HV7360/HV7361

High-Speed ±100V 2.5A Two-or-Three-Level Ultrasound Pulsers

Features

- HVCMOS® Technology for High Performance
- High Density Integration AC-coupled Pulser
- 0V to ±100V Output Voltage
- ±2.5A Source and Sink Minimum Pulse Current
- Up to 35 MHz Operating Frequency
- 2 ns Matched Delay Times
- 2.5V, 3.3V or 5V CMOS Logic Interface
- Built-in Two-terminal Low-noise Interface for HV7361
- Low Power Consumption and No Floating Power Supply Rails or Decoupling Capacitors

Applications

- Medical Ultrasound Imaging
- Piezoelectric Transducer Drivers
- Ultrasound Industrial NDT
- Pulse Waveform Generator

General Description

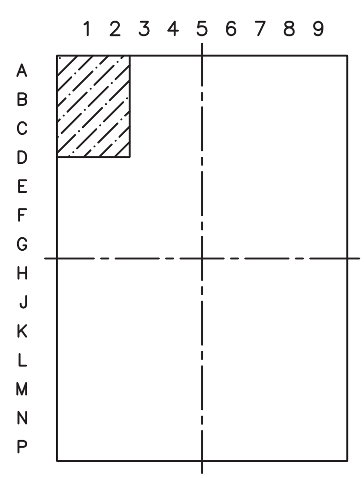
HV7360/HV7361 are high-voltage and high-speed pulse generators with built-in fast return-to-zero damping Field-Effect Transistors (FETs). An added feature to HV7361 is an integrated two-terminal low-noise T/R switch. These integrated circuits are designed not only for portable medical ultrasound image devices but also for NDT and test equipment applications.

Both HV7360/HV7361 are composed of controller logic interface circuits, level translators and AC-coupled Metal Oxide Semiconductor Field-Effect Transistor (MOSFET) gate drivers. They also have high-voltage and high-current P-channel and N-channel MOSFETs as output stages.

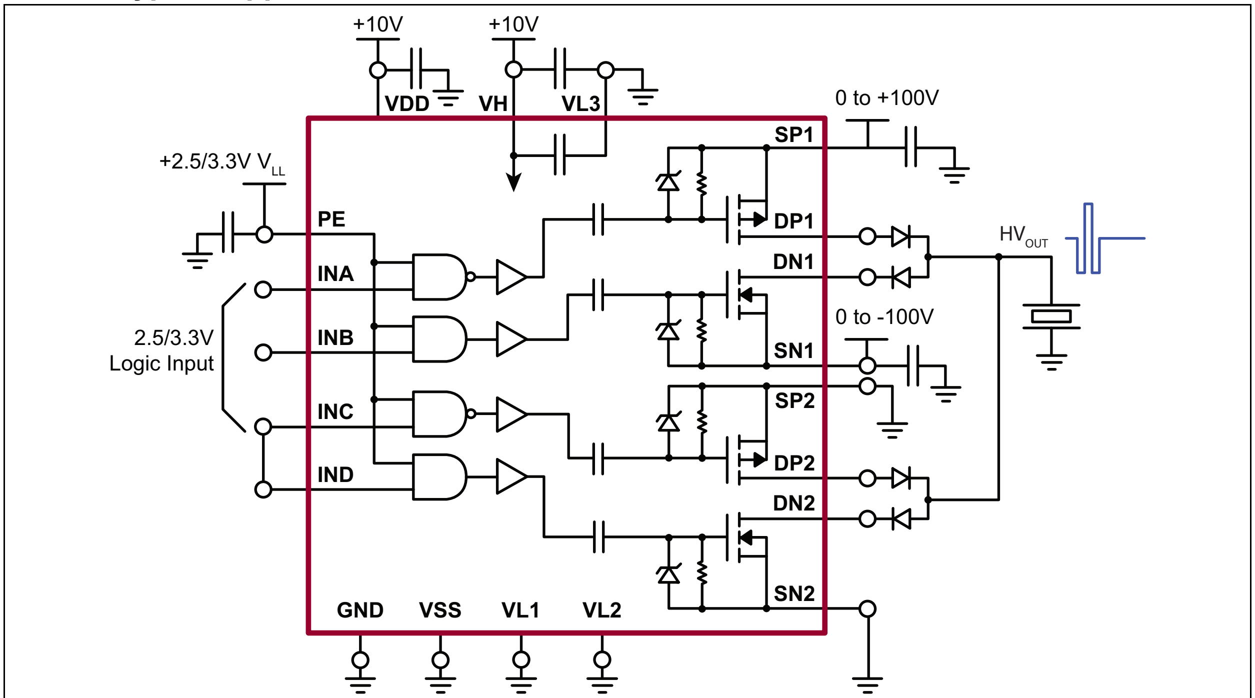
The peak output currents of each channel are guaranteed to be over ±2.5A with up to ±100V of pulse swing. The AC coupling topology for the gate drivers not only saves two floating voltage supplies but also makes the PCB layout easier.

Package Type

22-lead CABGA
(Top View)

