AN2303

4-Channel Integrated Ultrasound Pulser HV7321 Second Harmonic Distortion Measurement

Author: *Aytug Karalar*
Microchip Technology Inc.

INTRODUCTION

One of the most important transmit pulser requirements for ultrasound harmonic image systems is the second harmonic distortion (HD2). This Application Note introduces the Microchip Technology Inc. HV7321 4-channel 5-level high-voltage ultrasound pulser IC, discusses its performance, and explains how HD2 is measured and calculated.

HV7321 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 currents up to ±2.5A, and the output voltage can swing up to ±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 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} & 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 enables the part to be interfaced with FPGAs directly.

For additional details, refer to the HV7321 Data Sheet, *"4-Ch. 5-Level ±80V High-Voltage Ultrasound Pulser with T/R Switches"* (DS20005639A).

HV7321 FEATURES

- Power Sequencing Free 5 Output Levels including RTZ (Return-To-Zero)
- Output Voltage up to ±80V
- ±2.5A Peak Output Current
- ±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

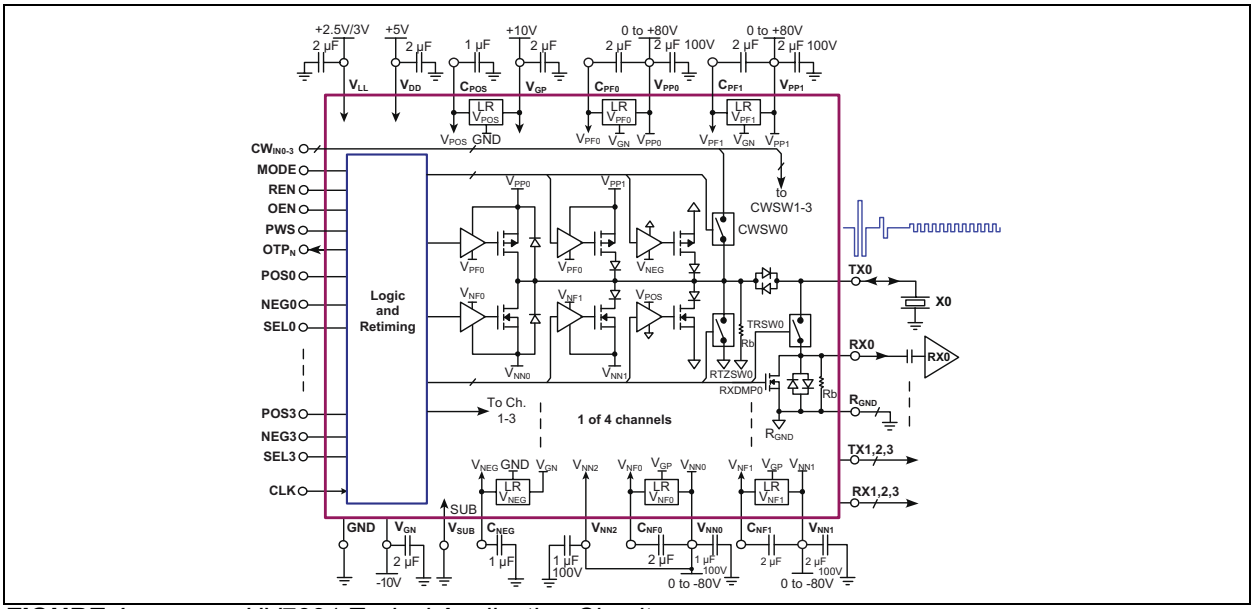

FIGURE 1: *HV7321 Typical Application Circuit.*

WHAT IS SECOND HARMONIC DISTORTION (HD2)?

HD2 is the ratio of second-order harmonic amplitude to the fundamental frequency, the first order of an ultrasound transmit pulser output. It is measured in decibels (dB).

WHY IS HD2 IMPORTANT TO ULTRASOUND TX PULSERS?

Harmonic medical ultrasound image systems are designed to construct the second-order harmonic by receiving the echo signals scattered by body tissue.

Normally, in order to minimize the TX pulser positive and negative waveforms differences in the system, standard-harmonic imaging uses TX pulse-inversion and pulse echo-cancellation.

Although there are some other echo-signal data-processing methods for harmonic imaging, this application note will focus mainly on the TX pulse inversion-cancellation method.

Normally, ultrasound transmitters use a few half-cycles of a square waveform pattern. A perfectly symmetric square wave, with exactly 50-50% duty cycle, should not contain any second harmonic component. But in the frequency spectrum of a slightly asymmetric or distorted square wave, the second-order harmonic component will show up.

TX pulsers use P-MOSFETs and N-MOSFETs to generate positive and negative pulses. P-MOSFETs are different from N-MOSFETs in principle. This is because one conducts by carrier and the other by electron. They are different in size when conducting the same current. Therefore, ultrasound harmonic image systems must use the inversion-cancellation method.

The purpose of pulse inversion-cancellation is to minimize the second harmonic spectrum components in the sum of two transmitting pulses, inverting and noninverting waveforms. If the TX pulser can make sure that the sum of second-order components of the inverting and noninverting waveforms is zero or near zero, then the user can assume that the second-order harmonic energy in the sum of the two echo signals is all generated from the body tissue.

HOW TO MEASURE THE HV7321 TX OUTPUT HD2?

The HV7321 HD2 measurement setup is shown in Figure 2. A competitor's 4-channel pulser was measured using the same setup for reference. Both ICs were installed on their dedicated evaluation boards.

