Using the Image File Generator Software.

The scan angle and efficiency of a beam-steered AO deflector depends on the frequency, amplitude, and phase of the RF driver signal. The scan angle is determined by the frequency. For a beam steered AO deflector (these have 2 or more RF inputs per axis) the phase between the RF inputs must be set correctly for optimum efficiency. The phase value depends on the frequency, wavelength and the AO design. For simplicity, the AO design factors are described by a single figure "AOD Geometric Phase Constant". This figure is provided with the each model. The amplitude value controls the intensity of the scanned laser beam.

The iHHS-4 synthesizer can store up to 1 million points. Each point contains frequency, amplitude, and phase data. A set of points is called an Image. For an X-Y scanner, the Image(s) can be a circle or square outline, spiral, solid shape, a single point etc. Many images can be programmed, downloaded and then output as required.

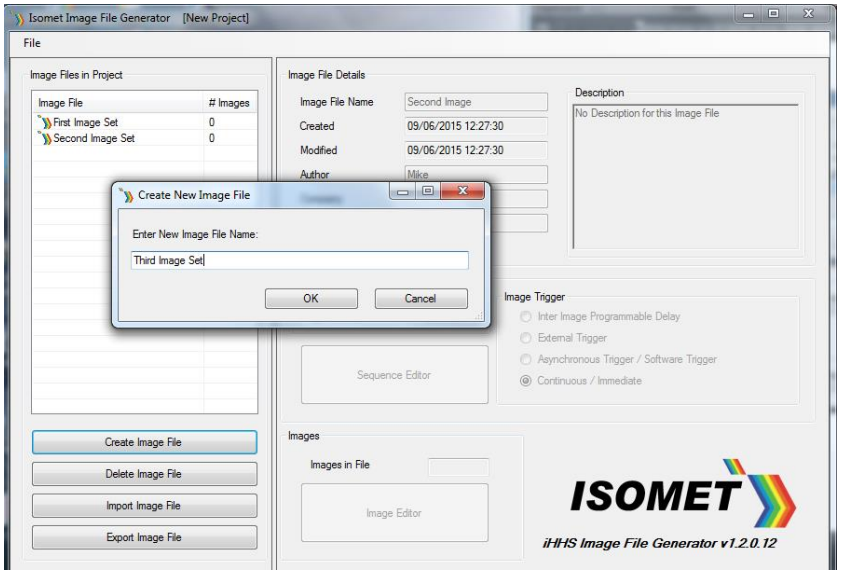
We supply a Windows program "ImageFileGenerator (version 1.2.0.12) ". This program enables Images to be generated or imported. It takes real "MHz" frequency values and converts them into the data format required by the DDS synthesizer within the iHHS-4. This software then calculates the correct phase value and amplitude weighting.

The Image File Generator software cannot generate complex frequency patterns directly e.g. spiral shape. However it is possible to use (say) an Excel spreadsheet to generate Frequency values and then import these into Image File Generator software.

The example below illustrates the process using three images; Circle, Vertical line and Horizontal line. Lines are generated using frequency values calculated using the inbuilt function generator. The circle data uses imported frequency values.

1: <u>Create one or more Image Files</u>

Press ***Create Image File*** and enter file name
Each file will contain one or many Images.



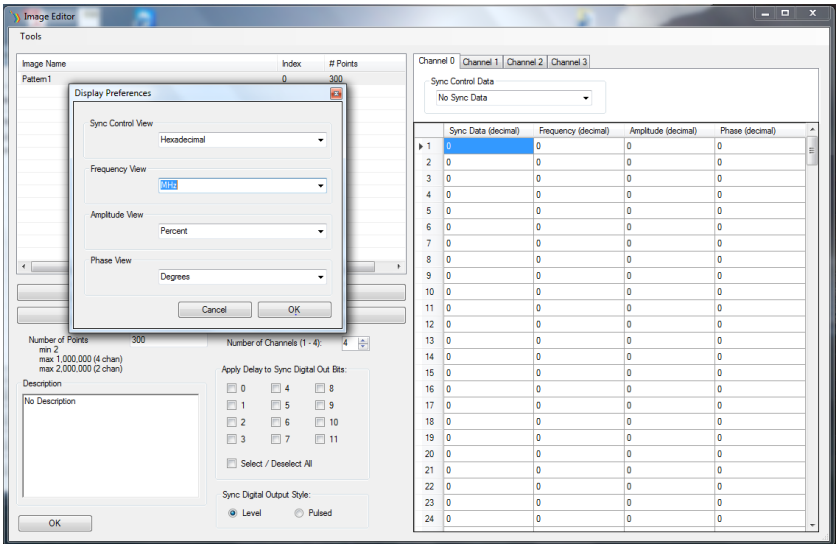
We now need to generate/import the Image data for each Image File.

Highlight the desired Image File e.g. *First Image Set*
Press ***Image Editor*** button.
This opens a second window. Note the Tools tab, top left.

