RF Carrier Spectrum Profile and Power Output of the ICE-D2AWG-m3

An arbitrary waveform generator with up to 500 MHz Bandwidth and output range of 1-6000 MHz

Overview – Signal Generation with high bandwidth output (up to 500MHz) from 1 MHz to 6000MHz is what the ICE-D2AWG-m3 provides. The newest digital-to-analog conversion module offered from ICE Enterprises, Inc. allows generation and controlled output power of your arbitrary waveform.

This application note describes the output spectrum profile from 0-2400 MHz (direct-to-RF) and the output spectrum profile from 2400-6000MHz (RF Mixer output). The mixer is embedded in the RFIC used on the module during the D2A conversion. Also described is a measured output power in dBm over the range of frequencies available. Conveniently, two of the ICE-D2AWG-m3 modules can be installed on one ICE-PIC8 card yielding two simultaneous, 500MHz wide, complex spectrums. This requires 4 Gigabytes/sec aggregate complex data streaming which ICE Enterprises can provide in an integrated system or small portable enclosure. Two complex integer streams running at 2 Gigabyte/sec are sent to two ICE-D2AWG-m3 modules on a single ICEPIC8 PCIe card. Signal generation and control of frequency and output power is available.

Application – The **D**igital-to-**A**nalog **W**aveform **G**enerator module, ICE-**D2AWG**-m3, is the newest module designed for use with the new ICEPIC8 series DSP card. High fidelity, 500MHz bandwidth, direct-to-RF output center frequencies from 1 MHz to 2400 MHz, and mixed-to-RF output center frequencies from 2400-6000MHz is available. Complex signal-source data can be streamed to the module for output. Streaming data can be from host system memory to the module installed or from a high-speed ICE-RAID capable of streaming from disk at the fast speeds required (up to 2 Gigabytes/sec) to feed wideband data to the ICE-D2AWG-m3. The module is a single-site module. When two ICE-D2AWG-m3 modules are installed on an ICEPIC8, and dual 2Gigabyte/sec complex data streams are provided, dual 500MHz outputs can be transmitted.

Direct-to-RF Single Complex Spectrum Output 1-2400 MHz (no custom RF filtering required)

Output of a single sinewave or complex spectrum can be generated. A maximum bandwidth complex spectrum up to 500 MHz with and corresponding output center frequency of 250 MHz to 2150 MHz is available (See figure 1). The 250 MHz center is the lowest that can be used when the bandwidth of the output signal is 500MHz. In the same scenario on the higher end of the output, the 2150 MHz center frequency is the highest that can be used when the bandwidth of the output signal is 500MHz. If a lower bandwidth signal was sourced, the carrier frequency could be as low as 1 MHz. A lowpass filter, used to attenuate any harmonic components above 2400MHz is recommended.

Example spectrum locations for generation of signals below 2400MHz.

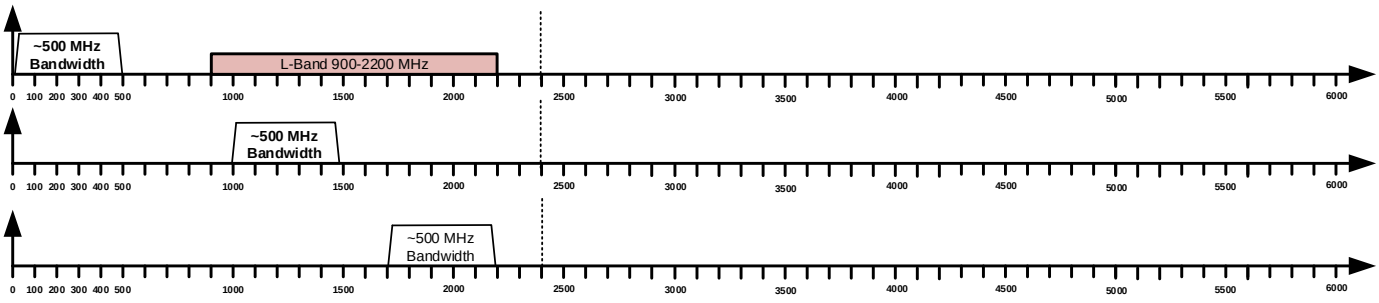

Figure 1 - ICE-D2AWG-m3 output spectrum below 2400MHz

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RF Lowpass Filtering – When the transmission frequency is below 2400 MHz bandpass filtering is not necessary. Only low pass filtering is required (see figure 2). This is an advantage of the direct-to-RF frequency range of 1-2400 MHz available with the ICE D2AWG-m3.