GUIs were installed on the PCs, and the GUIs communicate with the evaluation boards via USB. Measurements were acquired by a Tektronix TDS3034B oscilloscope. For both measurements, the oscilloscope was set to 4-average acquisition mode, 10k points horizontal resolution and 2.5 GS/s sample rate. Data was acquired from channel-0 of both evaluation boards.

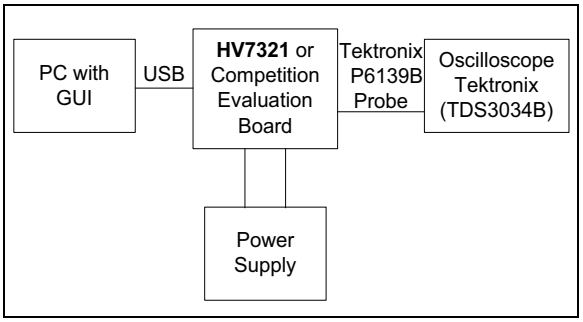

FIGURE 2: *HV7321 and Competitor IC HD2 Measurement Setup.*

Figure 3 shows the measurement of one cycle of ±70V 5 MHz signal (A) and its inversion (B) from channel-0 of the HV7321. Figure 4 shows the frequency spectrum of A-B and A+B. HD2 is measured as -48.2 dB.

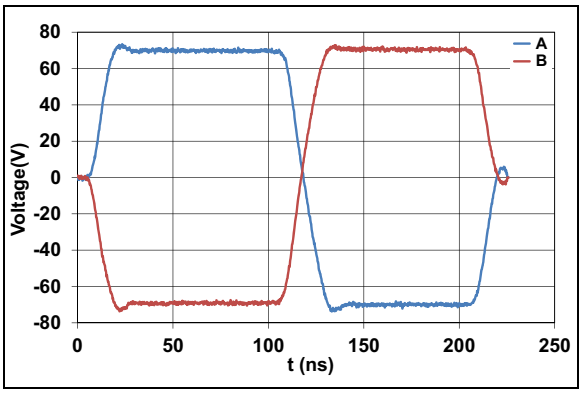

FIGURE 3: *HV7321 TX Output Waveform, 1-Cycle, 5 MHz with 220 pF//1 kΩ Load.*

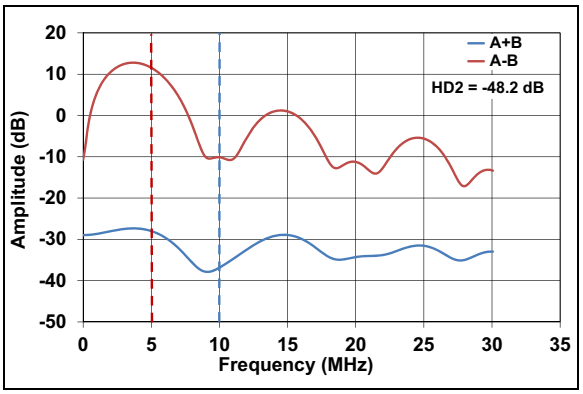

FIGURE 4: *HV7321 TX Output Spectrum, 1-Cycle, 5 MHz with 220 pF//1 kΩ Load.*

Figure 5 shows the measurement of one cycle of ±70V 5 MHz signal (A) and its inversion (B) from channel-0 of a competitor's pulser. Figure 6 shows the frequency spectrum of A-B and A+B. HD2 is measured as -32.4 dB.

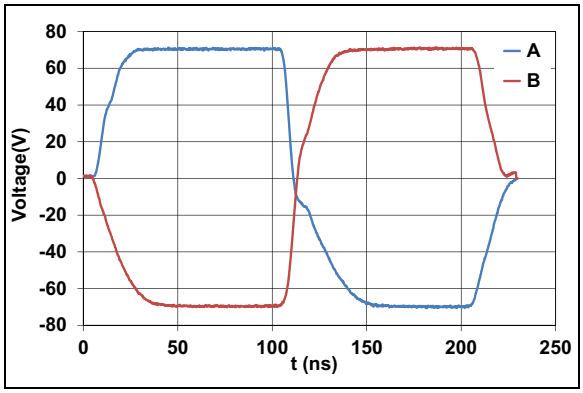

FIGURE 5: *Competitor TX Output Waveform, 1-Cycle, 5 MHz with 270 pF//100Ω Load.*

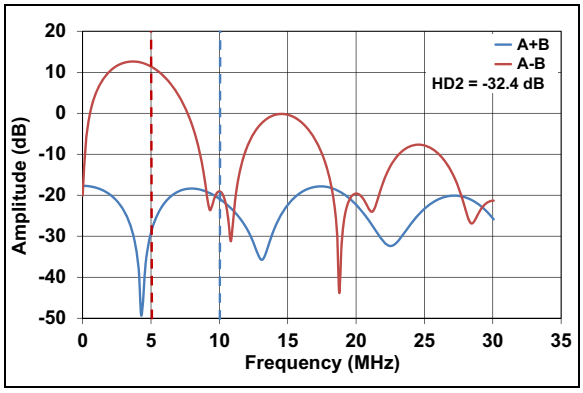

FIGURE 6: *Competitor TX Output Spectrum, 1-Cycle, 5 MHz with 270 pF//100Ω Load.*

CONCLUSION

Microchip's HV7321 4-channel 5-level high-voltage ultrasound pulser IC has less than -40 dB of second harmonic distortion. Due to the low second harmonic distortion, the HV7321 is a good pulser choice for portable medical ultrasound harmonic imaging systems, NDT ultrasound transmission pulsers, and piezoelectric or capacitive transducer drivers.

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.

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: 978-1-5224-1029-4

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: 905-695-1980
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