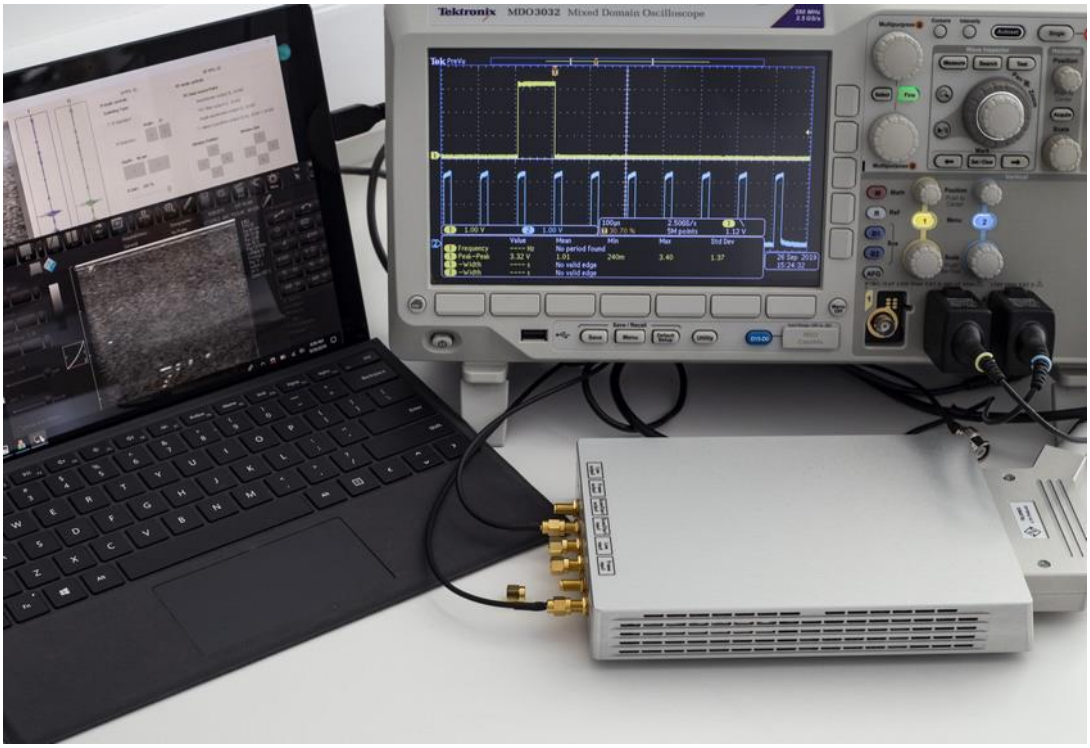
ArtUs EXT-1H/2H & ArtUs OEM-1H/2H

Ultrasound System



I/O MODULE USER GUIDE

TELEMED
ULTRASOUND MEDICAL SYSTEMS

Internet page: https://www.pcultrasound.com
Information E-mail: info@pcultrasound.com
Support E-mail: support@pcultrasound.com

Rev.3.0

Contents

Introduction
ArtUs beamformer can be equipped with an additional I/O module which allows controlling it using an external signal-providing device, such as a signal generator. The I/O module provides several coaxial cable connectors used for getting input and providing output signals. ArtUs with I/O module installed can be used in various scenarios of getting ultrasound images which are described later in this document.

1. Terms Used In This Guide

Line (**Ultrasound Line**) – a set of ultrasound echo signals acquired as a result of one transmission event.
Frame (**Ultrasound Frame**) – a set of ultrasound lines combined together and displayed simultaneously.
ScanStart – a signal that triggers the state of the beamformer between FREEZE and SCAN.

2. I/O Module Connectors Description

ArtUs EXT-1H/2H with I/O module installed looks like shown in the picture below (rear view), cooling fans “looking” down, see attached photo. Connectors are of SMA female type and require 50 Ohm coaxial cable equipped with SMA male plug on beamformer end. More information about connectors/cables see in QA chapter.

Connectors are labeled as shown in a table:

Line output	Frame output	ScanStart output	ScanStart input	Line input	Frame input

The names and designation of connectors:

A) **Ultrasound Line Output** (label **Line output**) signal, a falling edge of the output signal corresponds to start of ultrasound data acquiring from a tissue for one ultrasound line. Signal stays in logic level "0" at the end of the line
B) **Ultrasound Frame Output** (label **Frame output**) signal, a falling edge of the output signal corresponds to start of ultrasound data acquiring from a tissue for one ultrasound frame. Signal returns to logic level "1" at the end of the frame
C) **ScanStart output** signal, the system generates logic level "0" in FREEZE state and logic level "1" in SCAN state. This signal is not configurable
D) **ScanStart input** signal, system changes state from FREEZE to SCAN and from SCAN to FREEZE at each rising edge of the input signal (works like FREEZE button). This signal is not configurable

E) **Ultrasound Line Input** (label **Line input**) signal, upon receiving a rising edge of the input signal system starts acquiring ultrasound data from tissue for one ultrasound line with a delay of approximately 20 us
F) **Ultrasound Frame Input** (label **Frame input**) signal, upon receiving a rising edge of the input signal system starts acquiring ultrasound data from a tissue for one ultrasound frame with a delay of approximately 20 us.

ArtUs OEM-1H/2H with I/O module has the same set of connectors labeled as shown in the table below:

Line output	Frame output	ScanStart output	ScanStart input	Line input	Frame input

3. I/O Module Triggering Signals Description

Signal	Trigger	SCAN state	FREEZE state	Final State
Line Input	Rising Edge	Acquire one line delay 20 us	n/a	Logical 0
Line Output	Falling Edge	Acquired one line	n/a	Logical 0
Frame Input	Rising Edge	Acquire a set number of frames delay 20 us	n/a	Logical 0
Frame Output	Falling Edge	Acquired a set number of frames	n/a	Logical 1
ScanStart Input Unconfigured (FREEZE button simulation)	Rising Edge	To FREEZE	To SCAN	Logical 0
ScanStart Input Configured	n/a	Logical 1	Logical 0	n/a
ScanStart Output	Device state	Logical 1	Logical 0	n/a

Ultrasound Line input and **Ultrasound Frame input** signals require to be configured by **ArtUs Sync** utility:

- **Ultrasound Line input** - system starts acquiring ultrasound data from tissue for one ultrasound line approximately in 20 us after the rising edge of the signal

- **Ultrasound Frame input** - system starts acquiring ultrasound data from tissue for one ultrasound frame approximately in 20 us after the rising edge of the signal

Note: When using an external generator to synchronize ArtUs, the jitter of launches and signal reception by ArtUs can be up to 25 ns, i.e. period of the “system” clock.