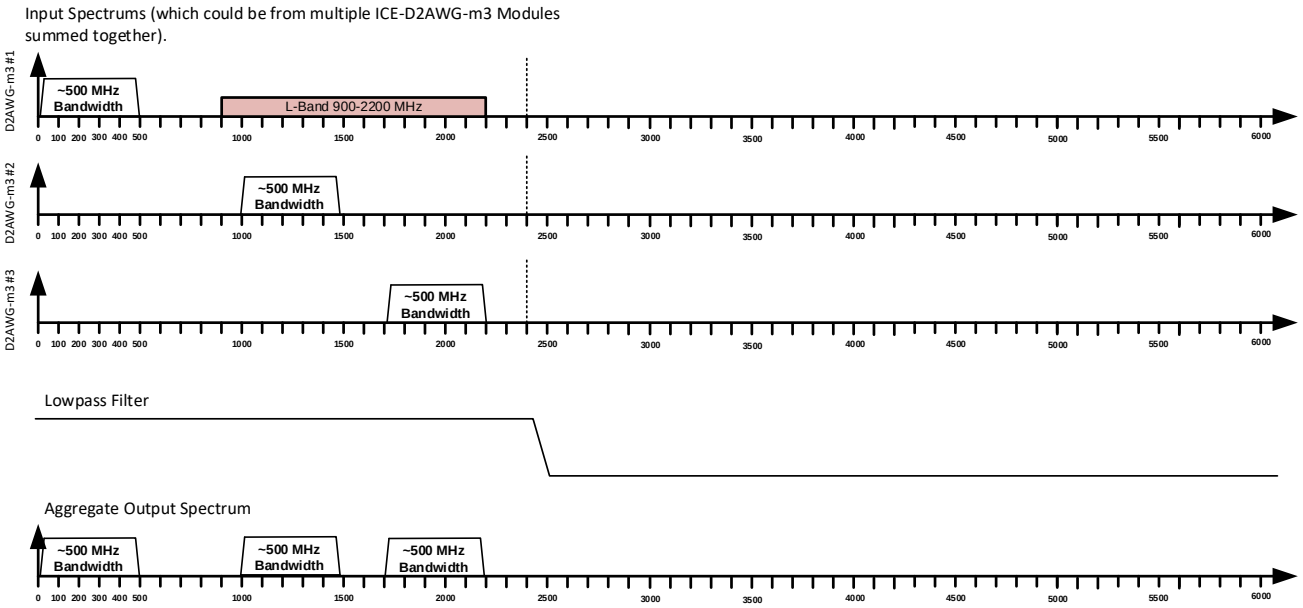

Figure 2 - ICE-D2AWG-m3 output spectrum using 3 different modules summed together below 2400MHz

RF Mixed Complex Spectrum output 2400-6000MHz (custom RF filtering is often necessary)

The same output sinewave or complex spectrum (used above) can be generated and output to frequencies above 2.4 GHz. The D2AWG-m3 switches to an RF mixed output embedded within the digital-to-analog converter (DAC). A maximum bandwidth up to 500 MHz with a corresponding output center frequency of 2750 MHz to 6000 MHz is available. In the same scenario on the higher end of the output, a 6000 MHz center frequency is the highest that can be used when the bandwidth of the output signal is 500MHz. Because of the introduction of a mixer in the output path, specific bandpass filtering will be necessary to pass only the spectrum desired. The images (sum and difference carriers) and the local oscillator (LO) would be filtered out with the bandpass filters and the resultant signal will only be the signal of interest (see figures 3-5).

