

Info. MérésLabor 2. tárgy *(tavaszi félév)*

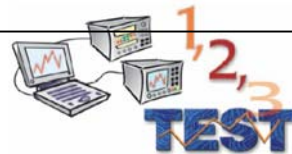
- **a Tárgy**

... **követelmények** és számonkérés

- *Mérések / mérőcsoport (2 fő)*

... saját **időtábla**

- **a Munkahely**



... szakszerűség, **biztonság (! aláírás !)**

alapMűszerek kezelése

a **Tárgy** → **Mérnöki/gyakorlati munka**

„ Ha én mérnök volnék, mér ’ne sokat mérnék ...”

Jegyzet: van (Mérési utm., Műszerismertető)

WEB lap:

<http://www.mit.bme.hu/oktatas/targyak/vimia216/>

Öt helyszín: IB413, IE226, **IL107**, V2/405 a,b

3 (4) időpont (kurzus) ...

Követelmények:

B+5 mérés, **1** ellenőrző mérés (**időtábla**)

- **Minden** mérést el kell végezni! •

Gondos munka

(és a mérőhelyek eszközeinek száma csak nőhet!)

Józan, de **szigorú** labor szabályok

(legfontosabb a BIZTONSÁG;
hetenként *több mint 150 ember* dolgozik a laborban)

3K szabály („főbenjáró bűnök”):

- **Késés** (hiányzás??)
 - **Készületlenség**
 - **szaKszerűtlenség**
- } → **Pótmérés**
(**csak 1** lehet)

Számonkérés:

B, 1. mérés: **nincs osztályzat**

2-5. mérés: **egyéni Házi feladat** WEB lapról
közös e-Jegyzőkönyv (magyar!)
külön-külön (!) osztályzat

Ellenőrző mérés: gyakorlati – **egyedül**
írásbeli – egyedül

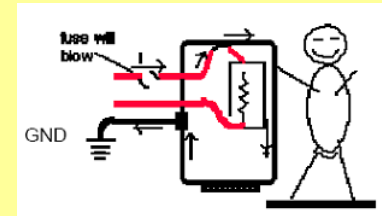
Nincs „szivatás”,
de „Róbert bácsik” sem vagyunk ...

A mérésvezető **egyénenként** ad osztályzatot

- a **felkészülés** ellenőrzése (!),
- az otthon *egyedül (!)* elkészített
Házi feladat megoldása,
- a **labormunka** és
- a **közös e-Jegyzőkönyv** alapján

a Munkahely:

Balesetmegelőzési és tűzvédelmi rendszabályok betartása



Lásd még: **Hírdetőtábla**
! aláírás !

Hálózati **főkapcsoló** (csak mérésvezető), **tanári gép ... csak ezután**



Mérőhely táp-elosztó bekapcsolás,
számítógép be(!) ... és várakozás(!),
műszer(ek) be/ki kapcsolás

Mérőhely bekapcsolás

1. Mérőhely táp-elosztó – *BE*kapcs.

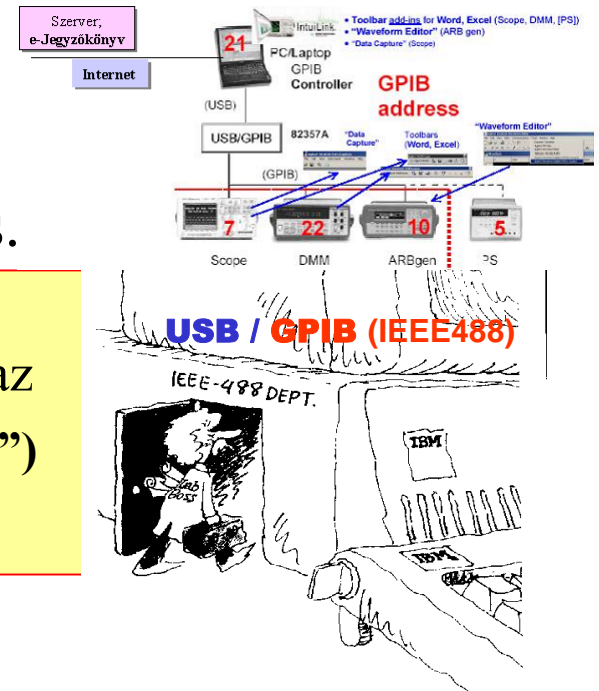
2. Számítógép – *BE*

... és „magára hagyjuk” (!), amíg az *aut.* konfigurálás lefut („fekete ablak”) (→ alaphelyzet!)

