	0	0	RTZ	OFF	OFF	ON
	1	1	0	1	↑	1	0	1	V <sub>PP1</sub>	OFF	OFF	ON
	1	1	0	1	↑	1	1	0	V <sub>NN1</sub>	OFF	OFF	ON
	1	1	0	1	↑	1	1	1	high Z	OFF	OFF	ON
CW Mode-0 <sup>(2)</sup>	1	1	0	0	↑	0	0	0	RTZ	OFF	OFF	ON
	1	1	0	0	↑	0	0	1	V <sub>PP0</sub>	OFF	OFF	ON
	1	1	0	0	↑	0	1	0	V <sub>NN0</sub>	OFF	OFF	ON
	1	1	0	0	↑	0	1	1	RTZ+ <sup>(4)</sup>	ON	OFF	OFF
	1	1	0	0	↑	1	0	0	RTZ	OFF	OFF	ON
	1	1	0	0	↑	1	0	1	V <sub>PP1</sub>	OFF	OFF	ON
	1	1	0	0	↑	1	1	0	V <sub>NN1</sub>	OFF	OFF	ON
	1	1	0	0	↑	1	1	1	high Z	OFF	OFF	ON
CW Mode-1 <sup>(3)</sup>	1	1	1	x	x	other than 011			high Z	OFF	ON	ON
						0	1	1	RTZ+ <sup>(4)</sup>	ON	OFF	OFF
Device Disabled	x	0	x	x	x	x	x	x	high Z	OFF	OFF	ON
Thermal Protection Activated	0	x	x	x	x	x	x	x	high Z	OFF	OFF	ON

**Note 1:** In Pulsed-Echo mode, low duty cycle must be used due to the IC power dissipation limit.  
**Note 2:** When PWS = 0, V<sub>PP1</sub>/V<sub>NN1</sub> output current is reduced for low-voltage CW mode-0. V<sub>PP0</sub>/V<sub>NN0</sub> output current is unaffected when PWS = 1, as in Pulsed-Echo mode.  
**Note 3:** In CW MODE = 1, the CWSW is turned on to use external CW waveform at CWIN, if the channel SEL = NEG = POS = 0.  
**Note 4:** When SEL = 0, NEG = 1, POS = 1, the channel is in Receiving mode (RTZ+).

## 1.1 TYPICAL TIMING DIAGRAMS

Figure 1-1 shows the timing of control inputs and RTZ, T/R and RXDMP switches per each channel of the HV7321.

Upon the completion of a receiving period, an RTZ period (SEL, NEG, POS = 000) should be asserted before transmitting again.

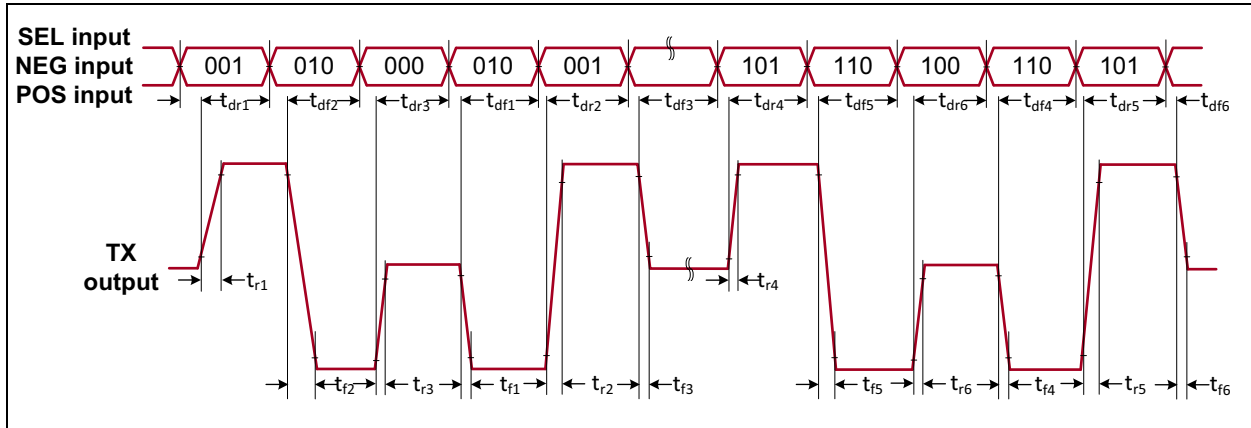


FIGURE 1-1: Logic Input Timing Diagram.