The three examples below show the RF mixed output spectrum profiles:

Example 1 - a low signal, LO, and high image

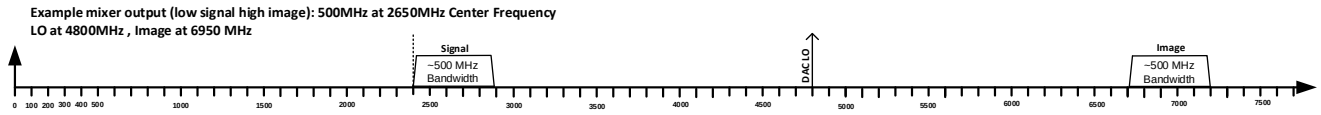

Figure 3 - ICE-D2AWG-m3 output spectrum above 2400MHz, mixed, low signal, high image

Example 2 - a close-in signal, LO, and close-in image

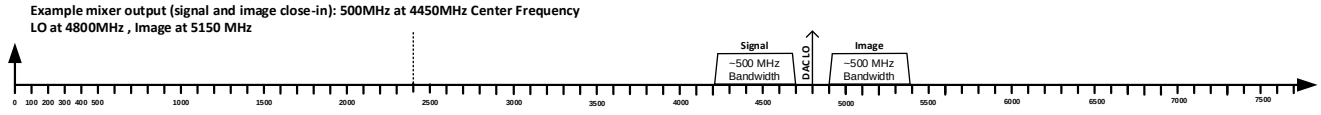

Figure 4 - ICE-D2AWG-m3 output spectrum above 2400MHz, mixed, close-in image

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Example 3 - a high signal, LO, and low image

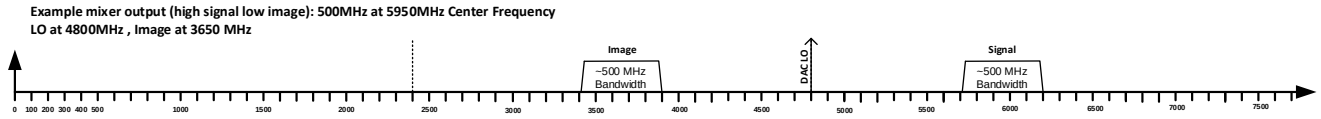

Figure 5 - ICE-D2AWG-m3 output spectrum above 2400MHz, mixed, high signal, low image

The three RF-mixed scenarios above are examples of the frequency ranges available to the output spectrum. For the 500MHz bandwidth example, the RF-mixed output signal can be from 2650MHz center frequency up to 6000MHz center frequency, or anywhere in between. The DAC LO will remain fixed at the 4800MHz location and the image/signal will move up or down respective to the DAC LO.

RF Bandpass Filtering (normal) – RF Filtering is accomplished with a hardware filter designed for a specific frequency range. A basic example of a bandpass filter that will pass 500MHz bandwidth and reject all other frequencies is shown below.

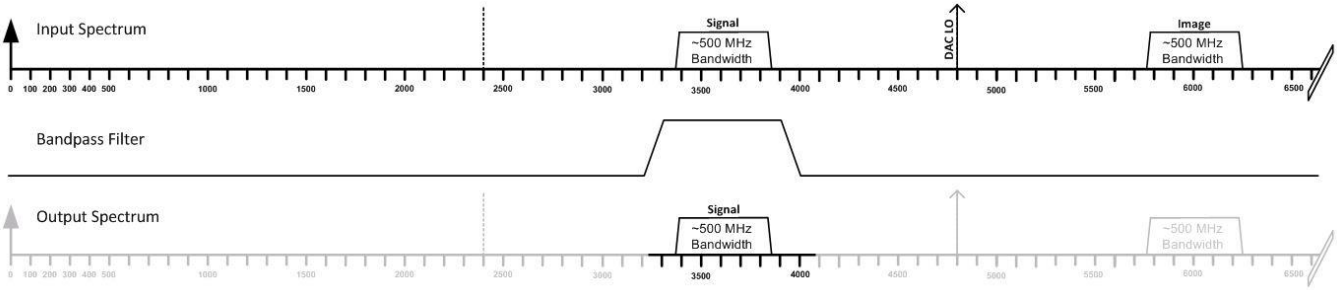

Figure 6 - ICE-D2AWG-m3 output spectrum above 2400MHz with custom RF filtering

RF Bandpass Filtering (sharp) – For locations where there are close-in signals like the DAC local oscillator (LO) and close-in images from the mixing process, it is necessary to have sharper filter cut-off frequencies to reject unwanted signals. The proper filter profile required is a decision made during frequency planning when the RF generation system is being designed. RF Filtering is accomplished with a hardware filter built for a specific frequency range. A bandpass filter that will pass 500MHz bandwidth and reject all other frequencies is shown below.

