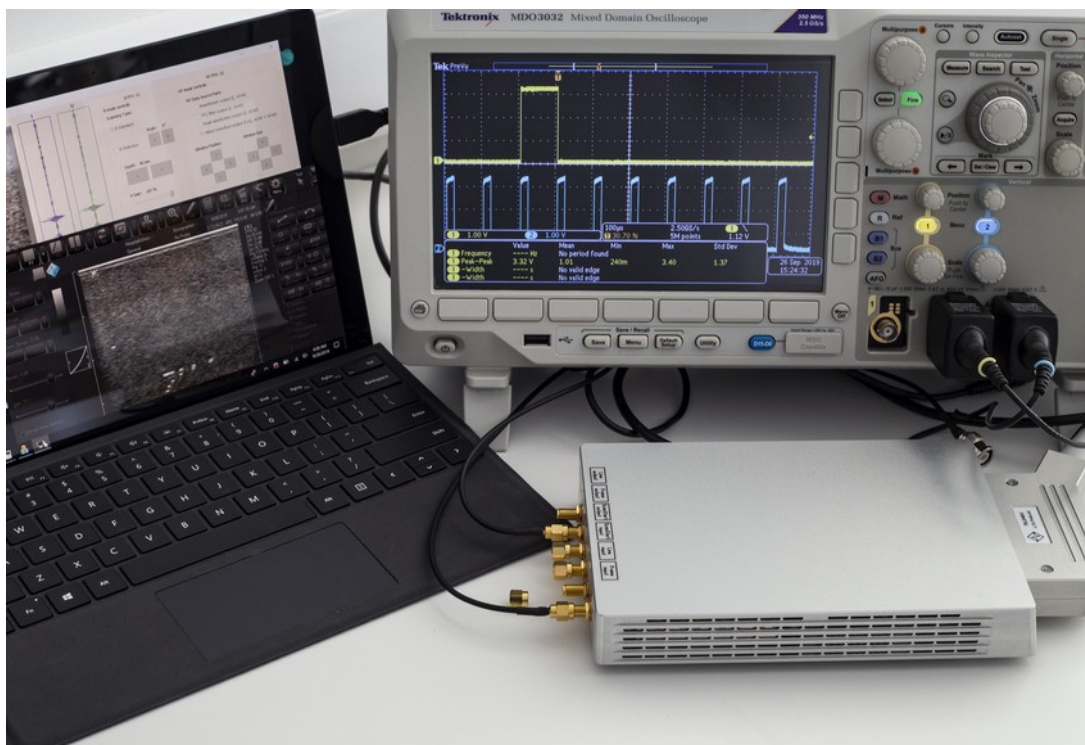


ArtUs EXT-1H / ArtUs OEM-1H

Ultrasound Diagnostic System



I/O MODULE USER GUIDE

Contents

<u>1.</u>	<u>Terms Used In This Guide.....</u>	<u>3</u>
<u>2.</u>	<u>I/O Module Connectors Description</u>	<u>3</u>
<u>3.</u>	<u>I/O Module Triggering Signals Description.....</u>	<u>4</u>
<u>4.</u>	<u>ArtUs Sync Options Utility.....</u>	<u>6</u>
<u>5.</u>	<u>Voltage Levels for Interface Signals</u>	<u>8</u>
<u>6.</u>	<u>Signal Diagrams</u>	<u>9</u>
<u>7.</u>	<u>External Equipment Connection Diagram.....</u>	<u>11</u>
<u>8.</u>	<u>Return to normal scan mode</u>	<u>11</u>
<u>9.</u>	<u>How to enable/disable I/O signals without ArtUs Sync Options Utility</u>	<u>11</u>
<u>10.</u>	<u>Twin Synchro ArtUs Setup.....</u>	<u>12</u>
	Configuration 1: 2 ArtUs, 2 PCs, Signal Generator for external frame synchronization ..	12
	Configuration 2: 2 ArtUs, PC with 2 Monitors, Signal Generator for external frame synchronization	14
	Setting the highest frame rate	16
<u>11.</u>	<u>Q&A Section.....</u>	<u>17</u>
<u>12.</u>	<u>Revision History.....</u>	<u>18</u>

Introduction

ArtUs beamformer can be equipped with additional I/O module which allows controlling it using an external signal providing device, such as signal generator. 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 – signal that triggers the state of beamformer between FREEZE and SCAN.

2. I/O Module Connectors Description

ArtUs EXT-1H with I/O module installed looks like shown on a 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.