2: Set the Displayed Units

Using the Tools tab, select ***Tools > Display Preferences***

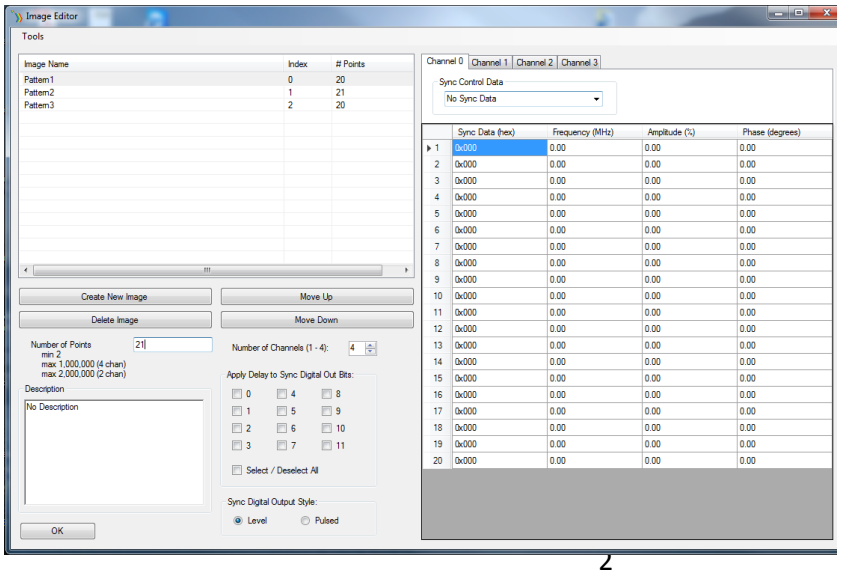
For this example, select Hex, MHz, % and Degrees as shown below



Press ***OK*** to update and store selection

3: Create one or more Images

Select ***Create New Image.***
Enter a name for the first image e.g. *Pattern1*

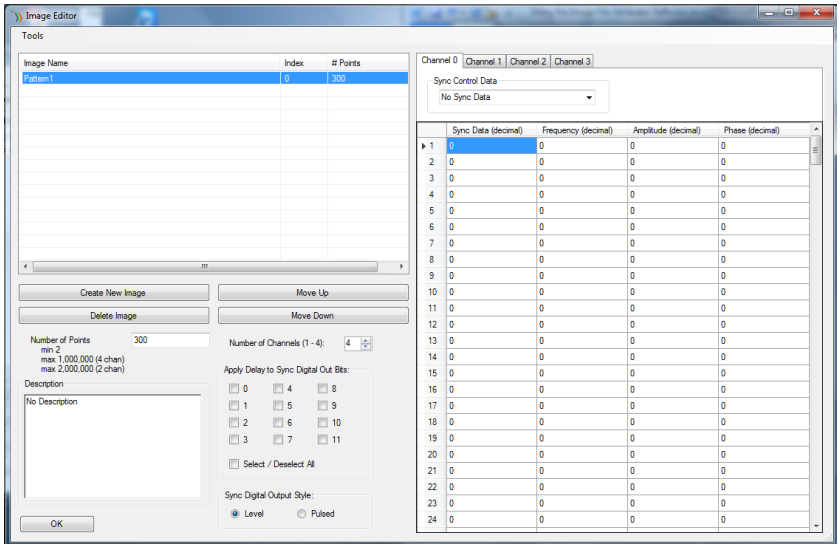


Repeated to create Pattern2 and Pattern3

3.1 Enter Image Data

Highlight ***Pattern1***

Enter ***Number of Channels*** using pull down box. (For an X-Y AOD enter 4)
Enter ***Number of Points*** (For clarity, less than 25 points are used in the examples)



For Pattern1, we will import frequency data from a Spreadsheet that generates a circle pattern for X-Y AO deflector.

Select ***Tools>Import Data***
Navigate to the required Spreadsheet using ***Open*** button
Select the desired Worksheet tab of the Spreadsheet using the pull down ***Worksheet***