Ultrasound Line output and **Ultrasound Frame output** work automatically, not require additional configuring:

- **Ultrasound Line output** - the falling edge of the input signal corresponds to the start of ultrasound data acquired from tissue for one ultrasound line. The signal stays in logic level "0" at the end of the line
- **Ultrasound Frame output** - the falling edge of the input signal corresponds to the start of ultrasound data acquired from tissue for one ultrasound frame. The signal returns to logic level "1" at the end of the frame

ScanStart input and **ScanStart output** without additional configuring:

- **ScanStart input** - system changes state from FREEZE to SCAN and from SCAN to FREEZE at each rising edge of the signal (works like FREEZE button)
- **ScanStart output** - system generates logic level "0" in Freeze mode and logic level "1" in scan mode

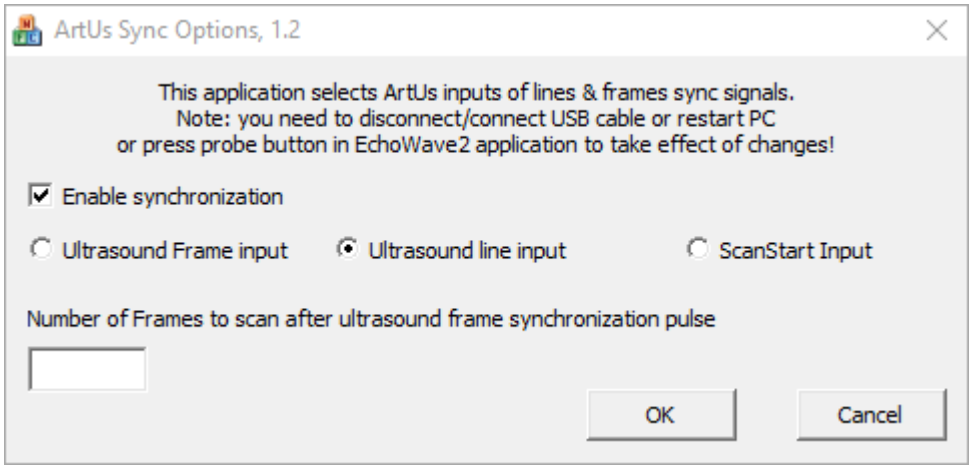
ScanStart input and **ScanStart output** with additional configuring:

- **ScanStart input** - system scans during logic level "1" and does pause (not equal FREEZE) of scanning during logic level "0". **Ultrasound Line output** is synchronized with **ScanStart input**
- **ScanStart output** - system generates logic level "0" in Freeze mode and logic level "1" in scan mode

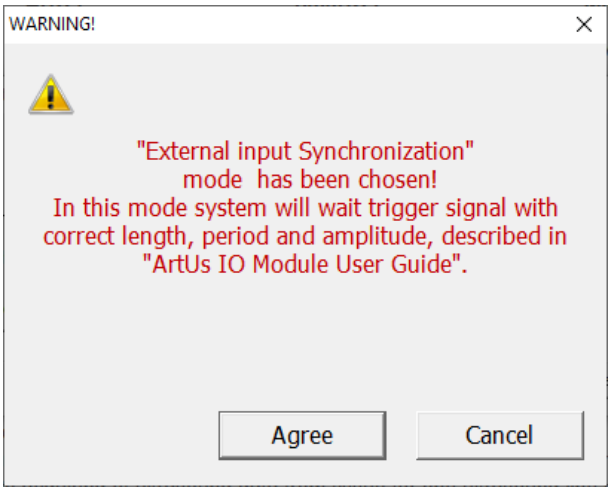
4. ArtUs Sync Options Utility

NOTE: If you have installed Echo Wave II 64-bit application only then you may be required to install additional Microsoft Visual C++ 2005 libraries. For additional instructions please see Q&A Section.

1. Run the **ArtUs Sync Options** utility in Administrator mode, and select **Ultrasound Line input** synchronization mode, see the picture below.

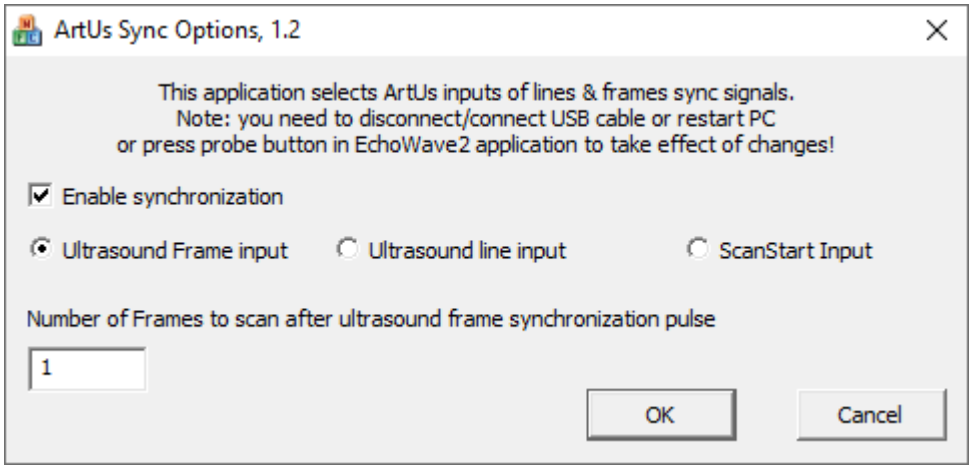


Please note, that after clicking the “OK” button user gets a warning message as shown below.

