



**PulseWave2D™**  
**Model PulseWave2D-300 USB**  
**Owner's Manual**

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**SpinCore Technologies, Inc.**  
<http://www.spincore.com>

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# I. Introduction

## Product Overview

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The PulseWave2D-300 is capable of storing 1.5 million samples for use in arbitrary waveform generation. The length of the waveforms is programmable, making the device quite versatile being able to store a large number of small waves, or a relatively small number of larger waveforms. Each independent output channel can output the waves from memory in different orders, through the use of the sequence tables. This feature allows waveforms to be re-used, removing the need for duplicate waveforms in memory, and making it so that waveforms do not need to be stored in order. There is one sequence table per channel, which contains a programmable sequence of wave addresses. Waveforms are output after each triggering signal, either from software or hardware. The PulseWave2D-300 is available in two standard options: a) the board-only option b) the single-bay standalone enclosure. If you require a specific enclosure design, please contact SpinCore directly.

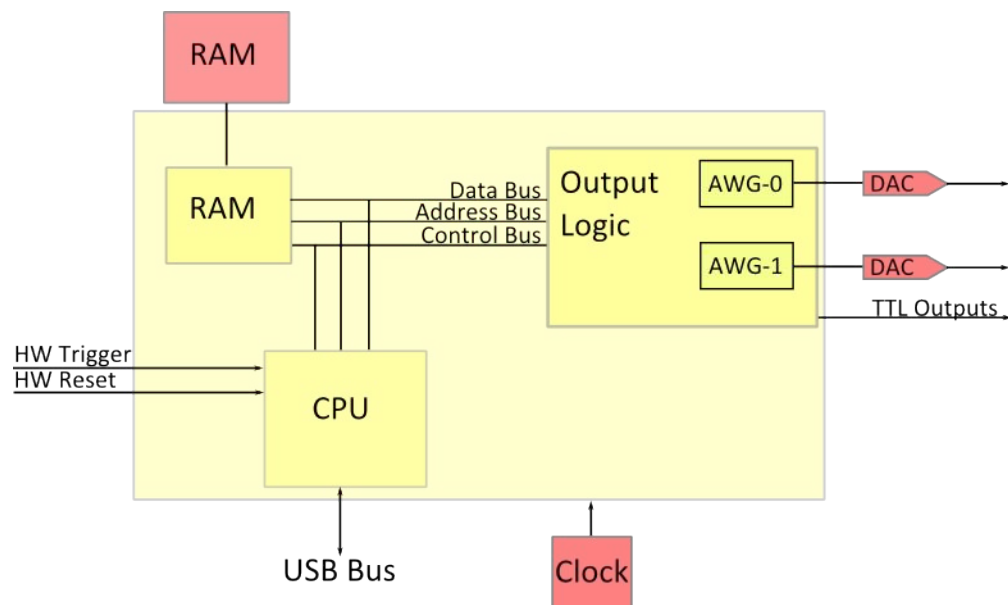
Key features of the PulseWave2D-300 include:

- Output resolution of 12 bits at 300 MSPS
- 2 independent output channels
- 18 Mb of waveform memory
- 4095 sequence table entries per channel
- Maximum waveform length of 8190 samples
- 15.61-2803.73 kHz triggering frequency (max)
- Output bits to indicate the start of waveform output

## Core Architecture

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Figure 1 presents the general architecture of the PulseWave2D-300 system. The two major building blocks of the system are the CPU and the independent AWG output cores. The CPU handles communication with the USB bus, memory, and the AWG cores. Once the CPU has configured the device and loaded the memories based on user input, the AWG cores handle the output to the DACs, and respond to user triggers through software or hardware. The AWG and CPU cores have been integrated onto a single silicon chip. High performance DAC chips and broadband output transformers complement the design. User control to the system is provided through the USB programming interface over the USB Bus.