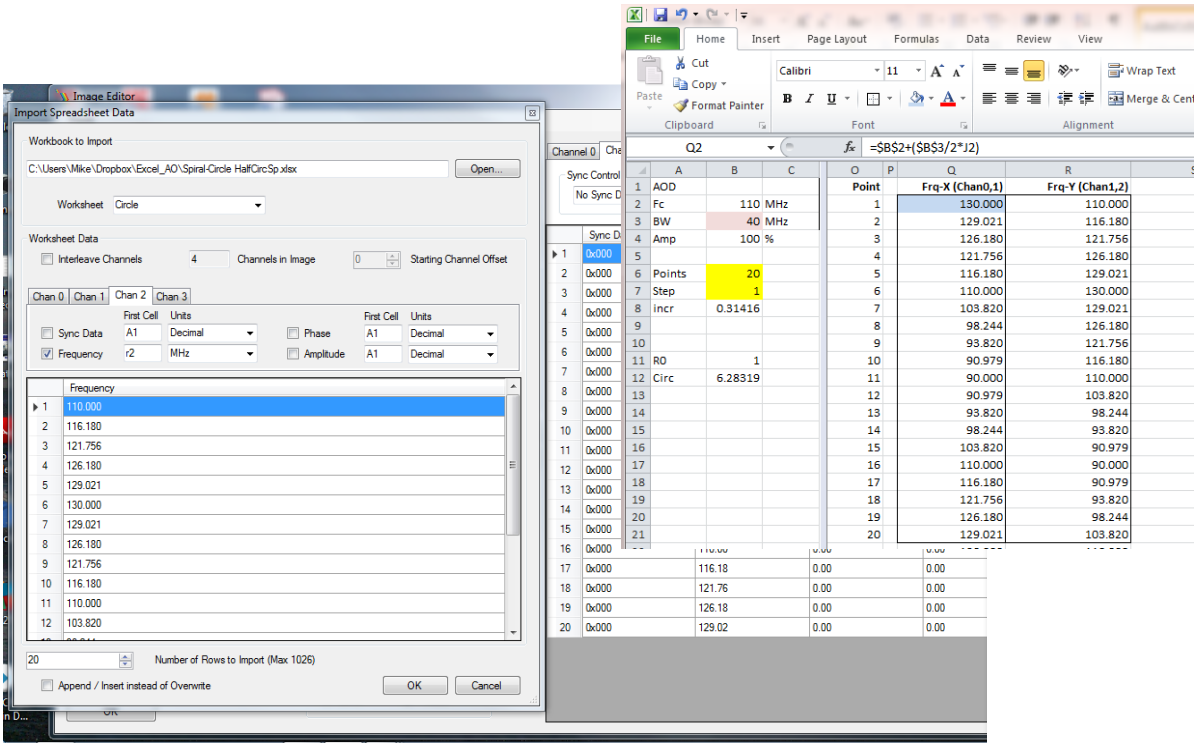
For an X-Y AOD,
Frequency values for Chan 0 = Chan 1
Frequency values for Chan 2 = Chan 3

Uncheck the ***Interleave Channels*** box

Select ***Chan 0*** tab

Check ***Frequency*** box only
Input the spreadsheet cell reference for the first frequency value (e.g. Cell Q:2)

Set the ***Number of Rows to Import*** (in this example 20)



Repeat all channels

Chan 0 = Chan 1, ***First Cell*** = Q2
Chan 2 = Chan 3, ***First Cell*** = R2

Click Channel tabs in main window to check values

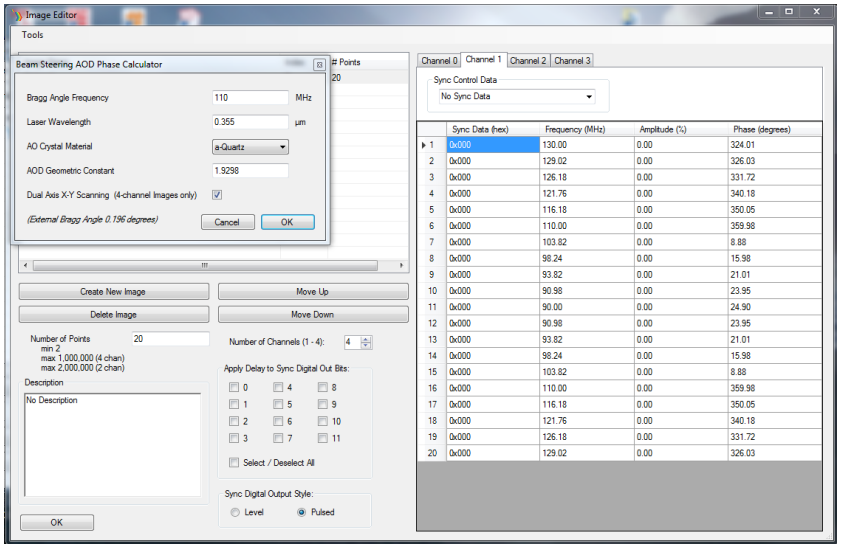
Press ***OK*** to update and store

4: Phase values

Next step is to calculate theoretical Phase values at for frequency

Note: The phase values are only correct IF the AOD Bragg angles have been adjusted at the Bragg Angle Frequency display below. This value is set by the user.
Initial Laser alignment is described in a separate document.

Select ***Tools> Beam Steering AOD Phase Calculator***



Input ***Bragg Angle Frequency*** (Usually set at the AOD centre frequency, 110MHz)
Input ***Laser Wavelength*** (355nm)
Select ***AO Crystal Material*** (a-Quartz)
Input ***AOD Geometric Constant.*** (The value of **1.9298** is correct for the D1340-XY-aQ110)

