

# Introduction to the Oscilloscope

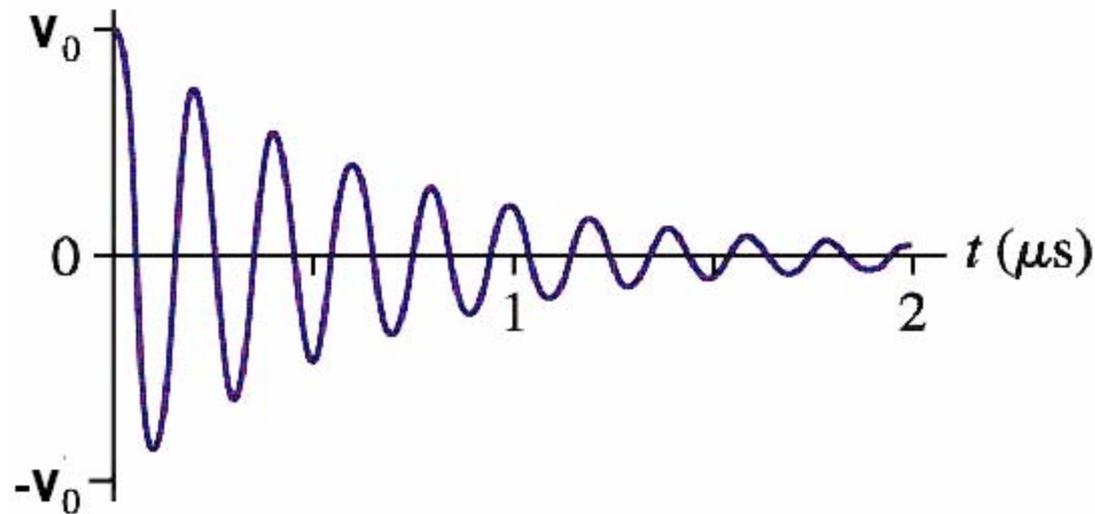
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# What is an oscilloscope?

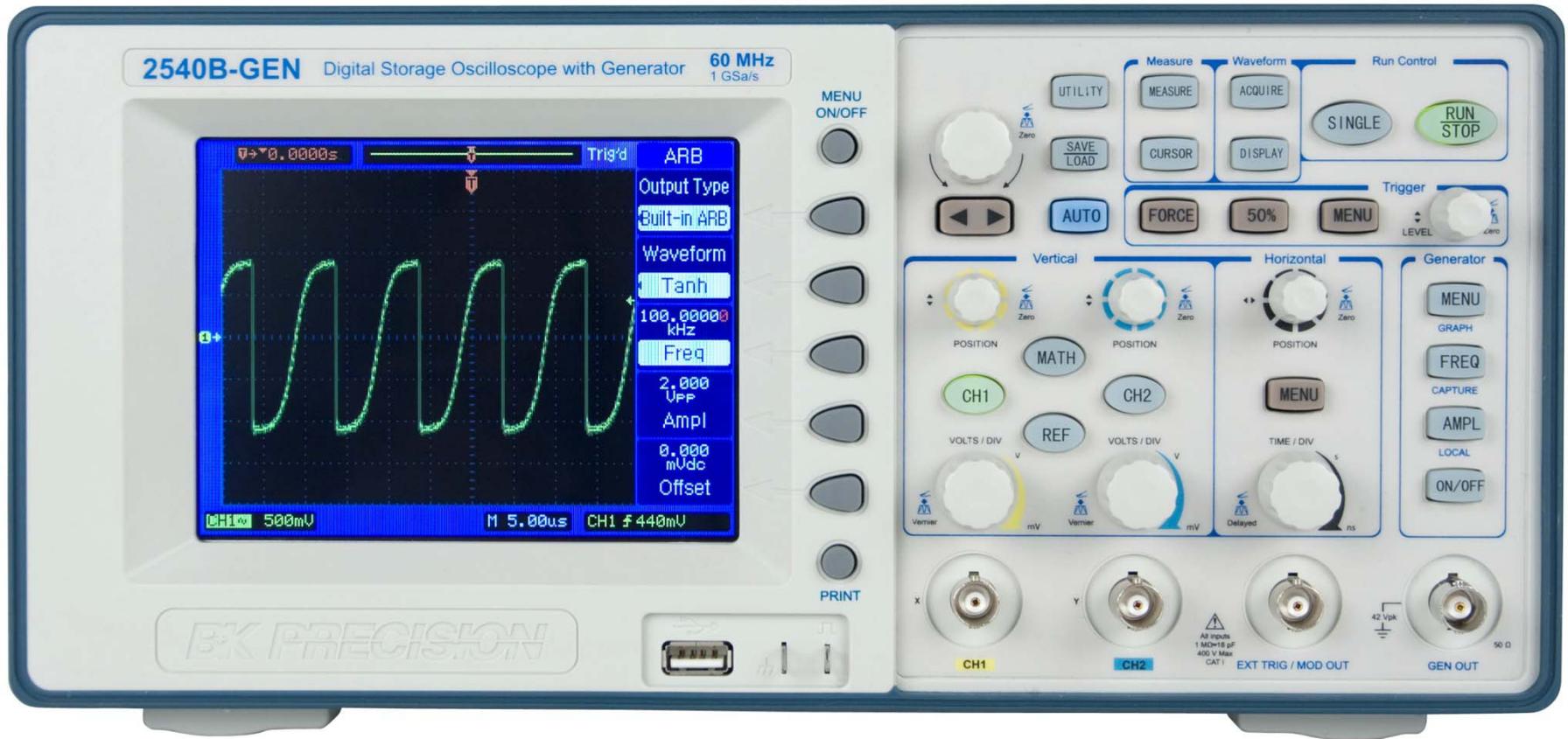
- Essentially it is an instrument that can display **voltage-time** graphs on a screen in real time.
  - Most useful for phenomena that change with time.