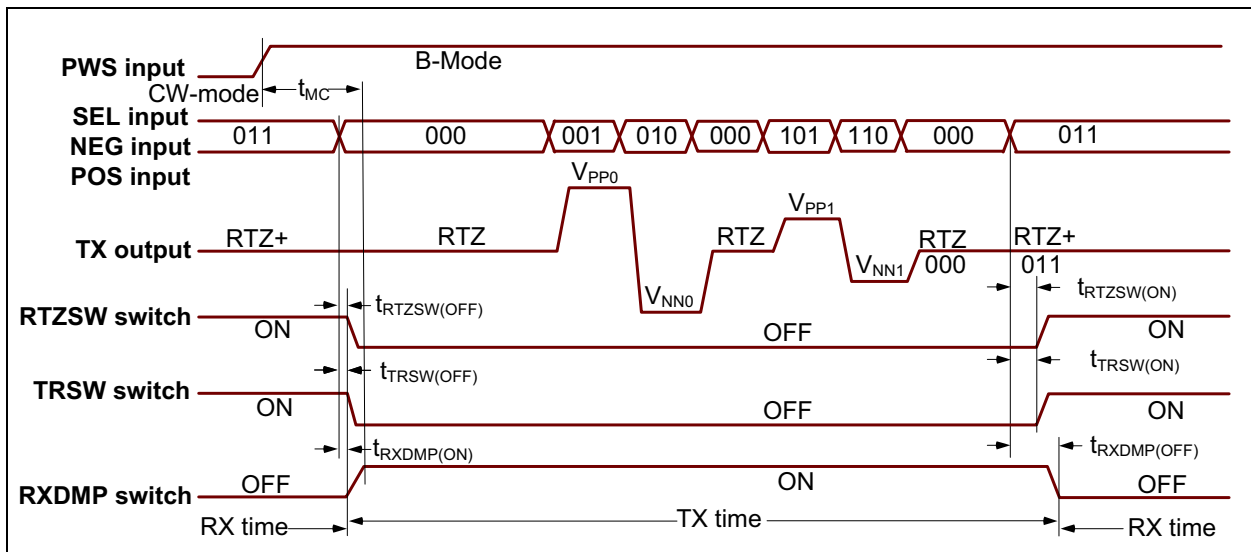


FIGURE 1-2: TX Output Timing Diagram.

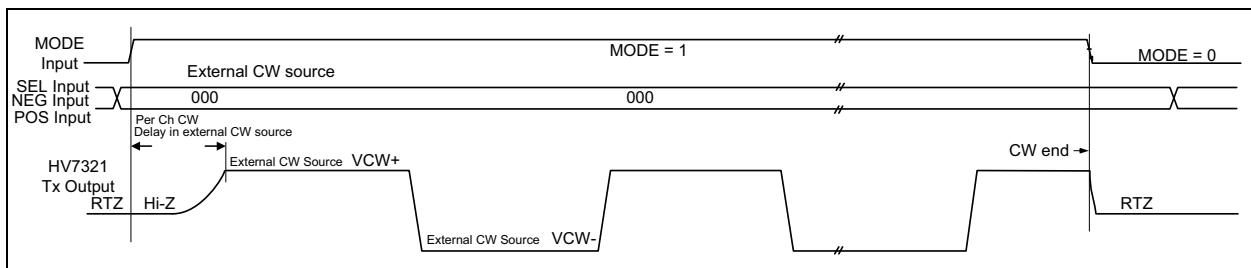


FIGURE 1-3: Timing Diagram of HV7321 TX Output and Switches in CW Mode-1 Driven by External CW Source.

# HV7321

---

NOTES:

## 2.0 TYPICAL PERFORMANCE CURVES

**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

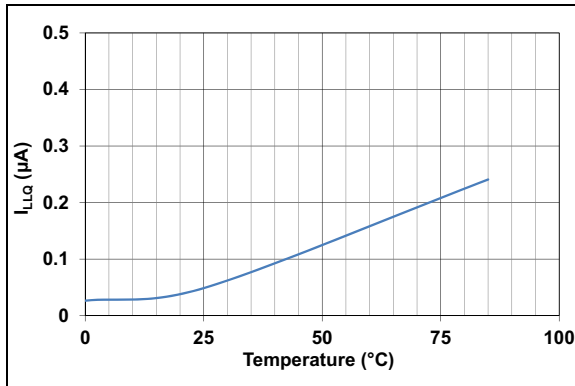


FIGURE 2-1:  $I_{LLQ}$  vs. Temperature.

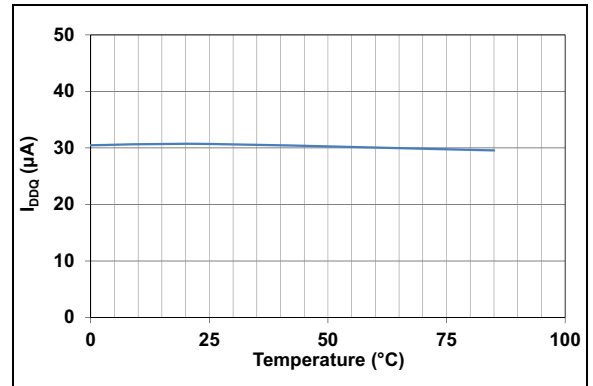


FIGURE 2-4:  $I_{DDQ}$  vs. Temperature.

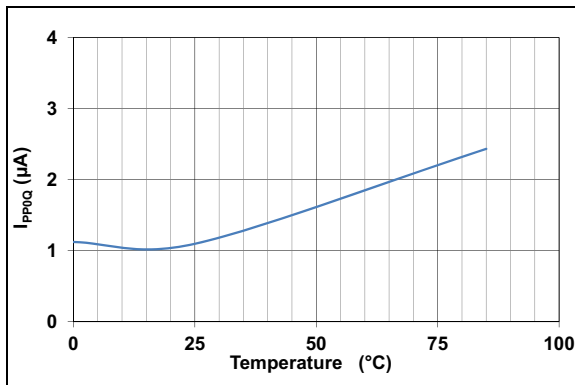


FIGURE 2-2:  $I_{PP0Q}$  vs. Temperature.

