# QuickKit Manual

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This manual is for illustration purposes only. The manual may not be up-to-date and sections have been dedacted from what is actually provided with QuickKit. Contact PhaseTech for a complete and up-to-date manual.

PhaseTech Spectroscopy, Inc. follows a policy of continuous product development. Specifications are subject to change without notice. Specifications are based on prototype performance assembled by PhaseTech. The user takes full responsibility for the assembly and performance of the QuickKit.

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# Contents

# 1. General Information

## 1.1. Introduction

The QuickKit mid-IR pulse shaping kit is designed to make building a mid-IR pulse shaping as easy as possible. Mid-IR pulse shaping has many applications including 2D IR (and 3D IR) spectroscopy, SFG (and 2D SFG) spectroscopy, coherent control as well as the temporal and spectral characterization of femtosecond mid-IR pulses.

This kit includes:

- shaper optics and optomechanics
- germanium acousto-optical modulator with high-power RF amplifier
- 300 MHz arbitrary waveform generator with LabView™ control software
- demonstration LabView™ code for a variety of pulse shaping tasks
- phased-lock external clock electronics
- manual with assembly instructions

Other items may be necessary depends on your particular laser or laser setup, including:

- digital delay generator and/or function generator capable of generating the trigger and gate described in manual below
- fast-response mid-IR detector and an oscilloscope
- HeNe laser or visible laser diode that is collinear with mid-IR source
- setup for generating and detecting SHG from the shaper output is useful for compressing the output pulse duration. We can provide an SHG accessory for sale upon request.
- selection of well-shielded coaxial cables with SMA and BNC connectors
- chilled water supply for cooling the RF amplifier (500 W capacity)
- low-impedance +24V DC power supply capable of providing ~24A of current
- PC with the Windows XP™ operating system and an available PCI slot

Please contact PhaseTech for current recommendations regarding selection of these items.

## 1.2. Specifications

| | |
|---|---|
| Input Center Frequency | 4.5-6.5 μm |
| Spectral Window | 1.5 μm at 5.5 μm[1] |
| Repetition Rate | ≤ 4 kHz |
| Effective Pixels | > 150[1] |
| Maximum Double Pulse Delay[3] | > 7 ps[1] |
| Input Beam Size ($1/e^2$) | 7 mm, collimated |
| Input Polarization | Linear, horizontal |
| Output Polarization | Linear, horizontal |
| Throughput Efficiency | > 25%[1] |

[1] Specification is based on our standard gratings and an input diameter of 7mm. Other gratings are available upon request or can be provided by the user.

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## 1.3. References

There are numerous useful literature references on mid-IR pulse shaping. We recommend the following references.

### Technique:

Residue-specific structural kinetics of proteins through the union of isotope labeling, mid-IR pulse shaping, and coherent 2D IR spectroscopy
Methods (2010), 52, 12-22
CT Middleton, AM Woys, SS Mukerhjee, MT Zanni
http://dx.doi.org/10.1016/j.ymeth.2010.05.002

Polarization shaping in the mid-IR and polarization-based balanced heterodyne detection with application to 2D IR spectroscopy
Opt. Express (2009), 17, 14526-14533
CT Middleton, DB Strasfeld and MT Zanni
http://dx.doi.org/10.1364/OE.17.014526

How to turn your pump-probe instrument into a multidimensional spectrometer: 2D IR and Vis spectroscopies via pulse shaping
Phys. Chem. Chem. Phys. (2009), 11, 748-761
SH Shim and MT Zanni
http://dx.doi.org/10.1039/B813817F

Automated 2D IR spectrometer mitigates the influence of high optical densities
Vib. Spec. (2009), 50, 136-142
W Xiong, DB Strasfeld, SH Shim, MT Zanni
http://dx.doi.org/10.1016/j.vibspec.2008.10.010

Femtosecond pulse shaping directly in the mid-IR using acousto-optic modulation
Opt. Lett. (2006), 31, 838-840
SH Shim, DB Strasfeld, EC Fulmer and MT Zanni
http://dx.doi.org/10.1364/OL.31.000838

Generation and characterization of phase and amplitude shaped femtosecond mid-IR pulses
Opt. Express (2006), 14, 13120-13130
SH Shim, DB Strasfeld and MT Zanni
http://dx.doi.org/10.1364/OE.14.013120

### Application:

Adding a dimension to the infrared spectra of interfaces using heterodyne detected 2D sum-frequency generation (HD 2D SFG) spectroscopy
Proc. Nat. Acad. Sci. USA (2011), 108, 20902-20907
W Xiong, JE Laaser, RD Mehlenbacker, MT Zanni
http://dx.doi.org/10.1073/pnas.1115055108

Time-Domain SFG Spectroscopy Using Mid-IR Pulse Shaping: Practical and Intrinsic Advantages
J. Phys. Chem. B (2011), 115, 3713-3724

JE Laaser, W Xiong, MT Zanni
http://dx.doi.org/10.1021/jp200757x

Mode selectivity with polarization shaping in the mid-IR
New J. Phys (2010), 11, 105046
DB Strasfeld, CT Middleton, MT Zanni
http://dx.doi.org/10.1088/1367-2630/11/10/105046

Tracking Fiber Formation in Human Islet Amyloid Polypeptide with Automated 2D-IR Spectroscopy
J. Am. Chem. Soc. (2008), 130, 6698-6699
DB Strasfeld, YL Ling, SH Shim, MT Zanni
http://dx.doi.org/10.1021/ja801483n

Controlling Vibrational Excitation with Shaped Mid-IR Pulses
Phys. Rev. Lett. (2007), 99, 038102
DB Strasfeld, SH Shim, MT Zanni
http://dx.doi.org/10.1103/PhysRevLett.99.038102

Automated 2D IR spectroscopy using a mid-IR pulse shaper and application of this technology to the human islet amyloid polypeptide
Proc. Nat. Acad. Sci. USA (2007), 104, 14197-14202
SH Shim, DB Strasfeld, YL Ling, MT Zanni
http://dx.doi.org/10.1073/pnas.0700804104

For more information on mid-IR pulse shaping and it's applications, please visit our website at www.phasetechspectroscopy.com.

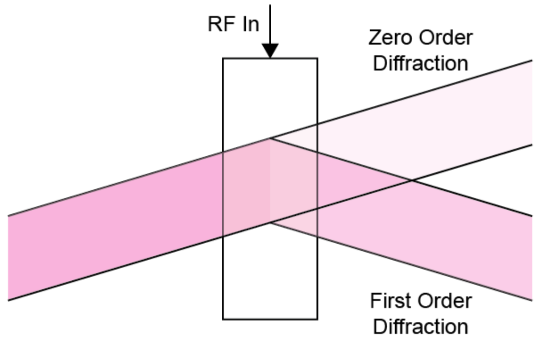
### 1.4. Basic Theory of Operation

The PhaseTech QuickKit mid-IR pulse shaper kit is based on a germanium acousto-optical modulator (AOM). The pulse is shaped in the frequency domain through the application of a complex-valued transfer function, or mask, according to Eq. 1,

$$E_{out}(v) = M(v)E_{in}(v) \tag{1}$$

where $E_{in}(v)$, $E_{out}(v)$ and $M(v)$, are the input-pulse electric field, output-pulse electric field and mask at each frequency $v$. For independent modulation of different frequencies, the incoming pulse is spectrally dispersed by a grating. A $CaF_2$ lens placed one focal length, $f$, from the grating is used to focus the beam, with each frequency focused at a different position at a Ge AOM. A piezoelectric transducer converts a 75 MHz carrier frequency waveform, generated by an arbitrary waveform generator (AWG) into an acoustic wave which propagates through the Ge crystal, perpendicular to the mid-IR pulse propagation, at a velocity of 0.55 cm/μs. Since the velocity of the mid-IR pulse through the Ge crystal is 4 orders of magnitude faster than the acoustic wave velocity, the periodic modulation of the Ge refractive index appears to the pulse as a static Bragg diffraction grating which diffracts a larger portion of the pulse. The amplitude and phase dependence of the RF waveform are transmitted to the diffracted pulse.