# Your Oscilloscope

- You will be using the **B&K 2540B-Gen Digital Storage Oscilloscope (DSO)**.
  - The ‘Gen’ indicates that it has a built in function generator in addition to the oscilloscope (DSO).
    - These are separate instruments that are operated by a common set of buttons/knobs.
  - The screen is divided into **divisions** by a grid.
    - The **vertical** (*voltage*) sensitivity can be set from 2 mV per division to 5 V per division giving a large measurement range (*0.002 V/div to 5V/div*).
    - The **horizontal** (*time*) per division can range from 2ns up to 2 seconds.

# Photo of the B&K 2540B-Gen DSO



# B&K 2540B-Gen

- The B&K 2540B-Gen is a **D**igital **S**ampling **O**scilloscope (DSO). A DSO measures the input and stores it into memory and allows great versatility in how the data is used.
  - It can measure Period or Frequency of a waveform
  - It can measure the Amplitude of a waveform
  - It can save its screen to a file
  - It can perform some mathematical operations such as averaging, addition, subtraction, etc.

# B&K 2540B-Gen

- A DSO is a very complicated device. The instruction manual for ours is 250 pages long. We will only make use of the most basic capabilities: viewing and measuring periodic voltages and capturing single events.
- DSO's have an '**AUTO**' button that works like magic to display the input. The B&K 2540B-Gen allows that function to be disabled so that you can learn how to use an oscilloscope.

# B&K 2540B-Gen

- In addition to being a DSO, the B&K 2540B-Gen has a function generator built into it.
  - A function generator creates voltages with a user chosen frequency, amplitude and shape.
  - The B&K 2540B-Gen has the usual waveforms:
    - Sine, Square, and Triangle
  - As well as many mathematical functions
  - And the ability to take an input file that defines the shape and generate a periodic function from it

First we begin by considering the display capabilities of the B&K 2540B-Gen DSO.

# **INTRODUCTION TO THE DSO**

# Turning the 2540B-Gen on

- Connect the AC Power Cord to the power input socket on the side of the DSO. **Press down** the power switch button at the top of the DSO to the ON position. Verify that the instrument turns on and the LCD screen goes into an initial boot screen.

# Cable Connections to the 2540B-Gen



Voltage Input  
'Channel 1'

Voltage Input  
'Channel 2'

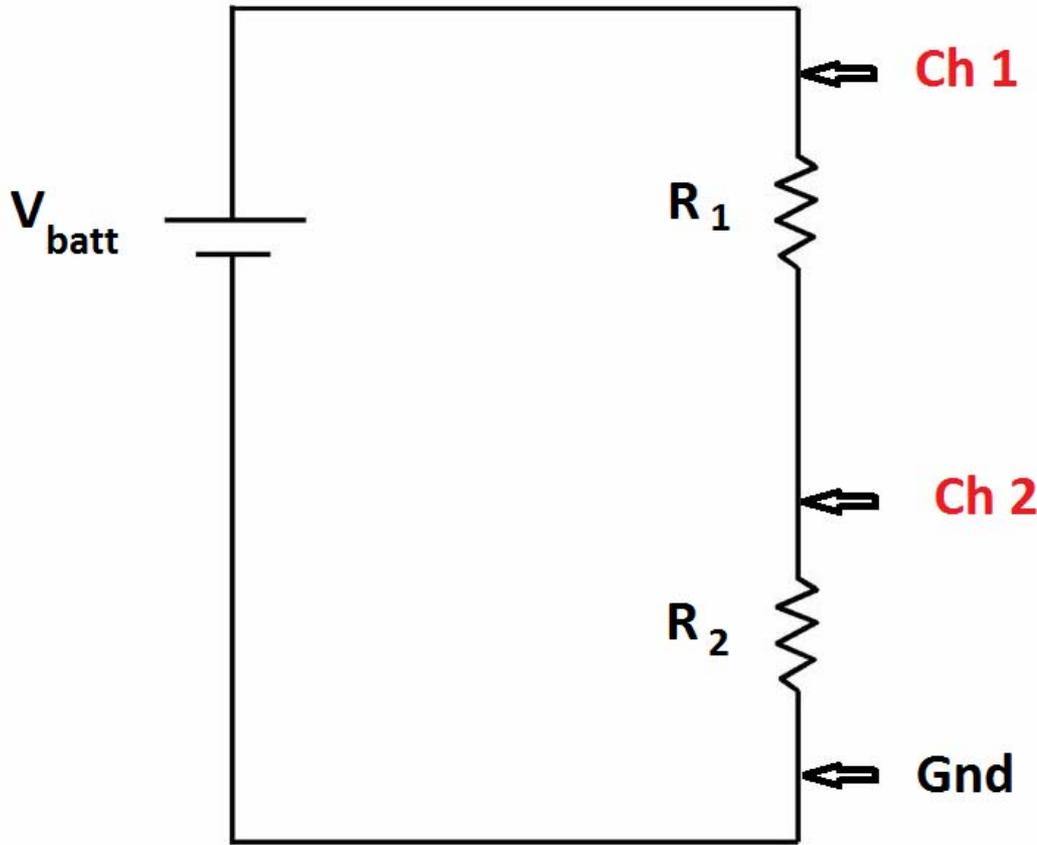
Function  
Generator  
Output

If the cables are not attached, slide the 'notches' in the cable over the 'lugs' seen in the photo and twist about one fourth of a turn clockwise to lock.

# 'Ground' Connections

- The black or braided lead of the test cables goes to the part of the connector with the lugs.
- This means that both inputs and the function generator share a common terminal (*'ground'*) and are electrically connected to each other.
- Having the grounds connected to different places in your experiments causes a lot of 'headaches' in lab!