3. Műszer(ek) – *BE* / **ki**

MOST: a műszereket a bemutatás sorrendjében kapcsoljuk be („ütemezett” műszerkezelés)

Ellenőrzés: a mérőhely *rendben* ...



Szerver;
e-Jegyzőkönyv

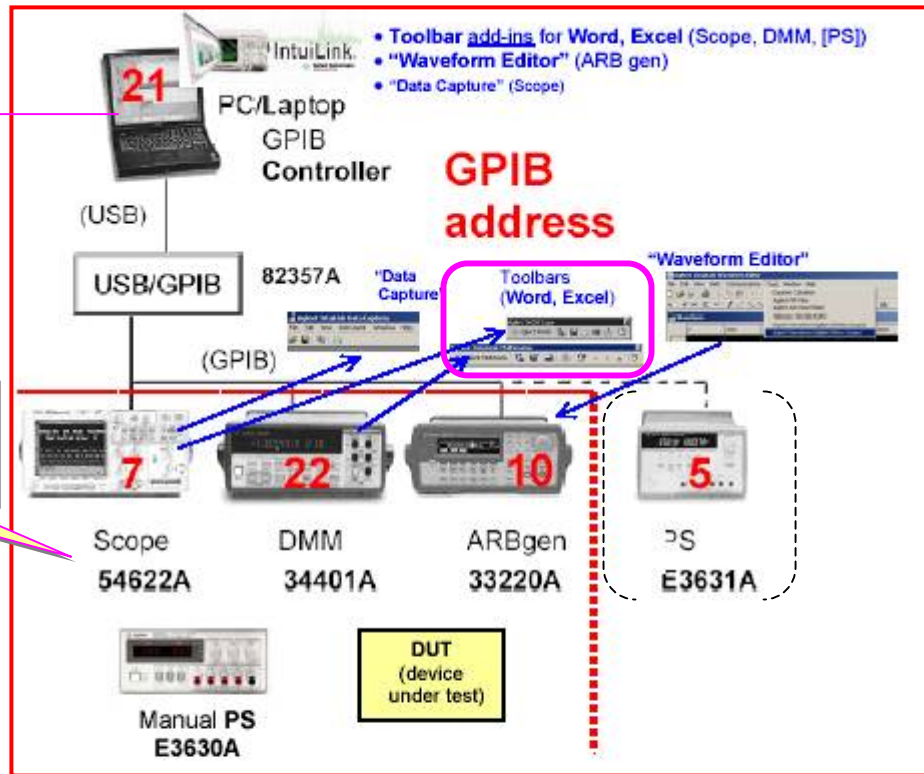
Internet

manuális
kezelés

...



METEX
ME-22T DMM



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)