**Figure 1:** PulseWave2D-300 System Core Architecture.

## Product Specifications

	<b>Parameter</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Units</b>
Analog Output <sup>(1)</sup>	D/A sampling rate		300		MHz
	D/A sampling precision			12	bits
	Output voltage range (peak-peak)			1.2 <sup>(2)</sup>	Vpp
Digital Output	Number of digital outputs		2		
	Logical 1 output voltage		3.3 <sup>(3)</sup>		V
	Logical 0 output voltage		0		V
	Output drive current			25	mA
	Rise/Fall time			< 1	ns
Digital Input (HW_Trig, HW_Reset, IRQ[2..0])	Logical 1 input voltage	0.7		3.3	V
	Logical 0 input voltage	0		0.7	V
AWG	# of samples		1.5M		samples
	# of waveforms			500000	
	# of samples/waveform <sup>(4)</sup>	3		8190	samples
	Triggering Frequency <sup>(5)</sup>			15.61-2803.73	kHz

**Table 1:** PulseWave2D-300 Product Specifications.

### Notes

- 1) The output must be properly terminated using a 50 Ohms terminating resistor. The output is AC coupled and will not hold a DC value. A reconstructive filter may be used at the output of the AWG channels if desired. Both BNC and SMA versions of low-pass and band-pass filters are available for this purpose.
- 2) Analog output voltage maximum is 1.2 Vpp on 50 Ohms.
- 3) This is the value seen without using termination. When the line is terminated with 50 Ohms, the output voltage will be lower.
- 4) Must be divisible by 3.
- 5) The triggering frequency (in kHz) is a function of the configured samples per waveform (n): 
$$\frac{900000}{7 \cdot n + 300}$$

## II. System Installation

To install the PulseWave2D-300 system you must complete the following four steps:

1. Install the latest API version and example programs found at:  
[http://www.spincore.com/support/spinapi/spinapi\\_examples.shtml#PulseWave2D](http://www.spincore.com/support/spinapi/spinapi_examples.shtml#PulseWave2D). The PulseWave2D-300 API is a C++ library which includes all the necessary objects for operating the PulseWave2D-300 device, and will be used in the sections below, including Testing the PulseWave2D-300. The API installer package will also install the necessary drivers.
2. Connect power cord to the PulseWave2D-300 enclosure. (Or connect Molex power connector to bare board)
3. Connect the PulseWave2D-300 system to the host computer using a USB 2.0 cable.
4. Apply power to your PulseWave2D-300.
5. Open the API installer and follow the installation prompts.
6. Optionally, install the example package.

Now you are ready to run the test programs provided in the example package. To compile and run your own C++ programs, it is recommended to either use Microsoft Visual C++, or the Windows SDK compilers. The provided library is compiled using the MSVC++ name mangling method, so the use of other compilers may require the user to recompile the C++ library (all necessary source and binary files are included) with their compiler of choice.

### Testing the PulseWave2D-300

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Once your PulseWave2D-300 system is installed properly, you are now ready to test the functionality of your device with the example programs. Included in the C:\SpinCore\PulseWave2D-300\Examples\ folder<sup>4</sup> is the C++ source code and executables for these test programs. You can begin by running the pre-compiled executables to test the functionality of your system. Then you can modify the C++ source files as needed to start making your own programs. All of the sequences are easily verified using an oscilloscope which can be triggered using TTL outputs 0 and 1.

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<sup>4</sup> This is the default location, and may be changed when the example package is installed.

## III. Using the PulseWave2D-300

Most applications can be programmed following these basic steps:

1. Enumerate devices.
2. Select the device (if using more than one device).
3. Initialize the device.
4. Load configuration with the desired values.
5. Load sequence tables with the desired values.
6. Load waveform memory with desired data.
7. Prime the output buffers.
8. Trigger the device through software or hardware.

These steps are described in detail below. For each of the steps, the relevant API functions are listed which control the actions needed to perform that particular step. Detailed API reference is included with the API installation.

### Selecting and Initializing the System

The API provides the `global_enumerate_devices()` function to detect all PulseWave2D-300 devices attached to the system. `global_enumerate_devices()` must be called once in order to generate device handles. After it has been called, it does not need to be called again by other `pulsewave2d` objects. The `choose_board(...)` routine must be used to select the PulseWave2D-300 device to be used, in each object. To determine the number of your device when multiple PulseWave2D-300 devices are connected, please check the Device Manager for device numberings.

Before using any API functions to control your system, it is necessary to first initialize the device using the `init()` routine. The `init()` routine resets the selected device, and prepares for communication with the device.

Once the device has been initialized, it is necessary to provide some information about the waveforms so that the API functions can operate correctly, and configuration registers on the device can be set. The function used for this is `set_waveform_info(...)` which sets the number of waveforms you will be storing, and the number of samples in each.