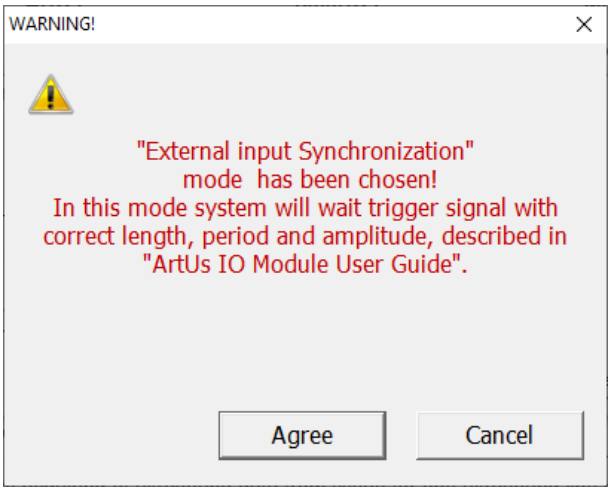


To activate device settings user needs to run the Echo Wave II program or if Echo Wave II is already running –push the “Probe” button.

2. Run the **ArtUs Sync Options** utility in Administrator mode, and select **Ultrasound Frame input** synchronization mode, see the picture below. “Number of Frames to scan after synch pulse” defines, how many frames will be received after each “Ultrasound Frame Input” signal. Set “0” to start non-stop scanning after the rising edge of the “Ultrasound Frame Input” signal.

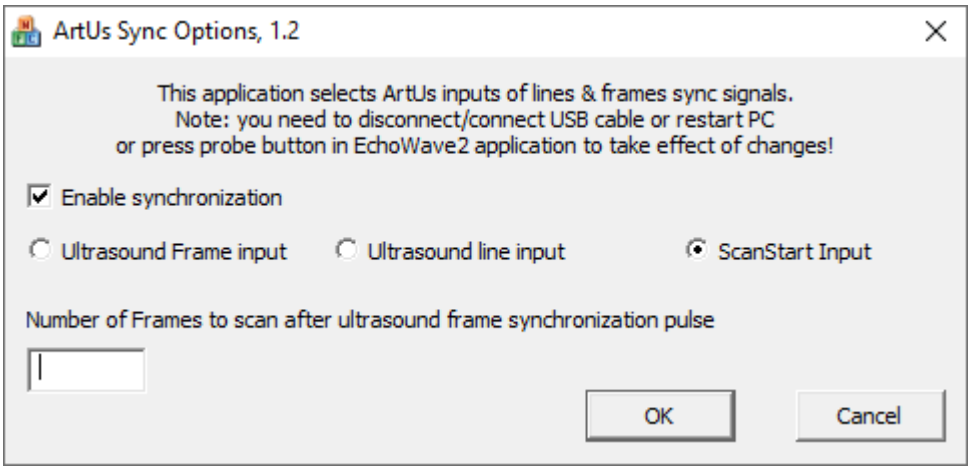


Please note, that after clicking the “OK” button user gets a warning message as shown below.

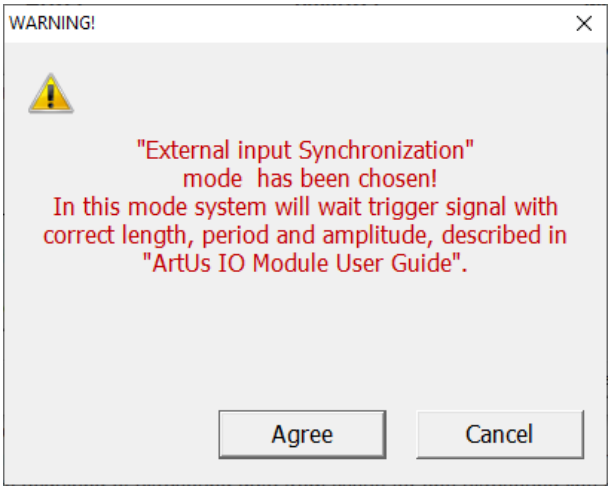


To activate device settings user needs to run the Echo Wave II program or if Echo Wave II is already running – push the “Probe” button.

3. Run the **ArtUs Sync Options** utility in Administrator mode, and select **ScanStart Input** synchronization mode, see the picture below.



Please note, that after clicking the “OK” button user gets a warning message as shown below.



To activate device settings user needs to run Echo Wave II program or if Echo Wave II is already running – to push the “Probe” button.

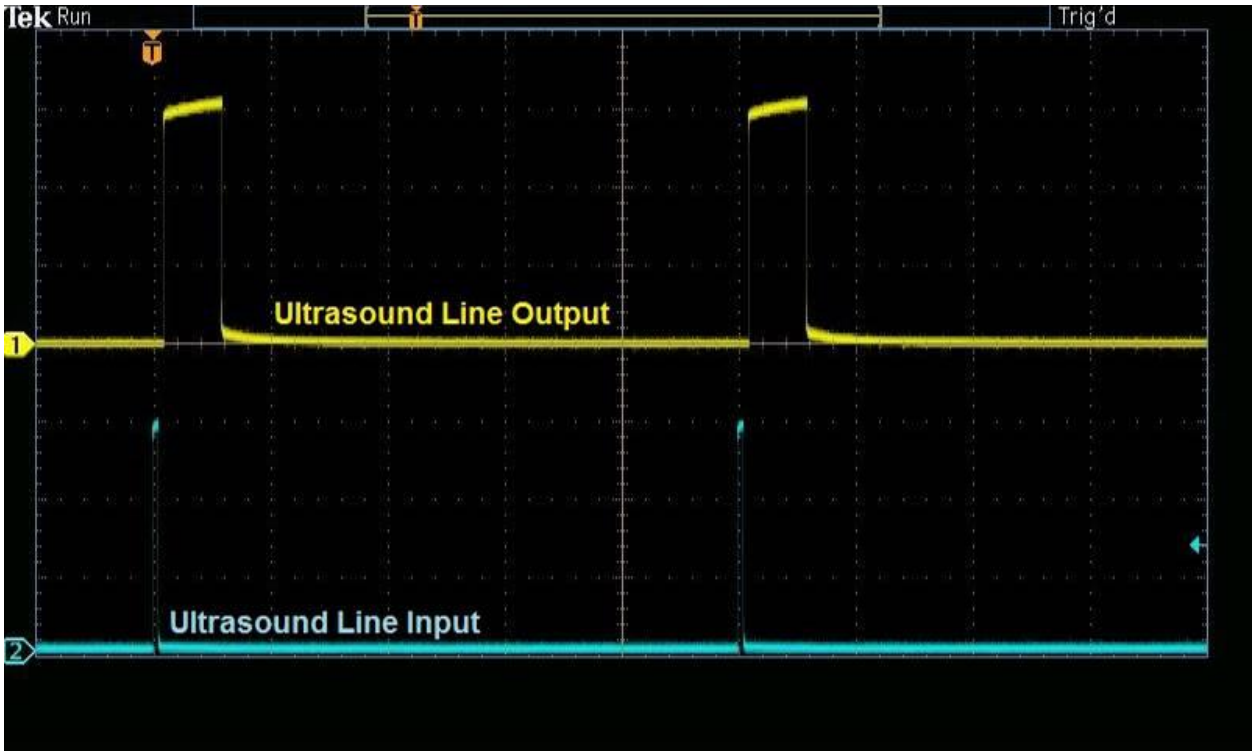
Note: Ultrasound Frames have one additional “passive” ultrasound line when any input is chosen in the **ArtUs Sync Options** utility.