Connectors are labeled as shown in a table:

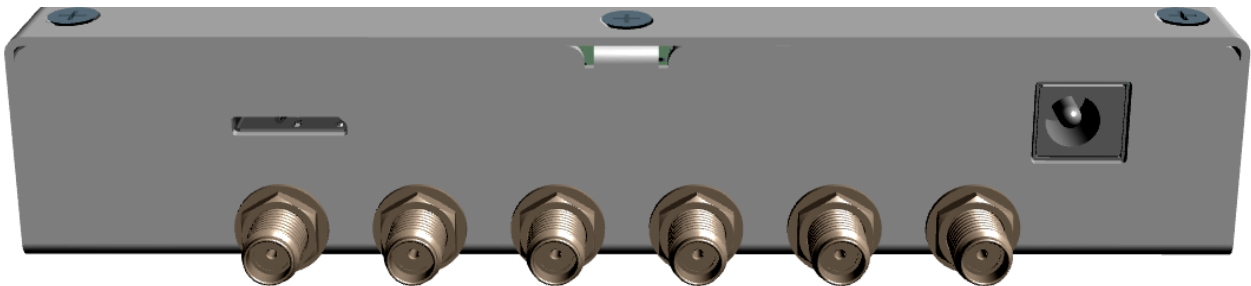
Line output	Frame output	ScanStart output	ScanStart input	Line input	Frame input
--------------------	---------------------	-------------------------	------------------------	-------------------	--------------------

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, 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 of ultrasound data from a tissue for one ultrasound line with 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 of ultrasound data from a tissue for one ultrasound frame with delay of approximately 20 us.

ArtUs OEM-1H 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 set number of frames delay 20 us	n/a	Logical 0
Frame Output	Falling Edge	Acquired 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 of ultrasound data from tissue for one ultrasound line approximately in 20 us after rising edge of the signal
- **Ultrasound Frame input** - system starts acquiring of ultrasound data from tissue for one ultrasound frame approximately in 20 us after rising edge of the signal

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

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

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

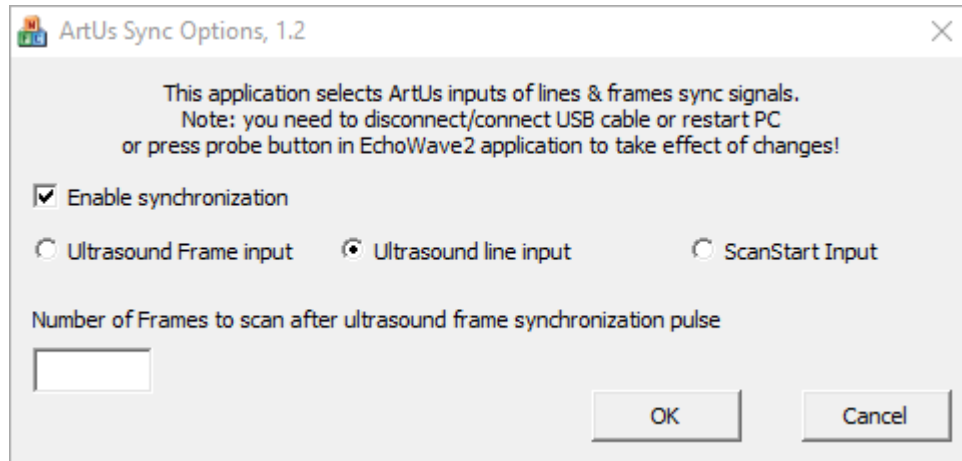
- **ScanStart input** - system changes state from FREEZE to SCAN and from SCAN to FREEZE at each rising edge of the signal (works like FREEZE button)
- **ScanStart output** - system generates logic level "0" in Freeze mode and logic level "1" in scan mode

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

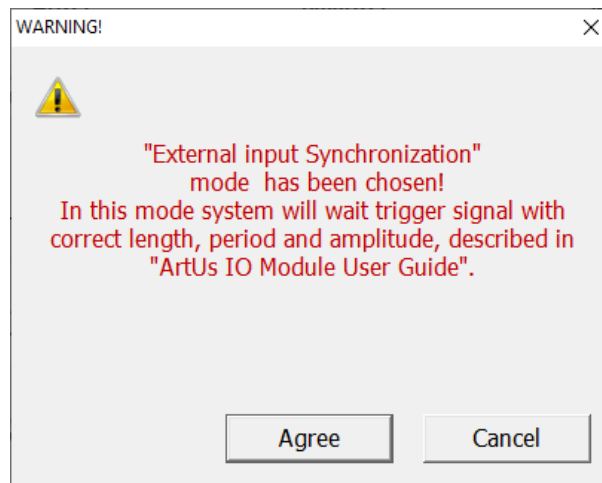
- **ScanStart input** - system scans during logic level "1" and does pause (not equal FREEZE) of scanning during logic level "0". **Ultrasound Line output** is synchronized with **ScanStart input**
- **ScanStart output** - system generates logic level "0" in Freeze mode and logic level "1" in scan mode

4. ArtUs Sync Options Utility

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

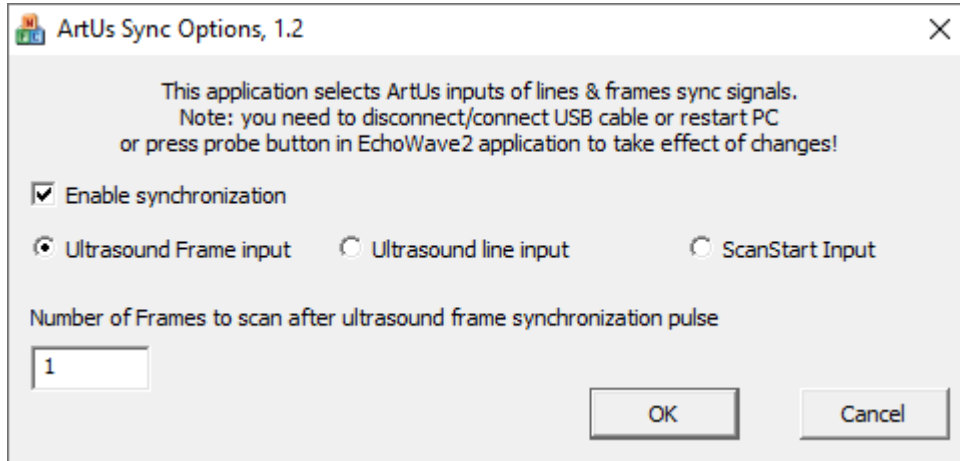


Please note, after clicking “OK” button user gets warning message as shown below.