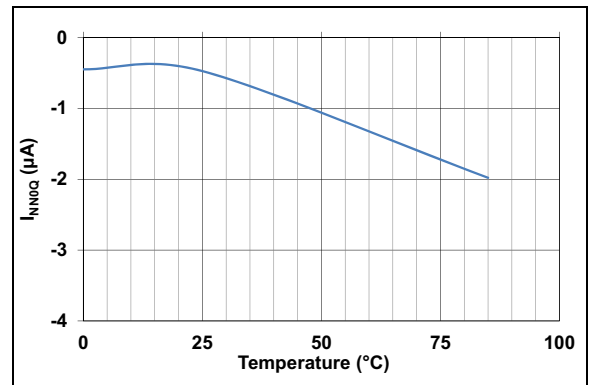


FIGURE 2-5:  $I_{NN0Q}$  vs. Temperature.

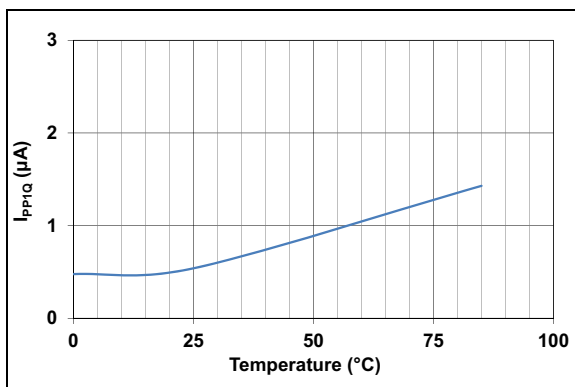


FIGURE 2-3:  $I_{PP1Q}$  vs. Temperature.

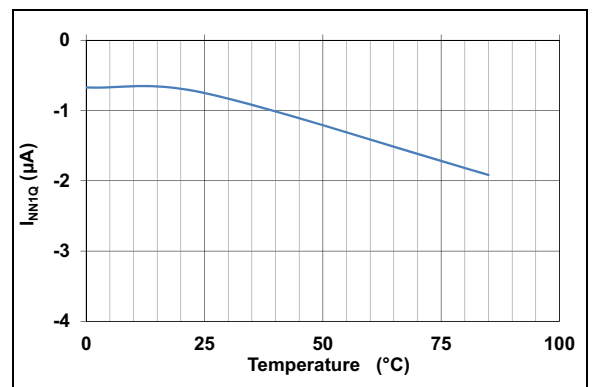
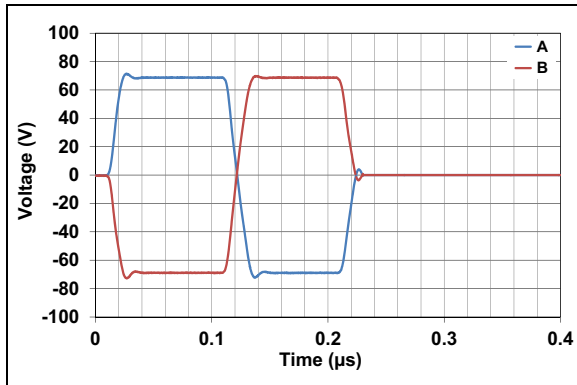
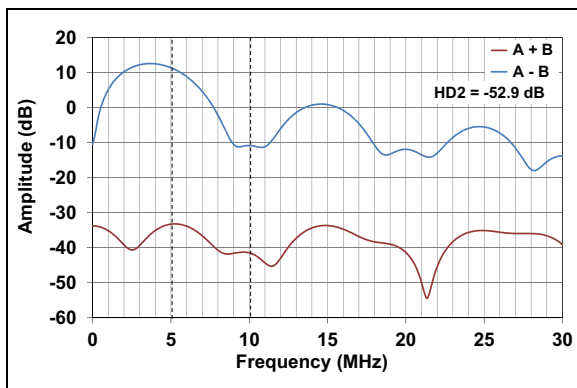


FIGURE 2-6:  $I_{NN1Q}$  vs. Temperature.