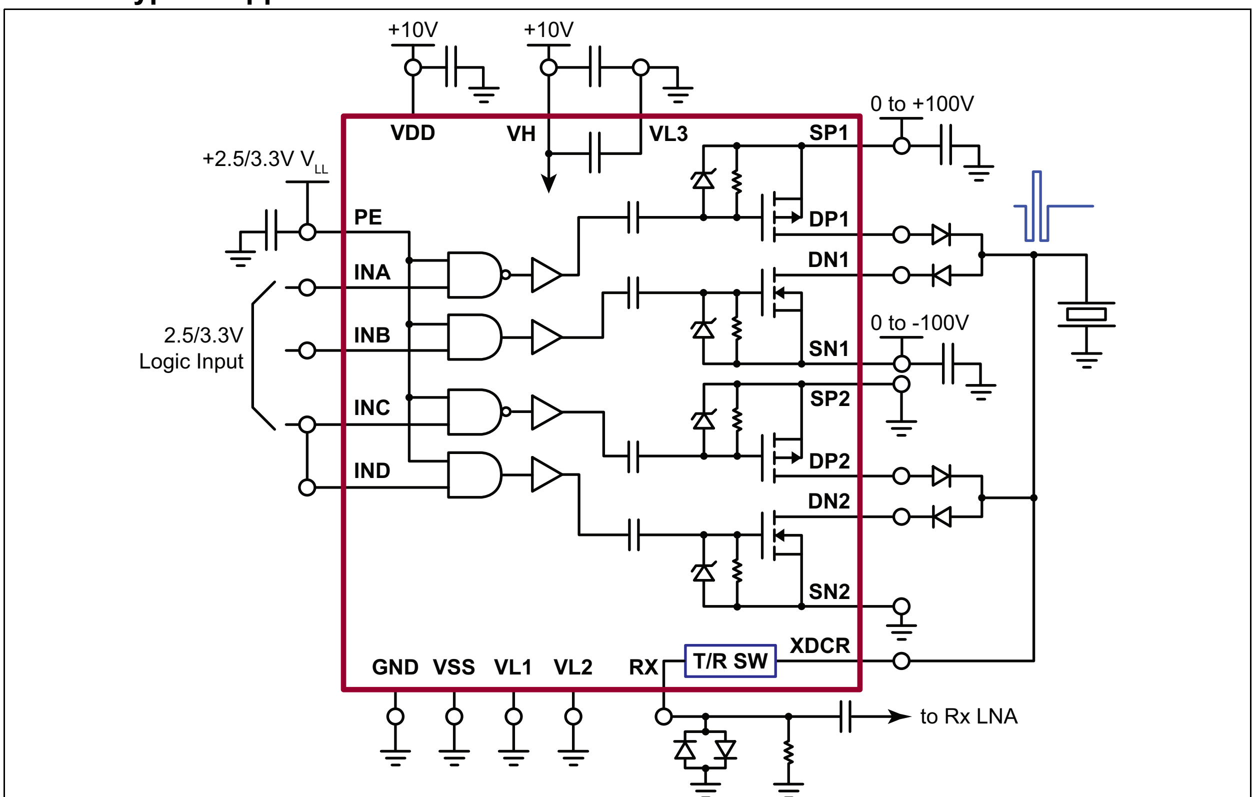


HV7360 Typical Application Circuit



+/-100V 2.5A Three-level RTZ Transmit Pulsers

HV7361 Typical Application Circuit



+/-100V 2.5A Three-level RTZ Transmit Pulsers with T/R Switch

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Chip Power Supply Voltage (V_{DD}-V_{SS}) .... –0.5 to +12.5V
V_H Output High Supply Voltage .... V_L–0.5 to V_{DD} +0.5V
V_L Output Low Supply Voltage .... V_{SS}–0.5V to V_H +0.5V
V_{SS} Low Side Supply Voltage .... –6 to +0.5V
Differential High Voltage (V_{SP1}-V_{SN1}), (V_{SP2}-V_{SN2}) .... +220V
$V_{SP1,2}$ Positive High Voltage .... –0.5 to +110V
$V_{SN1,2}$ Negative High Voltage .... +0.5 to –110V
All Logic Input Voltages .... V_{SS}–0.5V to GND +5.5V
Rx to XDCR Differential Drop .... ±140V
Coupling Capacitor Breakdown Voltage .... ±110V
Maximum Junction Temperature .... 125°C
Operating Temperature .... –20 to +85°C

† Notice: Stresses above those listed under "Absolute 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.

OPERATING SUPPLY VOLTAGES AND CURRENT

Electrical Specifications: GND = 0V, V_H = V_{DD} = +10V, V_L = V_{SS} = 0V, V_{PE} = 3.3V, V_{PP} = +100V, V_{NN} = –100V, T_A = 25°C unless otherwise specified.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Logic Supply Voltage Range	V_{LL}	2.25	—	3.63	V	
Supply Voltage	V_{DD}-V_{SS}	4.75	—	11.5	V	4 ≤ V_{DD} ≤ 11.5V
Low Side Supply Voltage	V_{SS}	–5.5	—	0	V	
Gate Drive High Side Voltage	V_H	V_{SS}+4	—	V_{DD}	V	V_H-V_L ≥ 4V
Gate Drive Low Side Voltage	V_L	V_{SS}	—	V_{DD}-4	V	
Output Positive High Voltage	$V_{SP1,2}$	0	—	100	V	
Output Negative High Voltage	$V_{SN1,2}$	–100	—	0	V	
V_{DD} Quiescent Current	I_{DDQ}	—	50	—	µA	No input transitions, PE = 0
V_H Quiescent Current	I_{HQ}	—	2	—	µA	
V_{DD} Quiescent Current	I_{DDQ}	—	1	—	mA	No input transitions, PE = 1
V_H Quiescent Current	I_{HQ}	—	2	—	µA	
V_{DD} Average Current	I_{DD}	—	4	—	mA	One channel On at 5 MHz, No load
V_H Average Current	I_H	—	10	—	mA	
Input Logic Voltage High	V_{IH}	V_{PE}-0.3	—	V_{PE}	V	For logic inputs INA, INB, INC and IND
Input Logic Voltage Low	V_{IL}	0	—	0.3	V	
Input Logic Current High	I_{IH}	—	—	1	µA	
Input Logic Current Low	I_{IL}	—	—	1	µA	
PE Input Logic Voltage High	V_{PEH}	1.7	3.3	5.25	V	For logic input PE
PE Input Logic Voltage Low	V_{PEL}	0	—	0.3	V	
PE Input Impedance to GND	R_{INPE}	100	—	—	kΩ	