The time-dependence of the RF waveform is mapped onto the spatial dimension of the AOM. The pulse is shaped by mapping the desired complex-value mask on to the RF wave according to Eq. 2,

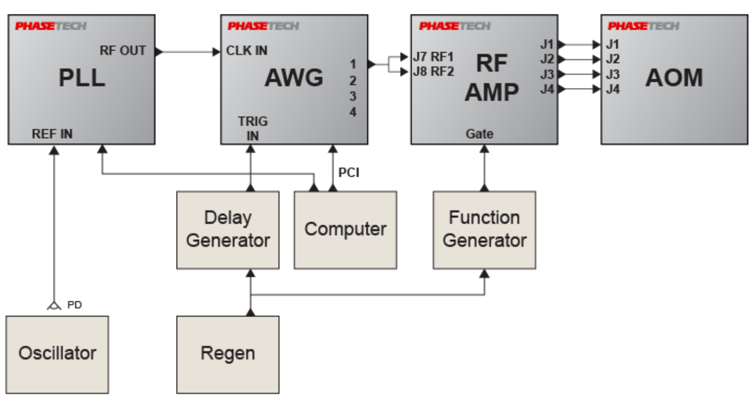
$$RF(t) = |M| \sin[Ft + \tan^{-1}(\mathrm{Im}(M)/\mathrm{Re}(M))] \tag{2}$$

The RF mask intensity should be calibrated to compensate for the nonlinear dependence of the AOM diffraction efficiency on the RF power. The diffracted beam is focused by a second CaF2 lens onto a second grating which finally spatially overlaps each diffracted frequency.

Since the focal length of the CaF2 lenses varies with wavelength, the lenses and AOM are on translation stages will allow for proper positioning of the stages for each wavelength.

### 1.5. Electronics Overview

There are a number of electronic devices involved in the operation the pulse shaper. A schematic diagram of the relationship between these devices, the AOM and a femtosecond laser is shown below.




The PhaseTech QuickKit provides the phase-locked loop external clock (PLL), the arbitrary waveform generator (AWG), the RF amplifier (RF AMP) and the Ge acousto-optical modulator (AOM). Details of the electronics setup may vary depending on your equipment and laser.

## 1.6. QuickKit Contents

| **Quantity** | **Item** |
|---|---|
| 1 x | Ge AOM |
| 1 x | RF Amplifier |
| 1 x | AOM/Amplifier Cable Pack |
| 1 x | Arbitrary Waveform Generator Card |
| 1 x | PhaseTech XC300 External Clock |
| 1 x | USB cable |
| 1 x | PhaseTech Kit Baseplate |

| | |
|---|---|
| 6 x | Post Holders |
| 6 x | Posts |
| 4 x | Iris Diaphragms |
| 2 x | Compact Mirror Mount |
| 2 x | Mirror Holder for Compact Mirror Mount |
| 2 x | Gold Circular Mirror |
| 2 x | Rotation Stage |
| 2 x | PhaseTech Grating Mount |

| | |
|---|---|
| 2 x | Mid-IR Gratings |
| 2 x | 25 mm Translation Stage with (4) Mounting Screws |
| 2 x | PhaseTech Lens Stand |

2 x	50 mm Lens Mount
2 x	CaF2 Lens
2 x	50 mm Translation Stage
1 x	PhaseTech AOM Breadboard

2 x	Aluminum Rectangular Mirror on Platform Mirror Mount
2 x	Kinetic Stop
1 x	PhaseTech AOM Mounting Bracket

1 x	PhaseTech Micrometer Mount

1 x	50 mm Micrometer

29 x	(A) Socket Head Cap Screw, M6x14mm
8 x	(B) Low-Head Socket Head Cap Screw, M6x12mm
2 x	(C) Socket Head Cap Screw, M6x50mm
2 x	(D) Socket Head Cap Screw, M4x50mm
4 x	(E) Nylon-Tip Set Screw, M4x10mm
4 x	(F) Socket Head Cap Screw, M6x22mm
2 x	(G) Socket Head Cap Screw, M4x18mm
8 x	(H) Socket Head Cap Screw, M6x8mm
2 x	(I) Socket Head Cap Screw, Black, M4x8mm

### 1.7. Assembly Overview

It is not necessary to follow a strict assembly order. For example, it is certainly possible to assemble the shaper and do some of the initial alignment steps before setting up the electronics. Also, it may be necessary to return to earlier steps later in the assembly for fine tuning. For example, it may be necessary to adjust the timing of the RF waveform in order to optimize the AOM diffraction. However we recommend the following general process.

1. Install PhaseTech XC300 external clock.
2. Install Arbitrary Waveform Generator
3. Install RF Amplifier and connect to AOM
4. Setup the timing of the AWG trigger pulse and RF amplifier gate pulse
5. Assemble the shaper
6. Align and optimize the shaper

This manual roughly follows this order of operations.

# 2. Phase-Tech XC300 External Clock


## 2.1. Connections and Indicators

| | |
|---|---|
| REF IN | Connect a photodiode signal of the oscillator pulse-train. Signal must be 80-90 MHz and 50-1000 mV peak-to-peak. In some cases, it may be helpful to clean up the signal with a lowpass or bandpass RF filter. |
| USB | Mini-USB connection for power and communication with computer. |
| RF OUT | Phase-locked 300 MHz signal, > 500 mV peak-to-peak, for input into the AWG CLK IN. |
| POWER | Indicates that the device is connected to power. |
| LOCK DETECT | Indicates that the device has achieved phase-lock with the REF IN signal. |

## 2.2. Installation

Run ExternalClockInstall.msi to install the software and drivers on a computer. NOTE: This does not need to be the same computer that the AWG will be installed in.

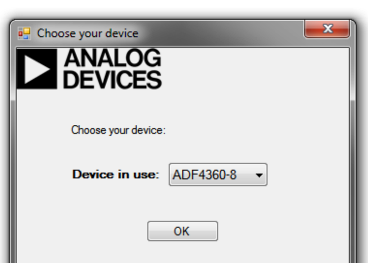
Connect the External Clock to the computer through the provided USB cable.

If the red POWER light does not turn on, try a different USB port on the computer.

Wait for the Windows XP™ operating system to find the driver software. This might take up to 2-3 minutes.

Run the ADF4360 program.

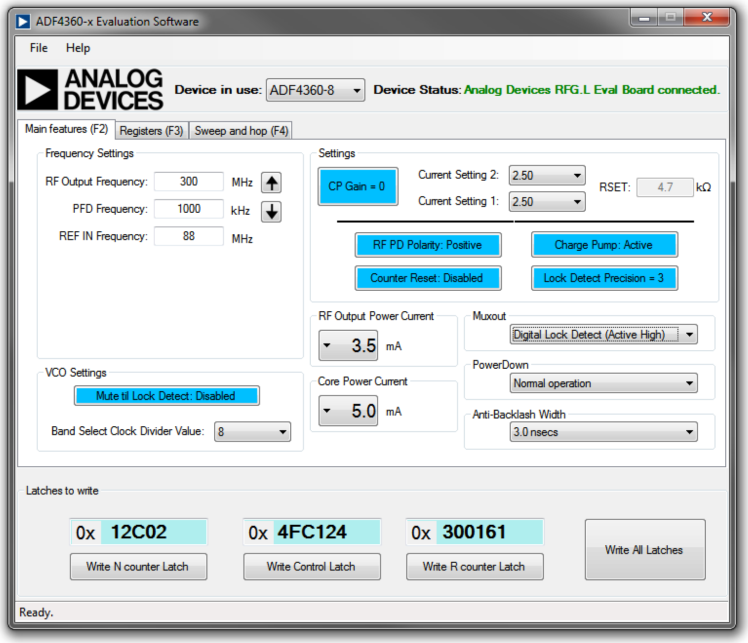
Choose “ADF4360-8” and click the OK button.



On the following screen check that the Device Status is "Analog Devices RFG.L Eval Board connected." If the Device Status is "No USB Device.", check the connection between the computer and External Clock.

Adjust the following settings and click the "Write All Latches" button (see figure).

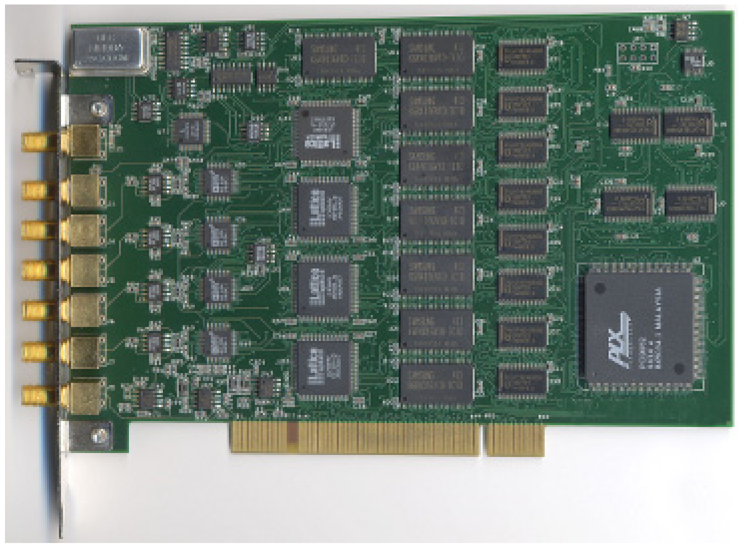
| | |
|---|---|
| RF Output Frequency: | 300 MHz |
| REF IN Frequency: | Set to your oscillator repetition rate |
| RF Output Power Current: | 3.5 mA |
| Muxout: | Digital Lock Detect |




Check that the green LOCK DETECT light has turned on. If not adjust the REF IN Frequency up and down in increments of 1 MHz until lock is achieved. Click the "Write All Latches" button after each adjustment.