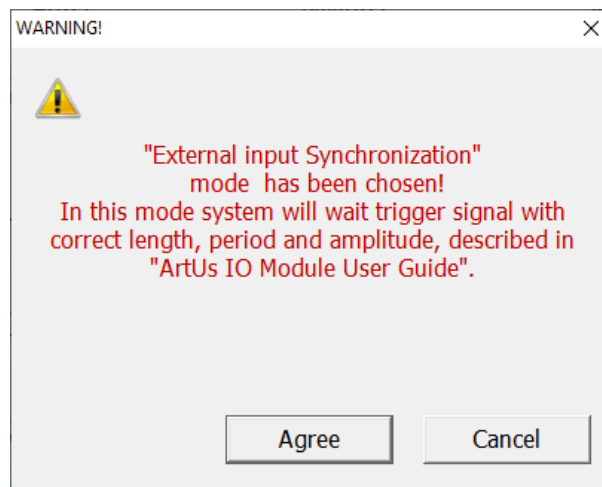


To activate device settings user needs to run EchoWave II program or if EchoWave II is already running – to push “Probe” button.

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

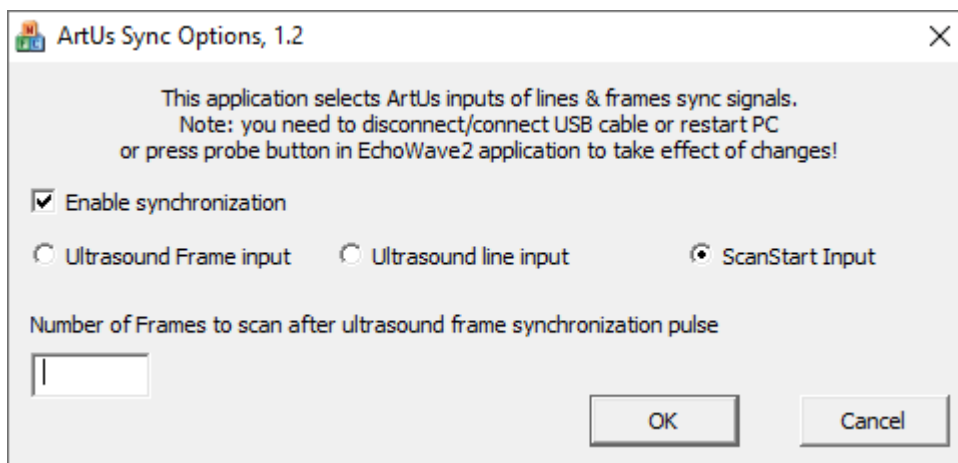


Please note, after clicking “OK” button user gets warning message as shown below.

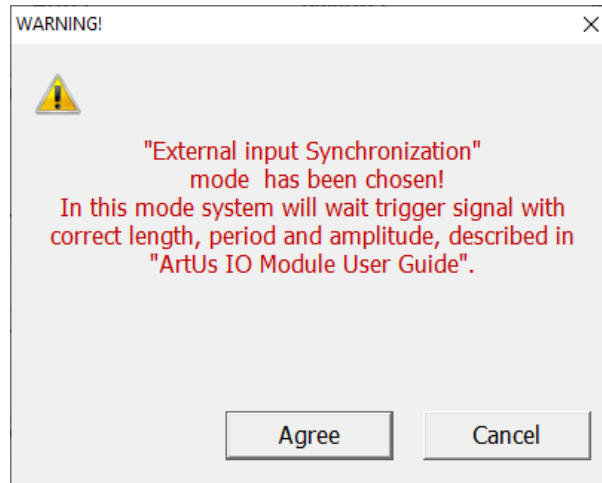


To activate device settings user needs to run EchoWave II program or if EchoWave II is already running – to push “Probe” button.

