## Eight-Channel, High Speed, ±60V, ±1.0A, Ultrasound RTZ Pulser

#### **Features**

- HVCMOS technology for high performance
- High density integrated ultrasound transmitter
- 0 to ±60V output voltage
- ±1.0A source and sink current in pulse mode
- ±1.0A source and sink current in RTZ mode
- ▶ Up to 20MHz operating frequency
- Matched delay times
- Optional clock re-alignment
- ► 3.3V CMOS logic interface and reference
- ▶ +3.3V low voltage supply for V<sub>DD</sub>
- Built-in linear regulators for floating gate driver
- Built-in output drain diodes & bleed resistors

## Application

- Portable medical ultrasound imaging
- Piezoelectric transducer drivers
- Pulse waveform generator

## **General Description**

The Supertex HV7350 is an eight channel monolithic high voltage highspeed pulse generator with built-in fast return to zero damping FETs. This high voltage and high-speed integrated circuit is designed for portable medical ultrasound image devices.

HV7350 consists of a controller logic interface circuit, level translators, MOSFET gate drives, and high current power P-channel and N-channel MOSFETs as the output stage for each channel.

The output peak currents of each channel are guaranteed to be over  $\pm 1.0A$  with up to  $\pm 60V$  pulse swings as well as return-to-zero (RTZ) mode. The gate drivers for the output MOSFETs are powered by built-in linear 5.0V regulators referenced to  $V_{PP}$  and  $V_{NN}$ . This direct coupling topology of the gate drivers not only saves four floating voltage supplies or AC coupling capacitors per channel, but also makes the PCB layout smaller and easier.

An input clock pin is available to realign all the logic input control lines to a master clock. Precise logic timing is always essential in any ultrasound systems.



## **Typical Application Circuit**

## **Ordering Information**

Part Number	Package	Packing
HV7350K6-G	56-Lead (8x8) QFN	250/ Tray
HV7350K6-G M937	56-Lead (8x8) QFN	2000/Reel

-G denotes a lead (Pb)-free / RoHS compliant package

## **Absolute Maximum Ratings**

Parameter	Value
VSUB, substrate voltage is GND	0V
V <sub>LL</sub> , Positive logic supply	-0.5V to +5.5V
$V_{\text{DD}}$ , Positive logic and level translator supply	-0.5V to +5.5V
C <sub>POS</sub> to GND, Positive level translator circuit	-0.5V to +5.5V
C <sub>NEG</sub> to GND, Negative level translator circuit	+0.5V to -5.5V
$(V_{PP} - C_{PF})$ , Positive gate driver circuit	-0.5V to +5.5V
$(C_{NF} - V_{NN})$ , Negative gate driver circuit	-0.5V to +5.5V
$(V_{PP} - V_{NN})$ Differential high voltage supply	+130V
$V_{PP'}$ High voltage positive supply	-0.5V to +65V
$V_{_{NN}}$ , High voltage negative supply	+0.5V to -65V
All logic input $PIN_x$ , $NIN_x$ , OEN and REN voltages	-0.5V to +5.5V
Operating temperature	-40°C to 125°C
Storage temperature	-65°C to 150°C

Absolute Maximum Ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied. Continuous operation of the device at the absolute rating level may affect device reliability. All voltages are referenced to device ground.

# ESD Sensitive Device

## **Pin Configuration**



•	L = Lot Number
HV7350K6	YY = Year Sealed
LLLLLLLL	WW = Week Sealed
YYWW	A = Assembler ID
AAA CCC	C = Country of Origin
	= "Green" Packaging

Package may or may not include the following marks: Si or

#### 56-Lead QFN

## **Typical Thermal Resistance**

3.  $I_{DMP}$  is current from +/-30V connected to  $T_x$  pin.