5. Voltage Levels for Interface Signals

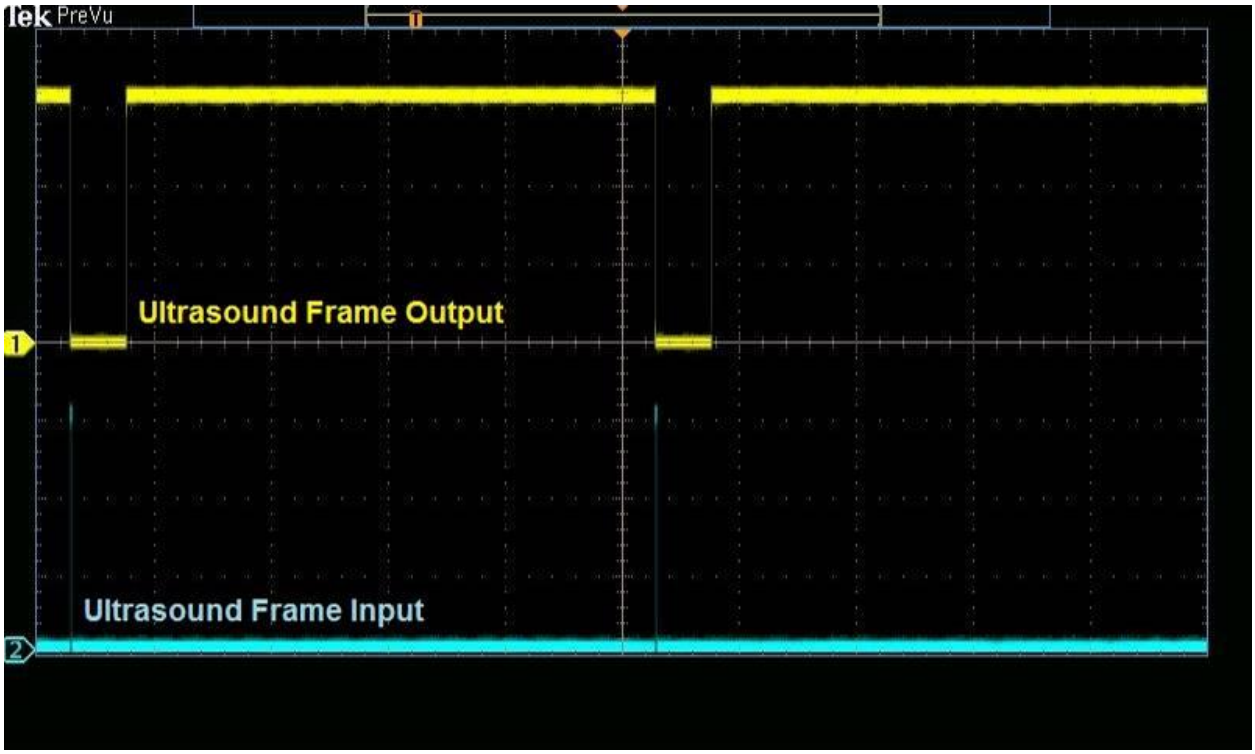
- **Input signals** – 2,5V or 3,3V CMOS level (5V logic tolerance)
- **Output signals** – 3,3V CMOS level