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



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



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

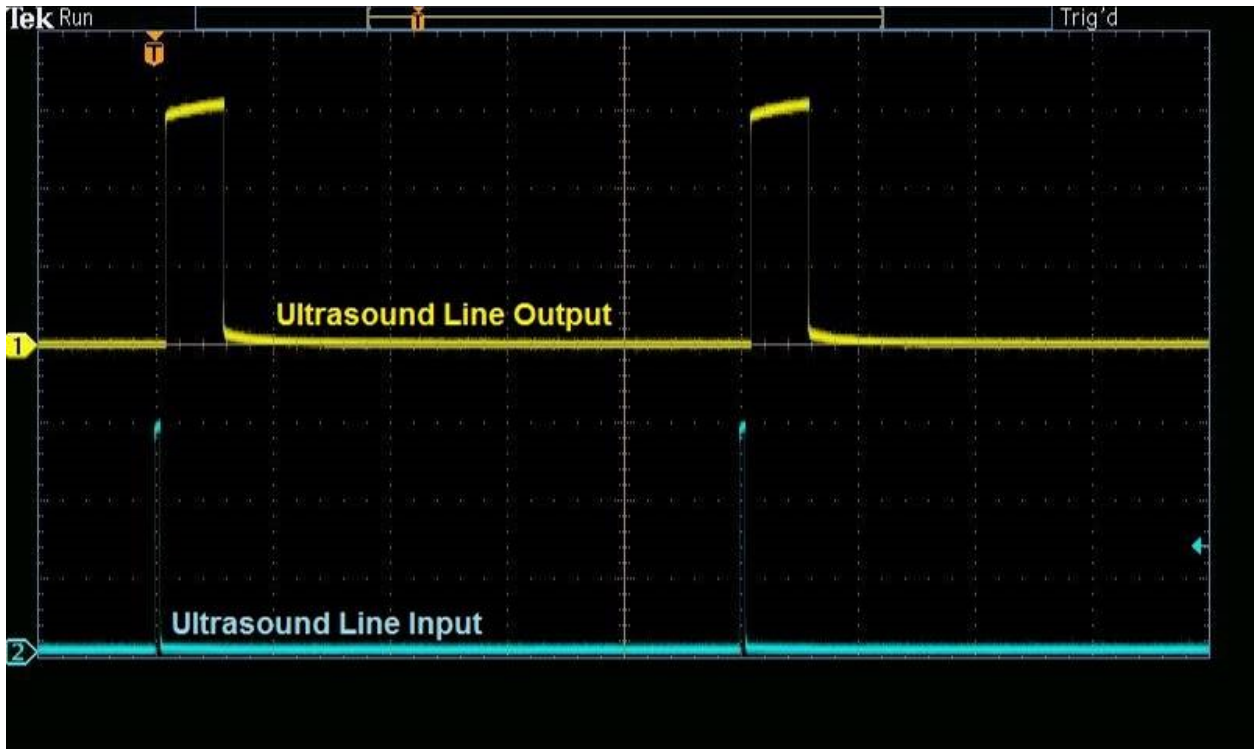
Note: Ultrasound Frames have one additional “passive” ultrasound line when any of inputs is chosen in **ArtUs Sync Options** utility.

5. Voltage Levels for Interface Signals

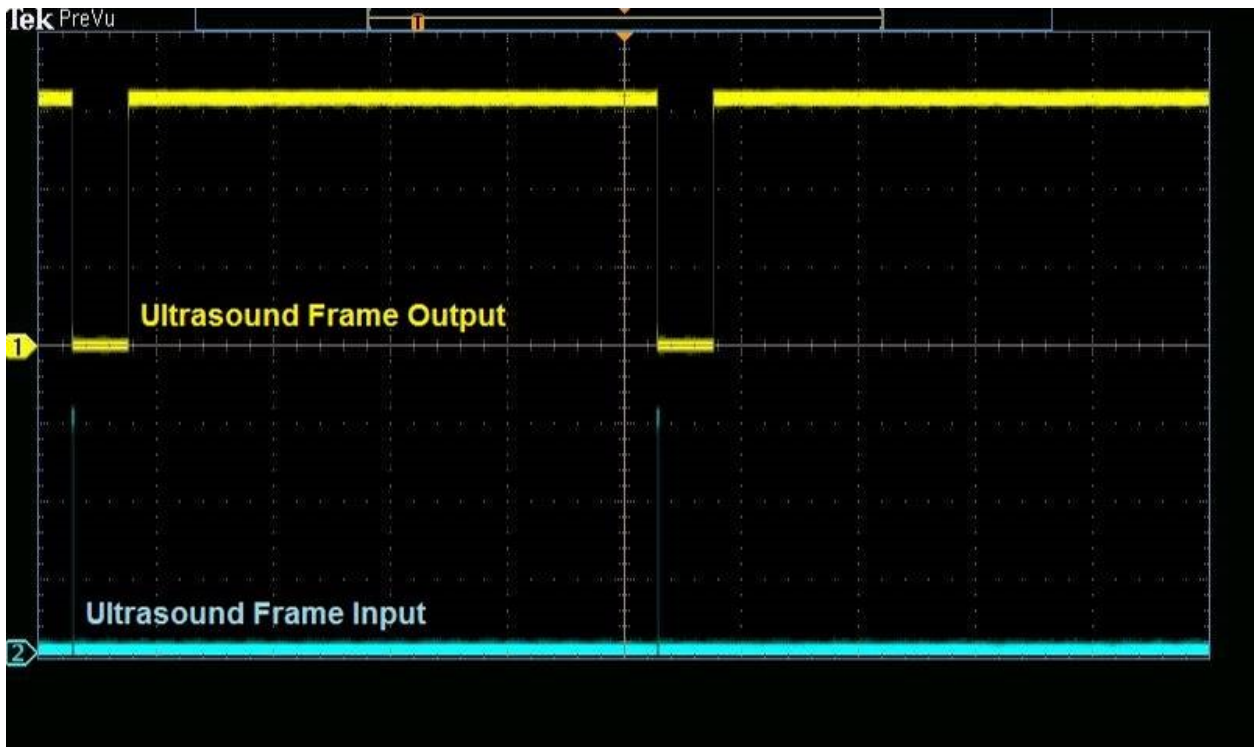
- **Input signals** – 2,5V or 3,3V CMOS level (5V logic tolerance)
- **Output signals** – 3,3V CMOS level