**Power-Down Sequence** 

4. Max pulse width for current measurement on  $T_x$  pin is 100ns.

Package	<b>θ</b> <sub>ja</sub>
56-Lead (8x8) QFN	21°C/W

Description

All logic signals go to low

 $V_{PP}$  and  $V_{NN}$ 

REN = 0 (external supplies off)

 $V_{DD}$ 

V

## Output Current & R<sub>on</sub>

	R	R		R	R
30	ONP	onn	DMP	ONDP	onDN
1.5A	13Ω	6.5Ω	1.5A	13Ω	8.0Ω

Step

1

2

3

4

5

Notes:

1. $V_{PP}/V_{NN}$  = +/-60V,  $V_{DD}$  = +3.3V; REN = 1 2.  $I_{SC}$  is current into 1.0Ω to GND;

#### **Power-Up Sequence**

Step	Description
1	$V_{_{LL}}$ with logic signal low
2	V <sub>DD</sub>
3	REN = 1 (external supplies on)
4	$V_{_{PP}}$ and $V_{_{NN}}$
5	Logic control signals active

#### Note:

Powering up/down in any arbitrary sequence will not cause any damage to the device. The powering up/down sequence is only recommended in order to minimize possible inrush current.

## **Operating Supply Voltages and Current (Eight Active Channels)**

(Operating conditions, unless otherwise specified,  $V_{LL}$  = +3.3V,  $V_{DD}$  = +3.3V,  $V_{PP}$  = +60V,  $V_{NN}$  = -60V,  $V_{CLK}$  = +3.3V,  $T_A$  = 25°C)

Sym	Parameter	Min	Тур	Max	Units	Conditions
V <sub>DD</sub>	V <sub>DD</sub> voltage supply	2.97	3.30	5.20	V	
	V <sub>DD</sub> UVLO	2.30	2.60	2.80	V	
V	Logic voltage reference	2.50	3.30	5.00	V	
UVLO	V <sub>LL</sub> UVLO	1.30	1.55	1.70	V	
V <sub>PP</sub>	Positive high voltage supply	+10	-	+60	V	
V <sub>NN</sub>	Negative high voltage supply	-60	-	-10	V	
I <sub>LLQ</sub>	V <sub>LL</sub> current	-	8.0	-		
I <sub>DDQ</sub>	V <sub>DD</sub> current	-	1.0	-		
I <sub>PPQ</sub>	V <sub>PP</sub> current	-	5.0	10	μΑ	OEN - KEN - U
I <sub>NNQ</sub>	V <sub>NN</sub> current	-	5.0	10		
I <sub>LLEN</sub>	V <sub>LL</sub> current	-	13	20		
	V <sub>DD</sub> current	-	480	700		OEN = REN = 1
I <sub>PPEN</sub>	V <sub>PP</sub> current	-	220	350	μΑ	5.0ms after f = 0MHz
I <sub>NNEN</sub>	V <sub>NN</sub> current	-	300	400		
I <sub>DDCW</sub>	V <sub>DD</sub> current	-	2.3	-		f = 5.0MHz. Continuous, no loads.
I <sub>PPCW</sub>	V <sub>PP</sub> current	-	80	-	mA	for calculation reference only.
I <sub>NNCW</sub>	V <sub>NN</sub> current	-	80	-		
I <sub>LL,CLK</sub>	V <sub>LL</sub> current	-	33	-	μA	$f_{CLK} = 10MHz$ , PIN = NIN = 0

### **Electrical Characteristics**

(Operating conditions, unless otherwise specified,  $V_{LL} = +3.3V$ ,  $V_{DD} = +3.3V$ ,  $V_{PP} = +60V$ ,  $V_{NN} = -60V$ ,  $V_{CLK} = +3.3V$ ,  $T_A = 25^{\circ}C$ )

#### **Pulser P-Channel MOSFET**

Sym	Parameter	Min	Тур	Max	Units	Conditions
Ι <sub>ουτ</sub>	Output saturation current	1.0	1.5	-	А	
R <sub>on</sub>	Channel resistance	-	13.2	-	Ω	I <sub>SD</sub> = 100mA