# HV7321



**FIGURE 2-7:** TX Output Waveform, 1-Cycle 5 MHz with 220 pF//1K Load.



**FIGURE 2-8:** TX Output HD2, 1-Cycle Inverting, 5 MHz with 220pF//1K Load.



## 3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in [Table 3-1](#).

**TABLE 3-1: PIN FUNCTION TABLE**

Pin	Symbol	Description
1	CW <sub>IN0</sub>	External CW input for channel 0
2	SEL1	SEL input logic pin selects transmission high-voltage rails for channel 1. If SEL = 0, select V <sub>PP0</sub> /V <sub>NN0</sub> . If SEL = 1, select V <sub>PP1</sub> /V <sub>NN1</sub> . See <a href="#">Table 1-1</a> .
3	NEG1	NEG input logic pin turns on/off corresponding output N-channel MOSFET for channel 1. See <a href="#">Table 1-1</a> .
4	POS1	POS input logic pin turns on/off corresponding output P-channel MOSFET for channel 1. See <a href="#">Table 1-1</a> .
5	CW <sub>IN1</sub>	External CW input for channel 1
6	OEN	Output enable logic input pin. When OEN = V <sub>LL</sub> , the transmitter outputs are enabled. When OEN = 0, the transmitter outputs are disabled.
7	PWS	Logic input pin. When PWS = 0, the output FETs for V <sub>PP1</sub> and V <sub>NN1</sub> are scaled down to reduce the output current for CW Mode-0.
8	CLK	Re-timing clock input pin. Connect CLK to ground for transparent mode.
9, 22, 59	GND	Ground
10	V <sub>LL</sub>	Input logic power supply pin
11	REN	Enable pin for the built-in voltage regulators. See section <a href="#">Section 4.3 “Operation Modes”</a> for details.
12	SEL2	SEL input logic pin selects transmission high-voltage rails for channel 2. If SEL = 0, select V <sub>PP0</sub> /V <sub>NN0</sub> . If SEL = 1, select V <sub>PP1</sub> /V <sub>NN1</sub> . See <a href="#">Table 1-1</a> .
13	NEG2	NEG input logic pin turns on/off corresponding output N-channel MOSFET for channel 2. See <a href="#">Table 1-1</a> .
14	POS2	POS input logic pin turns on/off corresponding output P-channel MOSFET for channel 2. See <a href="#">Table 1-1</a> .
15	CW <sub>IN2</sub>	External CW input for channel 2
16	SEL3	SEL input logic pin selects transmission high-voltage rails for channel 3. If SEL = 0, select V <sub>PP0</sub> /V <sub>NN0</sub> . If SEL = 1, select V <sub>PP1</sub> /V <sub>NN1</sub> . See <a href="#">Table 1-1</a> .
17	NEG3	NEG input logic pin turns on/off corresponding output N-channel MOSFET for channel 3. See <a href="#">Table 1-1</a> .
18	POS3	POS input logic pin turns on/off corresponding output P-channel MOSFET for channel 3. See <a href="#">Table 1-1</a> .
19	CW <sub>IN3</sub>	External CW input for channel 3
20	OTP <sub>N</sub>	Temperature sensor open drain output
21, 60	V <sub>DD</sub>	+5V supply
23	V <sub>GP</sub>	+10V supply pin for the linear regulator
24, 25, 56, 57	V <sub>PP0</sub>	Positive high-voltage supply pin. V <sub>PP0</sub> must be equal to or greater than V <sub>PP1</sub> .
26, 55	C <sub>PF0</sub>	Internal linear regulator output pin. Connect 2 μF 10V capacitor to V <sub>PP0</sub> .
27, 54	C <sub>NF0</sub>	Internal linear regulator output pin. Connect 2 μF 10V capacitor to V <sub>NN0</sub> .
28, 29, 52, 53	V <sub>NN0</sub>	Negative high-voltage supply pin. V <sub>NN0</sub> must be equal to or more negative than V <sub>NN1,2</sub> .
30, 51	V <sub>NN2</sub>	Negative high-voltage supply pin. V <sub>NN2</sub> connects to the most negative supply rail.
31, 50	V <sub>NN1</sub>	Negative high-voltage supply pin. V <sub>NN1</sub> must be equal to or less negative than V <sub>NN0</sub> .
32, 49	C <sub>NF1</sub>	Internal linear regulator output pin. Connect 2 μF 10V capacitor to V <sub>NN1</sub> .
33, 48	C <sub>PF1</sub>	Internal linear regulator output pin. Connect 2 μF 10V capacitor to V <sub>PP1</sub> .
34, 47	V <sub>PP1</sub>	Positive high voltage supply V <sub>PP1</sub> . Must be equal to or lower than V <sub>PP0</sub> .
35	TX3	Channel 3 transmitter output pin

# HV7321

TABLE 3-1: PIN FUNCTION TABLE (CONTINUED)

Pin	Symbol	Description
36	RX3	Channel 3 T/R switch output
37, 44	R <sub>GND</sub>	Power ground
38	RX2	Channel 2 T/R switch output
39	TX2	Channel 2 transmitter output pin
40	C <sub>NEG</sub>	Internal linear regulator output pin. Connect 1 $\mu$ F 10V capacitor to GND.
41	C <sub>POS</sub>	Internal linear regulator output pin. Connect 1 $\mu$ F 10V capacitor to GND.
42	TX1	Channel 1 transmitter output pin
43	RX1	Channel 1 T/R switch output
45	RX0	Channel 0 T/R switch output
46	TX0	Channel 0 transmitter output pin
58	V <sub>GN</sub>	-10V supply pin for the linear regulator
61	MODE	CW Mode selection pin. See section <a href="#">Section 4.3 “Operation Modes”</a> .
62	SEL0	SEL input logic pin selects transmission high-voltage rails for channel 0. If SEL = 0, select V <sub>PP0</sub> /V <sub>NN0</sub> . If SEL = 1, select V <sub>PP1</sub> /V <sub>NN1</sub> . See <a href="#">Table 1-1</a> .
63	NEG0	NEG input logic pin turns on/off corresponding output N-channel MOSFET for channel 0. See <a href="#">Table 1-1</a> .
64	POS0	POS input logic pin turns on/off corresponding output P-channel MOSFET for channel 0. See <a href="#">Table 1-1</a> .
Thermal Pad	V <sub>SUB</sub>	Connect to ground.

## 4.0 DEVICE DESCRIPTION

### 4.1 Overview

The HV7321 is a 4-channel, 5-level ultrasound transmitter with built-in T/R switches, output protection diodes and clamp diodes.

The HV7321 can provide up to  $\pm 2.6A$  and the output voltage swing can be up to  $\pm 80V$ .

