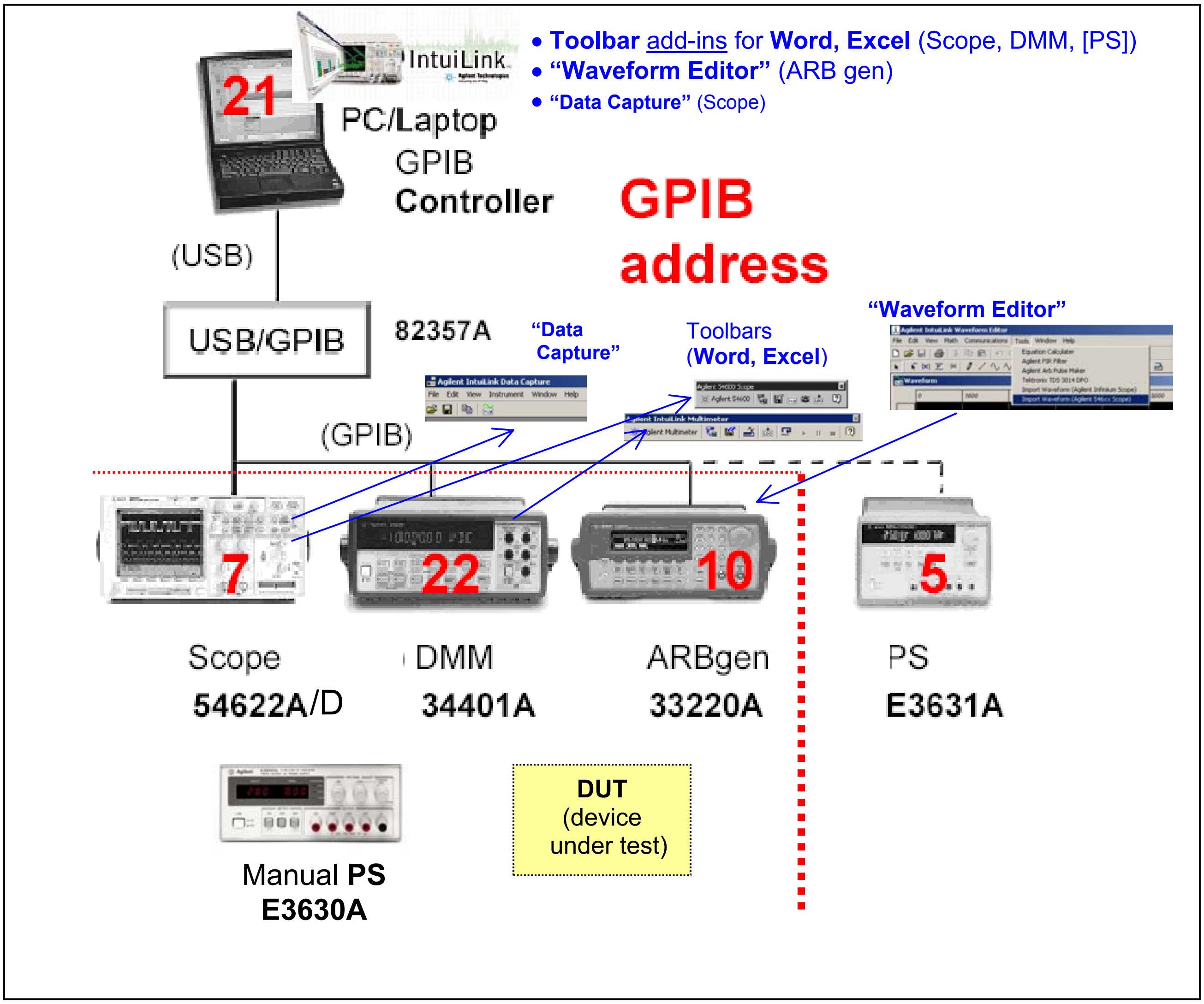
LAB basic HW Tools …

L107 Lab



Up to date info: http://www.hit.bme.hu/people/papay/edu/Lab/Tools.htm

E9340A LogicWave PC Logic Analyzer

34 channels; **100** MHz **state** (64K),
250 MHz **timing** (128K) analysis
Connects via **parallel port**
Single-screen user interface
(the most commonly used features,
and the captured data, are
available on one screen)

See in
'Logic Analysis'
booklet

E3630A <u>triple-output</u> <u>Power Supply</u> (Manual PS):

35W **triple** output; Constant voltage (**CV**) and current limit (**CL**) modes
6V, 2.5A & **± 20V,** 0.5A; Output **tracking** (± 20V)
Digital voltage and current meters:
<u>voltmeter</u> and <u>ammeter</u> always **monitor** any <u>one</u> supply <u>simultaneously</u>
Meter resolution – voltage: 10 mV, current: 10 mA

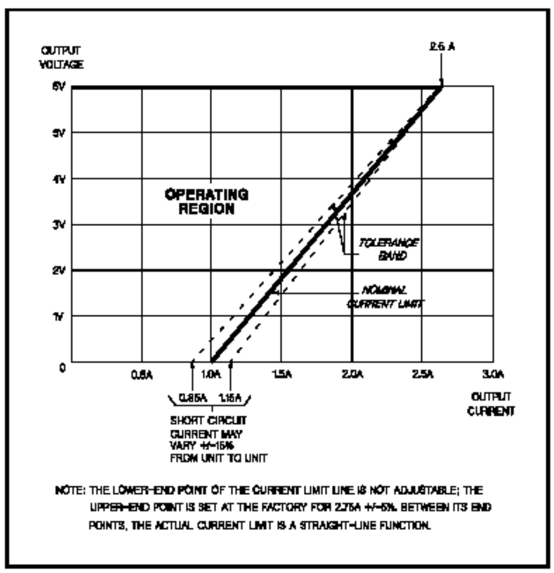
The E3630A's outputs are **current-limited** <u>for safety</u>: they will supply some maximum amount of current, and will drop the output voltage to ensure it.

In particular, if you short the outputs, instead of blowing fuses or becoming arc welders, these supplies peacefully supply the maximum current.

During the actual operation of the ±20V and +6V outputs, if a load change causes the current limit to be exceeded, the **OL** LED is lighted.