# Proper Way To Measure Two Voltages

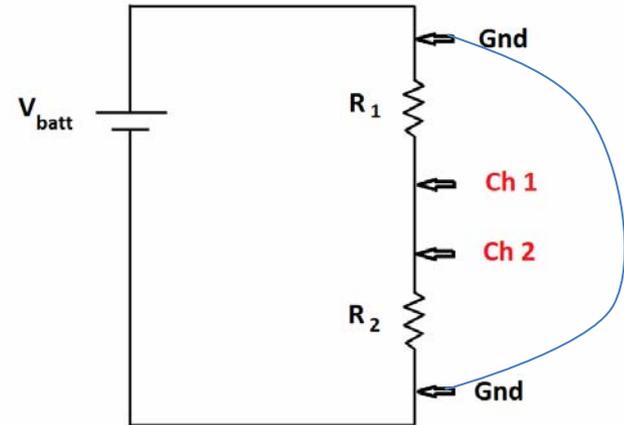
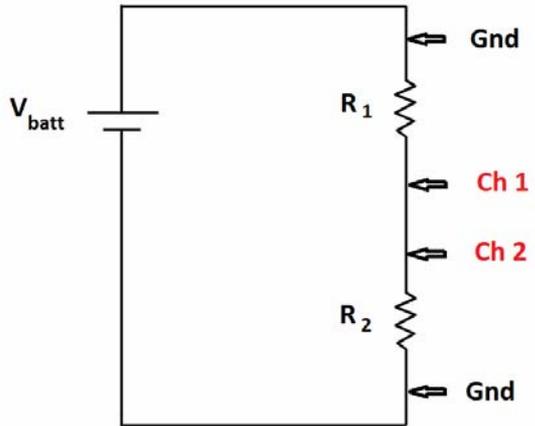


Ch 2 is the voltage across  $R_2$

Ch 1 is the sum of the voltages across both resistors.

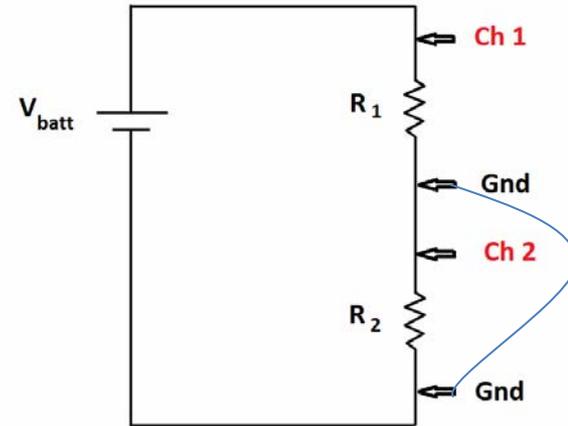
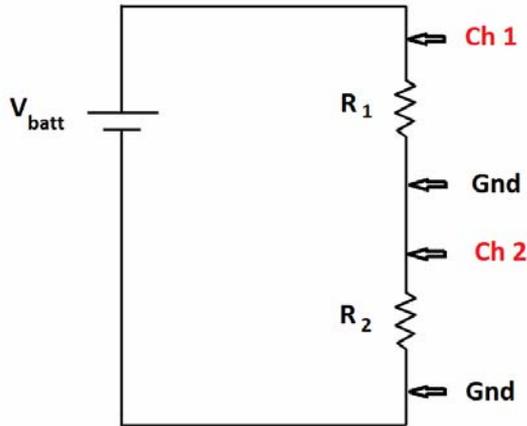
Math (or a calculator) can be used to determine the voltage across  $R_1$

# Improper Connections



The two ground connections **SHORT** the battery - **Dangerous**

# Improper Connections



The two ground connections SHORT  $R_2$  – you measure  $V_{\text{batt}}$  on CH 1 and 0 V on Ch 2.

# Using the B&K 2540B-Gen

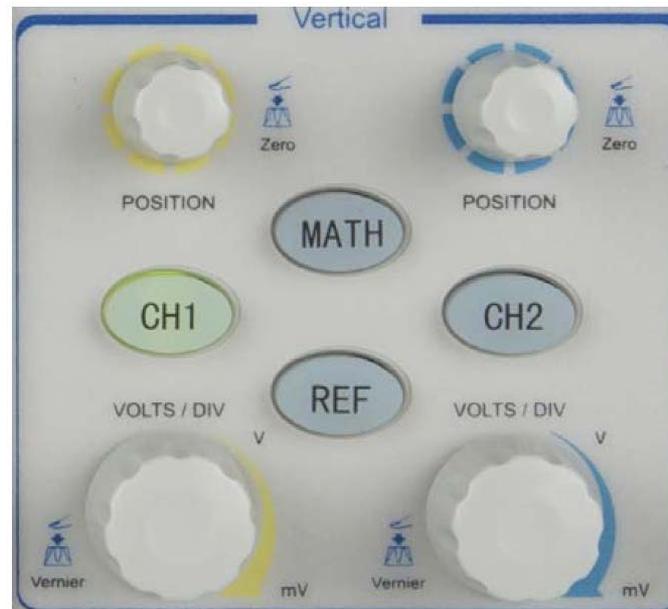
- Basic usage requires four things:
  - Choosing an appropriate number of V/div (*vert*)
  - Choosing an appropriate number of sec/div (*horiz*)
  - Setting the appropriate coupling:
    - AC to show only the time varying part
    - DC to show the total voltage
  - Setting a trigger – i.e. telling the DSO when to begin making a measurement.
- We will look at each section separately.