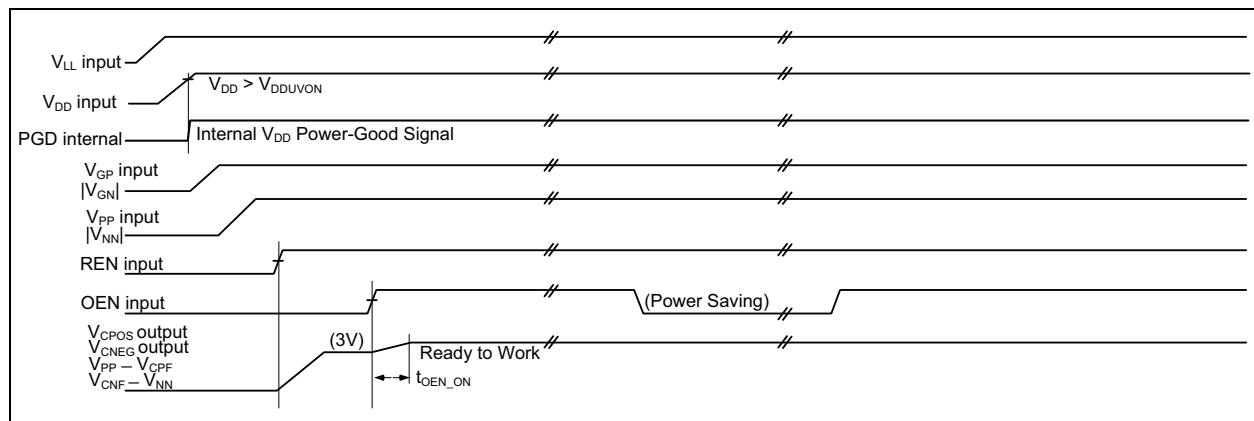
The HV7321 supports both Transparent and Re-Timing mode. The re-timing clock frequency can support up to 220 MHz. The re-timing feature helps reduce the output jitter introduced by the driving FPGA.

### 4.2 Recommended Power-up Sequence

Powering up/down in any arbitrary sequence will not cause any damage to the device. The powering-up sequences in [Table 4-1](#) are only recommended in order to minimize possible in-rush current. [Figure 4-1](#) shows the timing diagram of related signals.

**TABLE 4-1: POWER-UP SEQUENCE**

Step	Power-Up Description
1	$V_{LL}$ ON with logic signal low
2	$V_{DD}$ , $V_{GP}$ and $V_{GN}$ ON
3	REN = 1
4	$V_{PP0,1}$ and $V_{NN0,1}$ ON
5	OEN = 1 & Logic control signal active



**FIGURE 4-1: Power-On Events and Power-Saving Time Diagram.**

### 4.3 Operation Modes

There are five modes of operation: Device Disabled, Output Disabled, Pulsed-Echo Mode, CW Mode-0 and CW Mode-1.

#### 4.3.1 DEVICE ENABLE MODE

In Device Disabled mode, the regulators are turned off when REN is low. The regulators are ON when REN =  $V_{LL}$ . All regulators are ON except  $V_{NEG}$  and  $V_{POS}$  for power saving when REN = 1. When REN is low, OEN = X (OEN = 1 or 0) since device is disabled. Refer to [Table 4-2](#).

**TABLE 4-2: REN & OEN LOGIC INPUTS**

REN	OEN	Device	TX Output
0	X	Disabled	high Z
1	0	Enabled	high Z
1	1	Enabled	ON

#### 4.3.2 OUTPUT HIGH Z MODE

In Output Disabled mode, regulators are enabled REN = 1 and OEN = 0 (Output Enable logic input) and output pins (TX0-3) are in high Z state. OEN = 1 enables the outputs.

#### 4.3.3 PULSED-ECHO MODE

Pulsed-Echo mode (B-mode) enables the 5-level waveform generation. OEN = 1, MODE = 0, and PWS = 1 enable Pulsed-Echo mode after HV7321 powers on. SEL/NEG/POS inputs of desired channel determine the corresponding TX Output pulse.

# HV7321

## 4.3.4 CW MODE-0

CW Mode-0 enables continuous wave mode provided solely by the HV7321. OEN = 1, MODE = 0 and PWS = 0 activate CW Mode-0. FPGA selects  $V_{PP1}$  and  $V_{NN1}$  amplitudes via SEL/NEG/POS inputs.

In theory,  $V_{PP0}$  and  $V_{NN0}$  can be selected but this is strongly discouraged since  $V_{PP0}$  and  $V_{NN0}$  usage increases power consumption and causes excessive heating in CW Mode-0.

## 4.3.5 CW MODE-1

CW Mode-1 is enabled using an external CW signal source for continuous wave mode. OEN = 1 and MODE = 1 activate CW Mode-1. External CW signals can connect to any of  $CW_{IN0-3}$ . In this mode, the CW signal source also feeds the CLK input. See [Table 4-3](#) for details.