# 3. Arbitrary Waveform Generator (AWG)

The QuickKit comes with a 300 MHz, 4-channel, AWG with 4 Megasamples of memory per channel and 12-bit vertical resolution. This AWG is used to generate the waveforms that are sent to the AOM and determine the form of the acoustic wave that shapes mid-IR pulses.



The timing of the AWG output is controlled by an external TTL trigger, generally provided by the laser system. Additionally, the timing jitter of the waveform (relative to the laser pulse) can be minimized through the optional use of an external clock synchronized with the femtosecond oscillator source laser. Control of the AWG is performed via the provided LabView™ software.

## 3.1. Specifications (at 300 MS/s)

| | |
|---|---|
| Number of Analog Outputs | 4 SMA outputs |
| Output Coupling | DC, 50 Ohm |
| Vertical Resolution | 12 bit |
| Amplitude | 2.0 Vpp |
| Rise/Fall Time (10% to 90%) | 2.5 ns typical |
| Clock Jitter | < 20 ps RMS |

## 3.2. Installation

The QuickKit AWG card is currently only compatible with the Windows XP operating system. Support for other operating systems may be available upon request. Installation should be performed using an account with administrative privileges.

1. Do not install the PCI card into the computer yet.
2. Copy the contents of the “AWG” folder to “C:\temp\AWG”
3. Run the “Register_AWG.bat” file.
4. Copy the “PhaseTechAWG.dll”, “AWG_dll.dll”, and “chase_lib.dll” files to the “C:\Windows\system32\” directory.
5. Power off and unplug the computer.
6. Install the AWG card in a free PCI slot of a PC computer according the instruction manual for your computer.
7. Power on computer.
8. When Windows asks for a driver file, point to "PhaseTechAWG.inf".
9. Connect an external trigger to the TRIG IN connector on the card
10. Connect the output from the External Clock to the CLCK IN connector on the card
11. Test for proper function of the AWG using the provided Test.vi and following the instructions within.

## 3.3. Software

Details on the AWG card software are provided in the main Software section of the manual.

# 4. RF Amplifier and AOM

Detailed information on the RF amplifier can be found in the provide manual, "RF Amplifier Manual.doc".

**IMPORTANT NOTE:**

[redacted]

To install the amplifier, connect the RF amplifier and AOM, in parallel, to a source of clean chilled water. Then follow steps 3.1-3.3 and 3.5-3.6 in the manual. Step 3.4 has been done for you. It is not necessary to follow steps 3.7-3.16, optimization of the AOM will be conducted below.

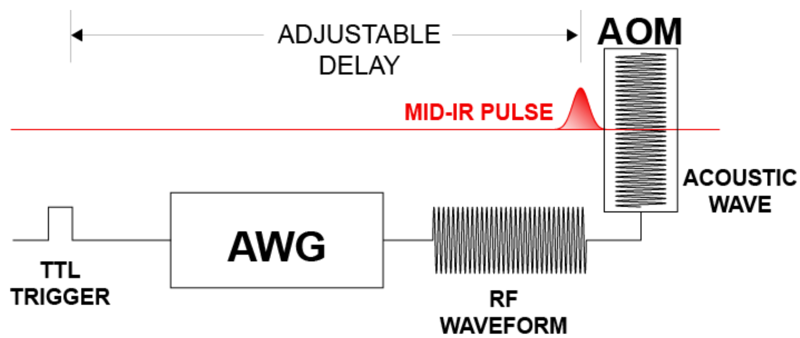
Please contact PhaseTech directly for troubleshooting and support of RF amplifier and AOM.

# 5. Timing

There are two important control signals that must synchronize with the laser with the correct timing in order for the shaper to function properly. The first is a TTL pulse which triggers the AGW to output an RF waveform, and the second is a gate pulse which is used to enable the RF amplifier to amplifier the RF waveform.

## 5.1. AWG Trigger Pulse

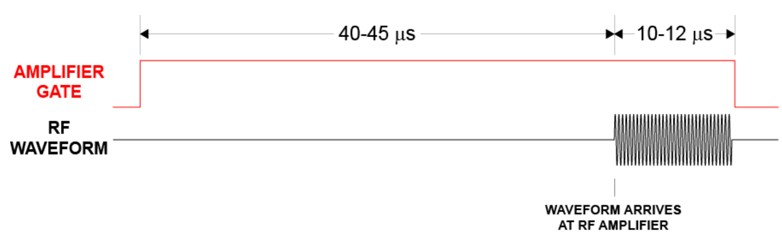
The AWG trigger pulse must be timed properly such that the acoustic wave is present in the AOM at the same moment that the mid-IR pulse passed through the AOM. Generally, a digital delay generator is used to adjust the relative timing of the AWG trigger relative to the laser pulse. Alternatively, a delay generator can be used to adjust the trigger for the laser to match the timing of the RF waveform.




The relative timing of the laser pulse and the RF waveform can displaying both the RF waveform and a photodiode signal of the laser pulse on an oscilloscope.

## 5.2. RF Amplifier Gate Pulse

The purpose of the RF amplifier gate pulse is to reduce the amount of heat generated by the amplifier. The rise of the gate pulse triggers the amplifier circuits to turn on and the fall of the gate pulse triggers the circuits to turn off when no longer needed. The gate pulse should rise 40 μs before the start of the RF waveform and fall after the end of the RF waveform.




It may be useful to add a few microseconds to either end of the gate in order to account for small changes in the RF waveform timing. However, an excessively long gate pulse will lead to unnecessary cooling demands.

# 6. Shaper

This guide is presented in roughly the best order for constructing the shaper although the order does not need to be followed strictly. For example, the initial steps of the shaper setup and alignment can be performed in parallel with the initial steps of the electronics setup.

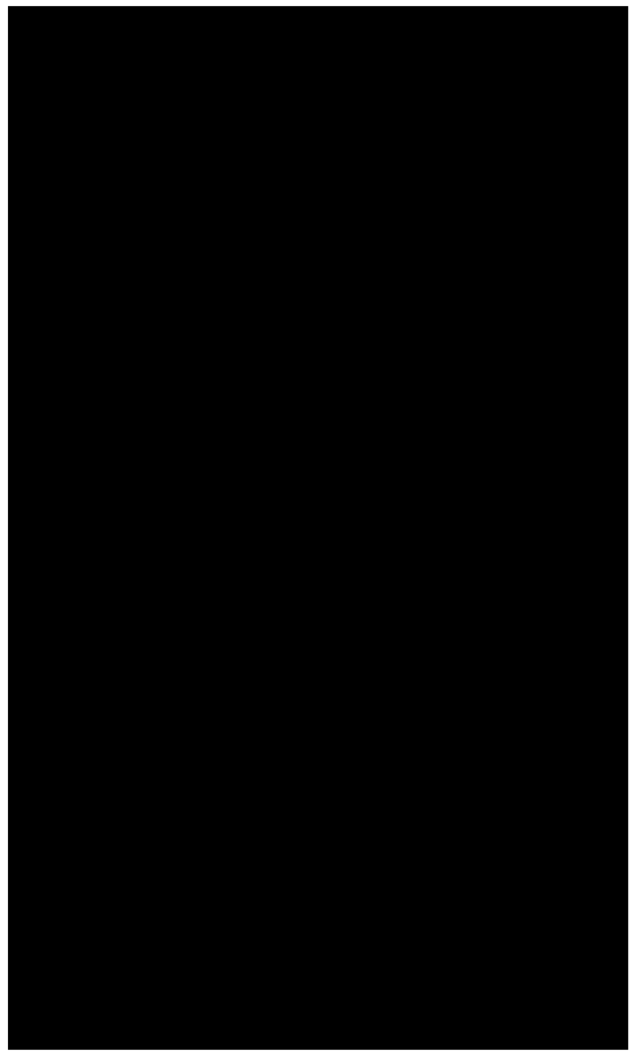
## 6.1. Assembly

Read all steps before starting assembly.

**STEP 1**

Place PhaseTech baseplate on optical table in desired location and secure using 4 M6x14 screws (A) and counterbored through holes.

The kit is designed for a beam height of 8.8 cm off the optical. If a larger height is required, it may be necessary to make riser legs for the baseplate.



**STEP 2**

Secure 6 PH2/M post holders to

**STEP 3**

Mount RP1 rotation stages to baseplate using M6x14 screws (A).

