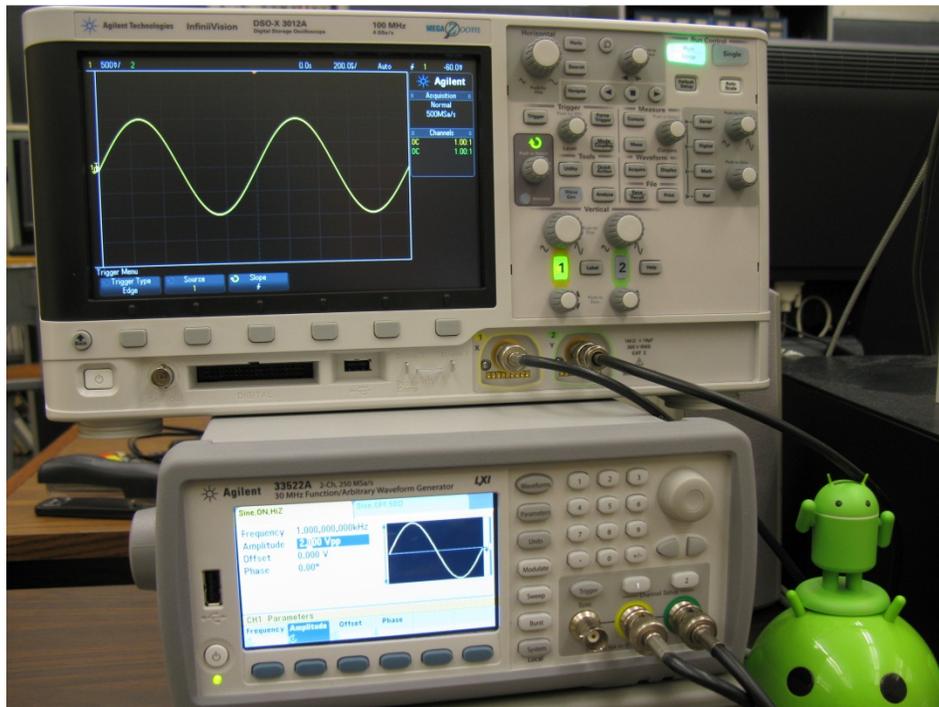


# Agilent 33522A Function/Arbitrary Waveform Generator

and

## Agilent DSO-X 3012A Oscilloscope



Agilent 33522A Function Arbitrary Waveform Generator (bottom) and Agilent DSO-X 3012A Oscilloscope (Top)

The signal source for this lab is the Agilent 33522A Function Arbitrary Waveform Generator. It can produce basic waveforms to frequencies from a few Hertz to 30 MHz. In addition an arbitrary waveform can be inserted into the waveform RAM memory using software. It has two separate outputs when can be independent or ganged together and the amplitude and frequency varied. It also has a Synch Output which is a TTL signal (0 – 5 V) used primarily for synchronization purposes.

The output connectors are female BNC. BNC means Bayonet N Connector which is a cylindrical conductor system.

The oscilloscope for this lab is the Agilent DSO-X 3012A. It is a two channel 100 MHz instrument which means one or two signals may be displayed as functions of time. It has a maximum sampling rate of 4 GSa/s. As long as the significant frequency content is below 100 MHz the waveforms will be undistorted. It also has an EXT TRIG input (located on the back) which is used for synchronization purposes. The input connectors are female BNC connectors.

Turn on the scope and FG with the on/off buttons located in the lower left. Wait for the instruments to boot. Obtain a male BNC to male BNC connector from the wall rack; this is a coaxial lead with a characteristic impedance of  $50 \Omega$ . Connect Output on from Channel 1 on the FG to CH1 input on the scope. Align the metal ridge with the metal slot and rotate clockwise until it clicks into place. Do not connect anything to the USB connectors on the FG or scope; if you need to charge your toys use the USB connectors on the pc. Do not press the button "Start 30-day Trial" on the scope and do not change the language to anything other than English.