6. Signal Diagrams

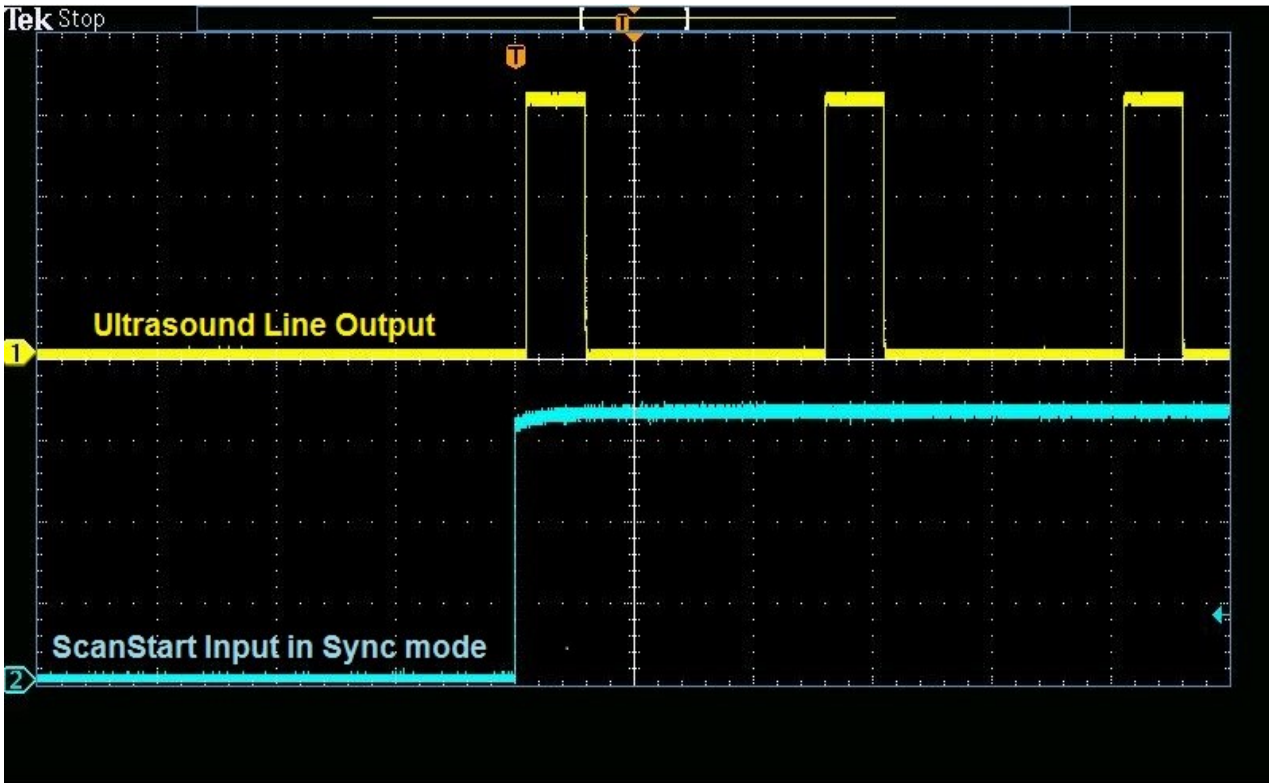
Diagrams show external equipment input signals and corresponding outputs.