If **overload** conditions occur, the **±20V** supplies will protect the load by <u>limiting</u> the current to 0.55 A and the **+6V** supply will protect the load by reducing both <u>**voltage** and current simultaneously</u> along the **foldback** locus as shown in Figure.

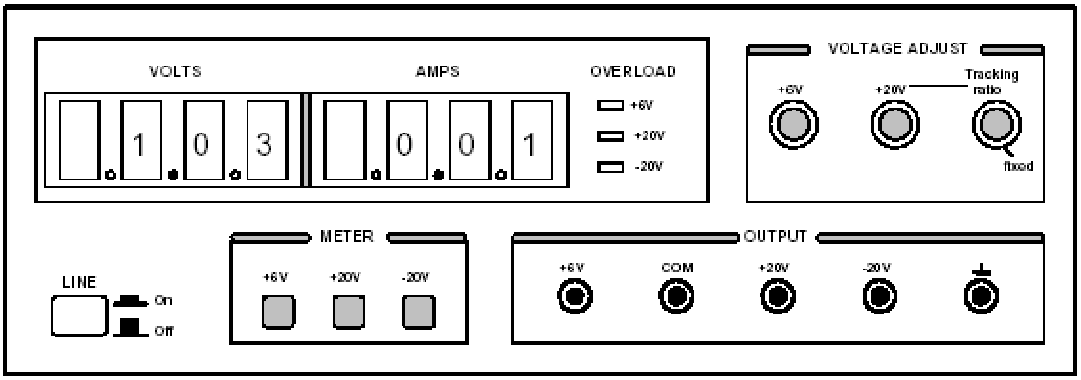
The ±20V and +6V supplies are <u>self restoring</u>; that is, when the overload is removed or corrected, the output voltage is automatically restored to the previously set value.



Current Limit Characteristic of the 6V Supply

Procedure to set a specific DC power supply value:

NOTE: the supply's three outputs share a **common** output terminal [COM], which is **ISOLATED** from chassis (earth) ground [⊥] !!

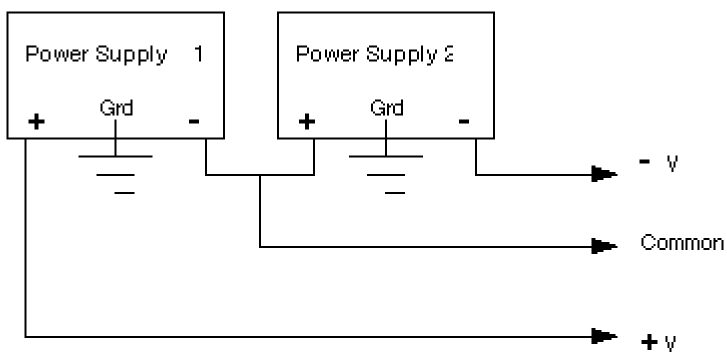


a) The + 6V control knob in the VOLTAGE ADJUST section sets the **0 to + 6V** output. (Push the + 6V METER button.)

b) If the power supply is **between + 6V and + 20V**, push the +20V button in the METER section and use ±20V knob in the VOLTAGE ADJUST section to set the power supply value (starting from 0V and adjusting upward).

c) The ±20V control sets the **0 to +20V** and the **0 to -20V** outputs simultaneously. With the **Tracking ratio** control turned fully clockwise to its **"fixed" position**, the voltage of the negative supply tracks the positive supply within 1%, giving *balanced* positive and negative supplies.

Example: Press the +20V METER button (to display the +20V output) and adjust the ±20V control knob to set the positive supply to**+15V**. Press the -20V meter button, the METER should read **-15V**. The positive and negative supplies are *balanced* **: ±15V**

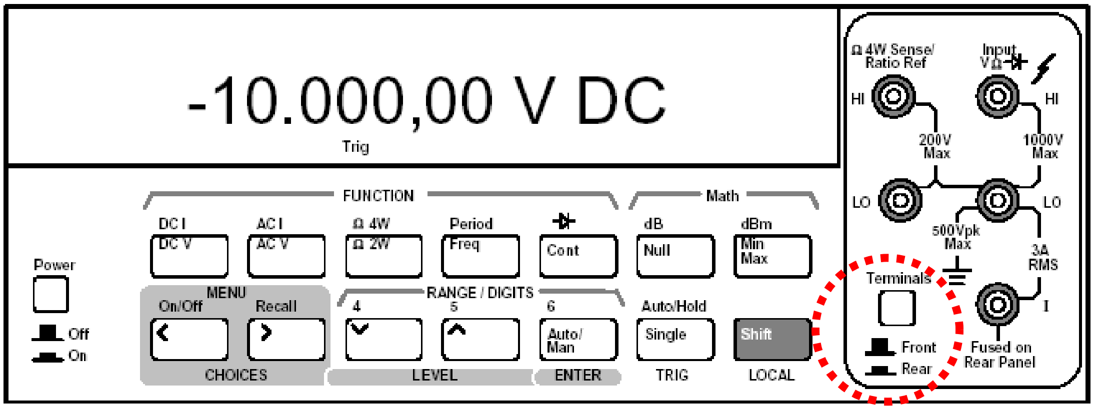


d) Turning the **Tracking ratio** control clockwise **out of its fixed position** allows you to set the voltage of the **-20V supply** to a fixed fraction (**less** than unity) of the +20V supply. Once this ratio is set, the ±20V control still controls both outputs and maintains a *constant ratio* between their voltages.

Example (continued): **Adjust** the **Tracking ratio** control until the negative supply reads **-5V**. (The positive supply should read +15 V). You now have a tracking ratio of **3** (i.e. **-5V and +15V**).
Note: To see how tracking works, press the +20V METER button and readjust the ±20 V control knob to set the positive supply to +18V. Press the -20V METER button: the negative supply should read -6V, since the voltage *ratio* of **3** was **not** changed.

34401A **Multimeter** (DMM):

6.5 digit resolution; AutoRanging
Voltage, **current**, **resistance** (2W, 4W), **True RMS** AC volts and current
Frequency, period; **Math**, Data logging



The front panel has two rows of keys to select various **functions**. Most keys have a *shifted* function printed in ***blue*** above the key.