Scope 54622D

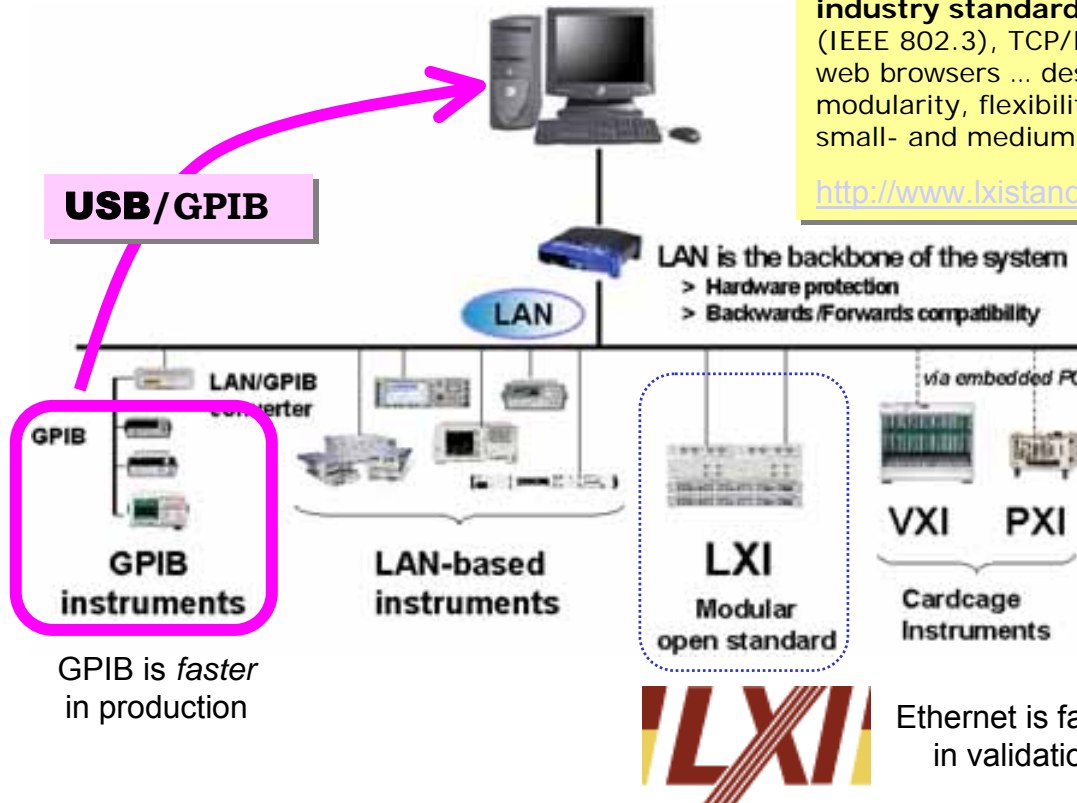
GPIB = **General Purpose Interface (Instrument) Bus**

NEW (2004): LXI = **L**AN **eX**tensions for **I**nstrumentation

LXI is an instrumentation platform based on **industry standard** Ethernet technology (IEEE 802.3), TCP/IP protocols, LAN cables, web browsers ... designed to provide modularity, flexibility and performance to small- and medium-sized systems.

<http://www.lxistandard.org/home>

**Info
LAB**



Működő mérőhely – ezt várjuk el, ilyet is hagyjunk ott!

- **kombinált (!) Vill. és Info** mérőhely(ek)
 - **alapműszerek** (tápegység, jelgenerátor; oszcilloszkóp, multiméter)
 - mérendő objektumok és kiegészítők
 - *speciális* mérőeszközök, *egyéb* mérőműszerek (!!)
 - **mérőkábelek, lezárók, IC-k ...**
 - **Win2K** op. rendszer, **MSOffice: WORD, Excel**
 - *speciális* SW-ek, *Matlab*, ...
 - **Internet**
- **e-Jegyzőkönyv: WORD** (← IntuiLink *Toolbar*)
 - jegyzőkönyvet **NEM nyomtatunk**

→ **e-mail, floppy ... pendrive(USB)**

 - **más jegyzőkönyvét NEM használhatjuk**



a Labor nem zártosztály

Mottó: „Bolondbiztos rendszert csak a bolondok használnak”

Folyománya:

- a HW elrontható → a **műszer NEM klaviatúra (!!)**
→ a **számítógép NEM játék-konzol (!!)**
- *nem igaz*, hogy „bármit működésbe lehet hozni, ha elég sokáig babrálod”
- *téveszme* az, hogy „ha valami bedugható, akkor azt dugd is be”

Műszer kezelés: SZAKSZERŰSÉG és BIZTONSÁG

- csak a **saját** eszközök használhatók (más mérőhelye *tabu*)
- *kétszer is* gondoljuk át a vezetékezést
- a méréshez szükséges műszer-üzemmódokat állítsuk be (!),
a műszer-alapbeállítást (**I/O kapcsolat**, nyelv, ... stb) **NE** módosítsuk,
CALibrálást **NE** kezdeményezzünk ... (óvatosan a *menü* választékkal !)