AC ELECTRICAL CHARACTERISTICS

Electrical Specifications: GND = 0V, V_H = V_{DD} = +10V, V_L = V_{SS} = 0V, V_{PE} = 3.3V, V_{PP} = +100V, V_{NN} = –100V, T_A = 25°C unless otherwise specified.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Input or PE Rise and Fall Time	t_{irf}	—	—	10	ns	Logic input edge speed requirement
Input to Output Delay	$t_{d1\text{-}4}$	—	7.5	—	ns	R_{LOAD} = 1Ω
Output Rise and Fall Time	$t_{r/f1\text{-}2}$	—	9.5	—	ns	C_{LOAD} = 330 pF, R_{LOAD} = 2.5 kΩ
Rise and Fall Time Matching	Δt_{rf}	—	2	—	ns	Channel to channel
Propagation Matching	Δt_{dC2C}	—	1	—		
Propagation Delay Matching	Δt_{dD2D}	—	±2	—	ns	Device to device delay match
PE On-time	$t_{PE\text{-}ON}$	—	—	5	µs	V_{PE} = 1.7 ~ 5.25V, V_{DD} = 7.5 ~ 11.5V, –20 ~ 85°C
PE Off-time	$t_{PE\text{–}OFF}$	—	—	4		
Output to MOSFET Gate Cap	C_{OG}	—	10	—	nF	100V X7S
V_H to V_{L3} Decoupling Cap	C_{VH}	—	0.22	—	µF	16V X7R

ELECTRICAL CHARACTERISTICS

Electrical Specifications: GND = 0V, V_H = V_{DD} = +10V, V_L = V_{SS} = 0V, V_{PE} = 3.3V, V_{PP} = +100V, V_{NN} = –100V, T_A = 25°C unless otherwise specified.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
PULSER AND DAMPING P-CHANNEL MOSFET						
DC PARAMETERS						
Drain-to-source Breakdown Voltage	BV_{DSS}	–200	—	—	V	V_{GS} = 0V, I_D = –2 mA
Gate Threshold Voltage	$V_{GS(th)}$	–1	—	–2.4	V	V_{GS} = V_{DS}, I_D = –1 mA
Change in $V_{GS(th)}$ with Temperature	$\Delta V_{GS(th)}$	—	—	4.5	mV/°C	V_{GS} = V_{DS}, I_D = –1 mA
Gate-to-source Shunt Resistor	R_{GS}	10	—	50	kΩ	I_{GS} = 100 µA, if applied
Gate-to-source Zener Voltage	V_{ZGS}	13.2	—	25	V	I_{GS} = –2 mA, if applied
Zero-gate Voltage Drain Current	I_{DSS}	—	—	–10	µA	V_{DS} = Maximum rating, V_{GS} = 0V
		—	—	–1	mA	V_{DS} = 0.8 maximum rating, V_{GS} = 0V, T_A = 125°C
ON-state Drain Current	$I_{D(ON)}$	–1.2	—	—	A	V_{GS} = –5V, V_{DS} = –25V
		–2.3	–2.5	—		V_{GS} = –10V, V_{DS} = –50V
Static Drain-to-source ON-state Resistance	$R_{DS(ON)}$	—	—	8.5	Ω	V_{GS} = –5V, I_D = –150 mA
		—	—	7		V_{GS} = –10V, I_D = –1A
Change in $R_{DS(ON)}$ with Temperature	$\Delta R_{DS(ON)}$	—	—	1	%/°C	V_{GS} = –10V, I_D = –1 mA
AC PARAMETERS						
Forward Transconductance	G_{FS}	400	—	—	mmho	V_{DS} = –25V, I_D = –500 mA
Input Capacitance	C_{ISS}	—	75	—	pF	V_{GS} = 0V, V_{DS} = –25V, f = 1 MHz
Common Source Output Capacitance	C_{OSS}	—	21	—		
Reverse Transfer Capacitance	C_{RSS}	—	6.5	—		
DIODE PARAMETERS						
Diode Forward Voltage Drop	V_{SBD}	—	—	1.8	V	V_{GS} = 0V, I_{SD} = 500 mA
Reverse Recovery Time of Body Diode	t_{rrBD}	—	300	—	ns	
PULSER AND DAMPING N-CHANNEL MOSFET						
DC PARAMETERS						
Drain-to-source Breakdown Voltage	BV_{DSS}	200	—	—	V	V_{GS} = 0V, I_D = 2 mA
Gate Threshold Voltage	$V_{GS(th)}$	1	—	2.4	V	V_{GS} = V_{DS}, I_D = 1 mA

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Specifications: GND = 0V, $V_H = V_{DD}$ = +10V, $V_L = V_{SS}$ = 0V, V_{PE} = 3.3V, V_{PP} = +100V, V_{NN} = –100V, T_A = 25°C unless otherwise specified.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Change in $V_{GS(th)}$ with Temperature	$\Delta V_{GS(th)}$	—	—	–4.5	mV/°C	$V_{GS} = V_{DS}$, I_D = 1 mA
Gate-to-source Shunt Resistor	R_{GS}	10	—	50	kΩ	I_{GS} = 100 µA
Gate-to-source Zener Voltage	V_{ZGS}	13.2	—	25	V	I_{GS} = 2 mA
Zero Gate Voltage Drain Current	I_{DSS}	—	—	10	µA	V_{DS} = Maximum rating, V_{GS} = 0V
		—	—	1	mA	V_{DS} = 0.8 maximum rating, V_{GS} = 0V, T_A = 125°C
ON-state Drain Current	$I_{D(ON)}$	1.3	—	—	A	V_{GS} = 5V, V_{DS} = 25V
		2.3	2.5	—		V_{GS} = 10V, V_{DS} = 50V
Static Drain-to-source ON-state Resistance	$R_{DS(ON)}$	—	—	6.5	Ω	V_{GS} = 5V, I_D = 150 mA
		—	—	6		V_{GS} = 10V, I_D = 1A
Change in $R_{DS(ON)}$ with Temperature	$\Delta R_{DS(ON)}$	—	—	1	%/°C	V_{GS} = 10V, I_D = 1A
AC PARAMETERS						
Forward Transconductance	G_{FS}	400	—	—	mmho	V_{DS} = 25V, I_D = 500 mA
Input Capacitance	C_{ISS}	—	56	—	pF	V_{GS} = 0V, V_{DS} = 25V, f = 1 MHz
Common Source Output Capacitance	C_{OSS}	—	13	—		
Reverse Transfer Capacitance	C_{RSS}	—	2	—		
DIODE PARAMETERS						
Diode Forward Voltage Drop	V_{SBD}	—	—	1.8	V	V_{GS} = 0V, I_{SD} = 500 mA
Reverse Recovery Time of Body Diode	t_{rrBD}	—	300	—	ns	