**STEP 4**

Secure the 50 mm micrometer in the PhaseTech micrometer mount using the provided retaining ring. See figure for the proper orientation of the micrometer.

Attach micrometer mount to baseplate using four low-head M6x12 screws (B).

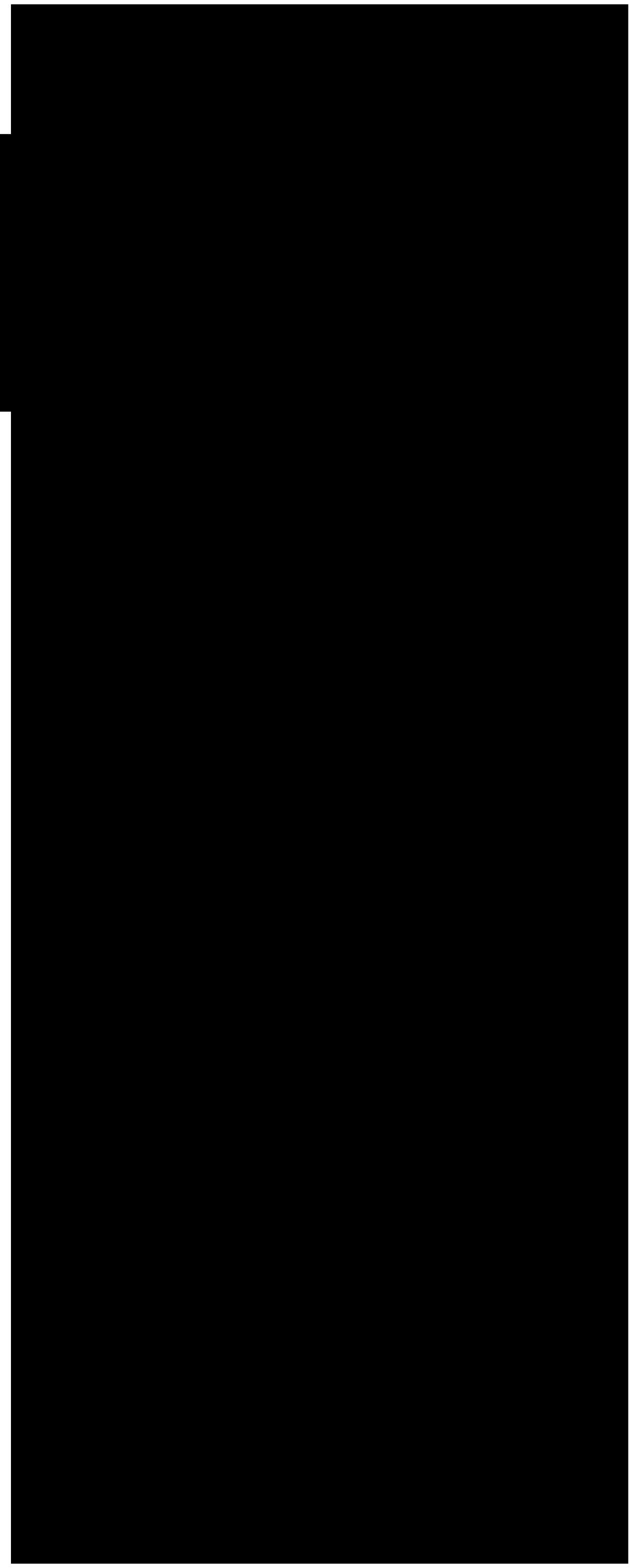
**STEP 5**

Mount PhaseTech grating mount onto rotation platform using M6x50mm screw (C) and M4x50mm screw (D). For ease of use, set the grating mount so that the M4 screw is aligned with the “0” on the angle reading, as shown in the figure.

Handle gratings carefully. Do not touch the front surface of the grating.

Carefully mount a grating on the grating mount using two M4x10mm nylon tip set screws (E). Do not apply too much pressure with the screws. Grating should be installed with arrows facing the center of the shaper.

Repeat for the second grating and mount.



**STEP 6**

Mount the CaF2 lens inside [redacted]

**STEP 8**

Add two more M6x8 (H) screws to the AOM breadboard (see figure). These will be used for alignment in the next step.

[redacted]

**STEP 9**

Attach mirror mounts with attached rectangular mirrors to the AOM Breadboard as shown, using M4x8 screw (I).

To set a 45º angle, the back surface of the mirror mount should rest against the screws placed in the previous step.

[redacted]

**STEP 10**

Secure the PhaseTech AOM Mount onto the AOM using four Low-Head M6x8 screws (J). Note the orientation of the mount in the figure, the curved end of the mount should be on the side of the AOM with water cooling attachments (not shown).

Set AOM aside for later use.

**STEP 11**

Optional.

Use two M6x14 (A) screws to secure the Thor KL01 kinetic stops to the AOM breadboard. These can be used to set the AOM position for removal and replacement.

## 6.2. Alignment and Optimization

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

# 7. Other Alignment Procedures

### 7.1. Realignment into Shaper

[redacted]

### 7.2. Changing Wavelength

[redacted]

[redacted]

### 7.3. Removing and Replacing the AOM

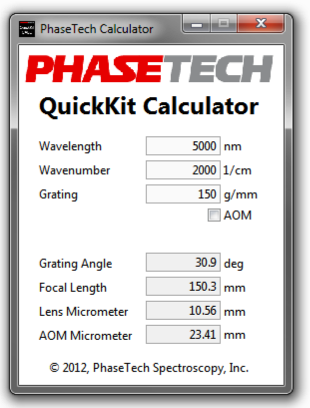
[redacted]

# 8. Software

## 8.1. QuickKit Calculator

The QuickKit Calculator can be used to calculate grating angles and translation stage positions in the QuickKit shaper for various wavelengths. There are four input parameters: wavelength, wavenumber, grating, and AOM. The calculated values will update if any of the four input values is modified.

The calculated values are meant for guidance only. The true values may vary depending on assembly of the shaper.




**Wavelength** is the desired center wavelength of the shaper in nanometers.

**Wavenumber** is the desired center frequency of the shaper in wavenumbers (1/cm).

Changing the wavelength will update the wavenumber and vice versa.

**Grating** is the grooves per mm of the gratings in use. The value for the standard QuickKit gratings is 150 g/mm.

**AOM** check this box if you are aligning the shaper with the AOM in place and uncheck if you are aligning without the AOM in place.

**Grating Angle** is the angle from 0 degrees that the gratings must be rotated. The direction of rotation (clockwise or counterclockwise) will depend on the grating.

**Focal Length** is the focal length of the standard QuickKit CaF2 lenses at the specified wavelength.

**Lens Micrometer** is target setting on the micrometers controlling the 25 mm lens translations stages.

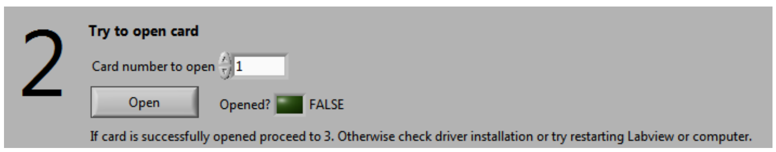
**AOM Micrometer** is target setting on the micrometer controlling the AOM translation stages.

## 8.2. QuickKit LabView™ Demo Code

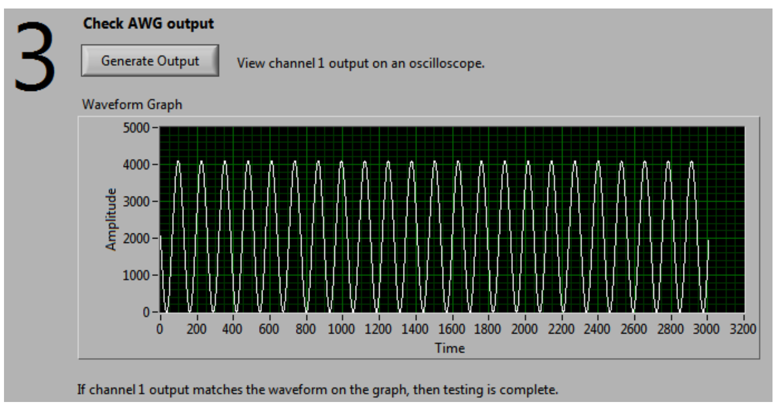
### 8.2.1. PT_Test.vi

This VI is useful for testing that the AWG is functioning properly after installation.


Click the “Count Cards” button. The number of AWG cards found on the computer will be displayed in the indicator. If “1” is displayed, the installed card has been recognized.




Choose the desired card number (typically 1) and click the “Open” button. If the card drivers are successfully opened, the indicator light will turn on.