Remark: The 'Shift' key also serves as a **LOCAL** key to restore front-panel control after remote interface operations.

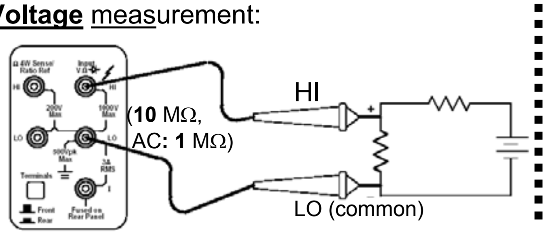
The **menu** (MEAS, MATH,TRIG, SYS, ~~I/O~~, ~~CAL~~) is organized in a top-down tree structure with 3 levels.

RANGE/DIGITS keys:

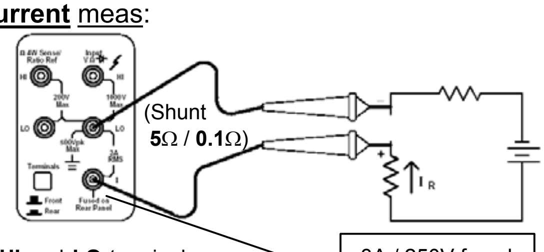
- **Auto** ranging is automatically selected at power-on. **Man**ual ranging: a higher (less sensitive) range, press the " ∧ " key; a lower (more sensitive) range, press the " ∨ " key
  If the input signal is greater than the present range can measure, the multimeter will give an **overload** indication ("OVLD").
  Make sure that the instrument is on the most sensitive range by pressing the " ∨ " key until "OVLD" is displayed and then pressing the " ∧ " key once.
- The **resolution** is set to 5-1/2 digits at power-on.
  To vary the number of digits *displayed* (i.e. masking): " **<** " (fewer digits) and " **>** " keys (the integration time is not changed).

You can select **ranging** and **resolution** for each function independently. The multimeter **remembers** the range and resolution when you switch between functions.

Voltage measurement:



Current meas:

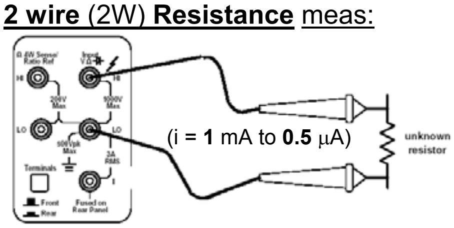


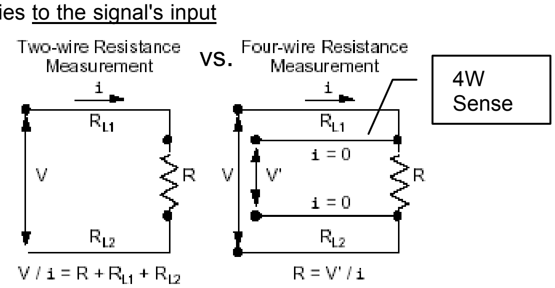
3A / 250V fused on rear panel

Note: to Measure **Frequency: F (or Period: T)** use the **HI** and **LO** terminals marked **1000 V Max** (as you would for voltage measurements). The meter can measure frequency from 3 Hz to **300 kHz** (period from 0.33 sec to 3.3 msec).

For frequency and period measurements, **ranging** applies to the signal's input *voltage*, **not** its frequency!

2 wire (2W) **Resistance** meas:





NOTE: the measurement portion of DMM is **ISOLATED** from chassis (earth) ground !!

The **max**imum **resolution** of this instrument is 1.2 million counts.

On the 1 V scale this mean that readings between -1.199999 and +1.199999 are possible. A reading of 0.999999 corresponds to 6 full digits of resolution, and the **20 % overrange** capability is said to provide an additional **1/2 digit** of resolution (actually, only log (1.2) = 0.08 digits of additional resolution).

Resolution as a fraction of full scale = 1 part in 1,200,000 ≈ 1 ppm = 0.0001 %.

The number of bits of resolution = $\log_2(1200000)$ + 1 sign bit = 21.19 ≈ 21 bits.

Thus, a resolution of **1,200,000** counts, **6-1/2** (6.08) **digits**, **0.0001 %**, **1 ppm**, and **21 bits** are all roughly equivalent.

Accuracy is far more important than resolution; however, accuracy depends on many factors external to the instrument itself. Accuracy is typically given as the sum of two terms: (i) relative error often expressed as a percent of reading and (ii) absolute error expressed either as a fixed value or as a percent of range. The accuracy of this instrument for **DC voltage** measurement may be *generally* rated at **0.005 % of reading** (relative error) plus **0.001 % of full scale** (absolute error).

Except for certain special settings, this multimeter uses a patented **multislope integrating** analog-to-digital (A/D) converter with autozero.

Resolution/integration-times (sampling rates):

(1) 4-1/2 digits, fast; (**2**) 4-1/2 digits, slow;
(3) 5-1/2 digits**,** fast; (**4**) **5-1/2 digits, slow**;
(**5**) 6-1/2 digits, fast; or (6) 6-1/2 digits, slow

(**2**), (**4**) or (**5**) if you press DIGIT keys

NPLCs **:** N° of Power Line Cycles

NMR **:** Normal Mode Rejection

set **indirectly** when you select Digits

Digits	NPLCs	Integration Time 60 Hz (50 Hz)	NMR
4½ Fast	0.02	400 µs (400 µs)	–
4½ Slow	1	16.7 ms (20 ms)	60 dB
5½ Fast	0.2	3 ms (3 ms)	–
5½ Slow	10	167 ms (200 ms)	60 dB
6½ Fast	10	167 ms (200 ms)	60 dB
6½ Slow	100	1.67 sec (2 sec)	60 dB

Range (Auto @ 10% and 120% of full scale / Man) – local to selected function

- **DCV :** 100mV, 1V, 10V, 100V, **1kV**
- (in MEAS menu) **DCV ratio :** Ratio ref. –12V to +12V **vs.** DCV [**ratio** = DCV/ref]