#### Pulser N-Channel MOSFET

Sym	Parameter	Min	Тур	Max	Units	Conditions
Ι <sub>ουτ</sub>	Output saturation current	1.0	1.5	-	A	
R <sub>on</sub>	Channel resistance	-	8.0	-	Ω	I <sub>sp</sub> = 100mA

#### Damping P-Channel MOSFET

Sym	Parameter	Min	Тур	Max	Units	Conditions
I <sub>OUT</sub>	Output saturation current	1.0	1.5	-	A	
R <sub>on</sub>	Channel resistance	-	13	-	Ω	I <sub>sp</sub> = 100mA

#### **Damping N-Channel MOSFET**

Sym	Parameter	Min	Тур	Max	Units	Conditions
I <sub>OUT</sub>	Output saturation current	1.0	1.5	-	A	
R <sub>on</sub>	Channel resistance	-	9.0	-	Ω	I <sub>sp</sub> = 100mA

## HV7350

#### Logic Inputs

Sym	Parameter	Min	Тур	Max	Units	Conditions
V <sub>IH</sub>	Input logic high voltage	0.7 • V <sub>LL</sub>	-	V	V	$V_{1} = 2.5 \text{ to } 2.2 V_{1}$
V <sub>IL</sub>	Input logic low voltage	0	-	0.3 • V <sub>LL</sub>	V	v <sub>LL</sub> - 2.5 to 3.3 v
V <sub>IH</sub>	Input logic high voltage	0.8 • V <sub>LL</sub>	-	V	V	
V <sub>IL</sub>	Input logic low voltage	0	-	0.2 • V <sub>LL</sub>	V	V <sub>LL</sub> = 5.0V
I <sub>IH</sub>	Input logic high current	-	-	10	μA	
I <sub>IL</sub>	Input logic low current	-10	-	-	μA	
C <sub>IN</sub>	Input logic capacitance	-	-	5.0	pF	

#### **MOSFET Drain Bleed Resistor**

Sym	Parameter	Min	Тур	Max	Units	Conditions
R <sub>B1~8</sub>	Output Bleed Resistance	12	17	25	kΩ	
P <sub>RB1~8</sub>	Bleed Resistors Power Limit	-	-	50	mW	

**AC Electrical Characteristics** (Operating conditions, unless otherwise specified,  $V_{LL}$  = +3.3V,  $V_{DD}$  = +3.3V,  $V_{PP}$  = +60V,  $V_{NN}$  = -60V,  $V_{CLK}$  = +3.3V,  $T_A$  = 25°C)

Sym	Parameter	Min	Тур	Max	Units	Conditions
t <sub>r</sub>	Output rise time	-	30	-	ns	330pF//2.5kΩ load
t <sub>r</sub>	Output fall time	-	30	-	ns	10 - 90%
t <sub>EN</sub>	Enable time	-	300	500	μs	Cap value see page 1 diagram.
t <sub>DIS</sub>	Disable time	-	2.8	10	μs	OEN = REN
t <sub>d1</sub>	Delay time on PIN <sub>x</sub> rise	-	12	-		
t <sub>d2</sub>	Delay time on NIN <sub>x</sub> rise	-	12	-		1.0Ω resistor load, D%<1%
t <sub>d3</sub>	Delay time on damping rise	-	12	-	ns	(See timing diagram) 50% inputs to 50% T_current
t <sub>d4</sub>	Delay time on damping fall	-	12	-		
t <sub>dc</sub>	Delay time on CLK rise	-	9.0	-		
Δt <sub>DELAY</sub>	Delay time matching	-	±3.0	-	ns	P to N, channel to channel
tj	Delay jitter on rise or fall	-	TBD	-	ps	$V_{PP}/V_{NN}$ = +/-25V, input tr 50% to HV <sub>OUT</sub> t <sub>r</sub> or t <sub>f</sub> 50%, with 330pF//2.5kΩ load
t <sub>rr</sub>	RTZ FETs drain diode $t_{rr}$	-	25	-	ns	$I_{F} = 1.0A, I_{R} = 1.0A, R_{L} = 10\Omega$
f <sub>clk</sub>	Re-timing clock frequency	10	220	-	MHz	
t <sub>RC</sub> , t <sub>FC</sub>	Re-timing clock rise & fall times	-	0.5	5.0	ns	
t <sub>su</sub>	Set-up time, PIN/NIN to CLK	2.0	-	-	ns	
t <sub>H</sub>	Hold time, CLK to PIN/NIN	1.0	-	-	ns	
t <sub>clk_lo</sub>	Clock time low	2.0	-	100	ns	CLK input must have at least one
t <sub>clk_HI</sub>	Clock time high	2.0	-	100	ns	pulse before PIN and NIN inputs are
t <sub>CLK_REC</sub>	Clock recognition time	-	2.0	-	ns	not zero. Be sure to return inputs to
t <sub>CLK_RLS</sub>	Clock release time	150	300	800	ns	Zero before stopping clock.
f <sub>out</sub>	Output frequency range	-	-	20	MHz	1000 register load
HD2	Second harmonic distortion	-	-40	-	dB	
C <sub>oss</sub>	Output capacitance	-	50	-	pF	$V_{_{DS}}$ = 25V, f = 1.0MHz , of $T_{_X}$ pin total