**TABLE 4-3: MODE & PWS LOGIC INPUTS**

Mode	PWS	State
0	0	CW Mode-0
0	1	Pulsed-Echo

**TABLE 4-3: MODE & PWS LOGIC INPUTS**

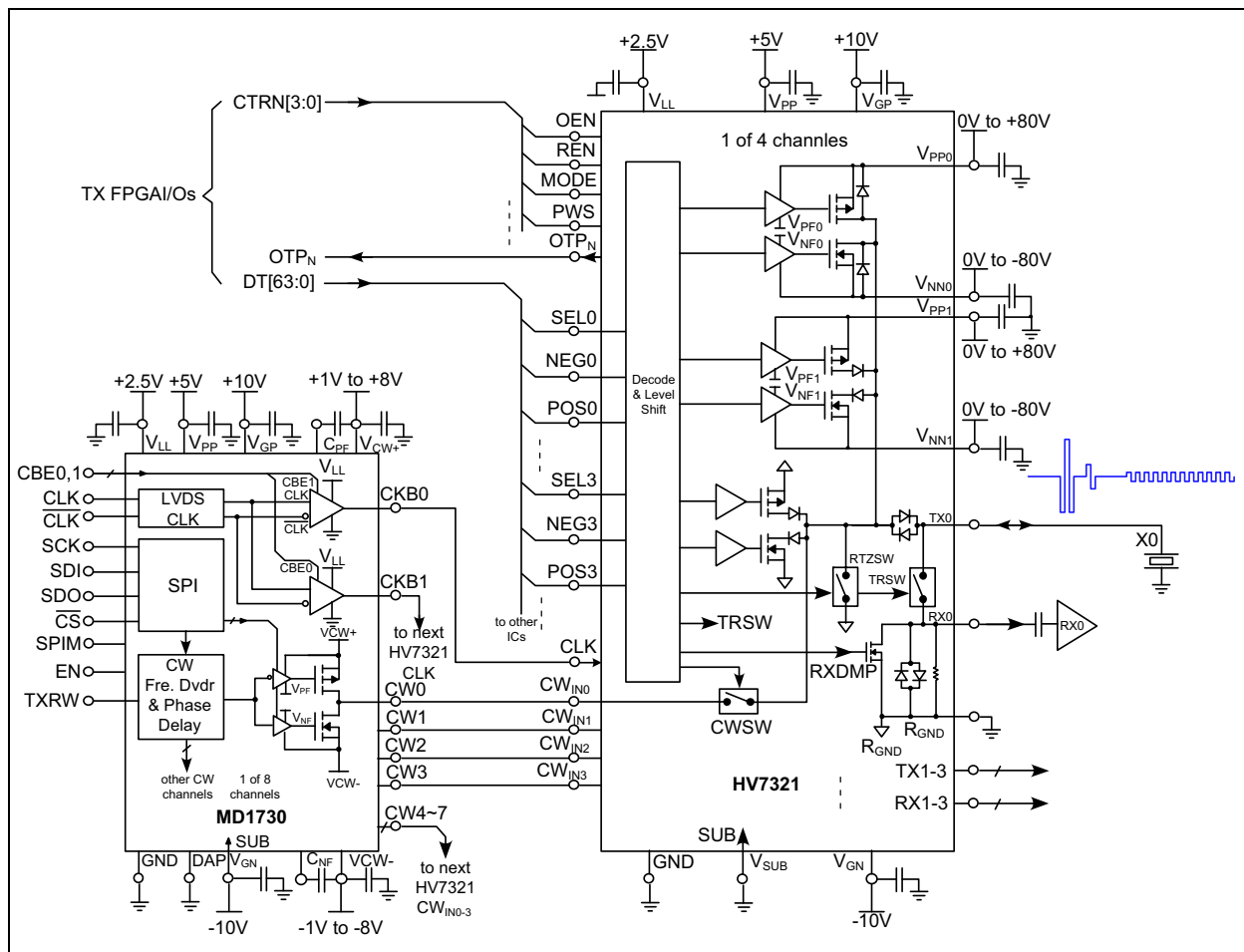
Mode	PWS	State
1	X	CW Mode-1

## 4.3.5.1 External CW Beamformer Option (CW Mode-1)

The HV7321 has built-in CW switches that allow the use of an external CW beamformer to further minimize jitter and phase noise on CW waveforms. This mode is called CW Mode-1.

One suggested external CW beamformer is the MD1730, which has very low phase noise and 8-channel CW output. A pair of HV7321s can operate with the MD1730 as an 8-channel CW waveform generator. See [Figure 4-2](#).

The MD1730 supports both differential and single-ended signals using CLKP and CLKN inputs. The MD1730 enables setting the CW output phase delay and frequency for channels via SPI. Please refer to the MD1730 data sheet for more information.



**FIGURE 4-2: HV7321 + MD1730 Integration.**

## 4.4 High Temperature Protection

When overtemperature is detected, OTPN = 0 and all outputs are high Z regardless of OEN and the other logic control inputs. [Table 4-4](#) shows the relationship between REN, OEN inputs, OTPN output, and the corresponding device status.

**TABLE 4-4: REN, OEN, OTP<sub>N</sub> VS. DEVICE STATUS**

OTPN	REN	OEN	Device	TX Output
0	0	X	Disabled	high Z
0	1	X	Enabled	high Z
1	0	X	Disabled	high Z
1	1	0	Enabled	high Z
1	1	1	Enabled	ON

# HV7321

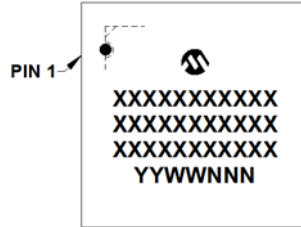
---

NOTES:

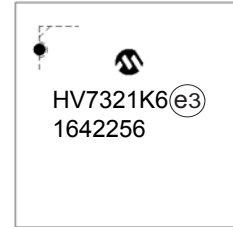
## 5.0 PACKAGING INFORMATION

### 5.1 Package Marking Information

64-Lead VQFN (9 x 9 x 1.0 mm)