HV7631 T/R SWITCH CHARACTERISTICS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Breakdown Voltage from XDCR to Rx	B_{VA-B}	±130	—	—	V	I_{A-B} = ±1 mA
Switch-on Resistance from XDCR to Rx	R_{SW}	—	15	—	Ω	I_{A-B} = ±5 mA
V_{A-B} Trip Point to Turn Off	V_{TRIP}	—	±1	±2	V	
Switch Turn-off Voltage	V_{OFF}	—	±2	—	V	I_{A-B} = ±1 mA
Switch-off Current	$I_{A-B(OFF)}$	—	±200	±300	µA	V_{A-B} = ±130V
Peak Switching Current	I_{PEAK}	—	±60	—	mA	
Turn-off Time	T_{OFF}	—	—	20	ns	
Turn-on Time	T_{ON}	—	—	20	ns	
Switch-on Capacitance from A to B or B to A	$C_{SW(ON)}$	—	21	—	pF	SW = On
Switch-off Capacitance from A to B or B to A	$C_{SW(OFF)}$	—	15	—	pF	V_{SW} = 25V
Small Signal Bandwidth	BW	—	100	—	MHz	R_{LOAD} = 50Ω

TEMPERATURE SPECIFICATIONS

Electrical Characteristics: Unless otherwise noted, for all specifications $T_A = T_J = +25°C$.						
Parameters	**Sym.**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
TEMPERATURE RANGES						
Maximum Junction Temperature	$T_{J(MAX)}$	—	125	—	°C	
Operating Temperature	T_A	–20	—	+85	°C	
PACKAGE THERMAL RESISTANCE						
22-Lead CABGA	θ_{JA}	—	106	—	°C/W	

POWER-UP AND POWER-DOWN SEQUENCE (Note 1)

Power-Up		Power-Down	
Step	**Description**	**Step**	**Description**
1	V_{LL}	1	PE inactive
2	V_{DD}, V_H, V_{SS} and V_L with signal logic low	2	V_{PP} and V_{NN} off
3	V_{PP} and V_{NN}	3	V_{DD}, V_H, V_{SS} and V_L off
4	PE active	4	V_{LL} off

Note 1: Powering up or down in any arbitrary sequence will not cause any damage to the device. The power-up sequence and power-down sequence are only recommended to minimize possible inrush current.

LOGIC CONTROL TABLE

PE	Input Pulse				Output MOSFETs			
	INA	**INB**	**INC**	**IND**	**SP1 to DP1**	**DN1 to SN1**	**SP2 to DP2**	**DN2 to SN2**
1	1	X	X	X	**ON**	X	X	X
	X	1	X	X	X	**ON**	X	X
	X	X	1	X	X	X	**ON**	X
	X	X	X	1	X	X	X	**ON**
	0	X	X	X	**OFF**	X	X	X
	X	0	X	X	X	**OFF**	X	X
	X	X	0	X	X	X	**OFF**	X
	X	X	X	0	X	X	X	**OFF**
0	X	X	X	X	OFF	OFF	OFF	OFF

2.0 PAD DESCRIPTION

Table 2-1 details the description of pads in HV7360/HV7361.

TABLE 2-1: PAD FUNCTION TABLE

Pad Location	HV7360 Symbol	HV7361 Symbol	Description
A1	GND	GND	Driver and level translator circuit ground return (0V)
A2	IND	IND	Damping N-FET control signal logic input, controlling N-FET2
A3	INC	INC	Damping P-FET control signal logic input, controlling P-FET2
A4	V_{SS}	V_{SS}	Negative voltage power supply (0V)
A6	V_{DD}	V_{DD}	Positive voltage supply (+10V), should connect to an external decoupling cap to V_{SS} (0V)
A7	INB	INB	Pulsing N-FET control signal logic input, controlling N-FET1
A8	INA	INA	Pulsing P-FET control signal logic input, controlling P-FET1
A9	PE	PE	Drive power enable Hi = On, Low = Off, logic '1' voltage reference input (+2.5V to +3.3V)
B2	V_{L2}	V_{L2}	Gate-drive negative voltage power supply (0V)
B8	V_{L1}	V_{L1}	Gate-drive negative voltage power supply (0V)
F4	V_H	V_H	Gate-drive positive voltage power supply (+10V)
F7	V_{L3}	V_{L3}	V_H to V_L decoupling cap. The trace connecting V_{L1}, V_{L2}, and V_{L3} (0V) to ground plane should be as short as possible.
G4	NC	—	No connection for HV7360
	—	RX	T/R switch output for HV7361
P1	SP2	SP2	Source of P-FET2, positive high voltage power supply (0 to +100V) or GND
P2	DP2	DP2	Drain of P-FET2, transmit pulser output
P3	DN2	DN2	Drain of N-FET2, transmit pulser output
P4	SN2	SN2	Source of N-FET2, negative high voltage power supply (0 to –100V) or GND
P5	NC	—	No connection for HV7360
	—	XDCR	T/R switch input for HV7361
P6	SP1	SP1	Source of P-FET1, positive high voltage power supply (0 to +100V)
P7	DP1	DP1	Drain of P-FET1, transmit pulser output
P8	DN1	DN1	Drain of N-FET1, transmit pulser output
P9	SN1	SN1	Source of N-FET1, negative high voltage power supply (0 to –100V)