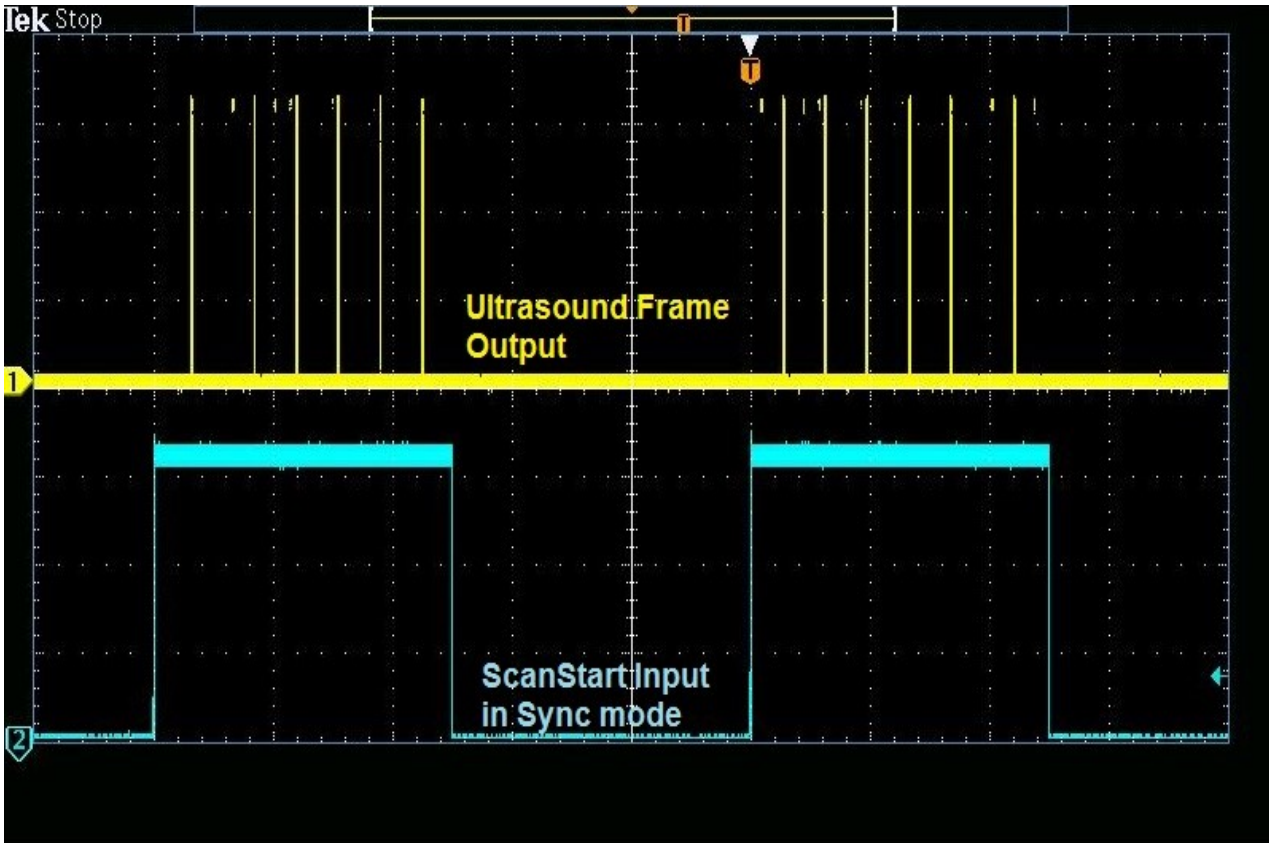
Ultrasound Line Input vs Ultrasound Line Output



Ultrasound Frame Input vs Ultrasound Frame Output



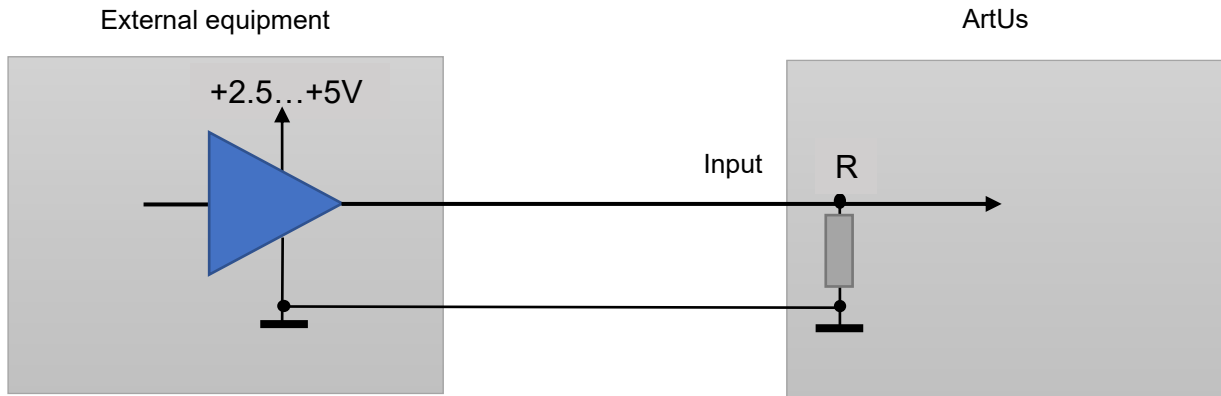
ScanStart Input in Sync Mode vs Ultrasound Line Output



ScanStart Input in Sync Mode vs Ultrasound Frame Output

7. External Equipment Connection Diagram

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



8. Return to normal scan mode

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

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

Run Registry Editor utility (regedit.exe)

Locate Registry path:

„HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\ArtUs\Parameters“.

To **Enable synchronization** and enable **Ultrasound Frame input**

Write value **1** to "External synch mode" register

To **Enable synchronization** and enable **Ultrasound Line input**

Write value **2** to "External synch mode" register

To **Enable synchronization** and enable **ScanStart output**

Write value **4** to "External synch mode" register

To define **Number of Frames to scan after ultrasound frame synchronization pulse**

Write number of frames to "Synch frames number" register

10. Twin Synchro ArtUs Setup

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

To use external hardware Freeze/Run button, edit a line shown below and save 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