# Vertical (Voltage-axis) Controls (Two Independent Channels)

**Position:** Changes the position of the trace on the screen. Press and release to set to zero.

**Math** is not normally used.

**Ch 1** in use if lighted



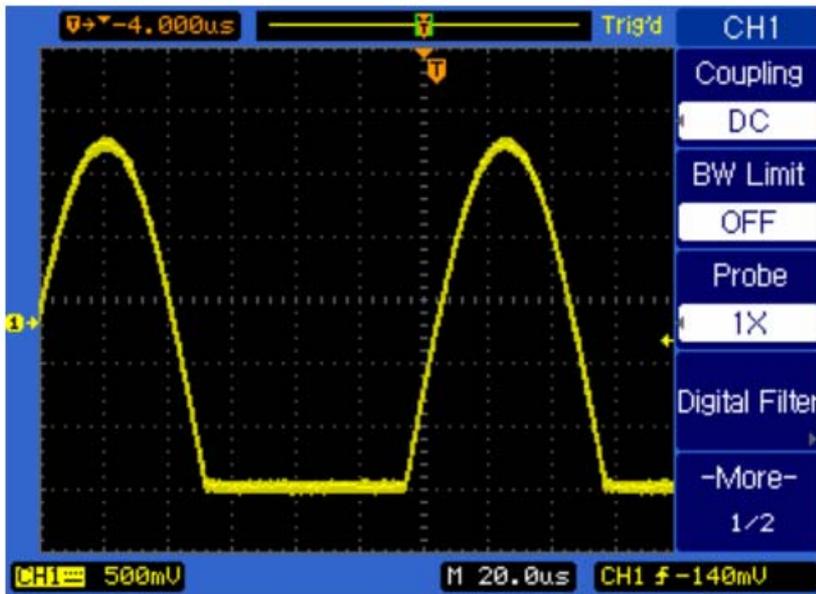
Vertical controls

**Ch 2** in use if lighted

**Ref** is not normally used.

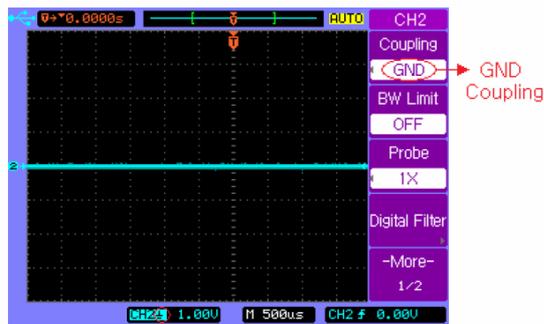
**Volts/Div:** How many volts are needed to cause a vertical change of 1 division. Clockwise is smaller; Counterclockwise is larger – displayed on the screen.

# Ch1 or Ch 2 Menu



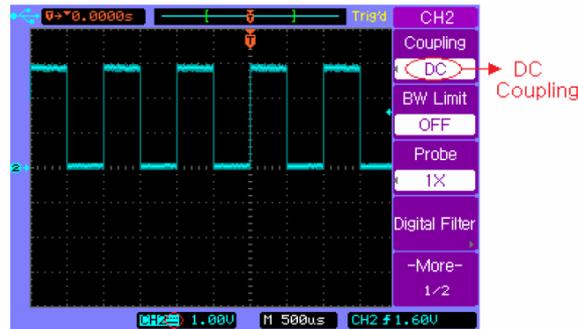
- **‘Coupling’** is dependent on the signal.
  - ‘DC’ shows any constant voltage as well as the time changing voltage
  - ‘AC’ only shows the time dependent voltage

# Coupling Options



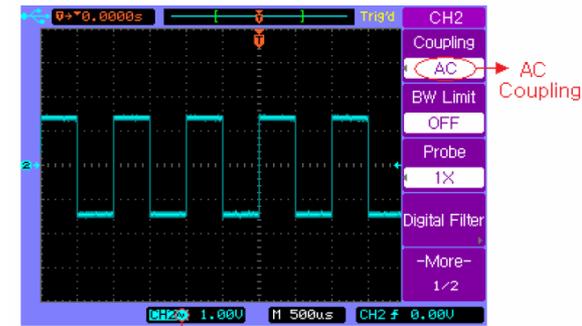
GND Coupling Status

**Gnd Coupling** makes the trace have a value of Zero. This is useful in setting the zero location of voltage for a channel.



DC Coupling Status

**DC Coupling** displays the algebraic value of the input. This trace varies from zero up to a maximum value of almost 3 V (3 div)(1 V/div)

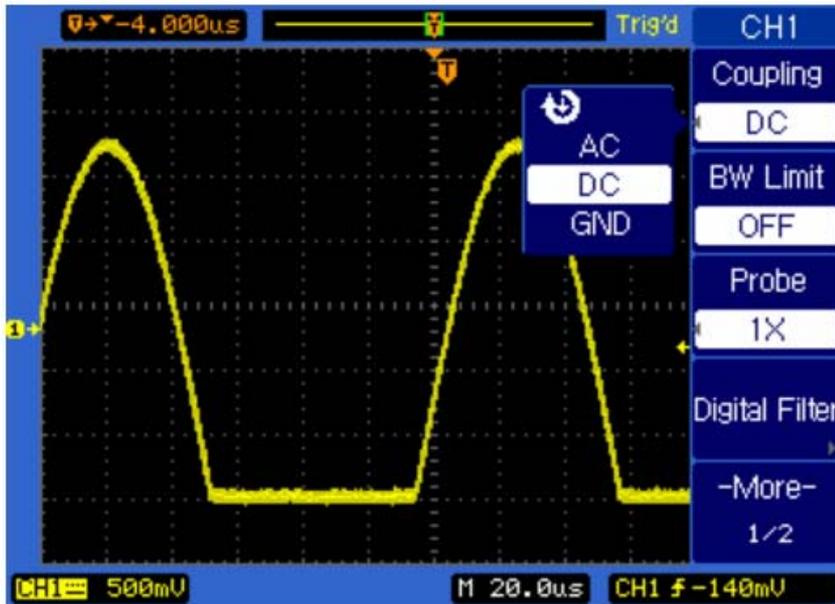


AC Coupling Status

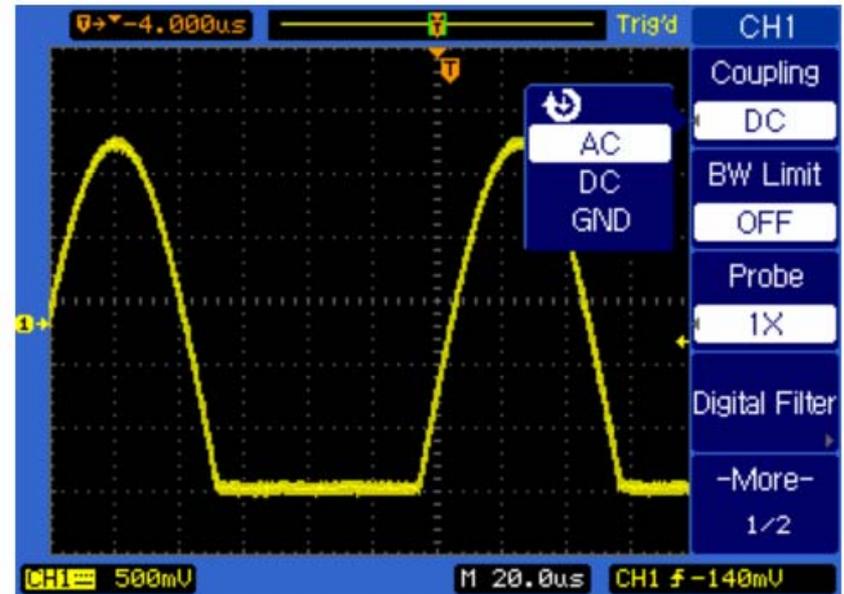
**AC Coupling** ignores any DC voltage and only shows the time varying part. Can cause distortion when the frequency of the signal is very low (<60 Hz)