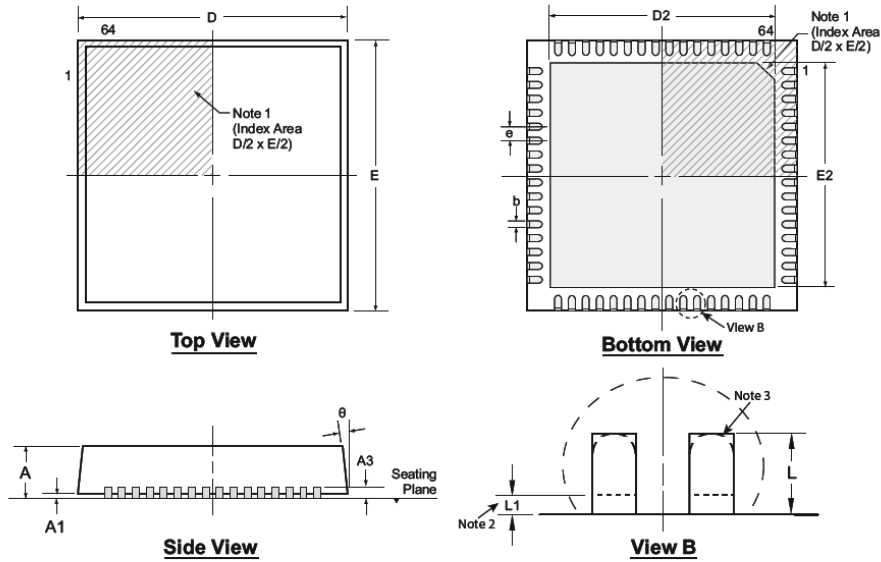


Example



<p><b>Legend:</b> XX...X Product Code or Customer-specific information          Y Year code (last digit of calendar year)          YY Year code (last 2 digits of calendar year)          WW Week code (week of January 1 is week '01')          NNN Alphanumeric traceability code          (e3) Pb-free JEDEC designator for Matte Tin (Sn)          *This package is Pb-free. The Pb-free JEDEC designator ( ) (e3) can be found on the outer packaging for this package.</p>
<p><b>Note:</b> In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.</p>

## 64-Lead QFN Package Outline (K6) 9.00x9.00mm body, 1.00mm height (max), 0.50mm pitch



Note: For the most current package drawings, see the Microchip Packaging Specification at [www.microchip.com/packaging](http://www.microchip.com/packaging).

**Notes:**

1. A Pin 1 identifier must be located in the index area indicated. The Pin 1 identifier can be: a molded mark/identifier; an embedded metal marker; or a printed indicator.
2. Depending on the method of manufacturing, a maximum of 0.15mm pullback (L1) may be present.
3. The inner tip of the lead may be either rounded or square.

Symbol	A	A1	A3	b	D	D2	E	E2	e	L	L1	θ	
Dimension (mm)	MIN	0.80	0.00	0.20 REF	0.18	8.85*	6.00	8.85*	6.00	0.50 BSC	0.30	0.00	0°
	NOM	0.90	0.02		0.25	9.00	7.70*	9.00	7.70*		0.40	-	-
	MAX	1.00	0.05		0.30	9.15*	7.80†	9.15*	7.80†		0.50	0.15	14°

JEDEC Registration MO-220, Variation VMMD-4, Issue K, June 2006.

\* This dimension is not specified in the JEDEC drawing.

† This dimension differs from the JEDEC drawing.

Drawings are not to scale.



## APPENDIX A: REVISION HISTORY

### Revision A (October 2016)

- Original Release of this Document.

# HV7321

---

NOTES:

## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<u>PART NO.</u>	<u>XX</u>	<u>-X</u>
Device	Package	Environmental
<b>Device:</b>	HV7321: 4-Ch. 5-Level $\pm$ 80V High-Voltage Ultrasound Pulser with T/R Switches	
<b>Package:</b>	K6 = Very Thin Plastic Quad Flat Pack, No Lead Package, 9.00 x9.00 x1.0 mm Body, 0.50 mm Pitch, 64-Lead (VQFN)	
<b>Environmental:</b>	G = Lead (Pb)-free/ROHS-compliant package	

**Examples:**

a) HV7321K6-G: 4-Ch. 5-Level  $\pm$ 80V High-Voltage Ultrasound Pulser with T/R Switches 64LD 9x9 mm VQFN package

# HV7321

---

NOTES:

---

---

**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

---

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

*Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELoc® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.*

**QUALITY MANAGEMENT SYSTEM  
CERTIFIED BY DNV  
= ISO/TS 16949 =**

### Trademarks

The Microchip name and logo, the Microchip logo, AnyRate, dsPIC, FlashFlex, flexPWR, Heldo, JukeBlox, KeeLoq, KeeLoq logo, Klear, LANCheck, LINK MD, MediaLB, MOST, MOST logo, MPLAB, OptoLyzer, PIC, PICSTART, PIC32 logo, RightTouch, SpyNIC, SST, SST Logo, SuperFlash and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

ClockWorks, The Embedded Control Solutions Company, ETHERSYNCH, Hyper Speed Control, HyperLight Load, IntelliMOS, mTouch, Precision Edge, and QUIET-WIRE are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, BodyCom, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP, Inter-Chip Connectivity, JitterBlocker, KlearNet, KlearNet logo, MiWi, motorBench, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, PureSilicon, RightTouch logo, REAL ICE, Ripple Blocker, Serial Quad I/O, SQL, SuperSwitcher, SuperSwitcher II, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.