Press the 1 button above the Output 1 BNC connector on the FG. On the soft menu that appears under the display on the FG, switch the Output to On, Output Load to High Z (High Z means the FG is to expect a load other than  $50 \Omega$  which is the characteristic impedance of the coaxial lead used for high frequency applications). On the buttons to the right of the display on the FG press Waveforms and select sine. Press Parameters, Frequency 1 kHz (use the numeric keyboard to the right of the display), and Amplitude 2 V pp (pp means peak-to-peak, viz the difference between the top and bottom of the waveform is then 2 V peak to peak, this is only correct if High Z was set).

On the scope press the Default Setup button on the top to the right of the display and under the illuminated Run/Stop button. Then press Auto Scale which is to the right of Default Setup. (These buttons are recessed to prevent accidental pressing.) Press the Channel 1 button which is illuminated in the lower right of the instrument.

Note that the display states in the upper left hand corner which channel is active, the VOLTS/DIV for that channel (there are 8 major vertical divisions) and the TIME/DIV (there are 10 major horizontal divisions). On the left at the beginning of the sine wave there is a small T indicating the trigger setting indicating that the scope is being triggered by the waveform on CH1, and the trigger level. Also there is a small picture of a ground indicating where 0 volts is located. Note that the soft menu under the display now indicates the coupling for CH1 and that the scope is set for a 1X scope probe with an input impedance of 1 M $\Omega$  (don't change either). To the right of the display it states that the current sampling rate, the trigger mode, and that each channel is dc coupled and set for a times 1X probe.

On the FG press Waveforms and select square. Note and record the effect of varying the Duty Cycle by pressing Duty Cycle and then varying the rotary knob on the upper right of the FG. The duty cycle is the percentage of the time the waveform is at the upper level.

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Press Waveforms and select Ramp. Press Symmetry and note the effect of varying the symmetry with the rotary knob on the right of the FG. What value of symmetry turns the ramp into a triangular wave?

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### **Trigger Control**

The trigger controls determine where  $t=0$  is on the display of voltage versus time. It begins in the middle of the screen with the voltage level selected with the slope selected. Press symmetry and select 100 % for the ramp output of the FG. On the scope press Trigger (just to the right of the display). Vary the Trigger Level knob

and describe what happens to the display. Describe what happens when the trigger level is set above the positive peak of the waveform.

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Press the trigger level button to set it to 50% for the trigger level.

Press the Slope button on the soft menu under the display. A green circular arrow indicated that it is linked to the knob to the right of the display with a green circular knob. Rotate the knob until the negative or falling slope is selected and press the button to select. Note the effect on the display.

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Set the trigger slope back to positive.