3.0 FUNCTIONAL DESCRIPTION

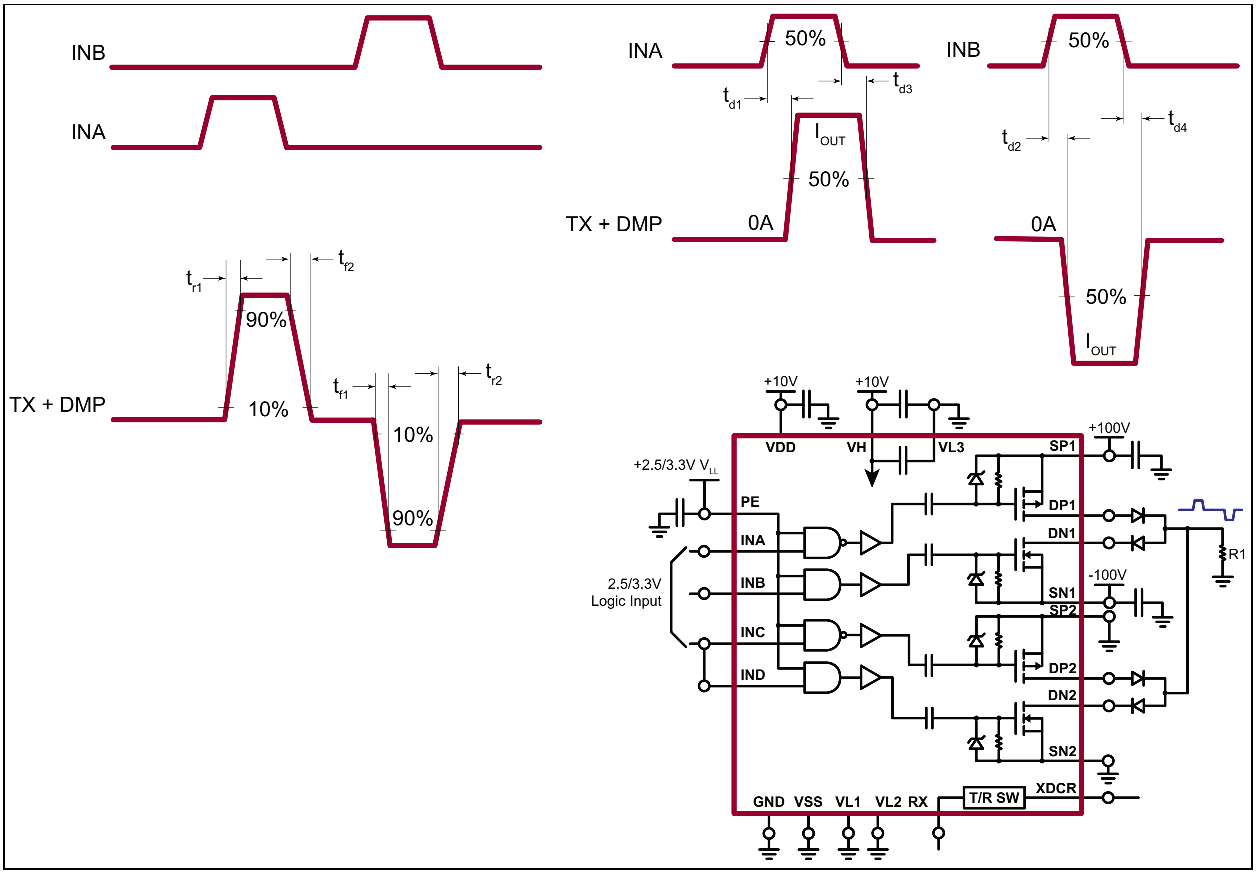


FIGURE 3-1: *Pulser Timing Test for HV7360/HV7361.*

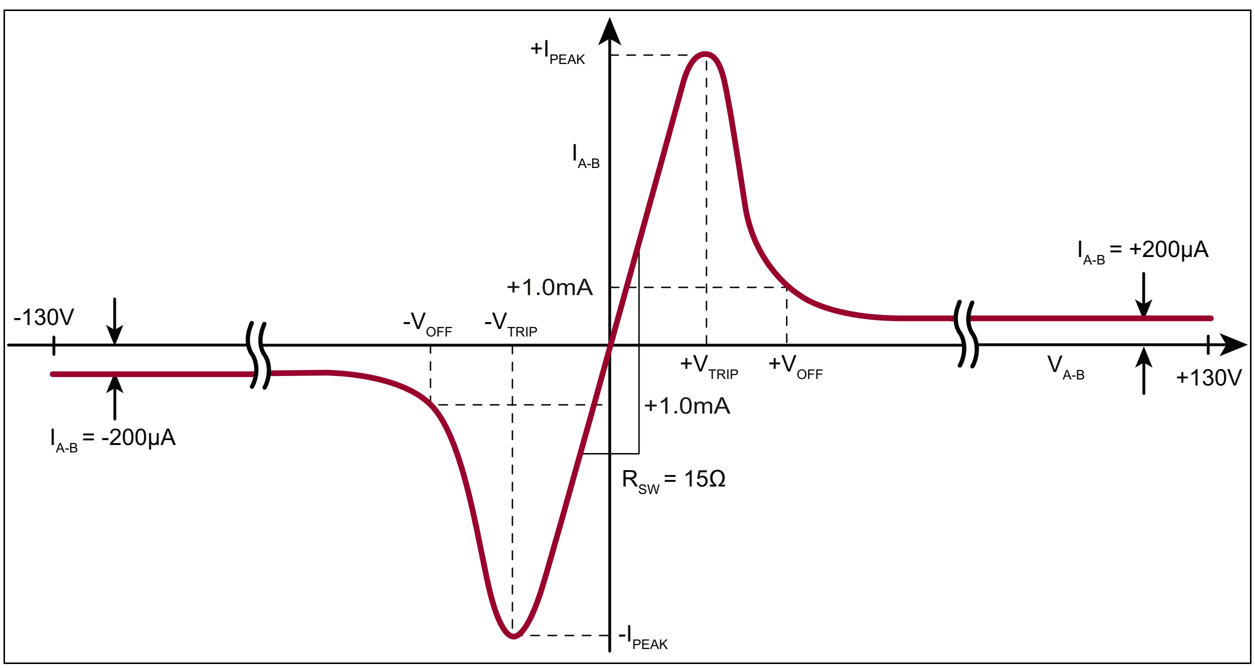


FIGURE 3-2: *T/R Switch I-V curve for HV7361.*