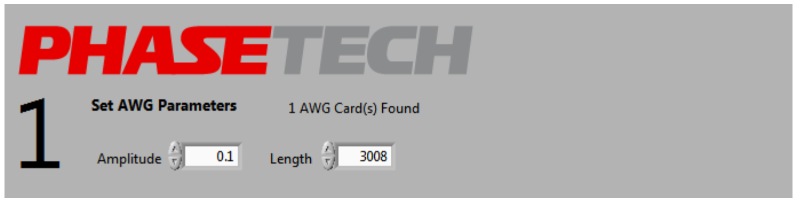

Click the “Generator Output” button to setup the AWG to output a low-frequency waveform from channel 1. View the channel 1 output on an oscilloscope and check that it matches the waveform graph. If all of these steps are completed successfully then the AWG is properly installed.

### 8.2.2. PT_FreqCalib.vi

This VI is used to conduct a frequency calibration of the shaper. Frequency calibration determines the relationship between the RF waveform sample number and the frequency of the pulse at the spatial location in the AOM that corresponding sample. Frequency calibration is necessary for generating double pulses and applying GVD or TOD correction.

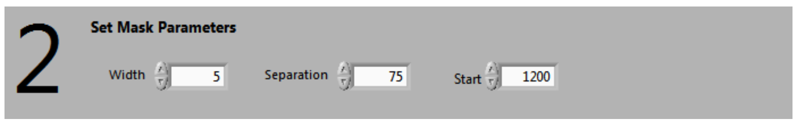
Frequency calibration is performed in a number of steps. First, a “Multi” waveform is used to obtain comb spectrum of the shaped pulse. Then, a “Single” waveform is used to obtain a spectrum of a narrow band pulse at a specific sample number. These spectra are then used to calibrate the spectrometer. The VI guides you through these steps.

Run the VI. If 0 AWG cards are found, check installation of the AWG card.




**Amplitude** sets the overall amplitude of the RF waveform

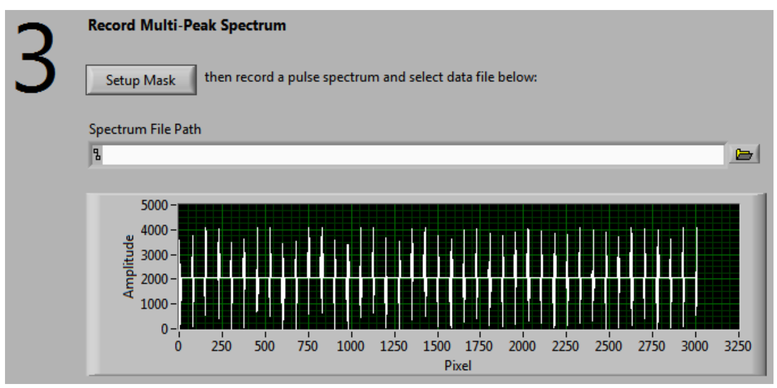
**Length** sets the length of the waveform




**Width** sets the width of the peaks in the comb and narrowband spectra.

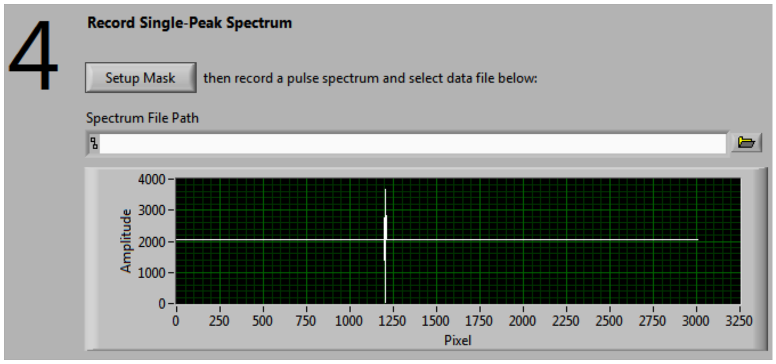
**Separation** sets the distance between peaks in the comb spectrum, in number of samples.

**Start** sets the position of the single peak in the narrowband spectrum.

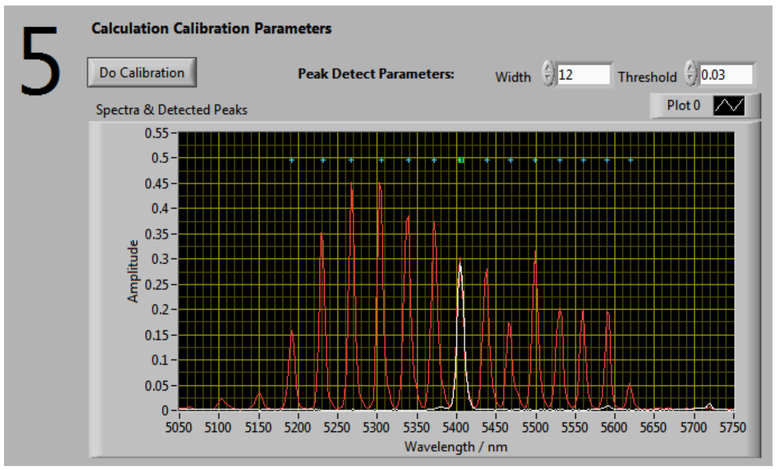



Click the “Setup Mask” button to generate the multi-peak mask. Record the spectrum of the shaped pulse with your acquisition software. Save the spectrum to a tab-delimited text file with two columns. The first column should be wavelength in nanometer, the second column should be the spectral intensity in any units. Enter the path to the spectral file in the provide box.

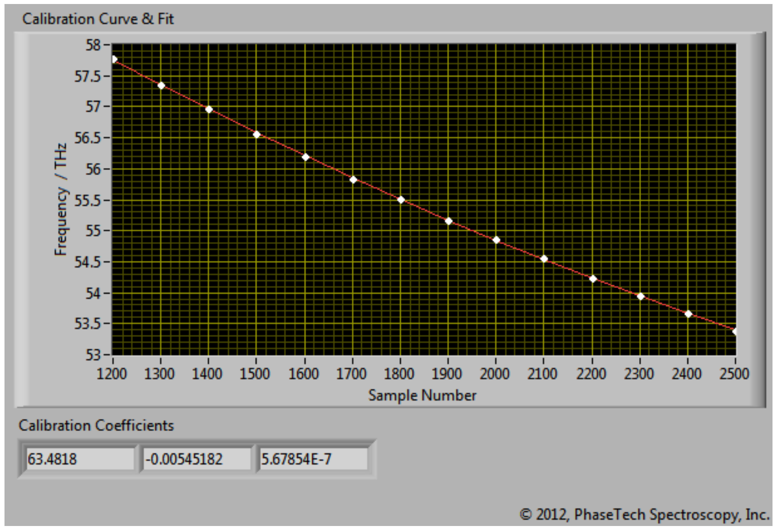
 




Repeat step 3 but for the single-peak spectrum.



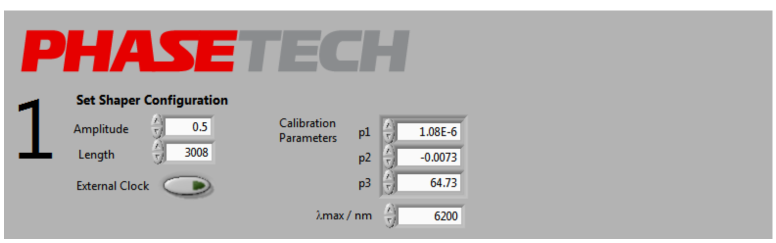

Click the "Do Calibration" button to perform the calibration routine. The multi-peak and single-peak spectra will be plotted in red and white respectively. The VI will attempt to detection the peaks in the spectra. Detected peaks in the multi-peak spectrum will be highlighted by a blue cross above the peak. There should be a contigous series of equally spaced detected peaks. If not, adjust the Peak Detect Parameters and try again. The detected peak in the single-peak spectrum will be highlighted by a green square above the peak. Again, if more or less than one peak is detected, adjust the Peak Detect Parameters.




The VI will automatically plot the frequency of the detected peaks vs. the sample number, as well as a best fit curve. Finally, the VI will display the fit coefficients which are the calibration parameters required by other VIs.