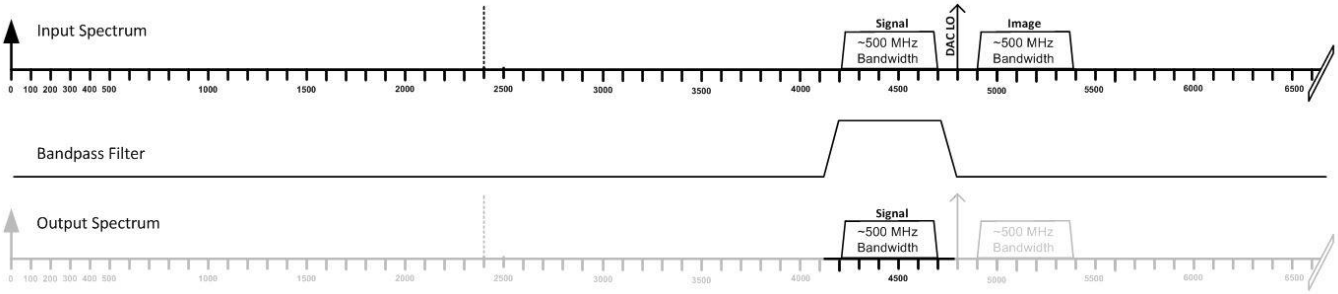

Figure 7 - ICE-D2AWG-m3 output spectrum above 2400MHz with customer close-in filtering

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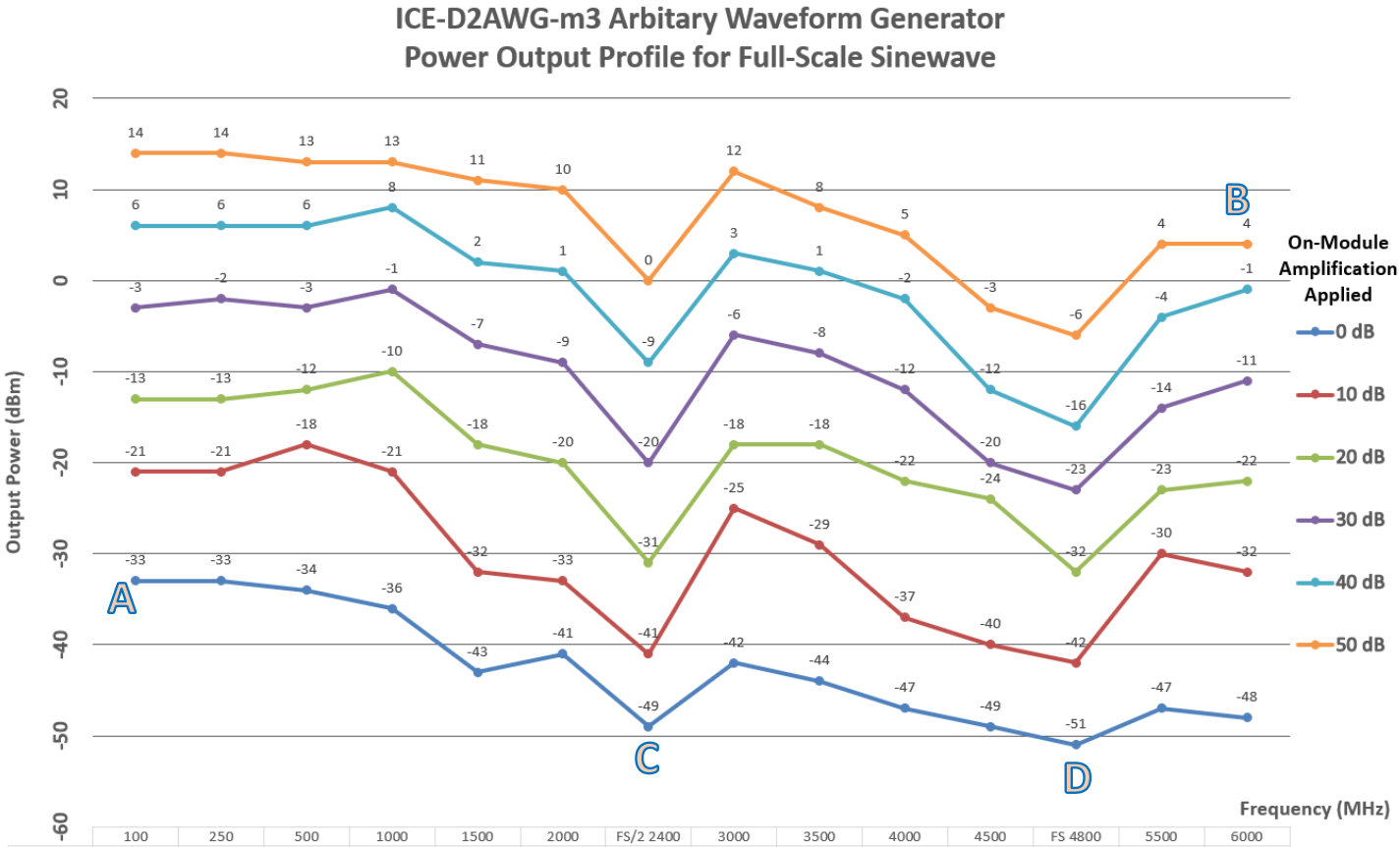
The D2AWG-m3 power output profile in dBm is shown in the below chart.