A: MEASurement MENU

1: AC FILTER → 2: CONTINUITY → 3: INPUT R → 4: RATIO FUNC → 5: RESOLUTION

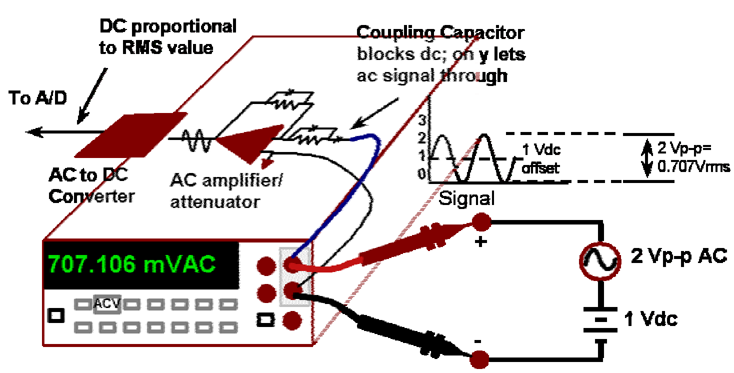
- AC-coupled* **ACV_{rms} :** 100mV, 1V, 10V, 100V, **750V** (accuracy spec ends @ **300kHz**)
- **F :** 3Hz … **300kHz**, **T** =1/F (reciprocal counting technique; gate time: 1s, 0.1s → 5-1/2digit, 0.01s)
- **DCI :** 10mA, 100mA, 1A, **3A**
- AC-coupled* **ACI_{rms} :** 1A, **3A**
- 2W or 4W **R :** 100Ω, 1kΩ, 10kΩ, 100kΩ, 1MΩ, 10MΩ, 100MΩ
- **cont**inuity**:** fixed 1 mA test current, user setable threshold between 1 and 1000 Ω, and on/off beep control
- **diode:** fixed 1 mA test current and 1 V range with beep for values between 0.3 and 0.8 V (Si diode)

* AC coupling **filter**: 3Hz [slow], 20Hz [medium], 200Hz (DC offset up to 400V; crest factor max 5:1 @ full scale)

An **ac-coupled true RMS** measurement is desirable in situations where you are measuring small ac signals in the presence of large dc offsets. [For example, this situation is common when measuring ac ripple present on dc power supplies.]

There are situations, however, where you might want to know the **ac+dc true RMS** value. You can determine this value by combining results from dc and ac measurements as shown below. You should perform the dc measurement using at least 10 power line cycles of integration (6 digit mode) for best ac rejection.

$$ac + dc = \sqrt{ac^2 + dc^2}$$



MATH (one-at-a-time)**:** store MIN – MAX, avg, count; subtract NULL ref; dB or dBm rel (only DCV or ACV); limit test (in MATH menu)

B: MATH MENU

1: MIN-MAX → 2: NULL VALUE → 3: dB REL → 4: dBm REF R → 5: LIMIT TEST → 6: HIGH LIMIT → 7: LOW LIMIT

TRIGger: **Single** or **Auto** (default, * [sample] annunciator turns on during each measurement).

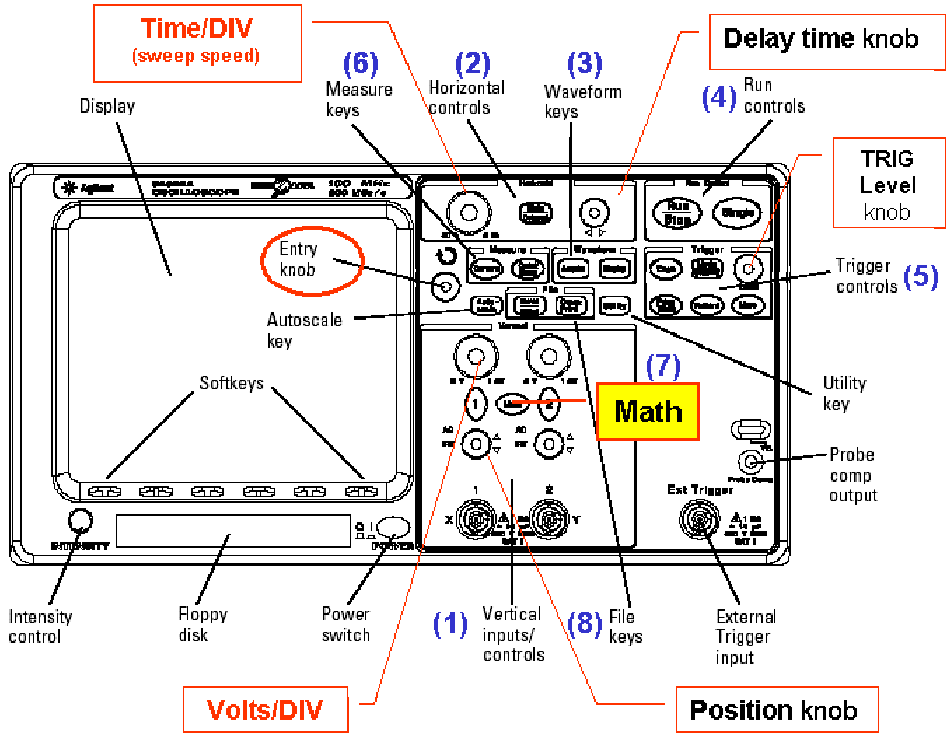
Note: The **Trig** annunciator turns on when the multimeter is waiting for a trigger (auto trig disabled).

Reading Hold sensitivities (in TRIG menu): 0.01%, **0.1%,** 1%, 10%

Reset state (default settings) @ power on.

54622A Oscilloscope (Scope):

2 Ch, **100** MHz; max **200** Msa/s, max **2** MB/Ch (**Mega*Zoom***)
Hi-Def display, flexible Trig; autoMeas, **2K FFT**
Buttons appearing with a **GREEN** light are active.