# Changing the Coupling

Press the button beside  
**'Coupling'** to see image below



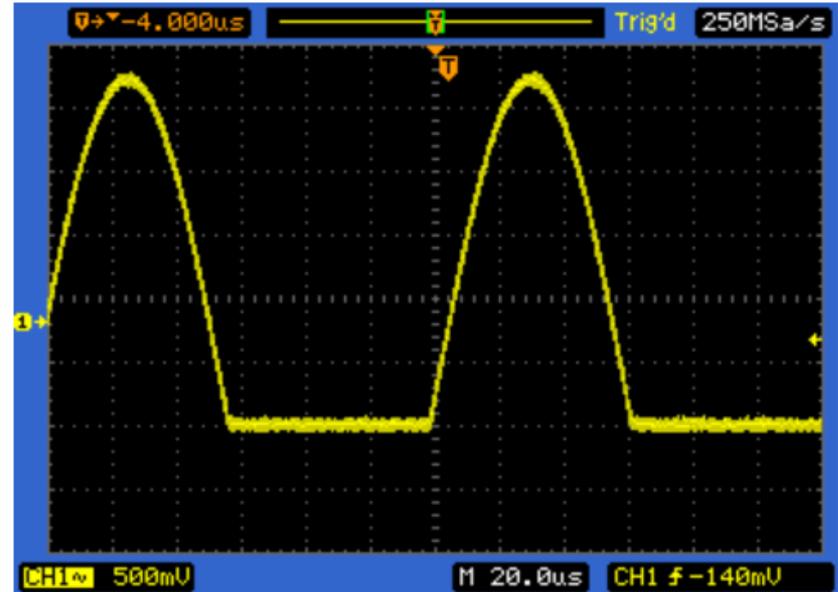
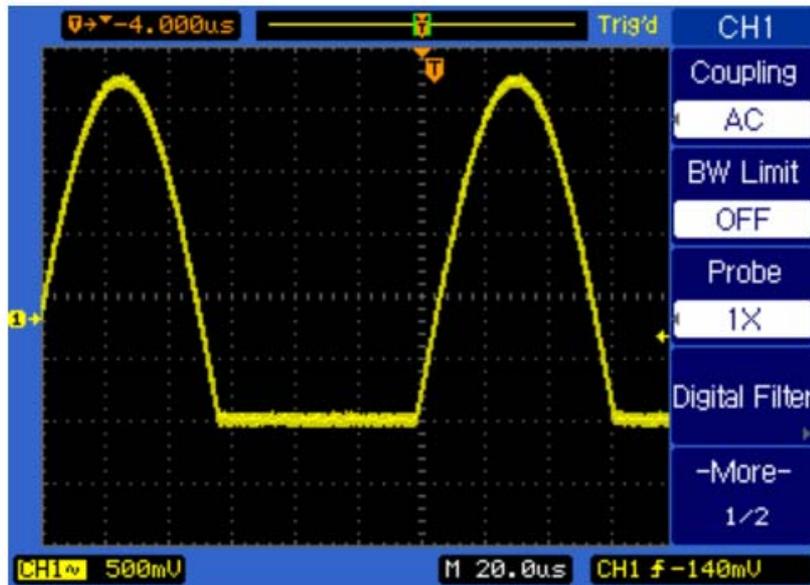
Use the unlabeled knob to the  
left and above the screen



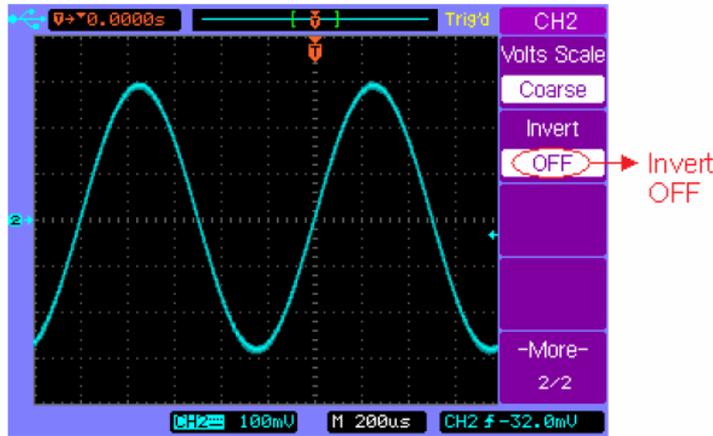
Rotate to change to **'AC'**, Then push  
in on the knob and it will click.  
Release

# Change the Coupling

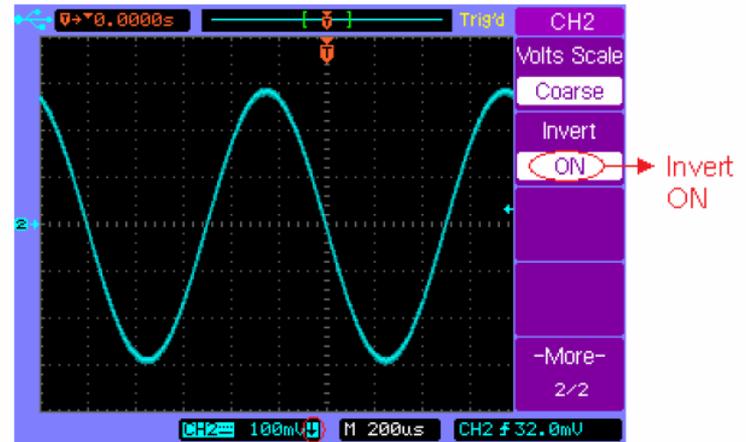
We are in 'AC' Coupling mode. Hide the menu.