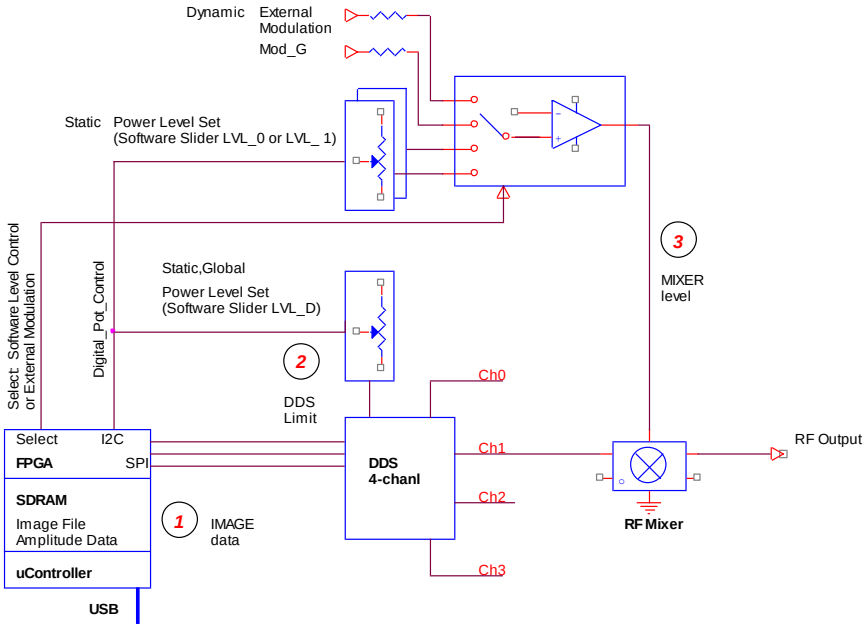
Check the ***Dual Axis X-Y Scanning*** box

Chan 0 and Chan 2 will always have zero phase values (or 360 deg)
Chan 1 and Chan 3 will show frequency dependent phase values

If frequency values are subsequently changed, the Phase calculator must be run again

5: Amplitude values

The final RF amplitude is controlled by a combination of 3 methods described in the illustration below.



The Image data defines the fundamental value.

For initial operation, this is set at a constant value for all frequencies.

[At a later stage during fine tuning and calibration of the system, these amplitude values may be adjusted depending on the frequency. This is one method, with the aid of an optical power meter, to optimize the uniformity across the X-Y scan field]

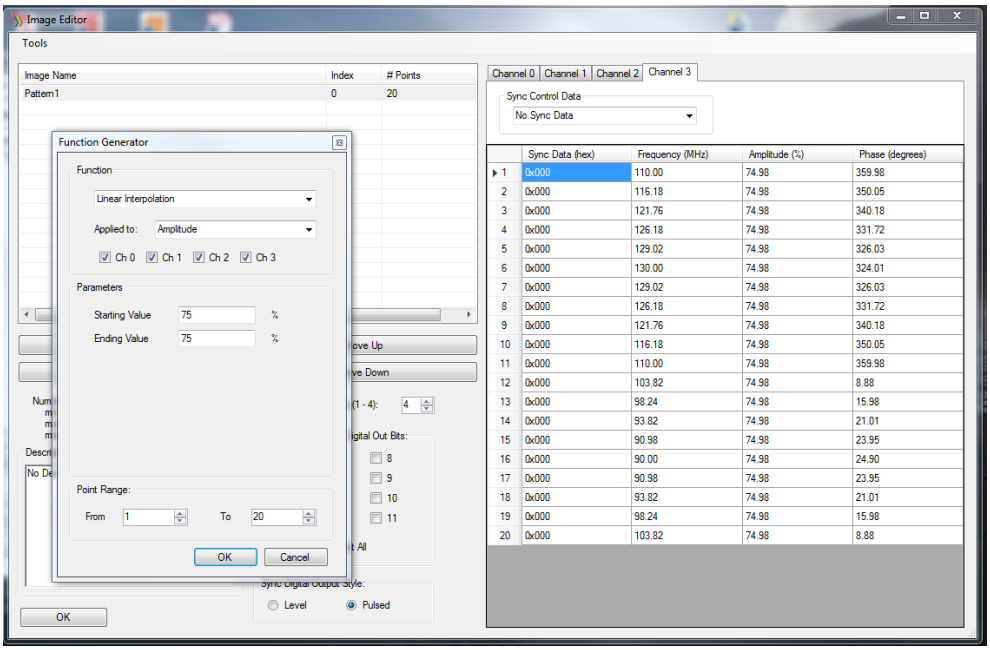
To pre-set amplitude to 75% maximum, all channels

Select ***Tools>Function Generator***

Function pull down, select ***Linear Interpolation***
Applied to pull down select ***Amplitude***
Check boxes, ***Ch 0, Ch 1, Ch 2*** and ***Ch 3***

Set ***Parameters***

Starting Value ***75*** %
Ending Value ***75*** %



Point Range.
Different sections of the image may be programmed with different amplitude values by changing the ***To*** and ***From*** points. For this example we set the amplitude to be the same for all points of the image Thus:

*From **1*** *To **20***

Press ***OK*** to save and exit Pattern 1

6: Highlight ***Pattern2***

For Pattern2, we will use the in-built function generator to create a vertical line midway along the X-axis.