At zero on-module amplification, with a full-scale sinewave sourced digital data, at a frequency of 100MHz, the total output power is approximately -33 dBm(A). This is at the low-end of the frequency output and at the low-end of the D2AWG-m3 power output.

At 50dB of on-module amplification, with a full-scale sinewave sourced digital data, at a frequency of 6000MHz, the total output power is approximately +4 dBm (B). This is at the high-end of the frequency output. Power output is frequency band dependent. The "RFGAIN" parameter is used to set the on-module amplification gain from 0 dBm to +60 dBm.

The DAC rate is adjustable. A 4.96 GHz DAC frequency is the maximum allowed. In this example a 4.80 GHz DAC rate is used. This DAC frequency introduces "fold-over" at 2400MHz (C) (Nyquist) and at the sample rate (D). **Note: To move the FS/2 location (C) To still have the ability to place signals on the 2400MHz location it is possible to lower the sample rate. The sample rate is be lowered to 'move' the fold-over and sample points to lower locations should a signal presence be required exactly at a fold point created from higher sample rate.**

A single complex carrier spectrum is generated when the output is below. As the output spectrum approaches 2400 (or FS/2) an image will begin to appear above 2400MHz. A 2400MHz lowpass filter can be used if generation of signals below 2400MHz are typical for your application. Typically, for an L-Band(900-2200MHz) implementation images do not appear above 2400. When frequencies above Nyquist (2400-6000MHz) are generated with a mixed output that contains a carrier at FS 4800 and sum and difference frequencies that require bandpass filtering to obtain only the spectrum of interest (complex carrier spectrum output).



	100	250	500	1000	1500	2000	FS/2 2400	3000	3500	4000	4500	FS 4800	5500	6000
0 dB	-33	-33	-34	-36	-43	-41	-49	-42	-44	-47	-49	-51	-47	-48
10 dB	-21	-21	-18	-21	-32	-33	-41	-25	-29	-37	-40	-42	-30	-32
20 dB	-13	-13	-12	-10	-18	-20	-31	-18	-18	-22	-24	-32	-23	-22
30 dB	-3	-2	-3	-1	-7	-9	-20	-6	-8	-12	-20	-23	-14	-11
40 dB	6	6	6	8	2	1	-9	3	1	-2	-12	-16	-4	-1
50 dB	14	14	13	13	11	10	0	12	8	5	-3	-6	4	4

Figure 8 - ICE-D2AWG-m3 output power profile across 50dB of on-module amplification from 100-6000MHz

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Implementation - Here is an example of an L-Band (900-2200MHz) input using the ICE-LB2D-m3 and an L-Band (900-2200) output using the ICE-D2AWG-m3 installed on and ICEPIC8 PCIe card. The input bandwidth of 120MHz is the largest bandwidth for the L-Band input module.