# Channel Invert (Multiplies by -1)



Vertical Invert off



Inversion Status

Vertical Invert on

Inverting a channel 'flips' the channel vertically. The 'Down Arrow' at the end of 100 mV indicates this display is inverted. The 'Soft Menu' will show Invert 'ON' only if no other key with a soft menu has been pressed since inverting the channel.

# Horizontal (time-axis) Controls



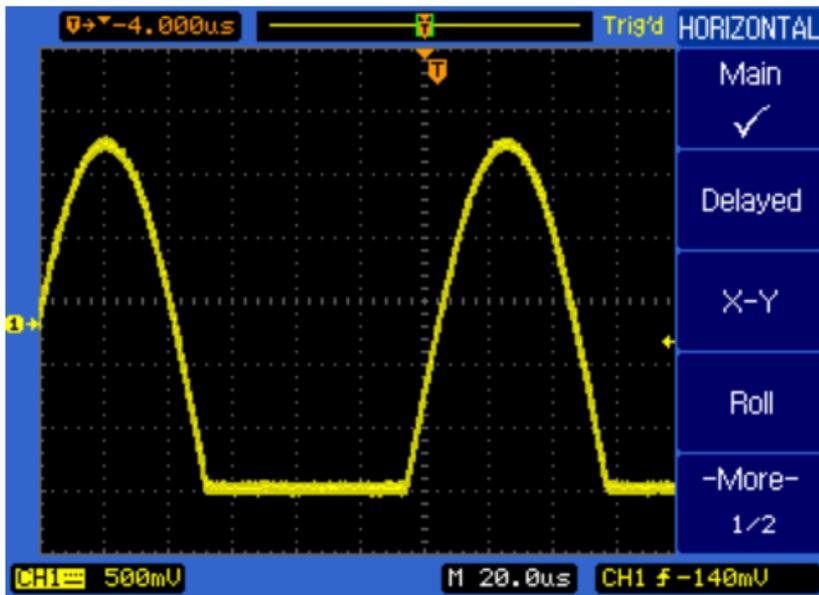
Horizontal Controls

**Horiz. Position:** Moves any displayed traces left or right, to make measurements from the screen easier and more dependable.

**Menu:** is not normally used.

**Time / Div:** Sets the amount of time each horizontal division represents. It can vary from microseconds to seconds.

# Timebase Menu



- '**Main**' is the normal usage mode.
- '**Delayed**' adds an extra delay before showing the waveform.
- '**X-Y**' plots Ch 1 vs. Ch2 .

# Scope Triggering



## Trigger Controls

**FORCE:** Starts a 'sweep' (i.e. a horizontal trace begins) immediately. Not often used

**50%:** Sets the sweep to begin when the voltage hits 50% of the value of the amplitude of the input voltage.

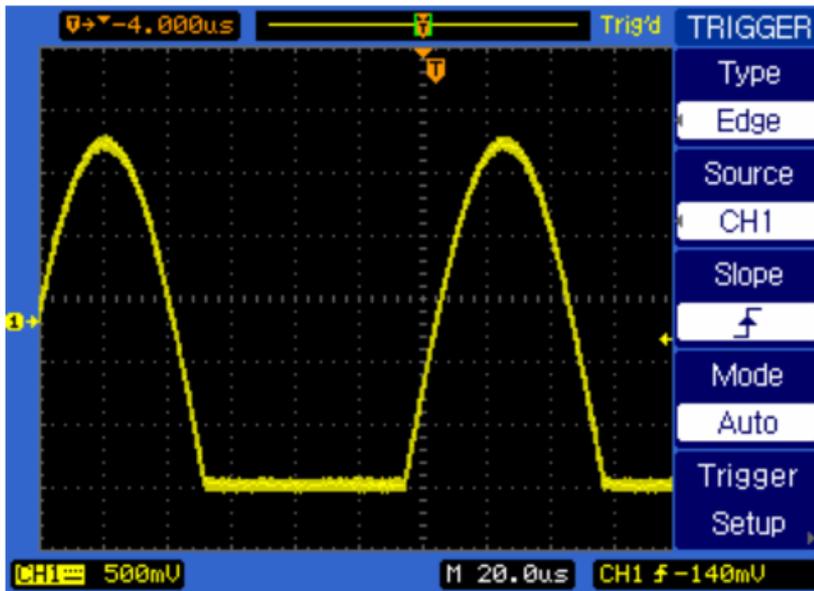
**Menu:** Several settings are possible the most frequently used ones are:

**Auto:** Allows the scope to trigger a sweep. Must be used to observe DC voltages.

**Manual:** Allows the user to set the voltage that causes a sweep to begin.

**LEVEL:** This knob sets the level that the input must be before a sweep begins.  
A 'press & release' sets the trigger level to zero volts.

# Trigger Menu



- **'Edge'** means that a sweep is started when the input reaches the trigger level.
- **'Source'** is which channel controls the start of the sweep.
- **'Slope'** shows that it must be rising.
- **'Mode'** shows that the DSO will determine when to start a sweep.

# Trigger Options



Softkey	Options	Description
<b>Type</b>	Video	Video triggering
	Edge	Edge triggering
	Pulse	Pulse width triggering
<b>Source</b>	CH1	Trigger on CH1
	CH2	Trigger on CH2
	EXT	Trigger on EXT
	EXT/5	Trigger on EXT/5
	AC Line	Trigger on AC line signal
	Alternating	Trigger on CH1 and CH2 alternately
<b>Slope</b>	↗	Rising edge of a signal
	↘	Falling edge of a signal
<b>Mode</b>	Auto	Trigger even without a valid event
	Normal	Trigger only on a valid event
<b>Trigger Setup</b>	----	Select trigger SETUP menu.