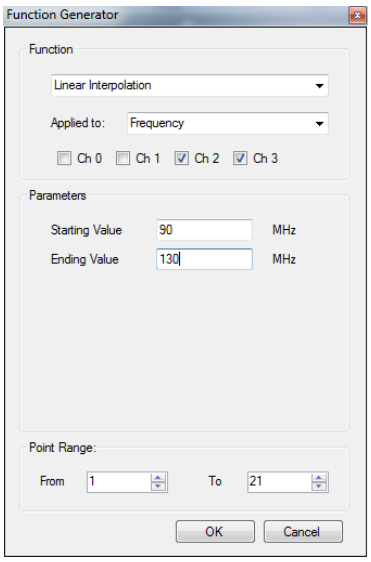
- Y-axis (scans)

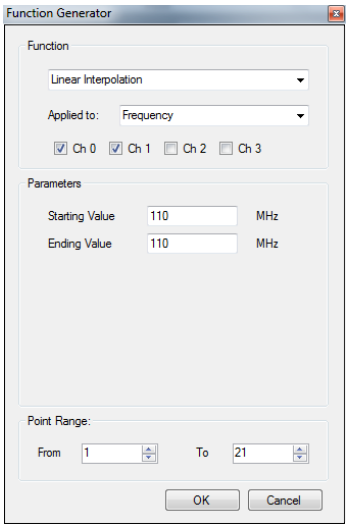
Select ***Tools>Function Generator***

Function pull down, select ***Linear Interpolation***
Applied to pull down select ***Frequency***
Check boxes, ***Ch 2*** and ***Ch 3*** only

Set ***Parameters***

Starting Value ***90*** MHz
Ending Value ***130*** MHz





- X-Axis (static)

Select ***Tools>Function Generator***

Function pull down, select ***Linear Interpolation***
Applied to pull down select ***Frequency***
Check boxes, ***Ch 0*** and ***Ch 1*** only

Set ***Parameters***

Starting Value ***110*** MHz
Ending Value ***110*** MHz

Phase values, repeat step 4: above
Amplitude values, repeat step 5: above

Press ***OK*** to save and exit Pattern 2

7: Highlight ***Pattern3***

For Pattern3, we will use the in-built function generator to create a horizontal line midway up the Y-axis.

- Y-axis (static)

Select ***Tools>Function Generator***

Function pull down, select ***Linear Interpolation***
Applied to pull down select ***Frequency***
Check boxes, ***Ch 2*** and ***Ch 3*** only

Set ***Parameters***

Starting Value ***110*** MHz
Ending Value ***110*** MHz

- X-Axis (scans)

Select ***Tools>Function Generator***

Function pull down, select ***Linear Interpolation***
Applied to pull down select ***Frequency***
Check boxes, ***Ch 0*** and ***Ch 1*** only

Set ***Parameters***

Starting Value ***90*** MHz
Ending Value ***130*** MHz

Phase values, repeat step 4: above
Amplitude values, repeat step 5: above

Press ***OK*** to save and exit Pattern 3

8: Sync Control Data

The iHHS-4 can output digital and analog signals synchronously with the frequency data output on any of the 4 channels. This is the ***Sync Control Data*** and can be used to synchronize external equipment.

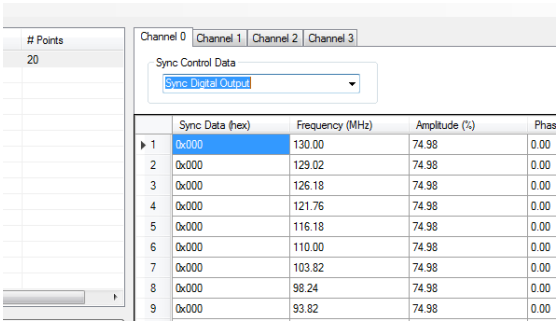
In the standard iHHS-4, there are 8 synchronous digital output signals. Each can be set independently to output a "High" or "Low" signal. These outputs may also be delayed by a predetermined period after the frequency data has changed. This delay option is applied to individual bits selected by the user.

The digital outputs can set to give an output ***Level*** or ***Pulsed*** per data clock (Internal or External). This is a global setting for all synchronous digital outputs.

Level = Constant level for the entire clock period
Pulsed = High level Pulse at ½ clock period

Typically the Sync control data is set on Channel 0 only
Highlight ***Channel 0*** tab

Sync Control Data pull down, select ***Sync Digital output***



Select ***Tools>Function Generator***

Function pull down, select ***Linear Interpolation***
Applied to pull down select ***Sync Data***
Check box, ***Ch 0*** only

We will set for a pulse to be generated on all 8 outputs at every point of the image