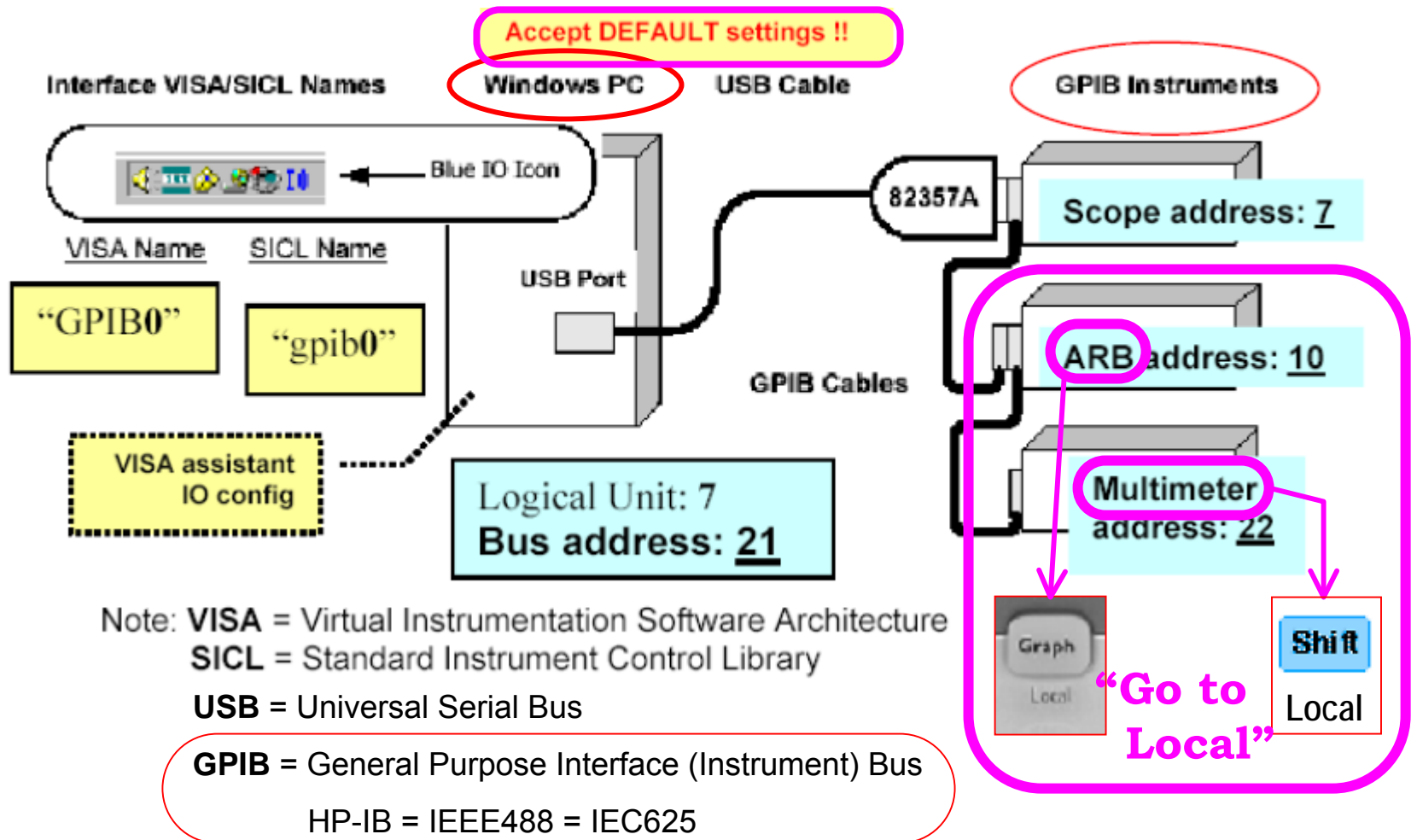
Ez súlyos
fegyelmi
vétség ...