(3) Waveform (press **Acquire** hardkey)

1 ms/DIV or slower
(10 ms/5 ns = 2M)

#AVG	resolution
1	8
4	9
16	10
64	11
256	12

(@ stable TRIG,
up to **16K** #AVG)

#AVG = 1	HiRes
2 us/DIV	8 bit
5 us/	9 bit
20 us/	10 bit
100 us/	11 bit
500 us/	12 bit

OS: oversampling &
DF: decimation filter

2 us/Div or faster *
(20 us/5 ns = 4K),
with reduced BW
(200MSPS/4= 50MHz)

(@ one TRIG event,
SINC interpolation)

* or infrequent trigger, complex waveform

Waveform (press **Display** hardkey)

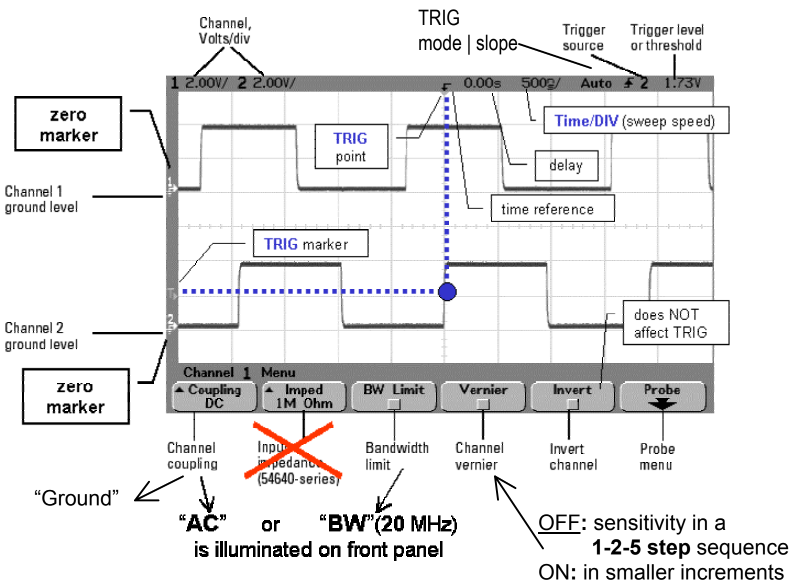
ON ("connect the dot":
LIN interpolation)

OFF

use Entry knob

NOTE: the **probe ground** (alligator clip) is **CONNECTED** to the **earth ground (chassis) !!**
If you use 2 probes, both alligator clip MUST be connected to the SAME point.

(1) Vertical (press **1** [or **2**] hardkey)



8 DIV vertical

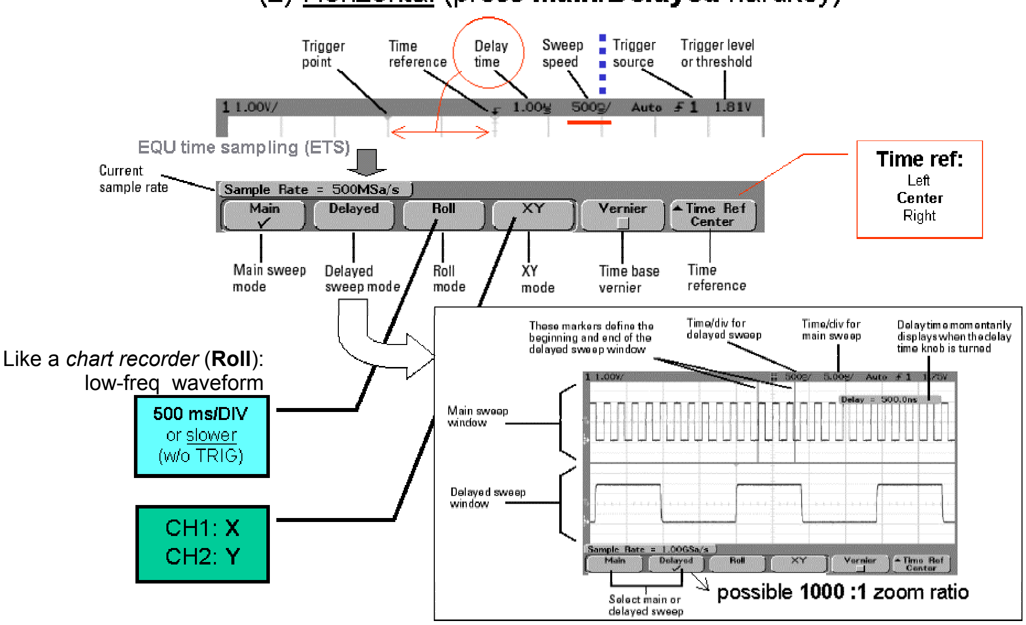
sensitivity:
1 mV/DIV to **5 V**/DIV

max 300V_{rms}, 400V_{pk}

With 10074C **10:1 probe**
(Auto probe): 500 V_{pk}
Impedance: **10 MΩ**
Ref button on probe:
zero ("Ground")

Note:
built-in **Help** - pressing and **holding** ANY key /the button function itself will NOT execute/

(2) Horizontal (press **Main/Delayed** hardkey)



Main horizontal mode is the normal viewing mode for the oscilloscope.

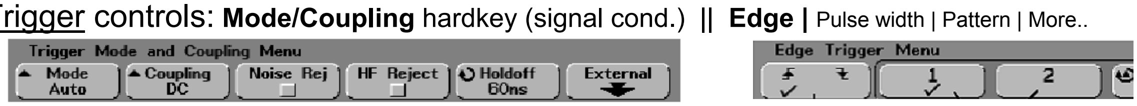
(4) Run controls
Run/Stop and **Single** key

Mega*Zoom*:
When the oscilloscope is stopped, you can use the Horizontal knobs to **pan and zoom** the waveform (about the Time reference point).

10 DIV horizontal

sweep speed:
5 ns/DIV to **50 s**/DIV
(resolution: 40 ps)

(5) Trigger controls: **Mode/Coupling** hardkey (signal cond.) || **Edge** | Pulse width | Pattern | More..



Mode: Normal / Auto / AutoLevel || **Coupling:** DC, AC, LF Reject, (TV) (slope: ↑) (source: 1)

(6) Measure keys: **Quick Meas** (→ auto) or **Cursors** (→ manual) hardkey

Measurements and math functions are performed on DISPLAYED data !!