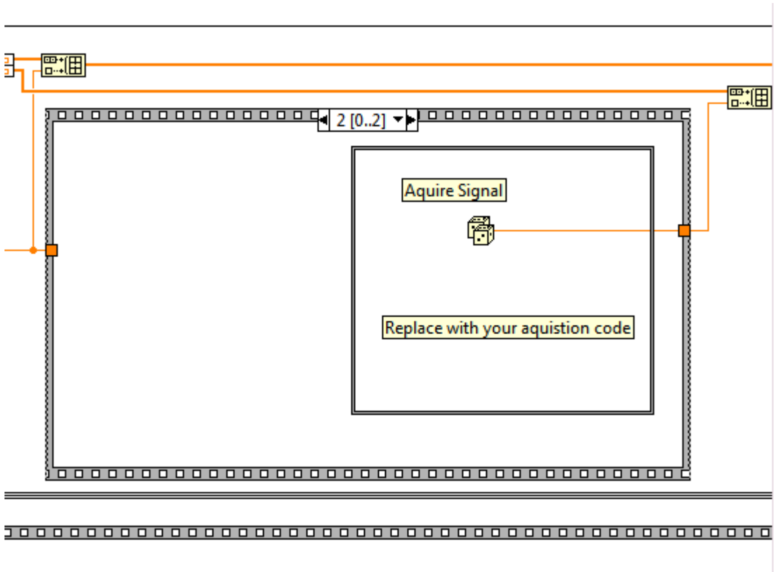
### 8.2.3. PT_ScanGVD.vi

This VI can be used to determine the amount of GVD to apply to the shaped pulse to optimize the pulse duration.

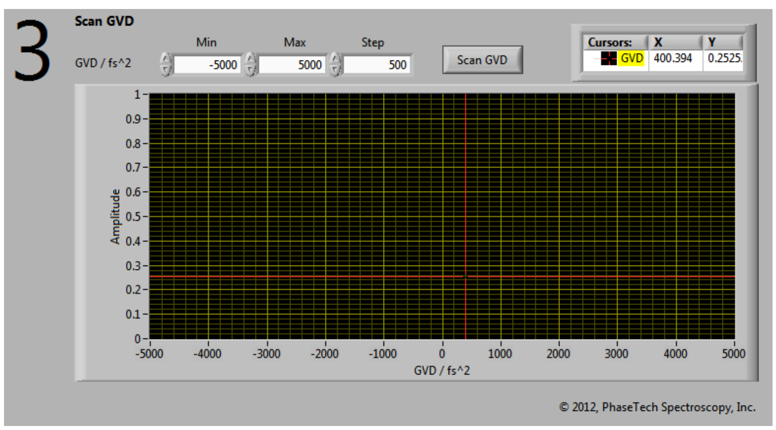



Set up the shaper configuration. Set the amplitude and length of the waveform as well as whether or not to use the external clock. Also input the calibration parameters (as determined from FreqCalib.vi) and the center wavelength of the pulse in nanometers.


Set the parameters for your signal acquisition. These will depend on your particular detection method. You will also have to insert your signal aquistion code into the appropriate place in the block diagram.




The signal acquisition code should output a single number representing the degree optimization. A common option is the amount of second-harmonic generation produces by the shaped pulse, measured via a single-channel MCT detector.




Chose a GVD scan range and step size. Then click the “Scan GVD” button. The VI will scan through the chosen GVD values and display the corresponding optmization metric. The best GVD value can then be used to compress the shaped pulse. The same approach can be used to determine an optimum TOD correction value.

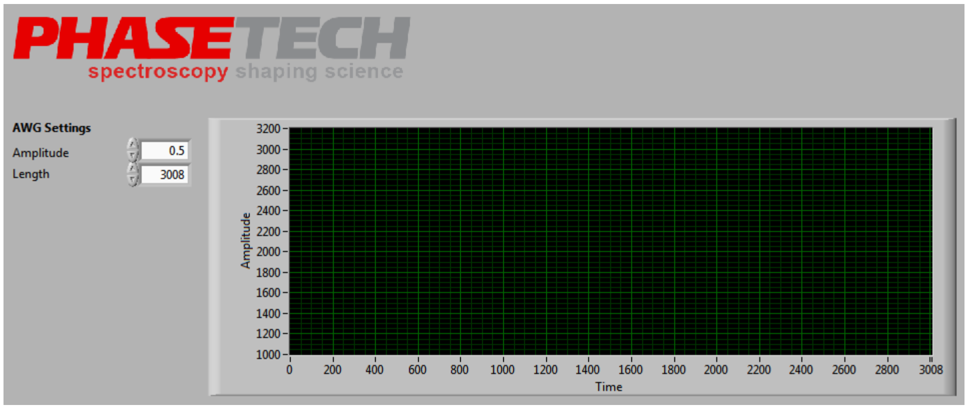
#### 8.2.4. PT_Chop.vi

This VI can be used to chop the shaped beam at half the repetition rate of the input trigger (presumably half the repetition rate of the laser).

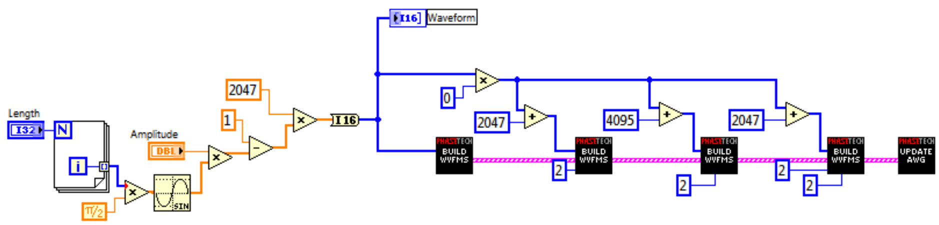
The VI sets the AWG to output a 75 MHz waveform on Channel 1 every other trigger and a 0 V waveform on the other triggers. Channel 2 outputs a full-length high-value pulse coincident with every 75 MHz waveform, which can be used to detect the phase of the chop. The calculated waveform will be display in the graph.

The user simply needs to select a waveform amplitude and length and then run the VI.

Front Panel




Block Diagram




### 8.2.5. PT_DoublePulse.vi

Generates a collinear pulse pair with a chosen delay. The phase of the two pulses (relative to the input pulse) can also be set and GVD and TOD correction can be applied.

Parameters

**Amplitude** sets the overall amplitude of the RF waveform

**Length** sets the length of the waveform

**Calibration Parameters** parameters that specify there relationship be AWG sample and frequency at the AOM. Determined using FreqCalib.vi

**Dispersion Correction** determines if GVD and TOD correction parameters are used in calculating the waveform

**λmax** the center wavelength of the pulse. Only used if Dispersion Correction is enabled.

**GVD** the GVD correction parameter. Only used if Dispersion Correction is enabled.

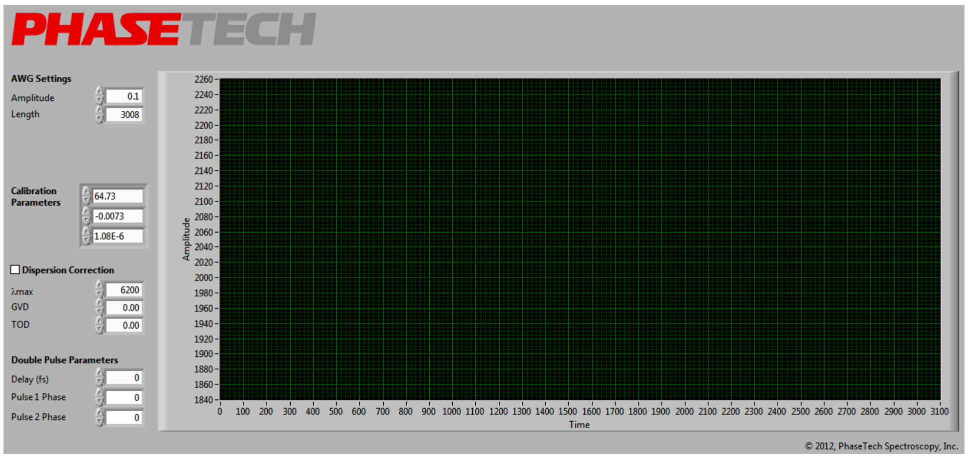
**TOD** the TOD correction parameter. Only used if Dispersion Correction is enabled.