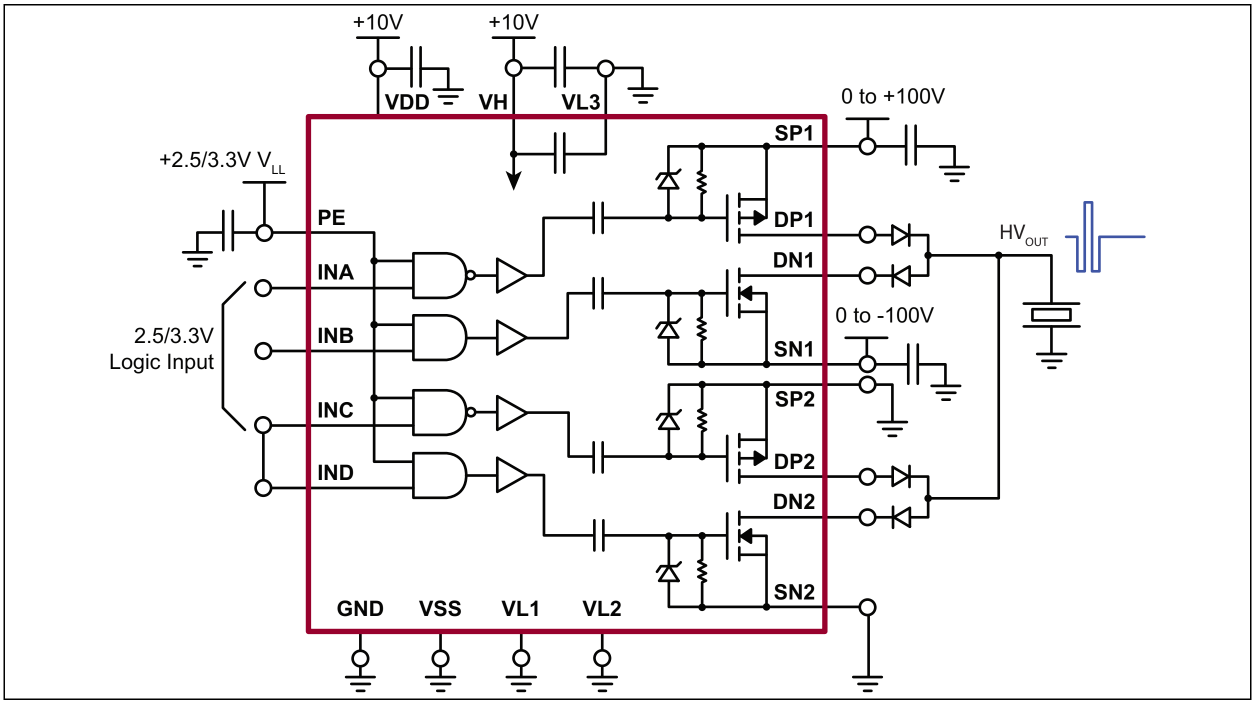


FIGURE 3-3: Typical Bipolar One-channel Three-level Ultrasound Transmitter Application Circuit for HV7360.

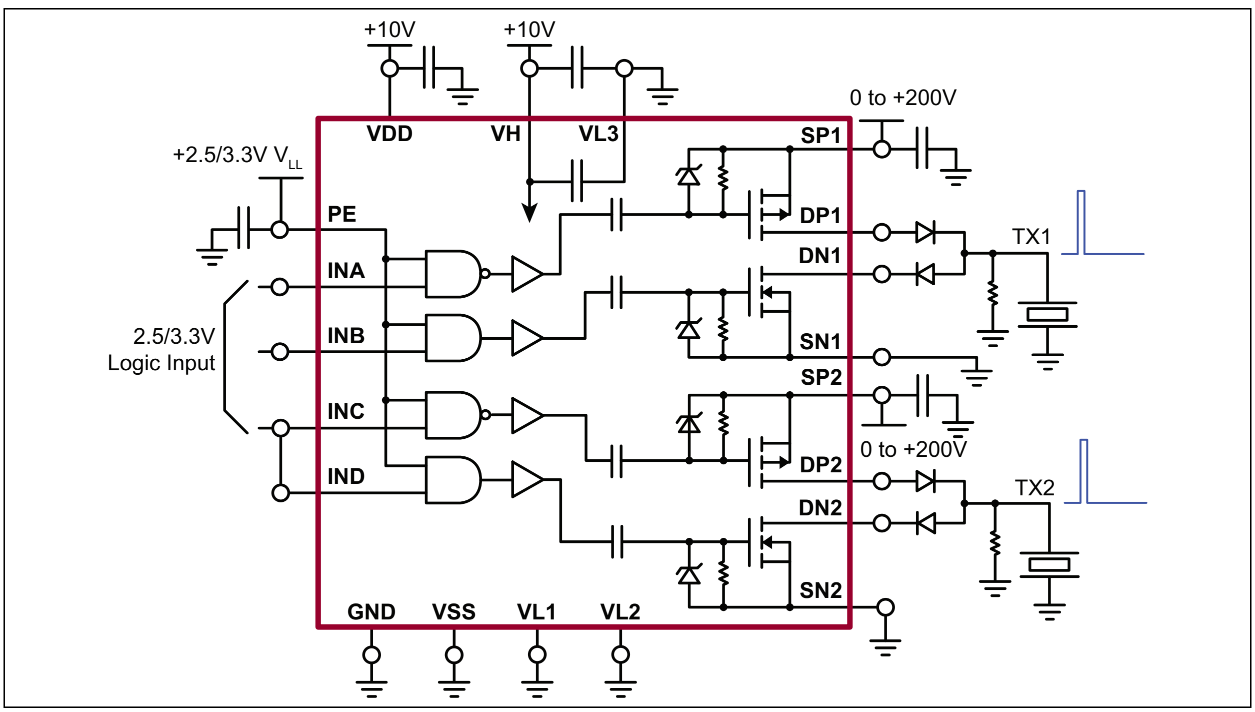
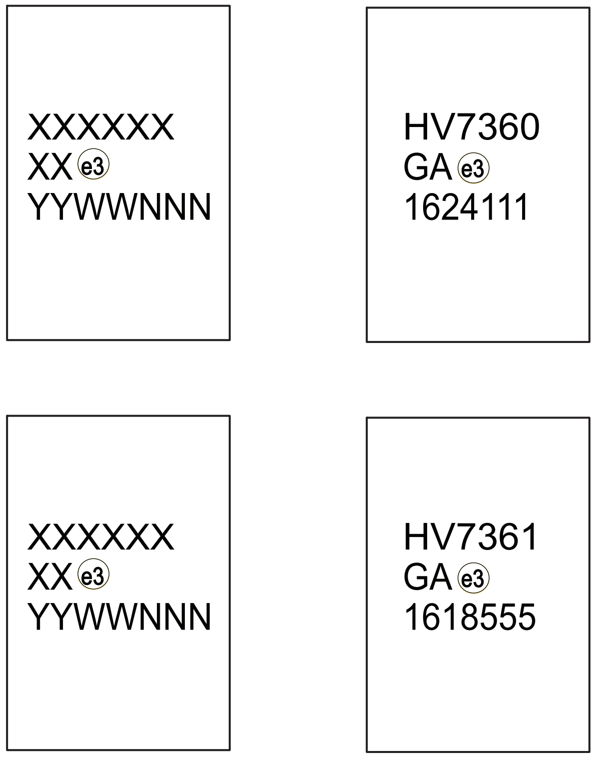