Note: • Average, **RMS (dc)** value of the waveform over one or more **full** periods (or on full width of the display)
• **Counter** (trig level crossing; reciprocal counting technique) up to **125 MHz**

(7) Math functions (press **Math** hardkey): **FFT (2K)**, **Mult, Sub, Diff, Int**

(8) File keys: **Save/Recall** (traces and setups; 3 internal non-volatile memory); ~~Quick Print~~

Default setting: 'Save/Recall' key 'Default Setup' softkey

54622A Oscilloscope (Scope) – 2K <u>FFT</u> <u>spectrum analysis</u>

N (= **2K**) point <u>FFT</u>**:**

(1) Data capture (time record)

$T = N \cdot \Delta t = 10 \cdot$**"Time/DIV"**

T: capture time

$\Delta t = 1/fs$, and **fs:** <u>FFT sample rate</u>

↓

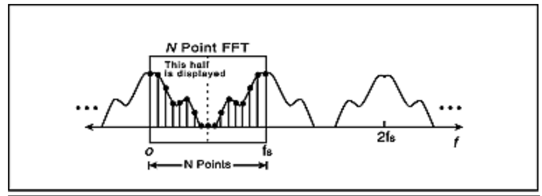
fs = (N/10)/**"Time/DIV"**

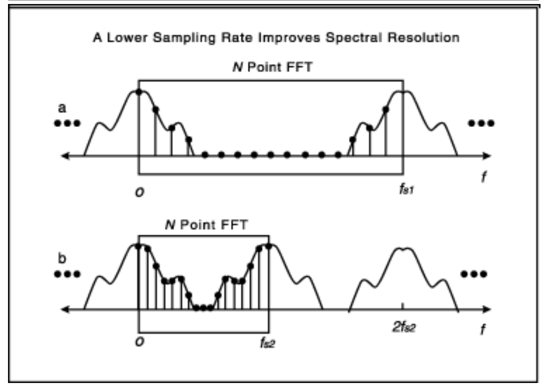
(2) <u>Math</u>: FFT (= DFT = Fourier series)

Span = <u>**fs**/2</u>

Resolution (Δf) = <u>1/T</u> = **fs**/N = 0.1/**"Time/DIV"**

- Key performance specifications of the FFT operation depend on the <u>sweep time</u> (**"Time/DIV"**)

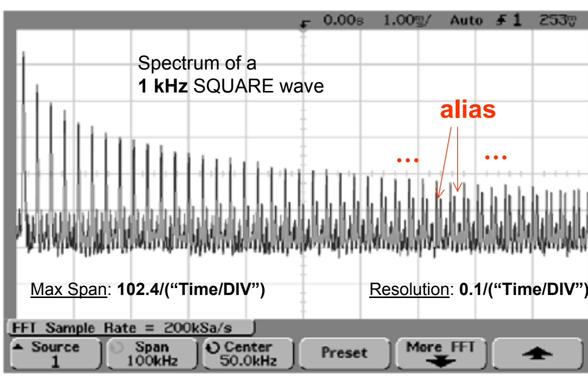


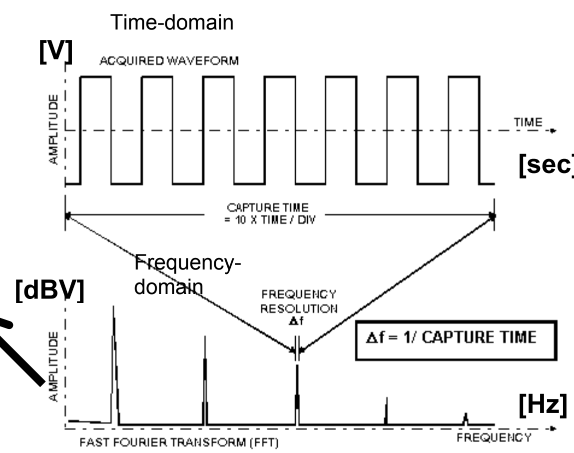


FFT Units The readout for the <u>horizontal</u> axis changes from time to **frequency** (Hz) and the <u>vertical</u> readout changes from volts to **dB**. FFT units (amplitude) will be displayed in **dBV** when channel units is set to Volts

<u>Note</u>: Once the function is displayed, the analog channel(s) may be turned off for better viewing

Aliasing Aliasing happens when there are frequency components in the signal <u>higher</u> <u>than</u> **half** the effective sample rate. Components of the input signal above the Nyquist frequency will be <u>mirrored</u> (aliased) on the display and reflected off the right edge





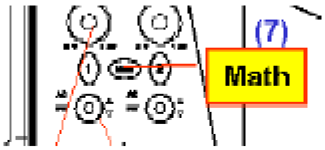
Window The type of "window" that is used to generate the FFT is important:

Hanning – for making **accurate <u>frequency</u> measurements** or for resolving two freq that are close together

Flat Top – for making **accurate <u>amplitude</u> measurements** of frequency peaks

Rectangular – good freq resolution and ampl accuracy, **but** use only where there will be no **leakage** effects; use on self-windowing waveforms (as pseudo-random noise, impulses, sine bursts, and decaying sinusoids)

Spectral Leakage The FFT operation assumes that the time record repeats. Unless there are an integral number of cycles of the sampled waveform in the record, a discontinuity is created at the end of the record. This is referred to as leakage. In order to minimize spectral leakage, **windows** that approach zero smoothly at the beginning and end of the signal are employed as filters to the FFT.



2K FFT (dBV vs. frequency)

Press the **Math** key, press the **FFT** softkey, then press the **Settings** softkey to display the FFT menu.

Source select

Frequency Span

Center frequency

Preset Span and Center frequencies

Vertical and Window FFT controls

Return to previous menu

1, 2, 1+2, 1-2, 1*2

set by Time/DIV

FFT Scale

FFT Offset

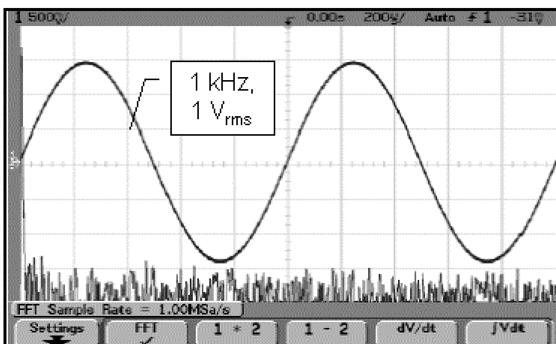
Window

Hanning (freq)
Flat Top (ampl)
Rectangular

Scale and offset considerations

If you do not manually change the FFT scale or offset settings, when you turn the horizontal sweep speed knob, the span and center frequency settings will automatically change to allow optimum viewing of the full spectrum. If you do manually set scale or offset, turning the sweep speed knob will not change the span or center frequency settings, allowing you see better detail around a specific frequency. Pressing the FFT **Preset** softkey will automatically rescale the waveform and span and center will again automatically track the horizontal sweep speed setting.