**Delay (fs)** sets the delay between the pulse pair, in femtoseconds.

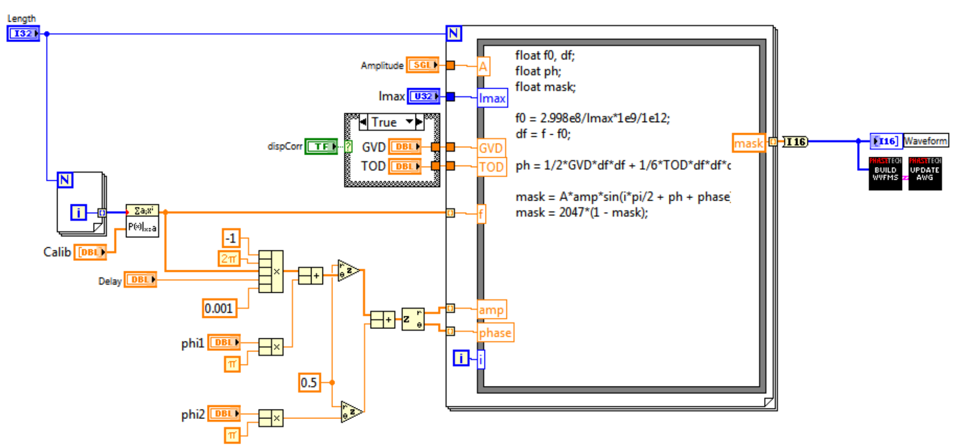
**Pulse 1 Phase** sets the relative phase of the first pulse, in units of π

**Pulse 2 Phase** sets the relative phase of the second pulse, in units of π

Front Panel




Block Diagram




## 8.2.6. PT_2DIR.vi

Generates a sequence of waveforms on channel 1 for measuring 2D IR spectra. Also generates an indicator pulse on channel 2 which can be used for determining which laser pulse corresponds to the first waveform. The indicator pulse can be used to rotate the acquired data to the proper order.

Parameters

**Amplitude** sets the overall amplitude of the RF waveform

**Length** sets the length of the waveform

**Calibration Parameters** parameters that specify there relationship be AWG sample and frequency at the AOM. Determined using FreqCalib.vi

**Dispersion Correction** determines if GVD and TOD correction parameters are used in calculating the waveform

**λmax** the center wavelength of the pulse. Only used if Dispersion Correction is enabled.

**GVD** the GVD correction parameter. Only used if Dispersion Correction is enabled.

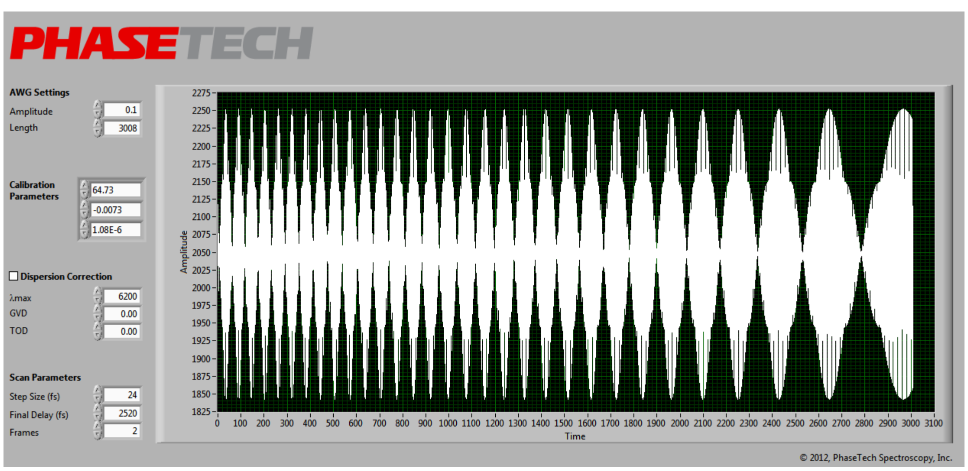
**TOD** the TOD correction parameter. Only used if Dispersion Correction is enabled.

**Step Size (fs)** sets the step size over which the pulse delays are scanned, in femtoseconds, starting at 0 fs.

**Final Delay (fs)** sets the final delay in the scan, in femtoseconds.

**Frames** determines if 2D IR spectrum is scanned using 2-frame method or 4-frame method. The 2-frame method is twice as fast whereas the 4-frame method is better at removing scatter.

Front Panel

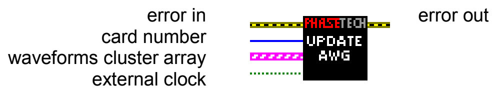


## 8.3. AWG Control LabView™ VIs, Basic

For most uses of the AWG, only one control LabView™ VI is required (UpdateAWG.vi). However, additional lower-level VIs are also supplied in order to provide additionally flexibility for those who desire it.

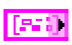
### 8.3.1. UpdateAWG.vi

Used to set the waveforms output by the AWG.




 **error in** describes error conditions that occur before this node runs. This input provides standard error in functionality. Optional, default value is no error.

 **card number** describes the AWG card number. Optional, default value is 1. Other values are only necessary for systems with more than one PhaseTech AWG card installed. Acceptable values are 1-4.

 **waveform cluster array** provides the waveform data used to control the output of the AWG card. Required.

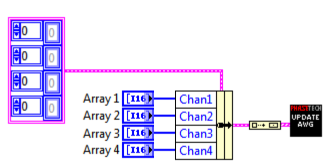
 **external clock** determine if the AWG internal clock or an external clock is used for sampling. Optional, default value is false (internal clock).

 **error out** contains error information. This output provides standard error out functionality.

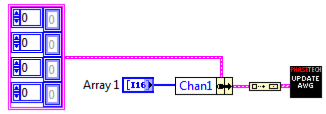
**Details**

Used to determine the sequence of waveforms generated by the AWG.

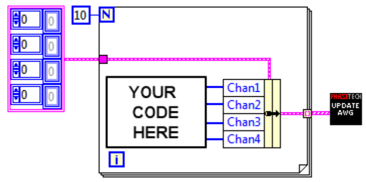
After the VI executes, each TTL trigger pulse initiates the output of successive elements of the cluster array. When the end of the array is reached, the AWG loops back to the first element. Each cluster element contains 4 arrays, one for each channel, of I16 numeric values between 0 and 4095, corresponding to -1 V and 1 V output, respectively. The maximum waveform length is 3008 samples. If a single-element array is provided, the same waveform will be output on every trigger.




It is not necessary to provide waveforms for all 4 channels.

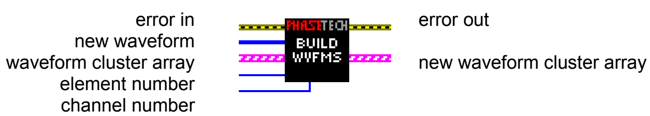



A simple looping example:




### 8.3.2. BuildWaveforms.vi

Helps to create the waveform cluster array necessary for UpdateAWG.vi.




 **error in** describes error conditions that occur before this node runs. This input provides standard error in functionality. Optional, default value is no error.

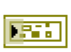
**new waveform** is the waveform data for one channel and one segment. Required.

 **waveform cluster array** is the waveform cluster array that will be filled with the new waveform data. Optional, default value is an empty waveform cluster array.

**element number** is the element in the waveform cluster array at which new waveform will be inserted. Optional, default value is 1.

**channel number** is the channel number for which the waveform will be inserted. Optional, default value is 1.

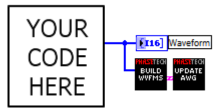
 **new waveform cluster array** is the waveform cluster array modified with the new waveform.

 **error out** contains error information. This output provides standard error out functionality.

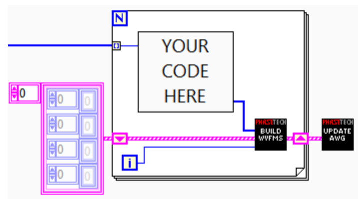
**Details**

If element number is greater than the length of the waveform cluster array the waveform cluster array will be extended, using blank elements, to the length element number and the new waveform inserted.

This VI can be used to simplify the creation of the waveform cluster array for the output of a single waveform,

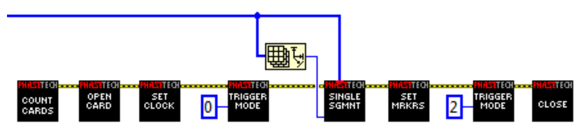



or a sequence of waveforms.



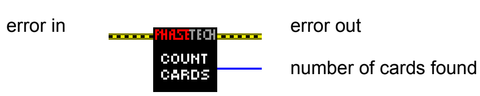

## 8.4. AWG Control LabView™ VIs, Advanced

The advanced functions provide greater control over the AWG settings. Note that the VIs must be called in the proper order in order to function properly, as in the following example.

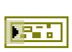


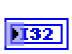

### 8.4.1. CountCards.vi

Returns the numbers of AWG cards properly installed on the computer.




 **error in** describes error conditions that occur before this node runs. This input provides standard error in functionality. Optional, default value is no error.

 **error out** contains error information. This output provides standard error out functionality.

 **number of cards found** return the number of installed AWG cards found on the system.

### 8.4.2. OpenCard.vi

Loads the AWG software drivers and sets the AWG card to its default state.


**error in** describes error conditions that occur before this node runs. This input provides standard error in functionality. Optional, default value is no error.

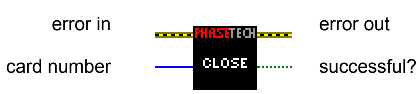
**card number** describes the AWG card number. Optional, default value is 1. Other values are only necessary for systems with more than one PhaseTech AWG card installed. Acceptable values are 1-4.