### Sequence Table Programming

The PulseWave2D-300 contains two AWG channels. Each AWG channel drives a Digital-to-Analog Converter (DAC) that forms the Analog Output channel. Each AWG channel reads from its own sequence table, which contains data pointers that make up the desired waveform output order. The user is isolated from calculating the data pointers through the use of the `local_store_seq_table_val(...)` function. This function takes the channel number and index of the wave as input, and calculates the data pointer and stores it in an array on the local computer. Each consecutive call of `local_store_seq_table_val(...)` adds an entry to that array, up to the maximum entries supported. The index of the wave is based on the order they are programmed, which will be discussed below. Note that the first wave programmed is at wave index 0. Once all desired sequence table entries have been entered, `send_seq_tables()` must



be called to send the sequence table data to the device. Only one call of `send_seq_tables()` is necessary; all channels' data will be sent.

## Waveform Programming

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Similarly to the sequence table programming method, waveforms are stored locally in a large array, and then sent to the PulseWave2D-300 all at once. `local_store_single_wave(..)` is used to store the user's wave data into the array. Consecutive calls add to the end of the array. Once all waveforms have been entered, they are sent with `send_all_waves()`. After the waveforms and sequence tables have been sent, the device is almost ready to be triggered. The last thing that has to be done is prime the output buffers by a single call to `start()`.

## Triggering

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The PulseWave2D-300 can be triggered in two ways, either by software trigger or hardware trigger. The software trigger is initiated by sending a command from the host PC with the `start()` function. Because these devices are typically used with non real-time operating systems, the exact time between issuing a software trigger and the device acting on that trigger cannot be precisely specified.

For precision control, the pulse program can also be triggered by the transition of the HW\_Trigger pin from logical 1 to logical 0. This will cause the device to assert the TTL output bit for each operating channel within 3 clock cycles, and 1 cycle after the TTL output bit is asserted the DAC receives valid data, after which 4.3 ns ( $\frac{1}{2}$  clock cycle +  $t_{PD_{DAC}}$ ) will elapse before the data is seen at the analog output (neglecting minimal PCB routing delay). The core clock used is 150 MHz (the DACs use an internal PLL to achieve 300 MSPS). Note that there may be 2 extra clock cycles of delay due to synchronization concerns.

TTL output bit 0 corresponds to Analog Out 1, and TTL output bit 1 corresponds to Analog Out 2. They will pulse high for one clock cycle (6.6 ns) when a waveform is beginning output. The timing of these signals is explained in the previous paragraph.

**NOTE:** *The PulseWave2D-300 requires a 3.3 V TTL input signal for HW\_Reset. A signal that is more than 3.3 V or less than 0 V will damage the device.*

## **Other methods for controlling the PulseWave2D-300**

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The functions provided with the API can be used to create more than just C++ executables. Custom software can be made using library. Examples of this are LabVIEW and MATLAB programs. We currently do not have MATLAB or LabVIEW example programs for this device. Custom software development is available, please contact SpinCore Technologies, Inc. for details.

## IV. Connecting to the PulseWave2D-300

The PulseWave2D-300 is available in two standard options: a) the board-only option b) the single-bay standalone enclosure. The connector information for both options is described below.

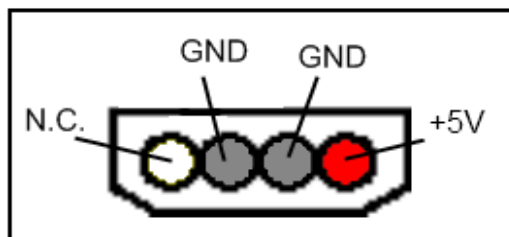
### Connector information for board-only option



**Figure 2:** Board connector locations. The board measures 4 X 6 inches (10.2 X 15.2 cm).

#### **Power Connector**

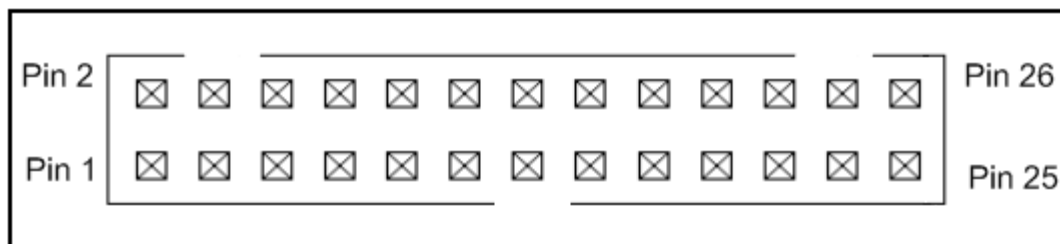
The PulseWave2D-300 board has a 4-pin Molex-style connector for supplying power. The pin and signal arrangements for this connector is as follows:



**Figure 3:** 4 Pin Molex-style Power Connector.

Please note that it is suggested that a PC power supply with the connector specified above is used. This is a standard connector type common on most PCs that will satisfy the power requirements and prevent damage (such as accidentally reversing polarity). The PulseWave2D-300 board does not contain over-voltage protection, reverse polarity protection, or undercurrent detection. If a PC power supply is not easily accessible it is suggested that a fixed-voltage +5 Volt power supply with a 2 Amp maximum current be used.

## Digital Output Connector (JP805)



**Figure 4:** Output Header JP805. Pin 1 is closest to the JP805 label on the silkscreen.

Pin number	Function	Pin number	Function
1	FLAG 0	14	Ground
2	Ground	15	FLAG 7
3	FLAG 1	16	Ground
4	Ground	17	FLAG 8
5	FLAG 2	18	Ground
6	Ground	19	FLAG 9
7	FLAG 3	20	Ground
8	Ground	21	FLAG 10
9	FLAG 4	22	Ground
10	Ground	23	FLAG 11
11	FLAG 5	24	Ground
12	Ground	25	No Connect
13	FLAG 6	26	Ground

**Table 2:** Onboard Output Header Signal List.

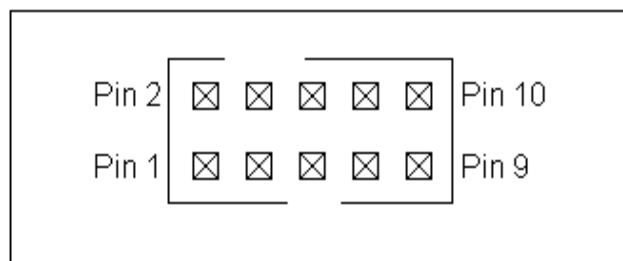
JP805 is a 26-position shrouded male header (Digi-Key part#: A33167-ND). For an appropriate mating connector use a matching 26-position IDC socket connector such as Digi-Key part#: HKC26H-ND. To purchase a cable with the appropriate connector, see: <http://spincore.com/products/InterfaceCable/>.

Alternatively, JP805 can be connected to an SP32 board (Figure 16) which allows the use of MMCX cables. This enables the individual bits of the PulseWave2D-300 to be more easily accessed. Pin 1 on the MMCX adapters can be identified with a square pin.

Note that the PulseWave2D-300 only uses FLAG 0 and FLAG 1.

## Digital Input Connector (JP302)

The male header on the PulseWave2D-300 board labeled JP302 contains the *IRQ*, *Hardware Trigger* and *Hardware Reset* lines. Please see Figure 14 on the next page.



**Figure 5:** Input Header JP302.

Pin number	Function
1	Ground
2	IRQ0
3	Ground
4	IRQ1
5	Ground
6	IRQ2
7	Ground
8	Hardware Trigger
9	Ground
10	Hardware Reset

**Table 3:** Input Header JP302 signal list.

JP302 is a 10-position shrouded male header (Digi-Key part#: A33159-ND). For an appropriate mating connector use a matching 10-position IDC socket connector such as Digi-Key part#: HKC10H-ND.

Note that the PulseWave2D-300 only uses the Hardware Trigger and Hardware Reset pins on this header.

## 10 MHz Reference Clock Output

PulseWave2D-300 board's 10 MHz SMA connector does not drive any useful signal, and should not be connected. If a reference output clock is desired, please contact SpinCore Technologies, Inc.