Számítógép használat: MŰSZER-KAPCSOLAT és e-Jegyzőkönyv

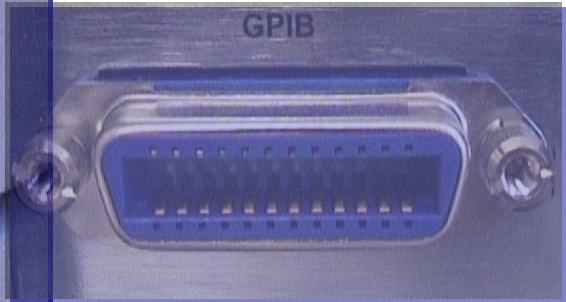
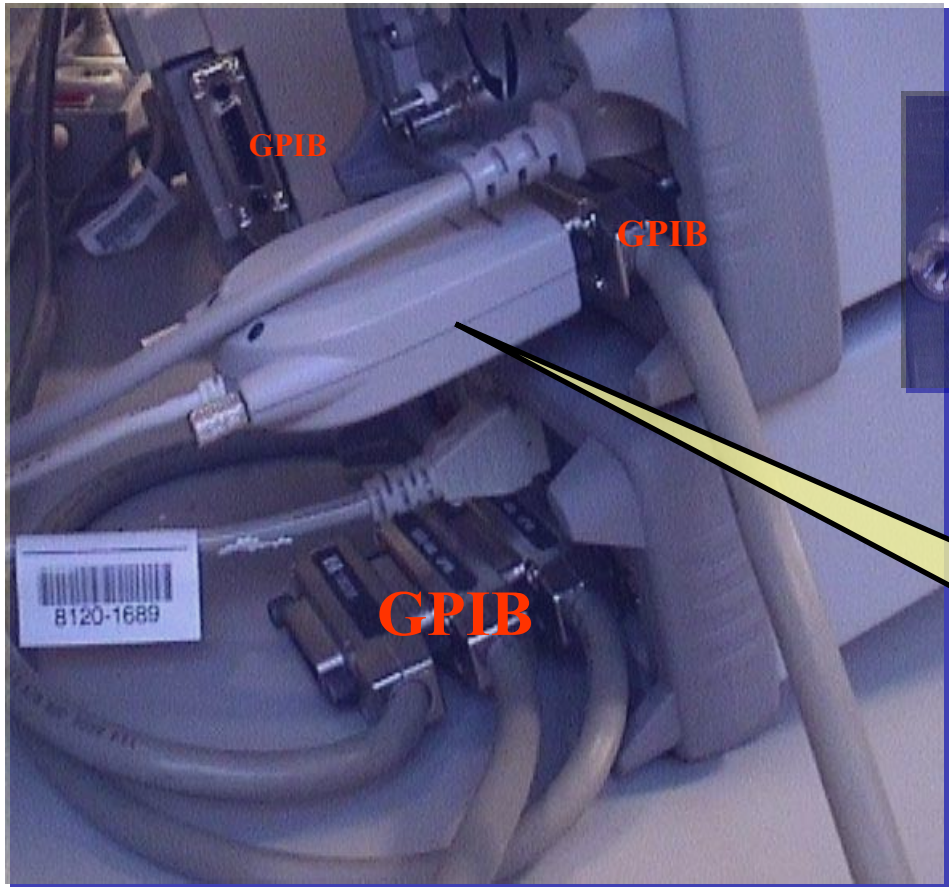
- **manuálisan** kell beállítani a műszereket: az *IntuiLink* SW „adat **copy(move)**”
és nem soft-panel (csak *néhány* funkció távvezérelhető ...)
- a **számítógépet** **NE** mozgassuk, benne **NE** turkáljunk (TILOS az **átkonfig.**,
új program betöltése, program törlés, zene-file letöltés ... stb.)