**error out** contains error information. This output provides standard error out functionality.

**successful?** return true if the card was opened successfully and false if it was not.

### 8.4.3. CloseCard.vi

Closes the AWG drivers.




**error in** describes error conditions that occur before this node runs. This input provides standard error in functionality. Optional, default value is no error.

**card number** describes the AWG card number. Optional, default value is 1. Other values are only necessary for systems with more than one PhaseTech AWG card installed. Acceptable values are 1-4.

**error out** contains error information. This output provides standard error out functionality.

**successful?** return true if the card was closed successfully and false if it was not.

**Details**

Should be called after finishing using the driver. However, if no other software uses the driver (usual situation), then there is no need to close it until user is ready to completely exit from using their main software program which calls the driver. If the user is loading the driver dynamically (during run time), then they should close before unloading the driver.

### 8.4.4. SetClock.vi

Sets the Digital to Analog converter clock rate. This function call is also used to select the external clock, if the external clock option is present.


**error in** describes error conditions that occur before this node runs. This input provides standard error in functionality. Optional, default value is no error.

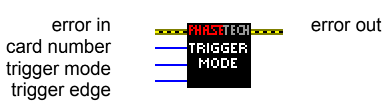
**card number** describes the AWG card number. Optional, default value is 1. Other values are only necessary for systems with more than one PhaseTech AWG card installed. Acceptable values are 1-4.

**clock frequency** is the desired sampling clock frequency in MHz. Optional, default value is 300. Acceptable values are 0, 75, 150, and 300. The value of 0 specifies that an external clock should be used.

**error out** contains error information. This output provides standard error out functionality.

### 8.4.5. SetTriggerMode.vi

Sets the AWG trigger mode.




**error in** describes error conditions that occur before this node runs. This input provides standard error in functionality. Optional, default value is no error.

**card number** describes the AWG card number. Optional, default value is 1. Other values are only necessary for systems with more than one PhaseTech AWG card installed. Acceptable values are 1-4.

**trigger mode** sets the trigger mode of the AWG Card. Optional, default value is 0. Acceptable values are:

| | |
|---|---|
| 0 | No output |
| 1 | Continuous output |
| 2 | Triggered output |

**trigger edge** determines if the AWG is triggered of a rising (0) or falling (1) edge. Optional, default value is 0 (rising edge).

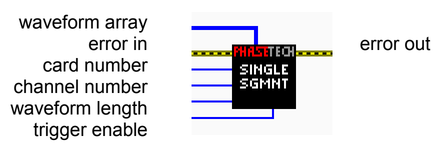
**error out** contains error information. This output provides standard error out functionality.

**Details**

Sets triggering modes. This command should be called (using mode=0) just after the driver is opened to initialize internal hardware registers before calling any other routines. This function also selects whether board is in triggered mode or not and polarity of external TTL triggered signal.

### 8.4.6. CreateSingleSegment.vi

Setup the AWG for output of a single waveform and creates the segment.




**waveform array** is the array of values specified the waveform to be output by the AWG. Required.

**error in** describes error conditions that occur before this node runs. This input provides standard error in functionality. Optional, default value is no error.

**card number** describes the AWG card number. Optional, default value is 1. Other values are only necessary for systems with more than one PhaseTech AWG card installed. Acceptable values are 1-4.

**channel number** is the output channel that the waveform should be output from. Optional, default value is 1. Acceptable values are 1-4.

**waveform length** is the number of samples from waveform array to be output by the AWG. Required. Must be less than or equal to the number of elements in waveform array. Maximum value is 3008.

**trigger enable** determines if waveform output will be determined by the external trigger. Optional, default values is 1. Acceptable values are 0 (disable) and 1 (enable, trigger mode must also be set to triggered).

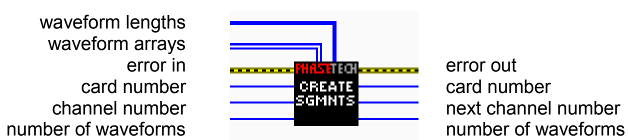
**error out** contains error information. This output provides standard error out functionality.

**Details**

Creates a single segment in memory. The user determines the size of the array and whether the segment is started automatically or waits for an external input trigger. After creating a single segment waveform, the user must call SetTriggerMode.vi to turn on/off output waveforms. In triggered mode there is a 64 samples of pad at the beginning and end of the segment with a level set at 2047. In nontriggered mode the only pad that is visible is the beginning pad when the output is started, then repeats data portion indefinitely until reset. All segments, regardless of whether it's triggered or not, have 64 sample pads at the beginning and end of the segments in actual memory, but may not be visible depending on whether the segment is triggered or not. See "CreateSegments.vi" for generating multiple segments.

### 8.4.7. CreateSegments.vi

Setup the AWG for output of a series of waveforms and creates the segments.




**waveform lengths** is an array specifying the number of samples of each waveform to output. Each lengths must be less than or equal to the number of rows in waveform array. Maximum value is 3008.Required.

**waveform arrays** is a two dimensional array of waveforms to be output by the AWG. Required.

**error in** describes error conditions that occur before this node runs. This input provides standard error in functionality. Optional, default value is no error.

**card number** describes the AWG card number. Optional, default value is 1. Other values are only necessary for systems with more than one PhaseTech AWG card installed. Acceptable values are 1-4.

**channel number** is the output channel that the waveform should be output from. Optional, default value is 1. Acceptable values are 1-4.

**number of waveforms** is the number of waveforms in the output sequence. Required. Must be less than or equal to the number of columns in the waveform array.

**error out** contains error information. This output provides standard error out functionality.

**card number** is the card number input into the VI.

**next channel number** provides a channel number useful for setting segments multiple channels and is based on the input channel number (1 -> 2 ->3 -> 4 -> 1).

**number of waveforms** is the number of waveforms in the output sequence.

**Details**

Creates any number of segments up to the size of memory. All segments have 64 samples of beginning pad and 64 samples of trailing pad which the user cannot access.

### 8.4.8. SetSoftTrigger.vi

Uses software to emulate an external trigger to the specified AWG card.


**error in** describes error conditions that occur before this node runs. This input provides standard error in functionality. Optional, default value is no error.

**card number** describes the AWG card number. Optional, default value is 1. Other values are only necessary for systems with more than one PhaseTech AWG card installed. Acceptable values are 1-4.

**error out** contains error information. This output provides standard error out functionality.

### 8.4.9. SetMarkers.vi

Sets the parameters for the marker output channel.

**address** is a RAM address location. Minimum resolution is 4 clock samples. Optional, default value is 64.

**error in** describes error conditions that occur before this node runs. This input provides standard error in functionality. Optional, default value is no error.

**card number** describes the AWG card number. Optional, default value is 1. Other values are only necessary for systems with more than one PhaseTech AWG card installed. Acceptable values are 1-4.

**nib1** must be greater than or equal to zero and less than or equal to 0xF. Optional, default value is 0xF.

**nib2** must be greater than or equal to zero and less than or equal to 0xF. Optional, default value is 0xF.

**error out** contains error information. This output provides standard error out functionality.

**Details**

Sets up TTL output marker locations relative to waveform memory. It is up to the user to place the markers correctly. There is always a startup 64 sample leading pad when a waveform first outputs. Please note that all segments have a 64 sample leading pad and a 64 sample trailing pad, regardless of whether they repeat or not. Resolution of the markers is 1/4 of the clock rate. Also, please note that this VI must be called after creating any segments since CreateSegments.vi and CreateSingleSegment.vi will overwrite the markers with zeros if done in the reverse order.

## 8.5. Error Codes

These codes are generated by PhaseTech AWG software on the following errors.

| **Code** | **Error** |
|---|---|
| 2001 | No cards found. |
| 2002 | Card found but could not be opened. |
| 2003 | Card found and already open. |
| 2004 | Card number cannot be less than 1 or greater than 4. |
| 2005 | Card already closed. |
| 2006 | Card number exceeds number of installed cards. |
| 2007 | Channel number cannot be less than 1 or greater than 4. |
| 2008 | NumSegs must equal the number of waveforms. |
| 2009 | Waveform matrix must be padded to 3008 columns. |
| 2010 | Number of lengths must equal numSegs. |
| 2011 | Total number of samples must be less than 4M per channel. |
| 2012 | TrigEn must have value of 0 or 1. |
| 2013 | Driver error. Please check that drivers were installed correctly. |

| | |
|---|---|
| 2014 | Length of UsrArray must be a multiple of 64. |
| 2015 | numPoints must be less than or equal to length of UsrArray. |
| 2016 | Valid values of Mode are 0, 1, 2. |
| 2017 | Valid values of ExPol are 0 and 1. |