## Clock Input Signal Standard

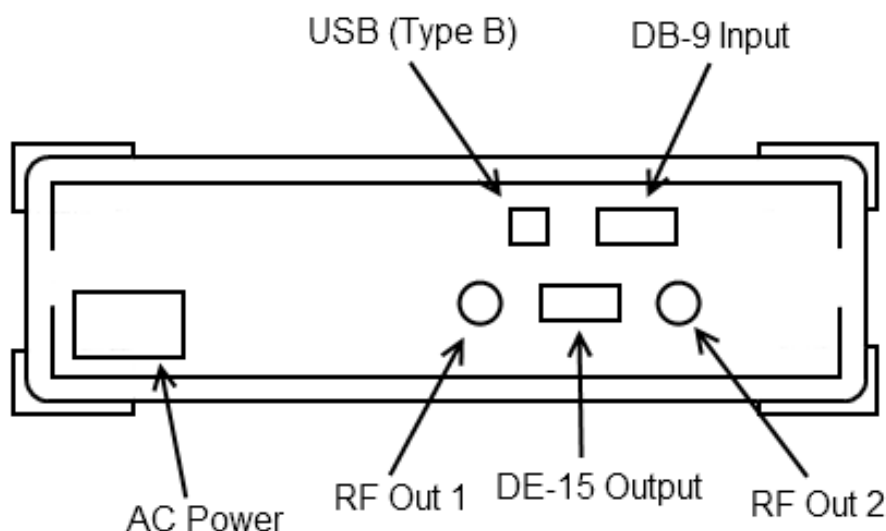
The PulseWave2D-300 is a digital system built in CMOS technology and powered off a 3.3 V DC source. It will accept external clock signals that conform to the low-voltage 3.3 V TTL standard only. Negative voltage below 0 Volts would damage the processor chip, and thus any external sinusoidal signal would need to be converted to the positive-only TTL signal prior to using with the PulseWave2D-300. The PulseWave2D-300 board is only designed to work with a 50 MHz clock. A sub-ppm stable oven controlled oscillator is available. If your application calls for a different clock rate, please contact SpinCore Technologies.

## Analog Output Connectors

The PulseWave2D-300 has two SMA analog outputs designated I\_OUT1 and I\_OUT2. These RF outputs should be connected to reconstructive filters (either low-pass or band-pass) and then passed to a 50 ohm resistor before reaching their destination. Both BNC and SMA versions of these filters are available.

## Connector information for single-bay enclosure

For the single-bay enclosure, the diagram below shows the location of all the connectors.



**Figure 6:** Connector locations at the rear of the enclosure.

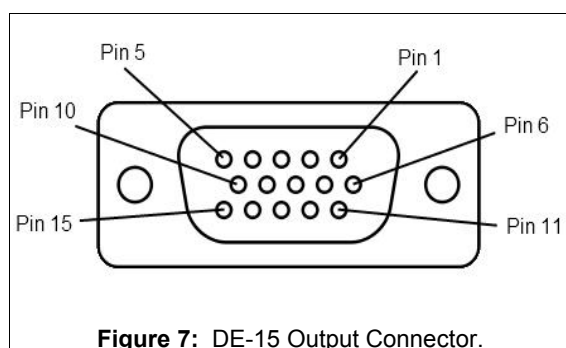
### **AC Power Connector**

The PulseWave2D-300 is provided with an internal auto-sensing universal AC power supply. An IEC C14 male connector is exposed at the rear of the enclosure which may be connected to 120/240V, 50/60Hz mains power.

### **Analog Output Connectors**

The PulseWave2D-300 has two BNC analog outputs designated RF OUT 1 and RF OUT 2. These RF outputs should be passed to a 50 ohm resistor before reaching their destination. Optionally, they can be connected to reconstructive filters (either low-pass or band-pass). Both BNC and SMA versions of these filters are available.

### DE-15 Output Connector (TTL)



Pin number	Function
1	FLAG 1
2	FLAG 3
3	FLAG 5
4	FLAG 7
5	FLAG 9
6	Ground
7	Ground
8	Ground
9	Ground
10	Ground
11	FLAG 0
12	FLAG 2
13	FLAG 4
14	FLAG 6
15	FLAG 8

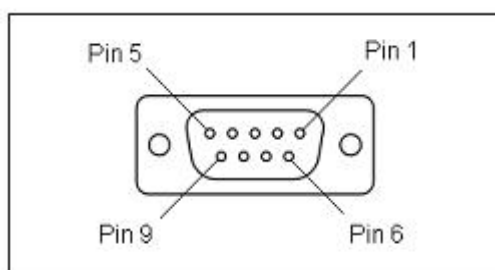
**Table 4:** Output DE-15 (TTL) signal list.

The TTL Output connector is a 15-pin D-sub socket connector (Digi-Key part#: 17HD015SAA000-ND). For an appropriate mating connector use a matching 15-pin D-sub pin connector such as Digi-Key part#: 17EHD015PAA000-ND. To purchase a cable with the appropriate connector, see: <http://spincore.com/products/InterfaceCable/>.

Only FLAG 0 and FLAG 1 will drive a useful signal on the PulseWave2D-300.