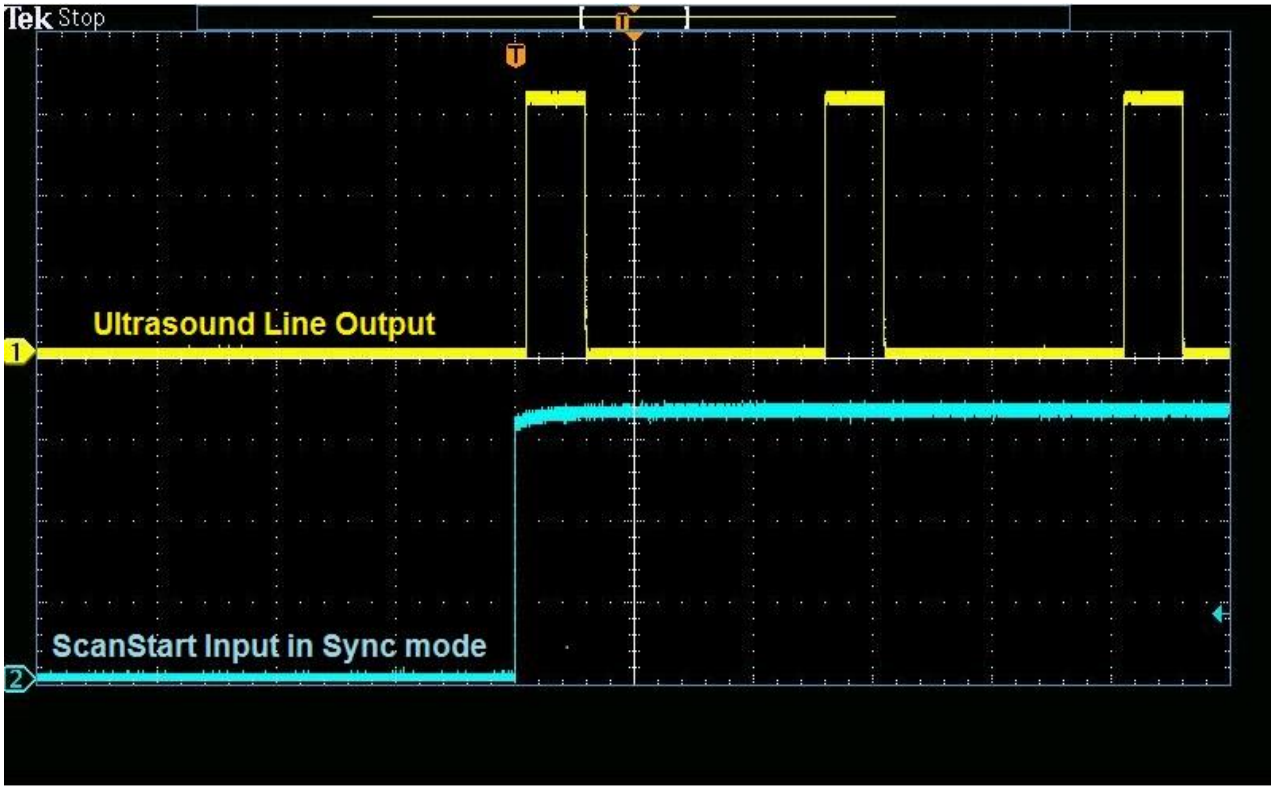
6. Signal Diagrams

Diagrams show external equipment input signals and corresponding outputs.

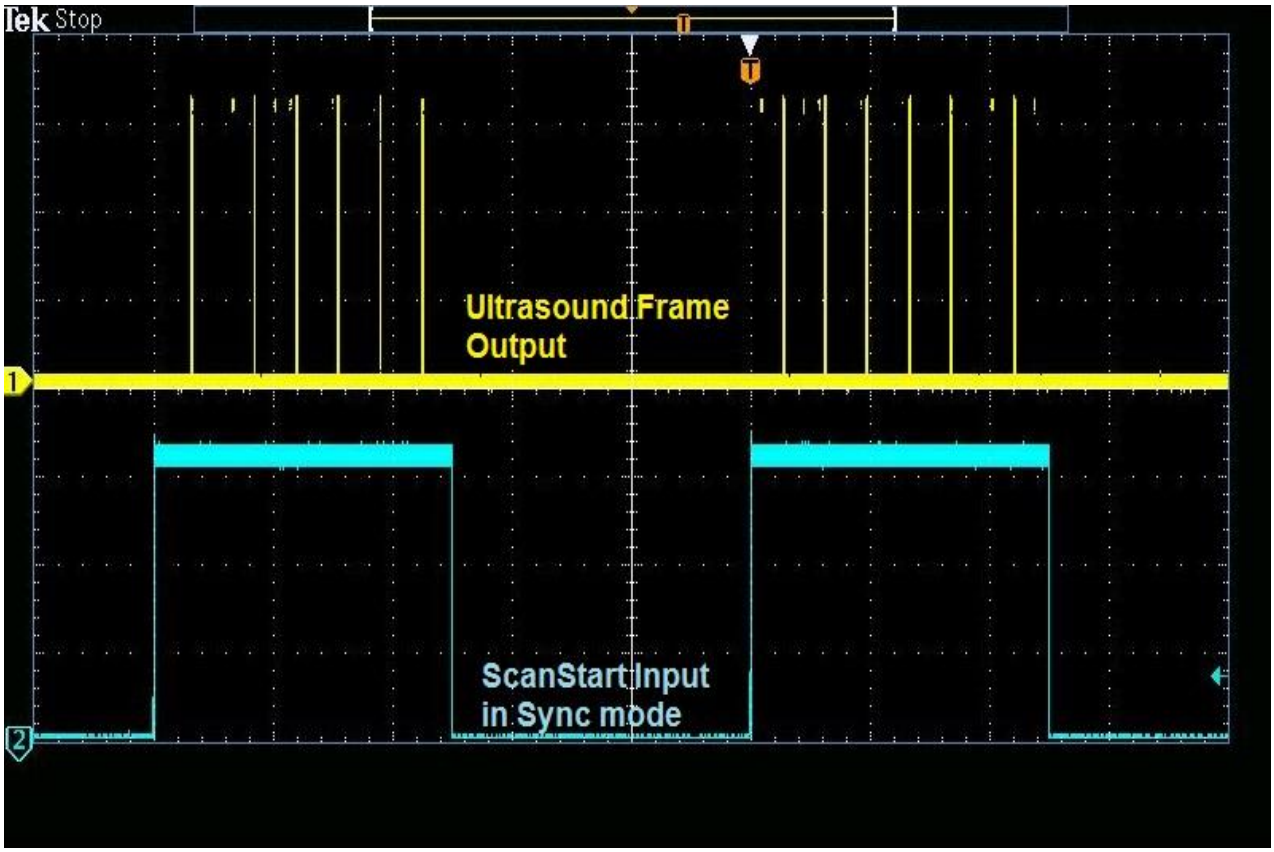


Ultrasound Line Input vs Ultrasound Line Output
Ultrasound Frame Input vs Ultrasound Frame Output