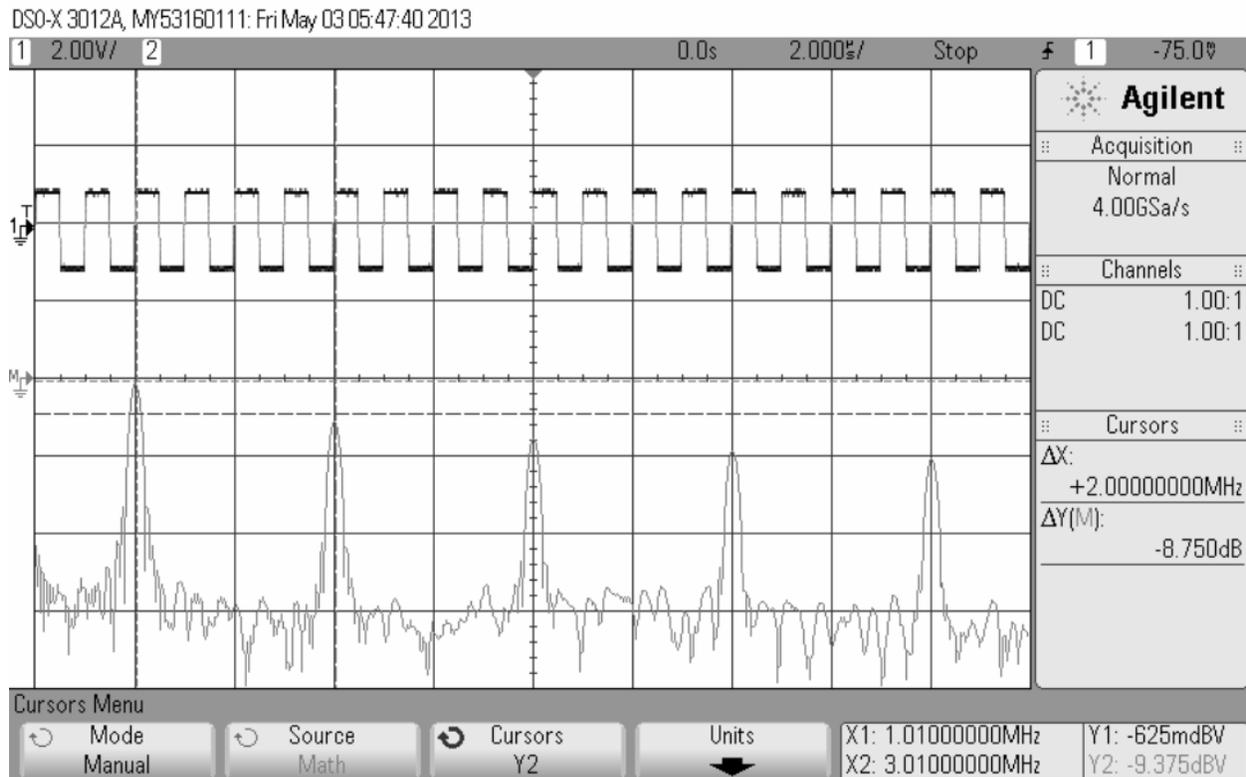
Press Waveforms on the FG, More, PRBS (Pseudo Random Binary Sequence). Press PRBS Data on the FG and select PN7. Press Auto Scale on the scope and then SINGLE (the button just above AUTOSET). Press Single several times and note what happens. Note the Bit Rate indicated on the screen of the FG.

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Print this display. Do so by downloading and running the Scope Capture Program on the class web page. Put the pointer in the middle of the screen shot, right click it, and select copy. Download the Laboratory Report Template from the class web page. Paste the screenshot into the open space to the right of the picture. Replace Tom Brewer's picture and name in the first square with your picture (bitmap) and your name.

## Spectra of Square Wave

Press Waveforms on the FG, select sine wave, Parameters, and set the frequency to 1 MHz and the amplitude to 1 Vrms. Press Auto Scale on the scope. Manually reduce the Volts/Div to 2V with the Channel 1 level button located above the illuminated 1. Manually reduce the Time/Div to 2 $\mu$ s per division by using the large knob labeled Horizontal to the right of the display. Use the Vertical Position Control for Channel 1 (small knob located below illuminated 1) to position the waveform near the top of the display. Press Math on the group of controls on the far right of the front panel of the scope, push the operator button, and then select FFT. Press the push to zero button to the right of the Math button on the scope. Press the Span button and rotate it until the span is 10 MHz. Press the Center button and rotate it until the center is 5 MHz. Note and print the display. Change the waveform to square on the function generator and note. Press cursors under the Measure grouping of buttons. Press Source and change to Math f(t). Use the knob in the cursor section to position the first cursor to the fundamental at 1 MHz. Then select cursor 2 and position it at the harmonic at 3 MHz. Press cursor selection on the soft menu under the display and select cursor Y1. Vary the knob under the Measure Grouping until it touches the top of the fundamental. Press the cursor selection knob again until it selects cursor Y2. Vary the knob until it is at the top of the harmonic at 3 MHz. Print the display and place it into the lab report template. It should look like.