Almost always use 'Edge' in class

Choose CH1 if only using 1 channel

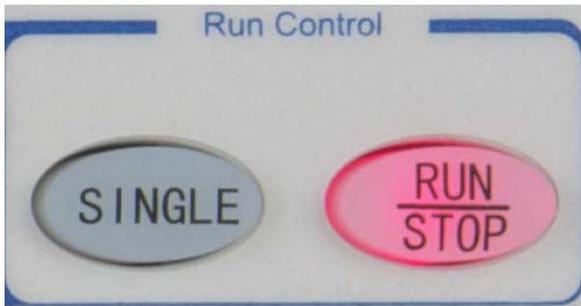
Otherwise, choose channel that measures the signal generator

Start a sweep as the input rises

Most often used – necessary for dc

Used when you want to control when the sweep begins

# Single vs. Continuous Sweep



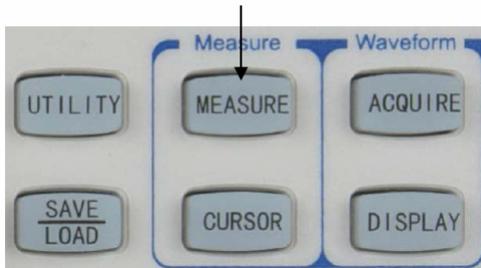
Run controls

If **'Single'** is selected, the scope will take one sweep when triggered (or forced) and display that result.

When in **'Run'**, the DSO will continually remeasure its input. Pressing **'Stop'** will freeze the display to allow you to analyze it or to store it if need be.

# Using the Measure Menu

## 3.2 MEASURE Menu



- Pressing the 'Measure' button will show the 'Measure' menu.

- The DSO will make measurements from the waveform and display the value for you.

- This is much more simple than using an analog oscilloscope!

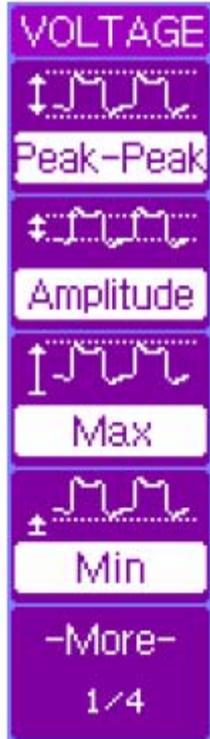
# Using the Measure Menu 2



Once 'Measure' has been pushed this menu is shown

- Pressing the 'Soft Key' beside Source changes from Ch1 to Ch2
- Pressing the 'Soft Key' beside Voltage brings up menus of the voltage measurement options – pk-pk is fine for our needs.
- The Time measurements work in a straightforward manner.
- Clears all of the 'Measure' functions
- Measures everything the DSO knows how to measure and clutters the screen so that you can't read it. Not Recommended!

# Using the Measure Menu 3



Once 'Voltage' has been pushed this menu is shown

- This 'Soft Key' chooses  $V_{pk-pk}$
- You must to read about the difference between pk-pk and Amplitude – use of this button is not recommended.
- Gives only the most positive value – useful for DC??
- Gives the most negative value
- Shows other voltage measurement options. Not Recommended!

The B & K 2540B-Gen also contains a signal generator that is very versatile.

## **ARBITRARY FUNCTION GENERATOR**

# Function Generator



‘**Menu**’ opens the soft menu for the function generator.

‘**Freq**’ sets the frequency of the function generator.

‘**Ampl**’ sets the amplitude of the function generator.

‘**On/Off**’ turns the generator on or off. The button is green when ‘On’.

# Menu Editing Controls

Turning the knob lets you scroll through sub-menus.

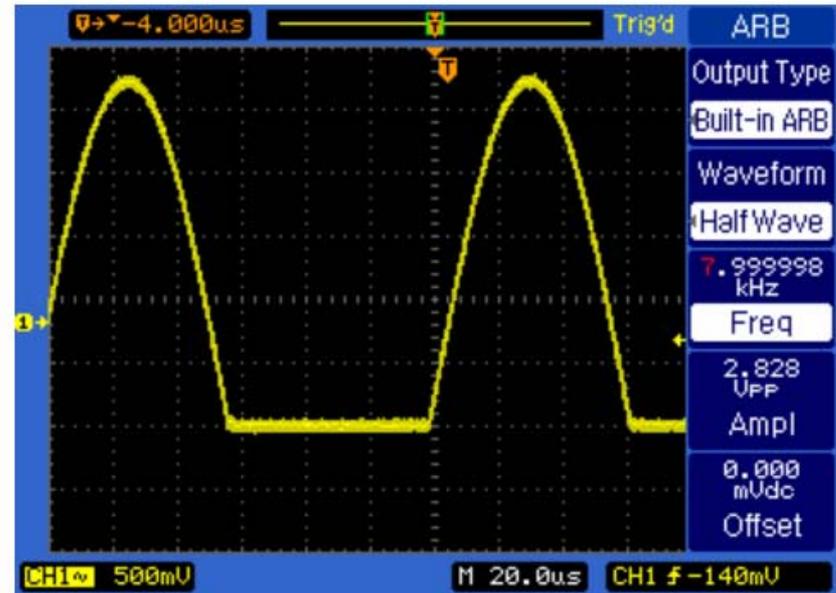
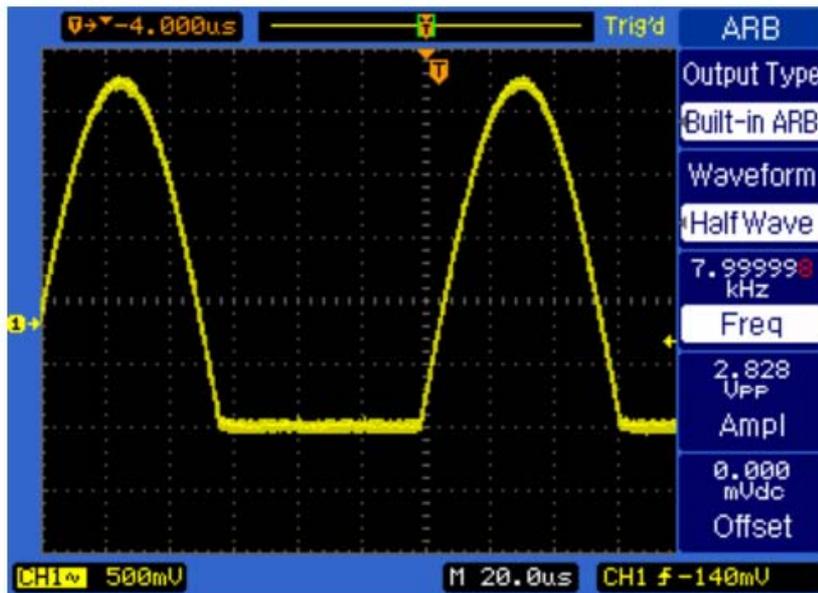


- When editing a number – like the frequency, the knob changes one digit at a time – counting up or down.
- The “arrows” move 1 digit right or left for each press.