FIGURE 3-4: Typical Unipolar Two-channel Two-level Ultrasound Transmitter Application Circuit for HV7361.

4.0 PACKAGING INFORMATION

4.1 Package Marking Information

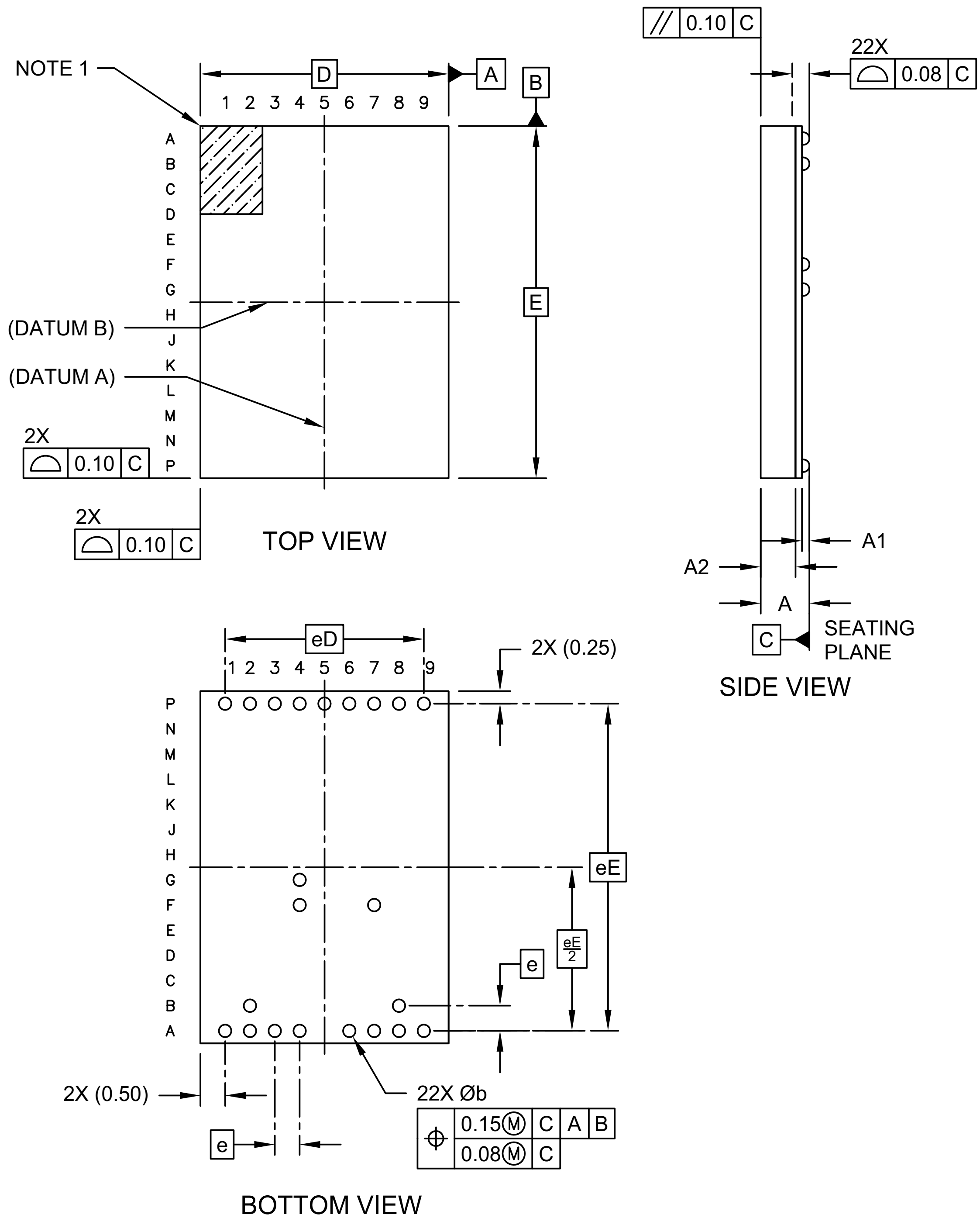


Legend:	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

Note: 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 product code or customer-specific information. Package may or not include the corporate logo.