### DB-9 Input Connector (IRQ/Trig/Res)

Digital inputs are provided through a female DB9 connector at the rear of the enclosure. These connections provide interrupt, trigger and reset support.



**Figure 8:** DB9 Input Connector.

Pin number	Function
1	IRQ0
2	IRQ1
3	IRQ2
4	Hardware Trigger
5	Hardware Reset
6	Ground
7	Ground
8	Ground
9	Ground

**Table 5:** Input DB9 (IRQ/Trig/Rst) signal list.

**IRQ[2..0]** (pins 1-3) Unused by PulseWave2D-300

**Hardware Trigger** (pin 4) is pulled high by default using a 10k $\Omega$  resistor. When this input detects a low signal (for example by shorting it with pin 6), a hardware trigger is produced. This has the same effects as issuing a trigger through software, though the hardware trigger is more precise, since there are no software latencies involved.

**NOTE:** *The PulseWave2D-300 requires a 3.3 V TTL input signal for HW\_Trigger. A signal that is more than 3.3 V or less than 0 V will damage the device.*

**Hardware Reset** (pin 5) is pulled high by default using a 10 k $\Omega$  resistor. When this input detects a falling edge (for example by shorting it with pin 7), the device is reset.

**NOTE:** *The PulseWave2D-300 requires a 3.3 V TTL input signal for HW\_Reset. A signal that is more than 3.3 V or less than 0 V will damage the device.*



## VI. PulseWave2D-300 Firmware Designs

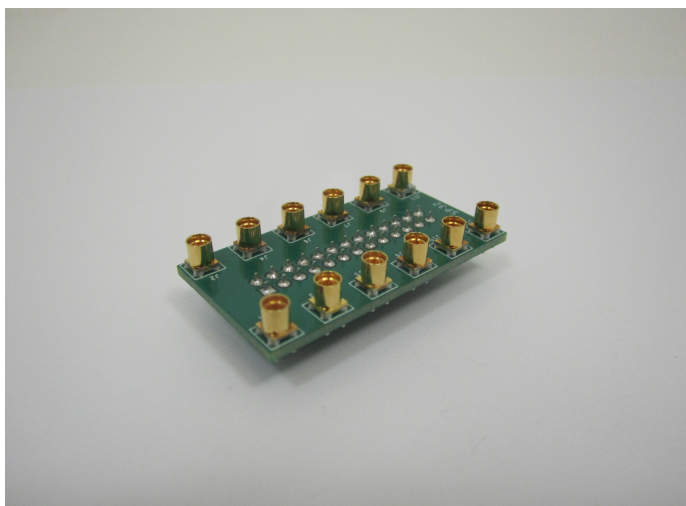
The chart below shows specifications for different PulseWave2D-300 firmware designs. The PulseWave2D-300 firmware design can be read from the board using the read\_firmware.exe example. (Note: the firmware ID can also be physically read from the label placed on the design EEPROM of each board).

<i><b>Firm ware</b></i>	<i><b>Clock Speed (on board INPUT- core-DAC)</b></i>	<i><b>Sequence Table Length</b></i>	<i><b>Maximum Wave Length</b></i>	<i><b>Sample Storage</b></i>	<i><b>Triggering Frequency (max)</b></i>	<i><b>TTL digital output flags</b></i>
<b>14-4</b>	50-150-300	4095	8190	18 Mb	2803.73 kHz	2

**Table 6:** Available Firmware designs for PulseWave2D-300.

## Related Products and Accessories

1. RadioProcessor – Complete single-card solution for RF pulse generation and acquisition. For more information, please visit <http://spincore.com/products/RadioProcessor/>.
2. If you require a specific number of sequence table entries, different maximum wave size, or an Oven Controlled Clock Oscillator (sub-ppm stability), please inquire with SpinCore Technologies through our contact form, which is available at <http://spincore.com/contact.shtml>
3. SpinCore MMCX Adapter Board Figure 16 – This adapter board allows easy access to the individual bits of the PulseWave2D-300. This adapter board can be part of a package that includes 12 MMCX to BNC cables and three SMA to BNC adapters. This package can be changed to include any number of cables and any number of adapter boards. For ordering information contact SpinCore at <http://www.spincore.com/contact.shtml>.



**Figure 9:** MMCX Adapter Board allows easy access to the Digital Output

## Contact Information

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## Document Information

Revision history available at SpinCore.