### Spectra of Square Wave

Compare the theoretical and experimental spectra for the square wave.

Turn off the cursors by pressing the Cursors button. Turn off the FFT by pressing the Math button.

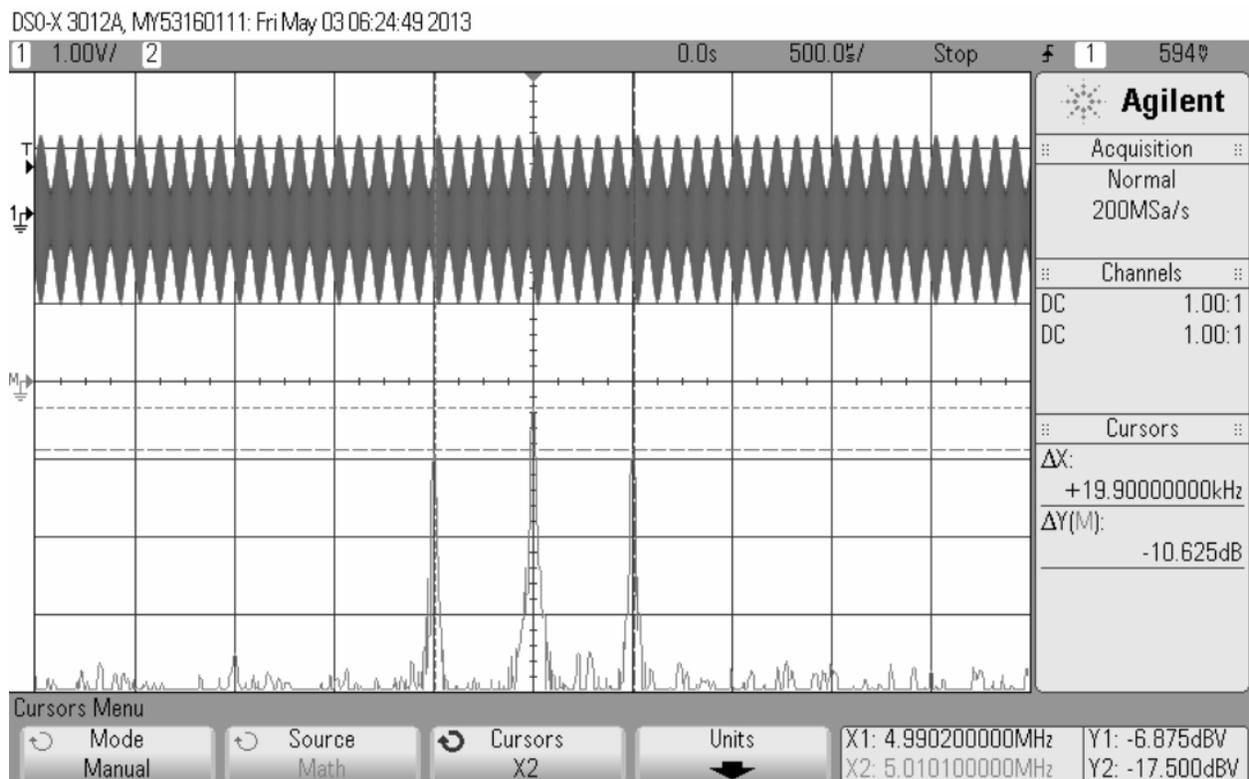
### AM (Amplitude Modulation)

Press Waveforms on the FG, select sine wave, Parameters, and set the frequency to 5 MHz and the amplitude to 1 Vrms. Press Auto Scale on the scope. Press Modulate on the FG (Make sure it is on.). Select AM modulation, AM depth 50%, more, AM Frequency to 10kHz (press More on the FG to get to the AM frequency). Manually change the TIME/DIV on the scope by rotating the HORIZONTAL button to 20  $\mu$ s/DIV. Press Trigger and change the level so that it is about  $\frac{3}{4}$  the way up the display between the peak and trough of the envelope. Press Trigger Mode Coupling and increase the Holdoff to about 60  $\mu$ s. A stable

display should result. Print the display and place in lab report. On the FG press AM Depth and observe the effect of varying it from 50 to 80%. Reset the AM Depth to 50%.