22-Ball Chip Array Ball Grid Array (JY) - 5x7 mm Body [CABGA]

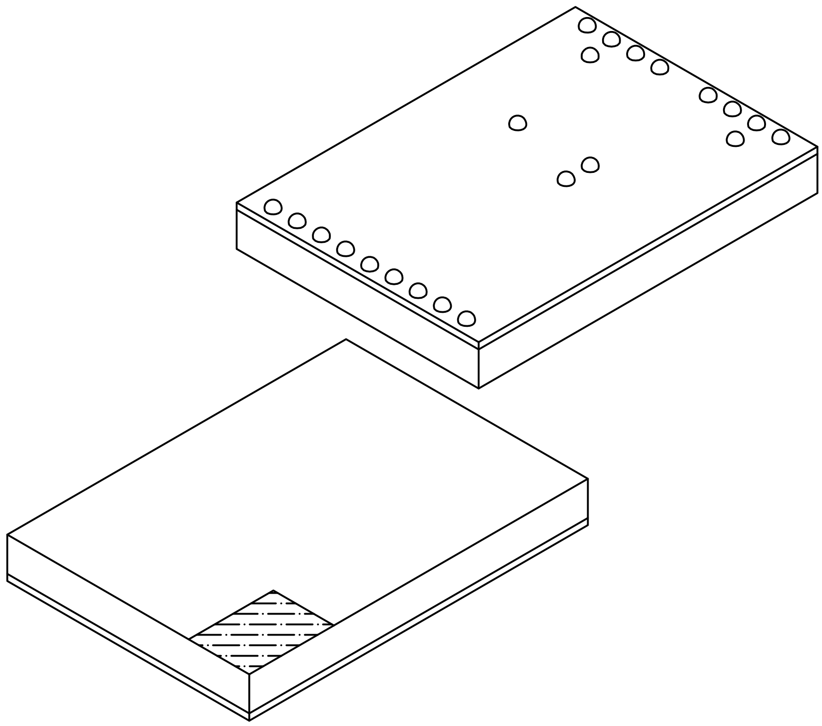
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-414A Sheet 1 of 2

22-Ball Chip Array Ball Grid Array (JY) - 5x7 mm Body [CABGA]

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	-		22	
Pitch	e		0.50 BSC	
Overall Height	A	0.91	0.98	1.05
Ball Height	A1	0.12	0.15	-
Package Thickness	A2	0.66	0.70	0.74
Overall Length	D		5.00 BSC	
Overall Terminal Pitch	eD		4.00 BSC	
Overall Width	E		7.00 BSC	
Overall Terminal Pitch	eE		6.50 BSC	
Ball Diameter	b	0.20	0.25	0.30

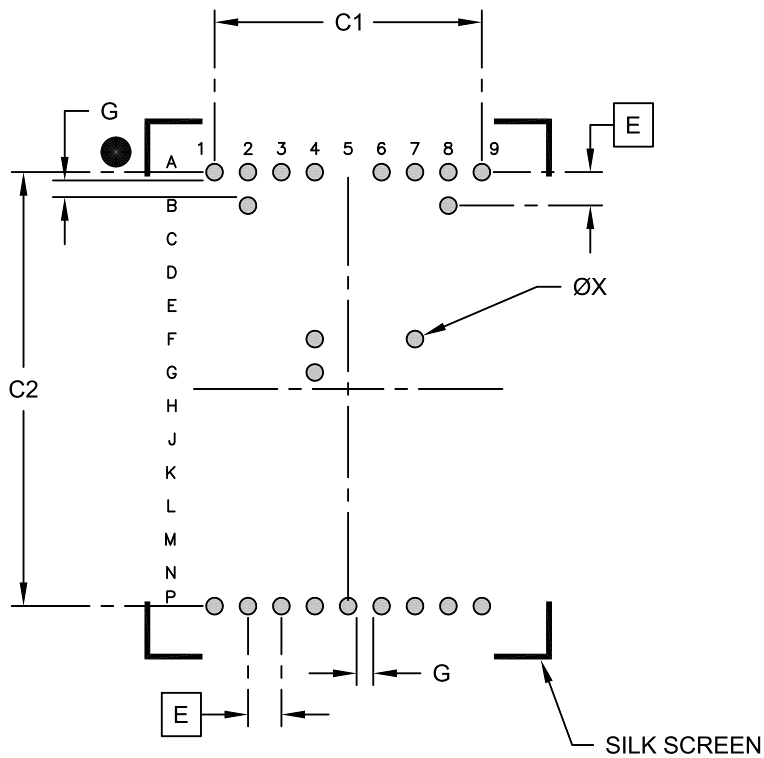
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-414A Sheet 2 of 2

22-Ball Chip Array Ball Grid Array (JY) - 5x7 mm Body [CABGA]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E	0.50 BSC		
Contact Pad Spacing	C1		4.00	
Contact Pad Spacing	C2		6.50	
Contact Pad Diameter (X22)	X		0.25	
Contact Pad to Contact Pad	G	0.20		

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-2414A

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (June 2016)

- Converted Supertex Doc# DSFP-HV7360 and Supertex Doc# DSFP-HV7361 to Microchip DS20005570A.
- Meged HV7360 and HV7361 into one document.
- Replaced the 22-lead LFGA “LA” package with 22-lead CABGA “GA” package.
- Made minor text changes throughout the document.

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

PART NO.	XX	-	X	-	X
Device	Package Options		Environmental		Media Type

Device:	HV7360	=	High-voltage High-speed Pulse Generator with Built-in Fast RTZ Damping FETs
	HV7361	=	High-voltage High-speed Pulse Generator with Built-in Fast RTZ Damping FETs and an Integrated Two-terminal Low-noise T/R Switch
Packages:	GA	=	22-lead CABGA
Environmental:	G	=	Lead (Pb)-free/RoHS-compliant Package
Media Type:	(blank)	=	364/Tray for GA Package

Examples:

a) HV7360GA-G: High-voltage High-speed Pulse Generator with Built-in Fast RTZ Damping FET, 22-lead CABGA Package, 364/Tray

b) HV7361GA-G: High-voltage High-speed Pulse Generator with Built-in Fast RTZ Damping FET and an Integrated Two-terminal Low-noise T/R Switch, 22-lead CABGA Package, 364/Tray

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.

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, KEELOQ® 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

ISBN: 978-1-5224-0668-6

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
Web Address:
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: 905-673-0699
Fax: 905-673-6509

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 - 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

07/14/15