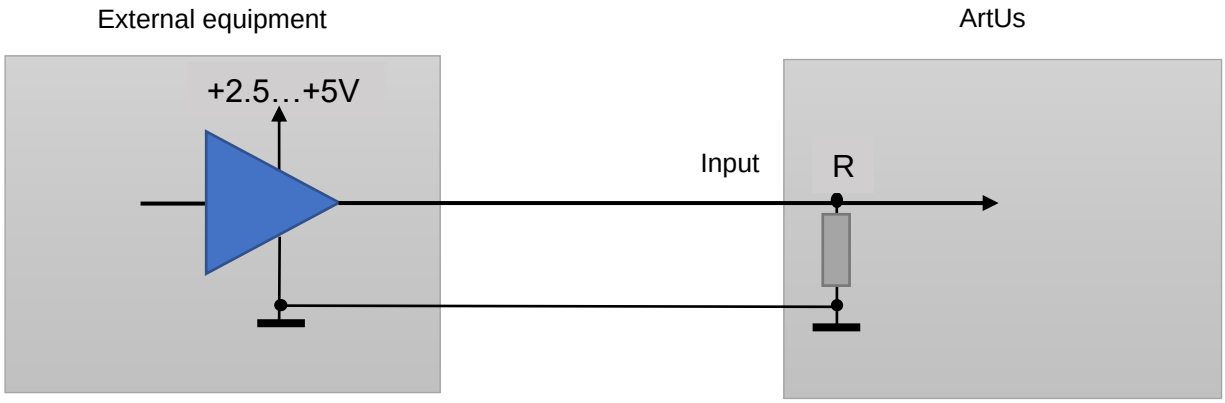
ScanStart Input in Sync Mode vs Ultrasound Line Output



ScanStart Input in Sync Mode vs Ultrasound Frame Output

7. External Equipment Connection Diagram

Block schematics below demonstrate how ArtUs inputs must be connected to external equipment outputs.



8. Return to normal scan mode

To switch the ArtUs scanner back to normal scan mode do not forget to run the **ArtUs Sync Options** utility in Administrator mode, clear the checkbox **Enable synchronization,** and click the “OK” button. Please note, that after clicking the “OK” button user needs to disconnect / reconnect the USB cable or reboot the PC.

9. How to enable/disable I/O signals without ArtUs Sync Options Utility

Run Registry Editor utility (regedit.exe)

Locate Registy path:
„HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\ArtUs\Parameters".

To **Enable synchronization** and **Ultrasound Frame input**
Write value **1** to "External synch mode“ register

To **Enable synchronization** and **Ultrasound Line input**
Write value **2** to "External synch mode“ register

To **Enable synchronization** and **ScanStart output**
Write value **4** to "External synch mode“ register

To define the **Number of Frames to scan after ultrasound frame synchronization pulse**
Write the number of frames to the "Synch frames number“ register

10. Twin Synchro ArtUs Setup

Some ultrasound applications require synchronous work of two or more beamformer devices. You can use the ArtUs system in such scenarios. There can be several possible configurations which are described below.

To use the external hardware Freeze/Run button, edit a line shown below and save the options2.txt file (located in C:\Program Files (x86)\TELEMED\Echo Wave II\Config\Options directory):

```
accept_ultrasound_keyboard_commands_when_window_is_not_focused;1
```

Configuration 1: 2 ArtUs, 2 PCs, Signal Generator for external frame synchronization

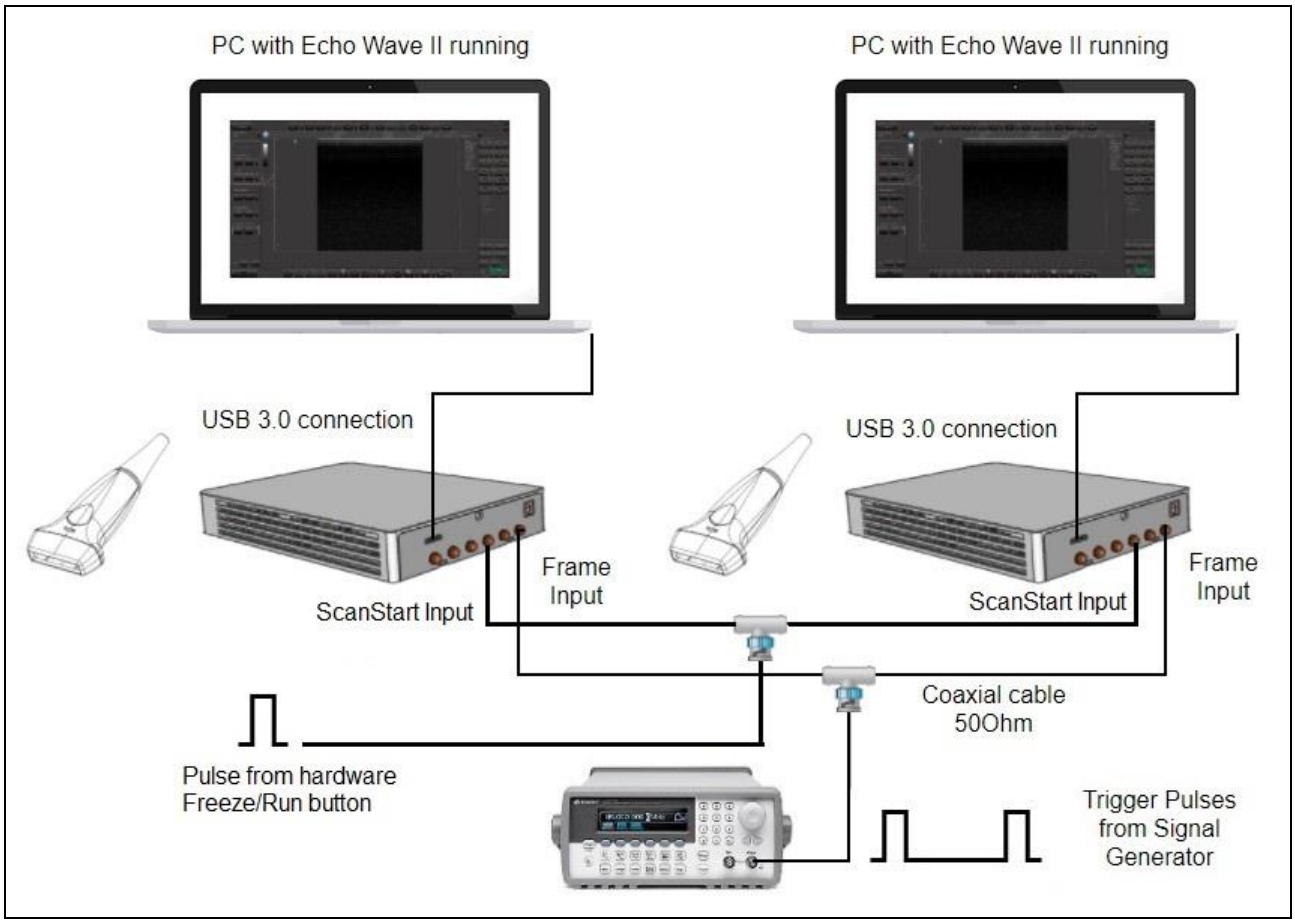


Figure 1 Twin ArtUs with 2 PCs

Configuration 1 setup:

1. Connect both ArtUs beamformers to their respective PCs using USB 3.0 or higher ports
2. Connect the Signal Generator to both ArtUs devices as shown in **Figure 1 Twin ArtUs with 2 PCs** using 50 Ohm coaxial cables and appropriate connectors. ArtUs has SMA50 connectors for coaxial cable attachment
3. Connect the hardware Freeze/Run button to ScanStart Inputs of both ArtUs devices as shown in **Figure 1**
4. Run **ArtUs Sync Options.exe** utility on each PC
5. Check ☑ Enable Synchronization and select ⊙ Ultrasound Frame Input

6. Push the **OK** button. Now both ArtUs devices are in external synchronization mode
7. Set the Signal Generator to pulse triggering with the frequency depending on the probe and scanning parameters (number of probe elements, depth, line density, and others, which fluence on ultrasound frame time)
8. Run the Echo Wave II program on each PC
9. To get synchronous Cine files, do the next steps:
   - 9.1. Turn OFF generator
   - 9.2. Click the Freeze button on Echo Wave II on each PC or press the hardware Freeze/Run button to stop scanning
   - 9.3. Click the Freeze button on Echo Wave II on each PC or press the hardware Freeze/Run button to start scanning
   - 9.4. Turn ON generator
   - 9.5. Perform scanning
   - 9.6. Turn OFF generator
   - 9.7. Click the Freeze button on Echo Wave II on each PC or press the hardware Freeze/Run button to stop scanning
   - 9.8. Save Cine clips as “avi” files on both Echo Wave instances

Note: Signal Generator can run continuously. In this case, captured frames at two PCs may be shifted to one or more frames relative to each other.

Configuration 2: 2 ArtUs, PC with 2 Monitors, Signal Generator for external frame synchronization

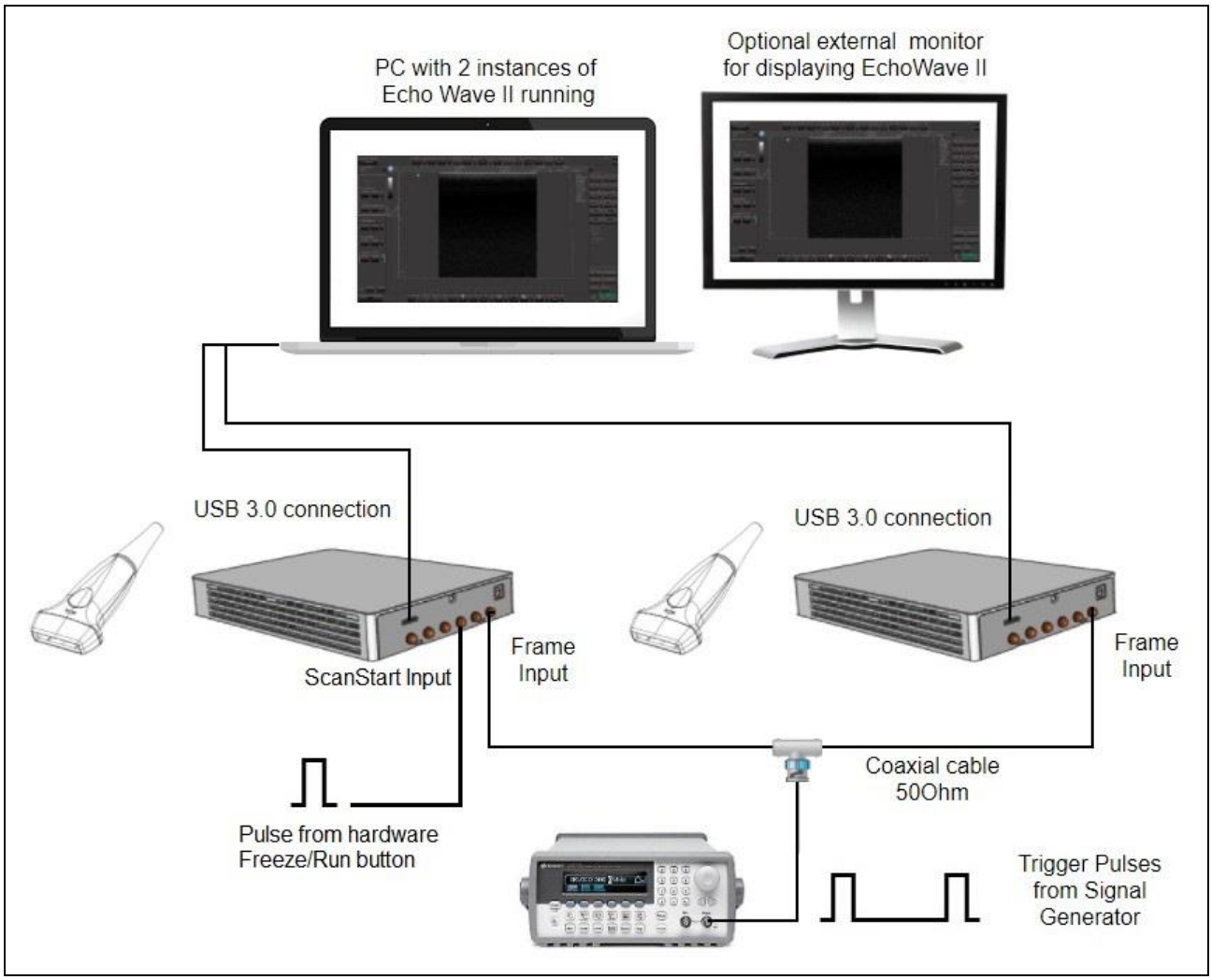


Figure 2 Twin ArtUs with a PC and optional external monitor (Frame Input)

Configuration 2 setup:

1. Connect both ArtUs beamformers to the PC using two USB 3.0 or higher ports
2. Connect the Signal Generator to both ArtUs devices as shown above using 50 Ohm coaxial cables and appropriate connectors. ArtUs has SMA50 connectors for coaxial cable attachment
3. Connect the hardware Freeze/Run button to the ScanStart Input of one of ArtUs devices as shown in Figure 2
4. Run **ArtUs Sync Options.exe** utility
5. Check ☑ Enable Synchronization and select ⊙ Ultrasound Frame Input
6. Push the **OK** button. Now both ArtUs devices are in external synchronization mode.
7. Set the Signal Generator to pulse triggering with the frequency depending on the probe and scanning parameters (number of probe elements, depth, line density, and others, which fluence on ultrasound frame time).
8. Run two Echo Wave II instances. Use each monitor to display one Echo Wave II window. Chose active probe for each instance
9. Run **CopyData.exe** utility (located in C:\Program Files (x86)\TELEMED\Echo Wave II\Config\Plugins\CopyData directory)
10. To get synchronous Cine files, do the next steps:
    10.1. Turn OFF generator

10.2. Click the Freeze/Run button on the **CopyData.exe** utility window or press the hardware Freeze/Run button to stop scanning
10.3. Click the Freeze button on the **CopyData.exe** utility window or press the hardware Freeze/Run button to start scanning
10.4. Turn ON generator
10.5. Perform scanning
10.6. Turn OFF generator
10.7. Click the Freeze button on the **CopyData.exe** utility window or press the hardware Freeze/Run button to stop scanning
10.8. Save Cine clips as “avi” files on both Echo Wave instances

Note: Signal Generator can run continuously. In this case, captured frames at two PCs may be shifted to one frame relative to each other.

Setting the highest frame rate

To set the maximum possible frame rate raise slowly triggering frequency on Signal Generator. At the same time monitor the frame rate shown in the Echo Wave II ultrasound window. Both frequencies should change accordingly. When you reach the maximum frame rate you will see a dramatic frame rate drop (approximately 2 times) in Echo Wave II. Adjust the frequency a little to lower the value to regain the frame rate in the Echo Wave II window as shown on Signal Generator. Now you have reached the maximum frame rate for current scanning settings.

Achievable result example:

You can reach up to 150 frames per second with the following settings:

- 128-element transducer
- Scan depth: 40 mm
- Line density: StandardS
- Number of focuses: 1
- iTHI mode: OFF
- Compound mode: OFF

NOTE: If you need other scanning parameters the achievable frame rate can be different. In this case, you will need to adjust the triggering frequency.

11. Q&A Section

Q: Where can I purchase the needed cables for the I/O module connection?

1. ArtUs rear panel connectors (click link): Amphenol Connex 132291
2. Recommended cables (click link): Amphenol Connex
3. Many cables alternatives (click links below):
   www.amazon.de
   www.amazon.com

Q: Is it possible to achieve higher frame rates than in your example case?

A: Yes, you can. To get higher frame rates you can:

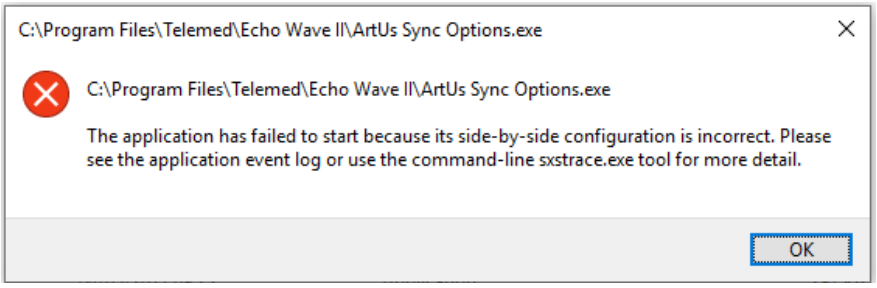
- Lower Line Density
- Make a smaller View Area
- Lower number of Focuses
- Lower Scan Depth

Q: Can I run two EchoWave II instances with two beamformers attached to one computer?

A: Yes, you can. To run two instances of the Echo Wave II application follow these steps:

1. Find options2.txt file in C:\Program Files (x86)\Telemed\Echo Wave II\Config\Options\
2. Open it with notepad.exe
3. Set parameter: **allow_scanning_by_all_software_instances;1** (replace “0” with “1”)
4. Save and close file options2.txt
5. Run the Echo Wave II application
6. Open Menu->Tools->Options
7. Select tab Technical
8. Set checkbox ☑ **Allow to start several software instances**
9. Shutdown Echo Wave II application
10. Attach two beamformers to the same computer using different USB ports
11. Start the Echo Wave II application and allow it to load completely
12. Start another instance of the Echo Wave II application
13. In both instances you should see live images from one of the attached beamformer/transducer sets. Click the probe button to choose another transducer.

Q: When I run ArtUs Sync Options utility I get the error message:



A: This message is caused by absence of required 32-bit libraries required to run the utility. To fix that you can do any of the following:

1. Install “Echo Wave II” 32-bit version. This software will install MS Visual C++ 2005 libraries.
2. Download and install MS Visual C++ 2005 libraries: https://www.microsoft.com/en-us/download/details.aspx?id=26347

12. Revision History

Revision	Revision Date	Description of Revision	Revision Author
1.0	2018.07.17	Initial Release	A. Prysiazhniuk
1.1	2018.07.19	Was added photo of rear panel	G. Volkov
1.2	2018.07.24	Added additional description	G. Volkov
1.3	2019.04.10	Added chapter 6.	A. Prysiazhniuk, G. Volkov
1.4	2019.05.07	Mistakes fixes	A. Prysiazhniuk
2.0 – 2.5	2020.02.05 – 2020.12.18	Chapters 9, 10, 11 edited. Small typo fixes	A.Kovalev
2.6	2020.01.12	Edited chapters 2, 3, 4. Added chapter 12	A. Prysiazhniuk
2.7	2021.03.18	Updated Sync Options Utility description - Chapter 4	A.Kovalev
2.8	2021.07.22	Added info in Q&A section	A.Kovalev
2.9	2022.12.21	Added company info. Added jitter note in ch. 3	A.Kovalev
3.0	2024.03.28	Added information about SMA-type connectors and cables in Q&A section, small typo fixes	G. Volkov