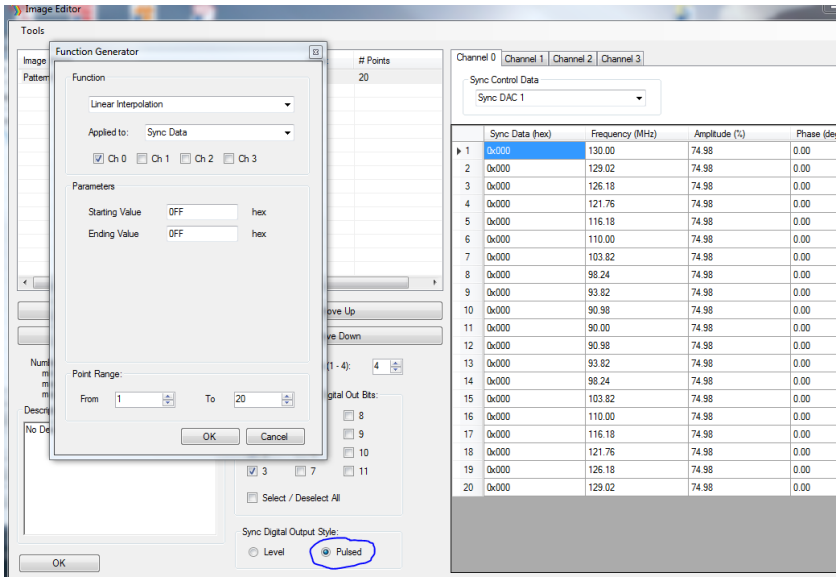
Set ***Parameters***

Starting Value ***0FF*** hex
Ending Value ***0FF*** hex

Check the ***Pulsed*** radio button
(Pulse width = 1usec)

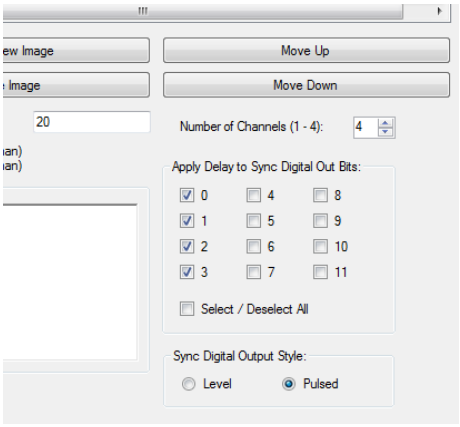
Digital outputs are available on Connector J6

SDIO bit0 = pin18	SDIO bit1 = pin17
SDIO bit2 = pin16	SDIO bit3 = pin15
SDIO bit4 = pin14	SDIO bit5 = pin13
SDIO bit6 = pin12	SDIO bit7 = pin11



We will also opt to have a delay applied to four of the lower bits (outputs)
The delay value is set later in this procedure.

Check the boxes ***Apply Delay to Sync Digital Out Bits***: ***0, 1, 2, 3***

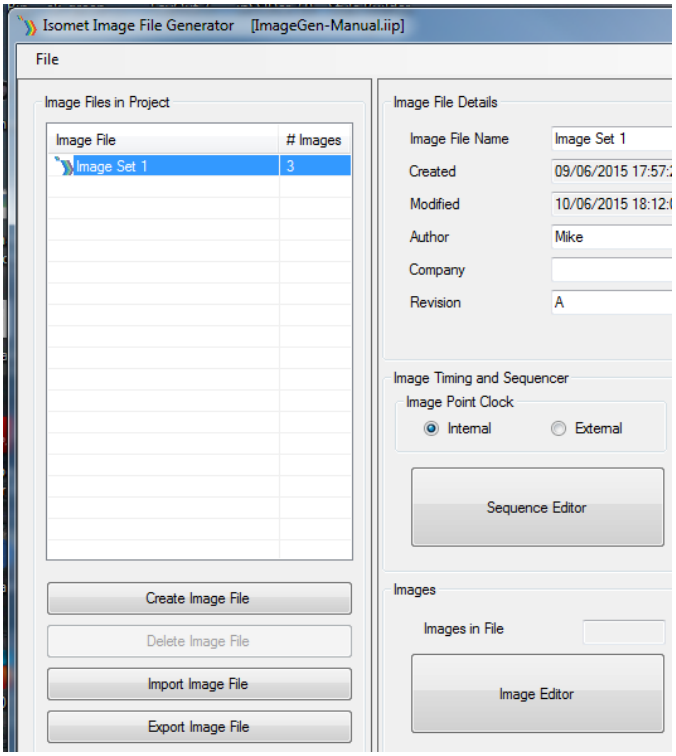


9: Image Control

To complete the Image file format, we need to specify the output control parameters including the Clock, Trigger and Sync data parameters for each image in the file.

For this example, the Image File (Image Set 1) contains 3 images;

- Circle of 20 points,
- Vertical line of 21 points
- Horizontal line of 21 points.



- CLOCK

The clock rate defines the dwell time at each frequency point of the image.
e.g. for an image of 20 points and a clock period of 5usec, the time to complete one play = 100usec

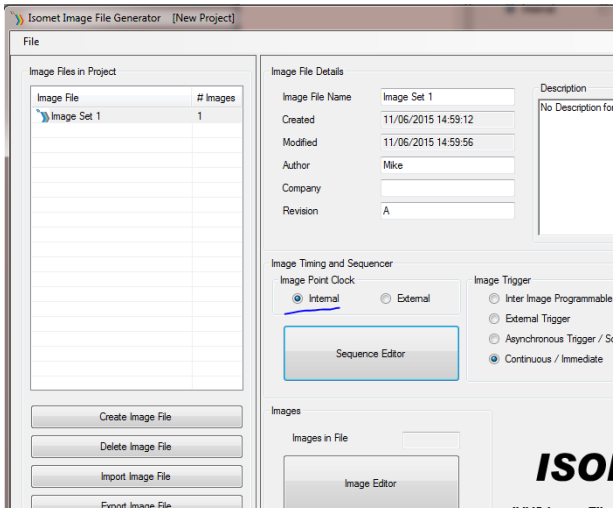
The frequencies at all 4 output channels are updated synchronously.