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Change the Volts/Div, Time/Div, and Vertical Position for Channel 1 on the scope until about 10 cycles are displayed near the top of the display. Turn on the FFT by pressing Math. Set the Center to 5 MHz and the span to 100 kHz. Change the Time/Div with the Horizontal knob on the scope until the three spikes look reasonable like straight lines. The one on the far left is known as the lower sideband, the one in the center is the carrier, and the one on the right is the upper sideband. Turn the cursors on and position them until the display appears as



Compare the theoretical and experimental spectra for the AM signal.

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Turn the cursors and FFT off.

### **FM Frequency Modulation**

Set the function generator to produce a 10 MHz sine wave with an rms value of 1 V. Turn the modulation on and set it to produce FM with a Frequency Deviation of 5 MHz and an FM Frequency of 1 MHz. Press Auto Scale on the scope. Observe the display. Reduce the FM frequency to 1 Hz and describe the display.

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Reset the FM Frequency on the FG to 1 MHz.

Turn on the FFT on the scope and set the Span for 20MHz and the Center for 10MHz. Manually use the Volts/Div and the vertical position control on the scope to position the waveform on Channel 1 on at the top of the display. Set the Time/Div to 1 $\mu$ s. Print the display and insert into lab report.

Turn the FFT off on the scope and the modulation off on the FG.

### **Burst**

Set the function generator to produce a sine wave with a frequency of 10 MHz and an amplitude of 1 Vrms. Press Burst on the FG and set the # of Cycles to 5 (button 5<sup>th</sup> from the left that states “# of Cycles” and the burst period to 1ms. Turn the Burst On. Press Auto Scale on the scope. On the Horizontal section on the scope press the spy glass button. Vary the setting of the Horizontal knob and position knob to its right and note the effect. Are there 5 cycles?

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Turn the spy glass button off and use the Volt/Div and vertical position buttons on the scope to position the waveform near the top of the display. Use the Horizontal knob to change the Time/Div to 5 $\mu$ s.

Turn on the FFT by pressing Math. Set the Span to 20 MHz and the Center to 10 MHz. Turn the cursor on. Use cursors X1 and X2 to determine the width of the

main lobe. Print and insert the display into the lab report. How does the width of the main lobe in Hertz compare with the theoretical value?

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Turn Burst off on the FG. Turn the FFT and cursors off on the scope

### **Lissajous Pattern**

Set the FG to produce a sine wave with a frequency of 1 kHz a peak to peak value of 2 V on Channel 1. Turn Channel 2 on, set it for High Z, an amplitude of 2 V peak-to-peak and a frequency of 1 kHz. Switch the scope to an XY display. Do this by pressing the Mode button to the right of the Horizontal knob and on the soft menu that appears below the display on the scope switch it to XY. Press Parameters phase, Sync Internal on one of the channels of the FG. Set the phase on one channel (not both) to 90 degrees. Use the Volts/Div setting and position controls for the two channels on the scope to obtain a display that takes up about 75 % of the display.

Change the frequency of the Channel 1 output on the FG to 2 kHz. Press Phase, Synch Internal, and then set the phase to zero degrees. Set the frequency on Channel 2 output of the function generator to 3 kHz, the phase to 90 degrees, and then Synch Internal. Print the display and insert in lab report.

Set the frequency of the Channel 1 output on the FG to 6 kHz and the frequency of the Channel 2 output to 9 kHz. Observe the display for a phase of zero degrees. Print both the display and insert into lab report.

Turn the modulation on for Channel 1. Select FM with a frequency deviation of 1 Hz and a modulating frequency of 0.1Hz. Describe the display.

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