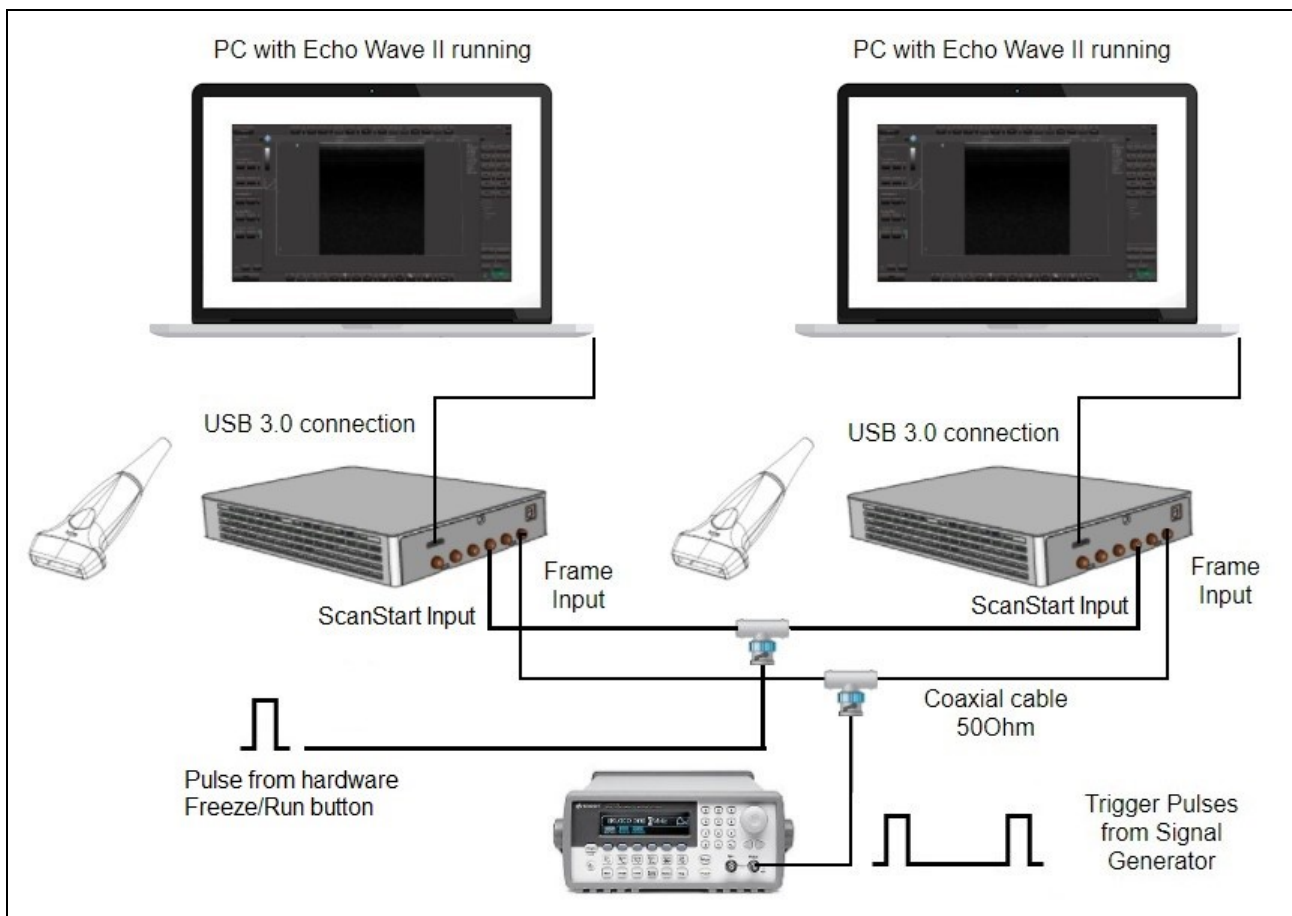


Figure 1 Twin ArtUs with 2 PCs

Configuration 1 setup:

1. Connect both ArtUs beamformers to their respective PCs using USB 3.0 or higher ports
2. Connect Signal Generator to both ArtUs devices as shown on **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 hardware Freeze/Run button to ScanStart Inputs of both ArtUs devices as shown on **Figure 1**
4. Run **ArtUs Sync Options.exe** utility on each PC
5. Check Enable Synchronization and select Ultrasound Frame Input
6. Push **OK** button. Now both ArtUs devices are in external synchronization mode
7. Set Signal Generator to pulse triggering with frequency depended on probe and scanning parameters (number of probe elements, depth, line density and other, which fluence on ultrasound frame time)
8. Run 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 Freeze button on Echo Wave II on each PC or press hardware Freeze/Run button to stop scanning
 - 9.3. Click Freeze button on Echo Wave II on each PC or press hardware Freeze/Run button to start scanning
 - 9.4. Turn ON generator
 - 9.5. Perform scanning
 - 9.6. Turn OFF generator
 - 9.7. Click Freeze button on Echo Wave II on each PC or press 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 one or more frames relatively to each other.