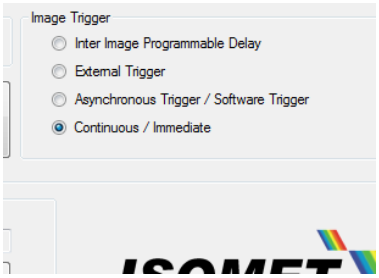
Select ***Image Point Clock*** radio button

Options:

- Internally generated user programmable clock (see ***Internal Oscillator Period***, page14)
- External input, LVTTL pin 19 J6 (see ***External clock Divider***, page14)

e.g. Internal (clock rate setting is described on page14)





- TRIGGER

The trigger signal initiates the image output sequence at a rate defined by the CLOCK signal.
A trigger is required for each separate image in the file set. There are four trigger options;

- After a pre-determined programmable delay (between each image of a multi-image file)
- External input to pin 20 J6, (one image play per trigger input *)
- Asynchronous trigger (via software)
- Immediate. Triggered on the second valid clock input edge

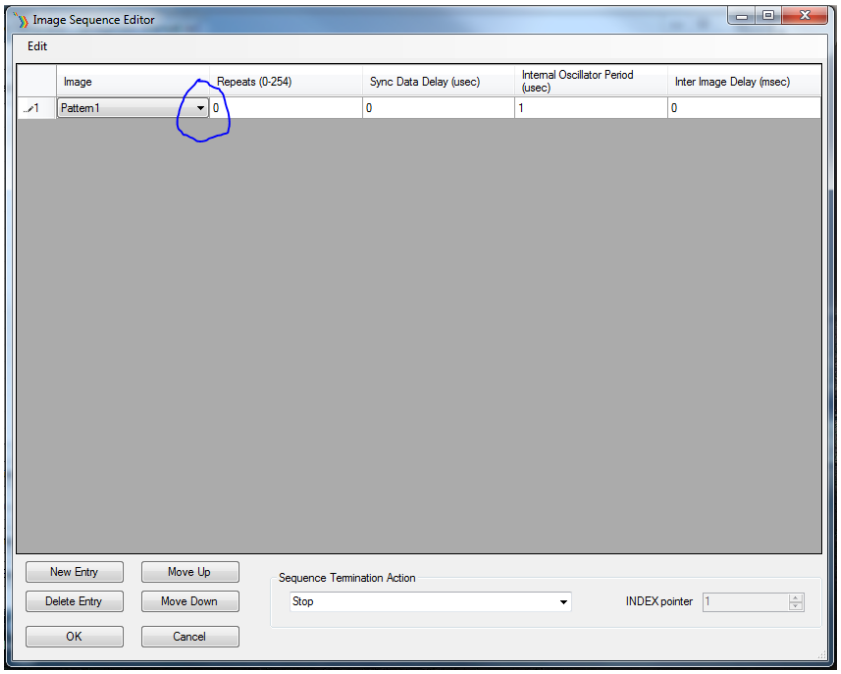
Image data output starts <u>two clock cycles after the Trigger input</u>

* External trigger initiates the output of one image play. Repeated images will require repeated triggers.
Each image in a multi-image sequence will require a trigger

10: Sequence Editor

Press the ***Sequence Editor*** button to reveal a new window.

The Sequence editor defines the play order of images, Repeats (= image play per trigger event), the Internal Oscillator Period (= output Clock rate), Sync Data Delay and the Inter–Image delay



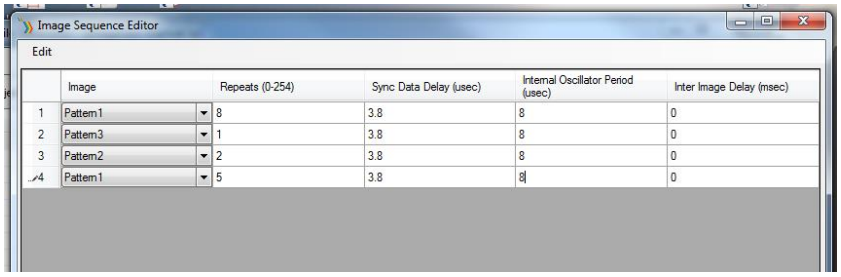
- Image play list

Use pull down (ringed) to select the required Image from the file set.

Add or delete Images into the play list as required, in any order using the ***New Entry*** or ***Delete Entry*** keys respectively.

The order of Play can be changed by highlighting the Image entry and using the ***Move Up*** or ***Move Down*** keys

e.g.