I/O interface: **USB/GPIB**

Plug-and-Play (PnP); Transparent interface



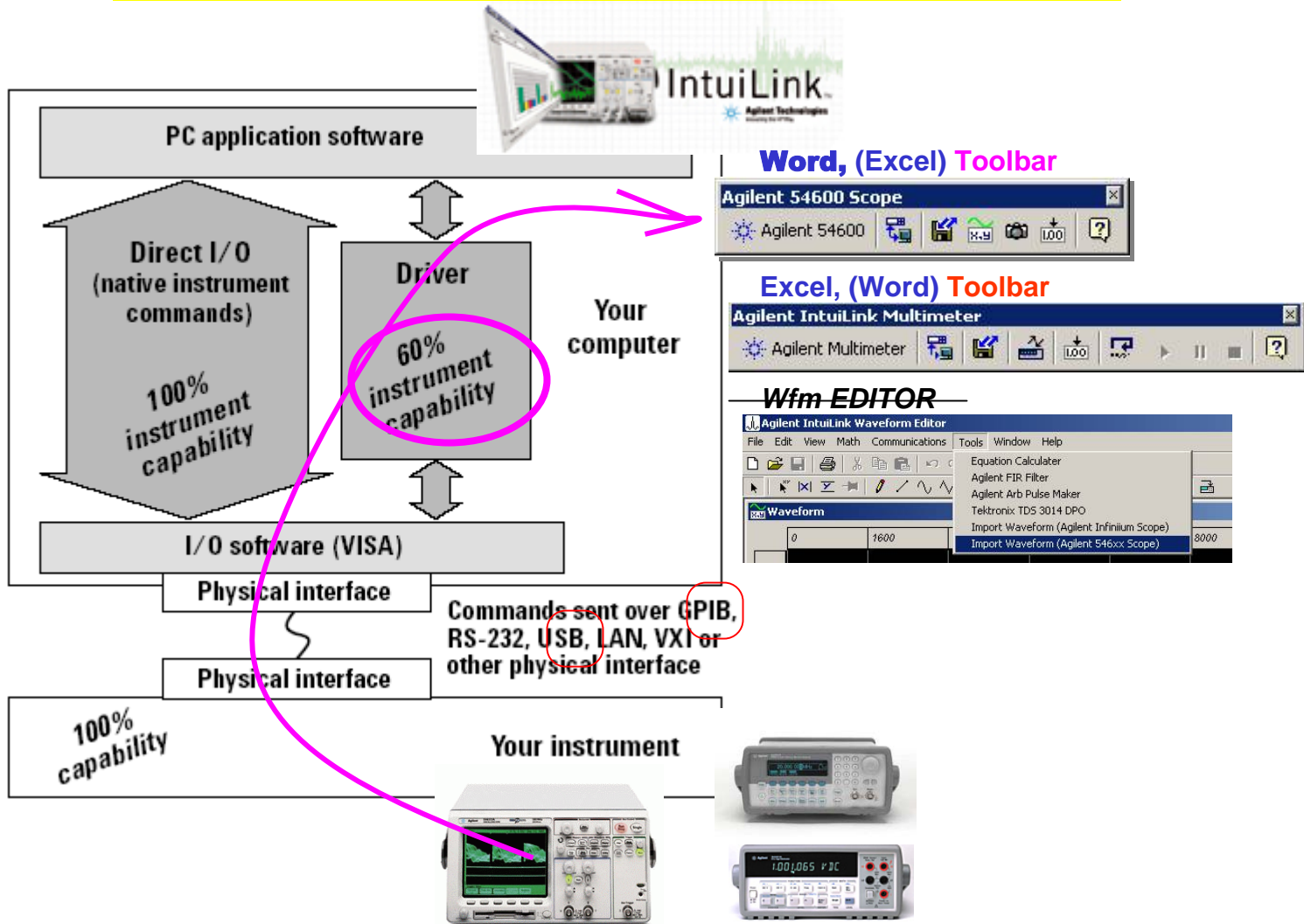
USB/GPIB



USB ↔ GPIB
átalakító
82357A

IntuiLink connectivity SW

Word, Excel **Toolbars**; stand-alone SW tools



e – Jegyzőkönyv / WORD /
(váz ← szervert)

A jegyzőkönyv ékezetes betűkkel készül!