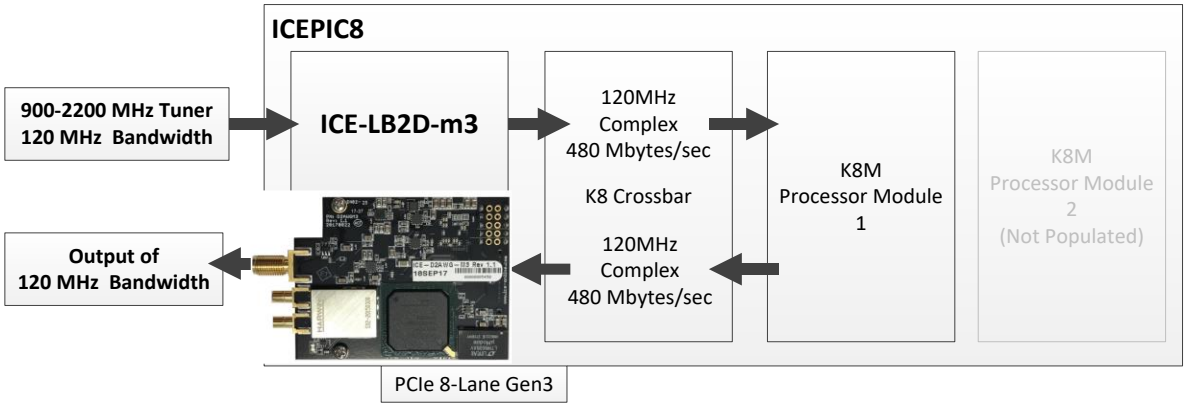

Figure 9 - ICE-D2AWG-m3 application with corresponding ICE-LB2D-m3 L-Band tuner

It is also convenient to use three ICE-D2AWG-m3 modules and generate enough bandwidth to create an entire L-Band spectrum and cover the entire L-Band 900-2200 MHz range (1300 MHz of total bandwidth).

The Module and the ICEPIC8 Card

ICE-D2AWG-m3 is installed on I/O Module 1 and/or 2 of the ICEPIC8 below.

Figure 10 - ICEPIC8 showing I/O module sites, K8 Crossbar, and Processor Module sites

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Different physical platforms for the above hardware are available. (www.ice-online.com)

ICE-uPAC Add and FPGA to any system

ICE-PAC Smallest form factor 2 Channel Appliance

ICE-POD8 Rugged Appliance

ICE-Briefcase Portable 4 Channel Recorder

ICE-BLOCK 1U Stand Alone Appliance

ICE-COOLer 1U PCi-e Extension over fiber

ICE-Recorder 2U up to Quad 400Mbytes/sec Recorder

ICE-CAP-8000 2U Sustained, 2 x 4 GBytes/sec Recorder

Figure 11 – Examples of available physical platforms for the ICEPIC8, ICE I/O Modules, and ICE Processor Modules

D2A Module: Digital to Analog (DAC) Arbitrary Wave Form Generator – ICE-D2AWG-m3
Finding the module: http://www.ice-online.com/hardware/io-modules/analog-modules/ice-d2awg-m3/
ICEPIC Card: PCI-Express Gen3 8-Lane Peripheral Interconnect Component – ICE-PIC8
Finding the ICEPIC Card: http://www.ice-online.com/hardware/dsp-cards/ice-pic8/

Please Note: This application note is provided as a *guideline* to help provide a better understanding of a device or signaling characteristics of a device offered by ICE Enterprises, Inc. Use cases and signaling scenarios are examples only. Implementation methods are up to the user. All data is believed accurate at date of publishing. Information is provided as is. No warranty is provided.

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