Select desired Image e.g. Pattern1

Four variables can be set for each image trigger event

Repeat: 0-255
The Image data can be output multiple times in succession per trigger event
(Note: 8 repeats means Pattern1 is output 9 times for each trigger).

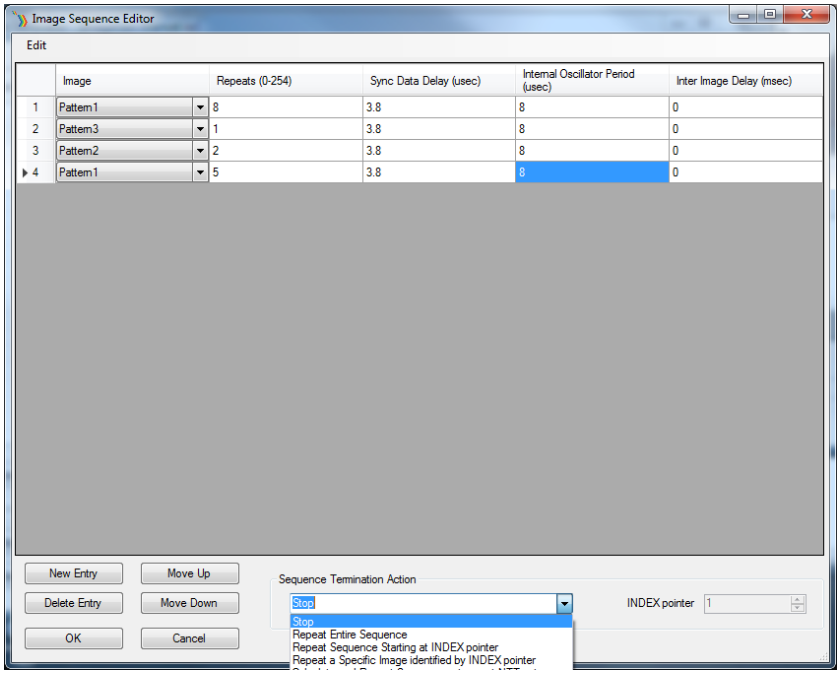
Sync Data Delay: 0.0 - 6500.0usec, resolution 0.1usec
A delay can be set between the Sync Data Output and the corresponding Frequency update clock.

Internal Oscillator Period: 1 - 65000usec, resolution 1usec
If the internal clock is selected, this value defines the frequency point update period
e.g. 8usec = 125KHz output rate

(If the external clock is selected, this value defines the external clock divider)

Inter Image Delay: 0.0 - 6500.0millisec, resolution 0.1millisec
Sets a delay value between end of Image N and start of Image N+1

Repeat for all images in the play list. All values can be different.



A Sequence Termination Actions MUST be select

This instructs the iHHS-4 what action to take once the triggered sequence has completed

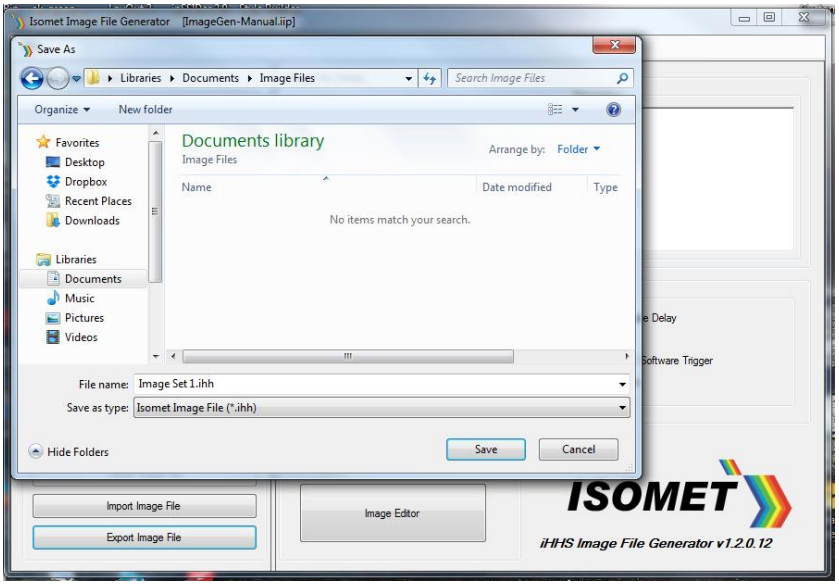
Select the required action from the ***Sequence Termination Action*** pull down
e.g. ***Repeat Entire Sequence*** at the next Trigger event

The ***INDEX pointer*** allows a different start image to be selected if the sequence is to be repeated. If ***STOP*** is selected, then your will need to Hit ***Run*** on the iHHS Tool software to arm the system for each Trigger event.

Press ***OK*** to save and exit

We have now created a combined Image and Sequence File in the correct format for the iHHS-4 "Image Mode". This needs to be Exported and Saved in a location available to the iHHS-4 control software.

Select ***Export Image File***



Enter file name e.g. spiralshape.ihh and press ***Save***

11: Saving the Project

Prior to exiting the software, the entire project can be saved using File>Save
File extension *.iip