GestIC is a registered trademarks of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2016, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

ISBN: 978-1-5224-1033-1



# MICROCHIP

## Worldwide Sales and Service

### AMERICAS

#### Corporate Office

2355 West Chandler Blvd.  
Chandler, AZ 85224-6199

Tel: 480-792-7200

Fax: 480-792-7277

Technical Support:

[http://www.microchip.com/  
support](http://www.microchip.com/support)

Web Address:

[www.microchip.com](http://www.microchip.com)

#### Atlanta

Duluth, GA

Tel: 678-957-9614

Fax: 678-957-1455

#### Austin, TX

Tel: 512-257-3370

#### Boston

Westborough, MA

Tel: 774-760-0087

Fax: 774-760-0088

#### Chicago

Itasca, IL

Tel: 630-285-0071

Fax: 630-285-0075

#### Cleveland

Independence, OH

Tel: 216-447-0464

Fax: 216-447-0643

#### Dallas

Addison, TX

Tel: 972-818-7423

Fax: 972-818-2924

#### Detroit

Novi, MI

Tel: 248-848-4000

#### Houston, TX

Tel: 281-894-5983

#### Indianapolis

Noblesville, IN

Tel: 317-773-8323

Fax: 317-773-5453

#### Los Angeles

Mission Viejo, CA

Tel: 949-462-9523

Fax: 949-462-9608

#### New York, NY

Tel: 631-435-6000

#### San Jose, CA

Tel: 408-735-9110

#### Canada - Toronto

Tel: 905-695-1980

Fax: 905-695-2078

### ASIA/PACIFIC

#### Asia Pacific Office

Suites 3707-14, 37th Floor  
Tower 6, The Gateway  
Harbour City, Kowloon

#### Hong Kong

Tel: 852-2943-5100

Fax: 852-2401-3431

#### Australia - Sydney

Tel: 61-2-9868-6733

Fax: 61-2-9868-6755

#### China - Beijing

Tel: 86-10-8569-7000

Fax: 86-10-8528-2104

#### China - Chengdu

Tel: 86-28-8665-5511

Fax: 86-28-8665-7889

#### China - Chongqing

Tel: 86-23-8980-9588

Fax: 86-23-8980-9500

#### China - Dongguan

Tel: 86-769-8702-9880

#### China - Guangzhou

Tel: 86-20-8755-8029

#### China - Hangzhou

Tel: 86-571-8792-8115

Fax: 86-571-8792-8116

#### China - Hong Kong SAR

Tel: 852-2943-5100

Fax: 852-2401-3431

#### China - Nanjing

Tel: 86-25-8473-2460

Fax: 86-25-8473-2470

#### China - Qingdao

Tel: 86-532-8502-7355

Fax: 86-532-8502-7205

#### China - Shanghai

Tel: 86-21-5407-5533

Fax: 86-21-5407-5066

#### China - Shenyang

Tel: 86-24-2334-2829

Fax: 86-24-2334-2393

#### China - Shenzhen

Tel: 86-755-8864-2200

Fax: 86-755-8203-1760

#### China - Wuhan

Tel: 86-27-5980-5300

Fax: 86-27-5980-5118

#### China - Xian

Tel: 86-29-8833-7252

Fax: 86-29-8833-7256

### ASIA/PACIFIC

#### China - Xiamen

Tel: 86-592-2388138

Fax: 86-592-2388130

#### China - Zhuhai

Tel: 86-756-3210040

Fax: 86-756-3210049

#### India - Bangalore

Tel: 91-80-3090-4444

Fax: 91-80-3090-4123

#### India - New Delhi

Tel: 91-11-4160-8631

Fax: 91-11-4160-8632

#### India - Pune

Tel: 91-20-3019-1500

#### Japan - Osaka

Tel: 81-6-6152-7160

Fax: 81-6-6152-9310

#### Japan - Tokyo

Tel: 81-3-6880-3770

Fax: 81-3-6880-3771

#### Korea - Daegu

Tel: 82-53-744-4301

Fax: 82-53-744-4302

#### Korea - Seoul

Tel: 82-2-554-7200

Fax: 82-2-558-5932 or

82-2-558-5934

#### Malaysia - Kuala Lumpur

Tel: 60-3-6201-9857

Fax: 60-3-6201-9859

#### Malaysia - Penang

Tel: 60-4-227-8870

Fax: 60-4-227-4068

#### Philippines - Manila

Tel: 63-2-634-9065

Fax: 63-2-634-9069

#### Singapore

Tel: 65-6334-8870

Fax: 65-6334-8850

#### Taiwan - Hsin Chu

Tel: 886-3-5778-366

Fax: 886-3-5770-955

#### Taiwan - Kaohsiung

Tel: 886-7-213-7828

#### Taiwan - Taipei

Tel: 886-2-2508-8600

Fax: 886-2-2508-0102

#### Thailand - Bangkok

Tel: 66-2-694-1351

Fax: 66-2-694-1350

### EUROPE

#### Austria - Wels

Tel: 43-7242-2244-39

Fax: 43-7242-2244-393

#### Denmark - Copenhagen

Tel: 45-4450-2828

Fax: 45-4485-2829

#### France - Paris

Tel: 33-1-69-53-63-20

Fax: 33-1-69-30-90-79

#### Germany - Dusseldorf

Tel: 49-2129-3766400

#### Germany - Karlsruhe

Tel: 49-721-625370

#### Germany - Munich

Tel: 49-89-627-144-0

Fax: 49-89-627-144-44

#### Italy - Milan

Tel: 39-0331-742611

Fax: 39-0331-466781

#### Italy - Venice

Tel: 39-049-7625286

#### Netherlands - Drunen

Tel: 31-416-690399

Fax: 31-416-690340

#### Poland - Warsaw

Tel: 48-22-3325737

#### Spain - Madrid

Tel: 34-91-708-08-90

Fax: 34-91-708-08-91

#### Sweden - Stockholm

Tel: 46-8-5090-4654

#### UK - Wokingham

Tel: 44-118-921-5800

Fax: 44-118-921-5820

06/23/16