## HV7350

#### **Truth Table**

	Logic	Inputs		TX <sub>n</sub> Output						
OEN	CLK	PIN <sub>x</sub>	NIN <sub>x</sub>	VPP	VNN	RGND	Note			
1	VLL	0	0	OFF	OFF	ON				
1	VLL	1	0	ON	OFF	OFF	Asynchronous Mode			
1	VLL	0	1	OFF	ON	OFF	Output change on PIN/NIN			
1	VLL	1	1	OFF	OFF	OFF				
1	1	0	0	OFF	OFF	ON	Synabronoue Mode			
1	1	1	0	ON	OFF	OFF	Output change at retiming			
1	1	0	1	OFF	ON	OFF	clock(CLK) rising edge,			
1	Ŀ	1	1	OFF	OFF	OFF				
0	Х	X	Х	OFF	OFF	OFF	Disabled			

## Switching Time Diagram



## HV7350

## **Pin Description**

Pin	Name	Description
1	PIN2	Input logic control of high voltage output P-FET for channel 2, Hi = on, Low = off. (see logic table)
2	NIN2	Input logic control of high voltage output N-FET for channel 2, Hi = on, Low = off. (see logic table)
3	PIN3	Input logic control of high voltage output P-FET for channel 3, Hi = on, Low = off. (see logic table)
4	NIN3	Input logic control of high voltage output N-FET for channel 3, Hi = on, Low = off. (see logic table)
5	PIN4	Input logic control of high voltage output P-FET for channel 4, Hi = on, Low = off. (see logic table)
6	NIN4	Input logic control of high voltage output N-FET for channel 4, Hi = on, Low = off. (see logic table)
7	OEN	Output enable Hi = on, Low = off. See logic truth table
8	REN	Built-in positive and negative 5V voltage regulators enable. Hi = on, Low = off. If REN = 0, exter- nal floating 5V power supplies may be supplied across CPF, CNF CPOS and CNEG capacitors
9	PIN5	Input logic control of high voltage output P-FET for channel 5, Hi = on, Low = off. (see logic table)
10	NIN5	Input logic control of high voltage output N-FET for channel 5, Hi = on, Low = off. (see logic table)
11	PIN6	Input logic control of high voltage output P-FET for channel 6, Hi = on, Low = off. (see logic table)
12	NIN6	Input logic control of high voltage output N-FET for channel 6, Hi = on, Low = off. (see logic table)
13	PIN7	Input logic control of high voltage output P-FET for channel 7, Hi = on, Low = off. (see logic table)
14	NIN7	Input logic control of high voltage output N-FET for channel 7, Hi = on, Low = off. (see logic table)
15	PIN8	Input logic control of high voltage output P-FET for channel 8, Hi = on, Low = off. (see logic table)
16	NIN8	Input logic control of high voltage output N-FET for channel 8, Hi = on, Low = off. (see logic table)
17	VLL	Logic supply voltage and reference input (+3.3V)
18	GND	Logic and circuit return ground (0V)
19	VDD	Positive voltage power supply (+3.3V)
20	VPP	
21	VPP	Positive high voltage power supply (+10 to +60V)
22	VPP	
23	CPF	Built-in linear voltage VPF regulator output decoupling capacitor pin, 1uF from VPP to CPF per each
24	CNF	Built-in linear voltage VNF regulator output decoupling capacitor pin, 1uF from CNF to VNN per each
25	VNN	
26	VNN	Negative high voltage power supply (-10 to -60V)
27	VNN	
28	TX8	T <sub>x</sub> pulser channel 8 output
29	RGND	Damping ground and bleed resistors common return ground
30	TX7	T <sub>x</sub> pulser channel 7 output
31	RGND	Damping ground and bleed resistors common return ground
32	TX6	T <sub>x</sub> pulser channel 6 output