# Change Freq and Mode Example

Press '**FREQ**' on DSO, menu appears. Red digit will change with the knob

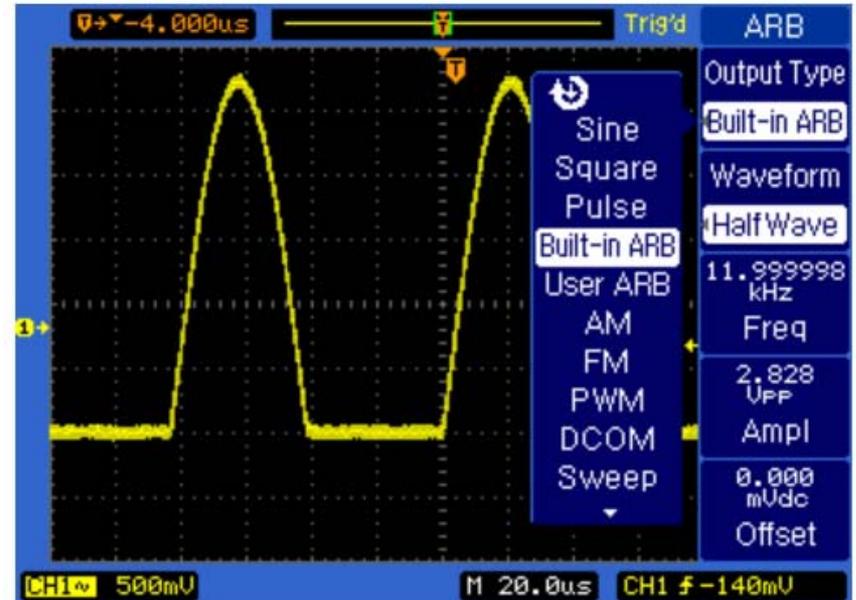
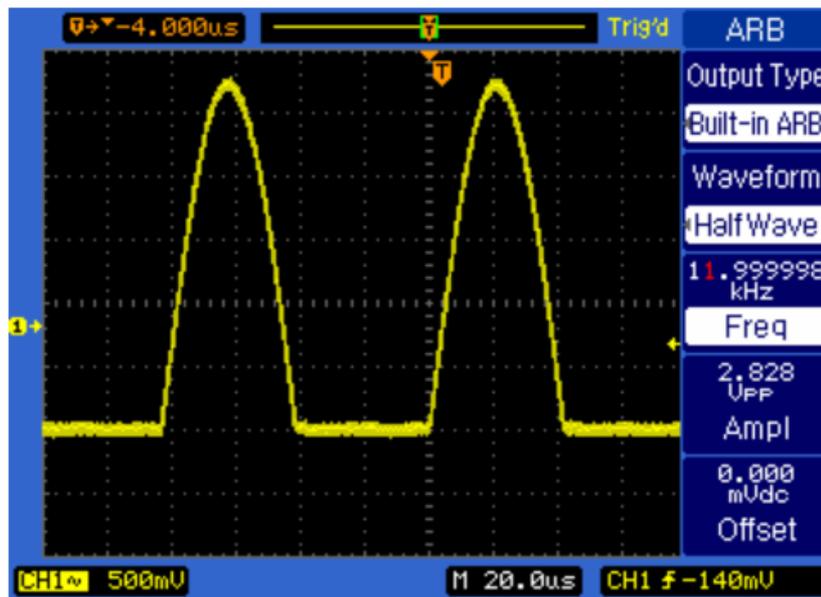
Press the left "arrow" under the knob until the 7 is red.



# Change to 'Sine' Waveform

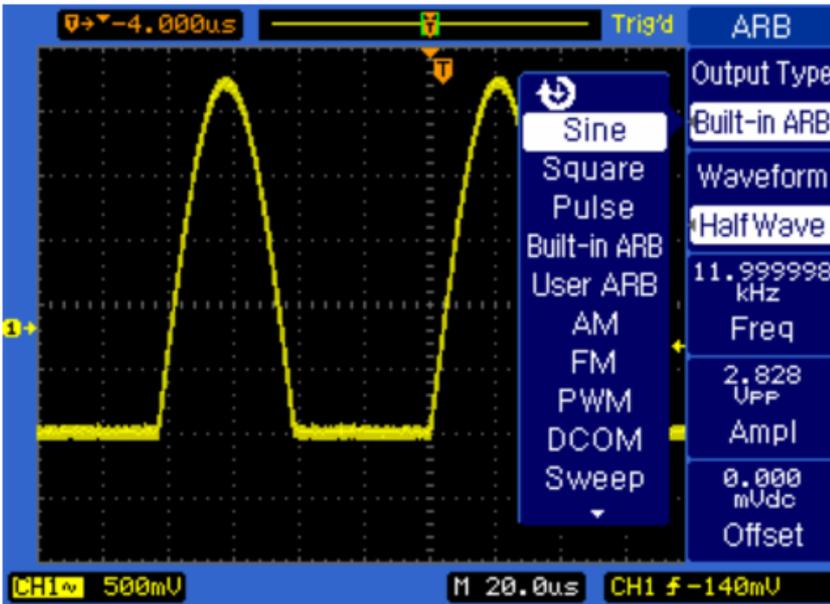
Rotate the knob to change from 8 to 11. The generator responds as you change.

Push the button by 'Output Type' and the sub menu appears showing current mode.



# Change Complete

Rotate the knob to select **'Sine'**. The down arrow in the rotate indicates that you have to 'Press & Release'..



Press the adjust knob in until it clicks and then release. Press the soft menu button to hide the menus