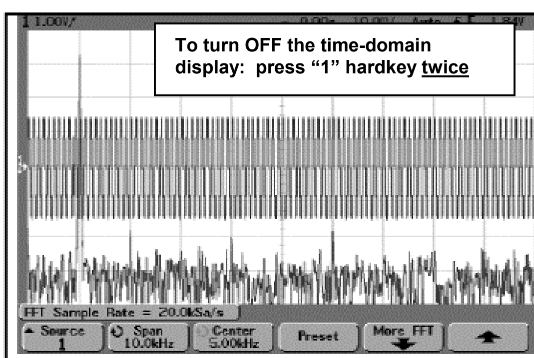
Time domain vs. frequency domain ($\Delta t \cdot \Delta f = 1/N$; $N = 2K$)



time/div = 200 µs
FFT sample rate = 1.00 MSa/s
Span = 500 kHz
Center = 250 kHz

Δt **= 1 / sample_rate**

change
the **time/DIV**
(i.e. sample_rate)



To turn OFF the time-domain display: press "1" hardkey <u>twice</u>

time/div = 10 ms
FFT sample rate = 20 kSa/s
Span = 10.0 kHz
Center = 5.00 kHz

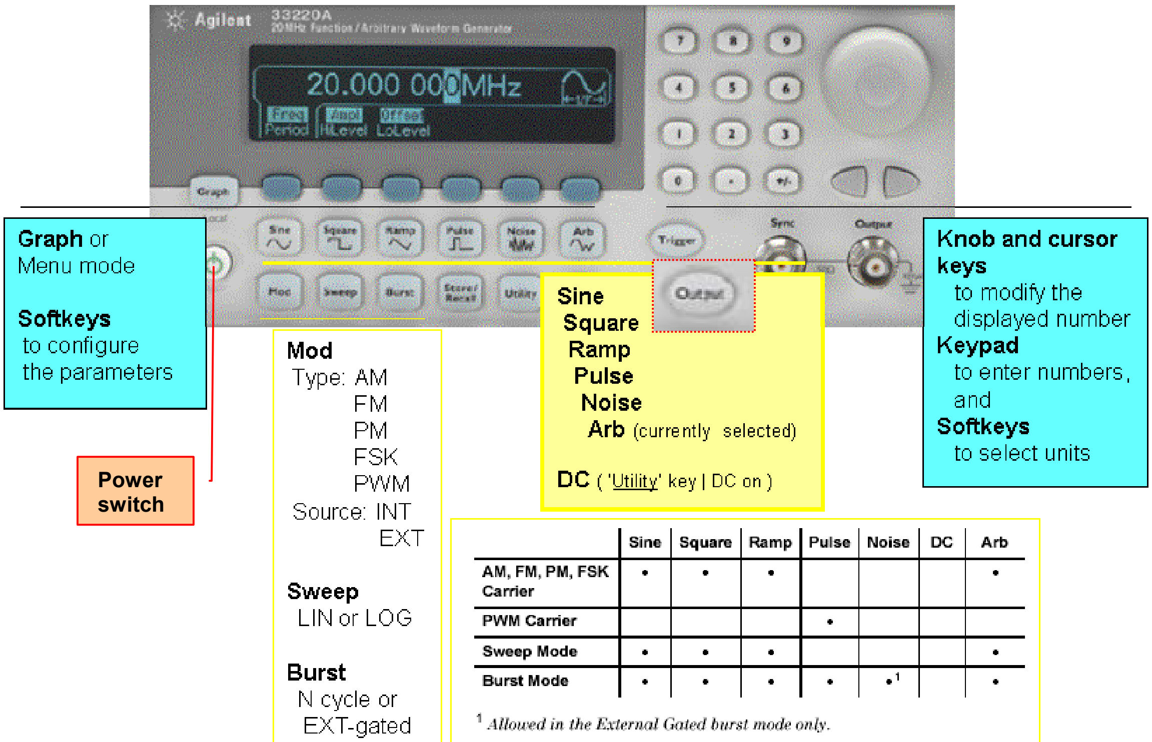
There are two (2) graphs shown here: voltage vs. time (over a 100 ms interval) and voltage vs. ***frequency*** (in a "window" 10 kHz wide).

Δf **= sample_rate / N**

33220A Function/ARBitrary waveform generator (ARBgen):

20 MHz sine and square; variable-edge **pulse**, ARBs, modulations
14-bit, **50** MSa/s, **64K**-point **DDS** (a 2^{nd} DDS for **Mod** INTernal sources)

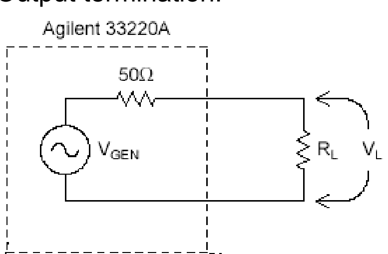
Output configuration: waveform and parameters



	Sine	Square	Ramp	Pulse	Noise	DC	Arb
AM, FM, PM, FSK Carrier	•	•	•				•
PWM Carrier				•			
Sweep Mode	•	•	•				•
Burst Mode	•	•	•	•	•[1]		•

[1] *Allowed in the External Gated burst mode only.*

Output termination:



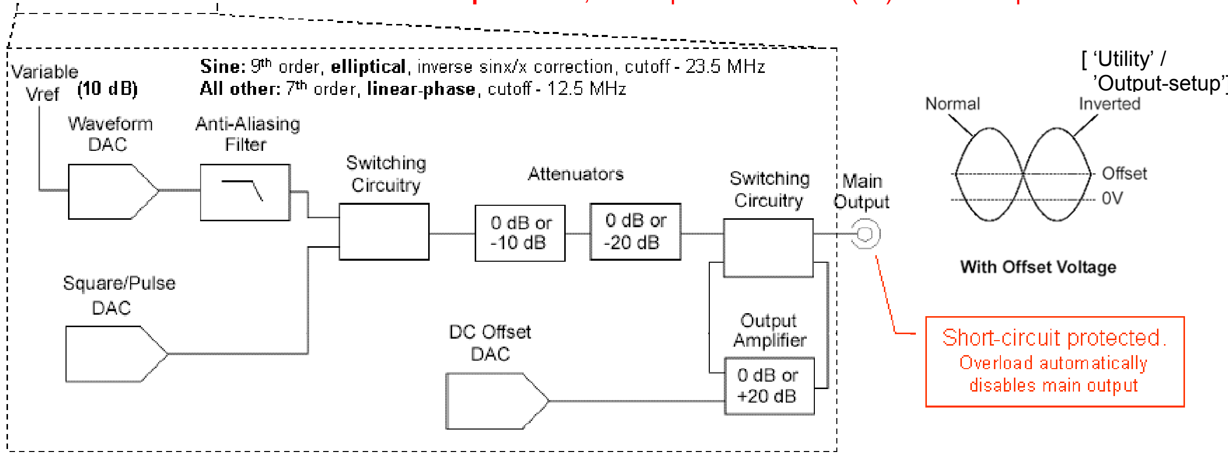
Setting of the **termination (R_L)** ['Utility' / 'Output-setup'] is simply provided *as a convenience* to ensure that **the displayed** voltage matches the **expected** load :

1 ohm – 10 Kohm or High impedance (High Z),

The default is **50 ohm**.

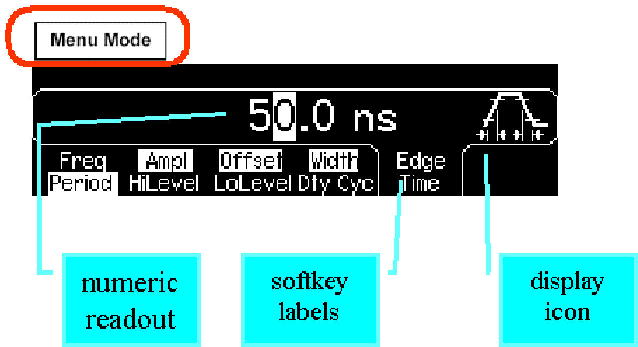
Note: matching prevents reflexions, $V_L = V_{GEN}/2$

If you specify 50 ohm termination but are actually terminating into an **open** circuit, the output will be **twice** (**2x**) the value specified !!



NOTE: the signal generation portion is **ISOLATED** from chassis (earth) ground !!

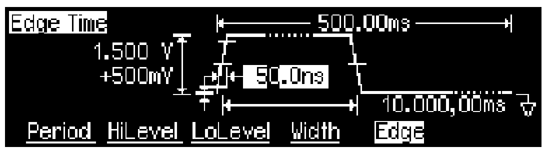
Display: **numeric** vs. **graphical** views



<u>Note</u>:
To get context-sensitive **help** on any front-panel key or menu softkey, <u>press</u> and <u>hold down</u> that key.

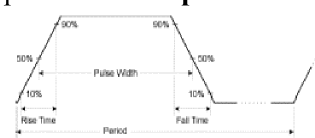
or
use **Help** key

Press the Graph key to enable the Graph Mode. The name of the currently selected parameter, shown in the upper-left corner of the display, and the parameter's numeric value field are both highlighted.



To exit the Graph Mode, press Graph again.

<u>Note</u>: parameters for **pulse** waveform



Pulse period: 200 ns to 2000 s.

Period $\geq$ Pulse Width + (1.6 X Edge Time)

Edge time: 5 ns to 100 ns

<u>Remark</u>: The '**Graph**' key also serves as a **<u>LOCAL</u>** <u>key</u>
to restore front-panel control after <u>remote interface</u> operations.

The function generator produces a **periodic** waveform with a user selectable **shape** (sine, …) <u>frequency</u>, <u>amplitude</u>, <u>offset</u>, and *modulation*. The output voltage is given by

$$V_{GEN}(t) = V_{DC} + V_{AC}(t) = V_{offset} + A \cdot u(t)$$

where u(t) **:** normalized periodic waveform, **u(t+T) = u(t),** *min* u(t) = **-1**, *max* u(t) = **+1** for all t
T **:** period of waveform (**frequency : f** = 1/T)
A **: amplitude**, **A** = $V_{pp}/2$ = CF·V_{rms}
V_{pp} **:** peak-to-peak AC voltage
V_{rms} **:** effective (root-mean-square) voltage, $V_{rms} = \sqrt{\frac{1}{T}\int_o^T \left(V_{GEN}(t) - V_{offset}(t)\right)^2 dt}$
CF **:** crest factor, CF = A/V_{rms}

Function	Minimum Frequency	Maximum Frequency
Sine	1 µHz	20 MHz
Square	1 µHz	20 MHz
Ramp	1 µHz	200 kHz
Pulse	500 µHz	5 MHz
Noise, DC	Not Applicable	Not Applicable
Arbs	1 µHz	6 MHz

$V_{pp} \leq 2 \text{ X } (V_{max} - |V_{offset}|)$

V*max* is the **maximum** *peak voltage* for the selected output termination,
5 Volts for a <u>50 ohm</u> <u>load</u> or
10 Volts for a <u>high-impedance</u> <u>load</u>.

Amplitude range**:** 20 mV_{pp} to **20 V_{pp}** into **<u>open</u>** <u>circuit</u>; units**:** V_{pp}, V_{rms}, dBm; resolution **:** 4 digits
<u>Note</u>: set the AC magnitude before setting the offset !
DC offset range (peak AC + DC)**:** ± **10 V** into **<u>open</u>** <u>circuit</u>; resolution **:** 4 digits

ARBitrary waveforms: 5 built-in (Sinc, Cardiac …) + user-defined (*Waveform Editor*)

Default setting: 'Store/Recall' key 'Set to default' softkey