## Pin Description (cont.)

Pin	Name	Description								
33	RGND	Damping ground and bleed resistors common return ground								
34	TX5	T <sub>x</sub> pulser channel 5 output								
35	CNEG	Built-in linear voltage -5V regulator output decoupling capacitor pin, 1.0uF from CNEG to GND								
36	CPOS	Built-in linear voltage +5V regulator output decoupling capacitor pin, 1.0uF from CPOS to GND								
37	TX4	T <sub>x</sub> pulser channel 4 output								
38	RGND	Damping ground and bleed resistors common return ground								
39	TX3	T <sub>x</sub> pulser channel 3 output								
40	RGND	Damping ground and bleed resistors common return ground								
41	TX2	T <sub>x</sub> pulser channel 2 output								
42	RGND	Damping ground and bleed resistors common return ground								
43	TX1	T <sub>x</sub> pulser channel 1 output								
44	VNN									
45	VNN	egative high voltage power supply (-10 to -60V)								
46	VNN									
47	CNF	Built-in linear voltage VNF regulator output decoupling capacitor pin, 1uF from CNF to VNN per each								
48	CPF	Built-in linear voltage VPF regulator output decoupling capacitor pin, 1uF from VPP to CPF per each								
49	VPP									
50	VPP	Positive high voltage power supply (+10 to +60V)								
51	VPP									
52	VDD	Positive voltage power supply (+3.3V)								
53	GND	Logic and circuit return ground (0V)								
54	CLK	Re-timing register clock input. Connect to $V_{LL}$ to disable the re-timing function								
55	PIN1	Input logic control of high voltage output P-FET for channel 1, Hi = on, Low = off. (see logic table)								
56	NIN1	Input logic control of high voltage output N-FET for channel 1, Hi = on, Low = off. (see logic table)								
VSUB (Thermal Pad)		Substrate bottom is internally connected to the central thermal pad on the bottom of package. It must be connected to GND (0V) externally								

## 56-Lead QFN Package Outline (K6)

8.00x8.00mm body, 1.00mm height (max), 0.50mm pitch



#### Notes:

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		Α	A1	A3	b	D	D2	E	E2	е	L	L1	θ
Dimension (mm)	MIN	0.80	0.00	0.20 REE	0.18	7.85*	2.75	7.85*	2.75	0.50 BSC	0.30	0.00	<b>0</b> 0
	NOM	0.90	0.02		0.25	8.00	5.70	8.00	5.70		0.40	-	-
	MAX	1.00	0.05		0.30	8.15*	6.70 <sup>†</sup>	8.15*	6.70 <sup>†</sup>		0.50	0.15	14 <sup>0</sup>

JEDEC Registration MO-220, Variation VLLD-2, 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.

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(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to <u>http://www.supertex.com/packaging.html</u>.)

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<sup>1.</sup> 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.

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