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

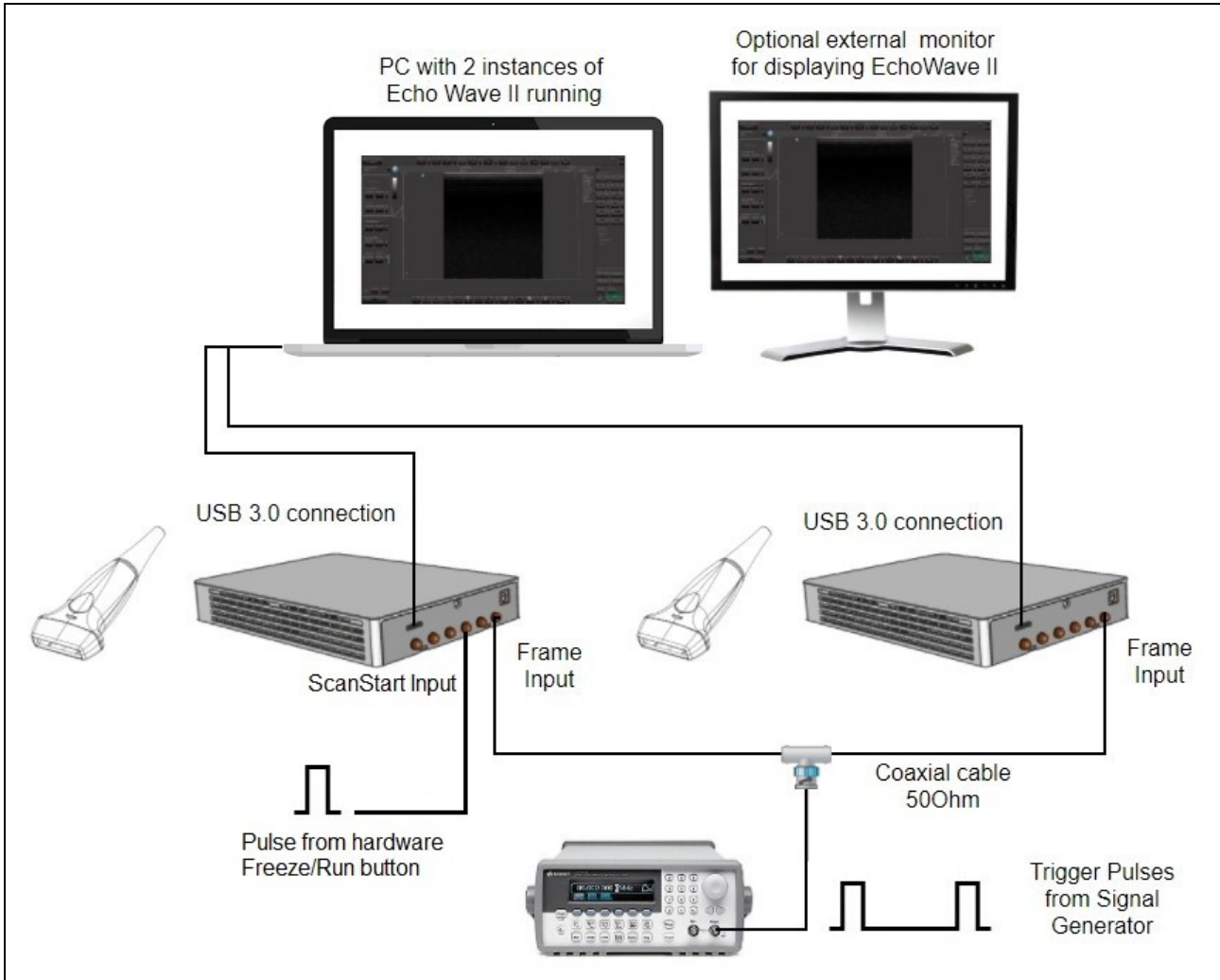


Figure 2 Twin ArtUs with a PC and optional external monitor (Frame Input)

Configuration 2 setup:

1. Connect both ArtUs beamformers to PC using two USB 3.0 or higher ports
2. Connect 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 hardware Freeze/Run button to ScanStart Input of one of ArtUs devices as shown on Figure 2
4. Run **ArtUs Sync Options.exe** utility
5. Check Enable Synchronization and select Ultrasound Frame Input
6. Push **OK** button. Now both ArtUs devices are in external synchronization mode.
7. Set Signal Generator to pulse triggering with frequency depended on probe and scanning parameters (number of probe elements, depth, line density and other, 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 Freeze/Run button on **CopyData.exe** utility window or press hardware Freeze/Run button to stop scanning
 - 10.3. Click Freeze button on **CopyData.exe** utility window or press hardware Freeze/Run button to start scanning
 - 10.4. Turn ON generator
 - 10.5. Perform scanning
 - 10.6. Turn OFF generator
 - 10.7. Click Freeze button on **CopyData.exe** utility window or press 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 one frame relatively 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 Echo Wave II ultrasound window. Both frequencies should change accordingly. When you reach maximum frame rate you will see dramatic frame rate drop (approximately 2 times) in Echo Wave II. Adjust the frequency a little to lower value to regain frame rate in Echo Wave II window as shown on Signal Generator. Now you 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: Standard
- Number of focuses: 1

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

11. Q&A Section

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

A: You can purchase ready to use cables at Amazon, see example [link](#).

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 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 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 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 Echo Wave II application and allow it load completely
12. Start another instance of Echo Wave II application
13. On both instances you should see live images from one of attached beamformer/transducer sets. You Probe button to choose another transducer.

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