Jegyzőkönyv írás előtt ellenőrizzük a hálózatot!

connect to Scope

data & graph

meas

Screen image

WORD /
IntuiLink Toolbar:

The image shows two screenshots of the Agilent 54600 Scope software interface. The left screenshot shows a time-domain waveform with a yellow callout box labeled 'signal' and another labeled 'spectrum'. A red circle highlights a 'Word Text box' containing the text 'Word'. Below the waveform, the 'More FFT' button is circled in green. The right screenshot shows a frequency-domain spectrum plot with a yellow callout box containing the text 'FFT (= "Fourier sor"), most nem használjuk'. A red circle highlights the 'Screen image' icon in the toolbar. Red arrows point from the 'connect to Scope', 'data & graph', and 'meas' labels to their respective icons in the toolbar. A red arrow points from the 'Screen image' label to the red circle around the camera icon. A green arrow points from the 'More FFT' button in the left screenshot to the 'More FFT' button in the right screenshot.

Agilent 54600 Scope

Agilent Technologies

1 1.00V/ 0.0s 500g/ Auto F E 2.17V

Agilent Technologies

0.0s 5.00g/ Stop F E 2.17V

SPECTRUM

FFT (= "Fourier sor"), most nem használjuk

Max(M): -15.3dBV
XatMax(M): 5.00kHz

FFT Sample Rate = 400kSa/s

FFT Sample Rate = 40.0kSa/s

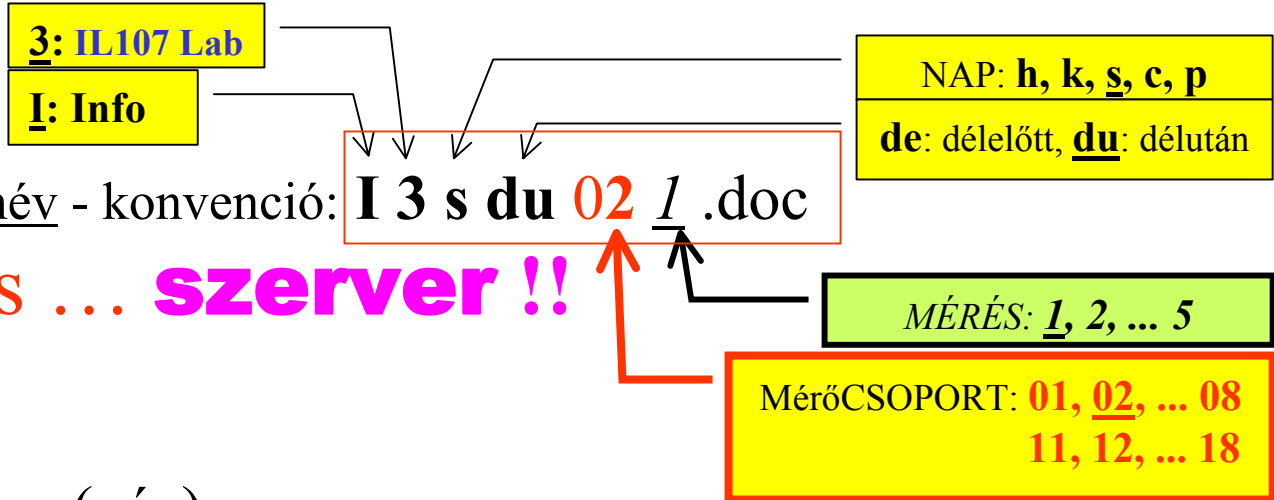
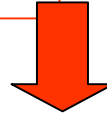
Source 1 Span 200kHz Center 100kHz Preset More FFT

Scale 10dBV/ Offset -40.0dBV Window Hanning

(press Math / FFT)

(press More FFT)

e-Jegyzőkönyv: **kód . doc** Word file



e-Jegyzőkönyv (váz): *szerveren*

a jegyzőkönyv ékezetes betűkkel készül!

Méréstechnika ...

Analóg jel (time domain):

- Tápegység (PS) ¹ **+ 6 V, ± 20 V**
- Jelgenerátor (ARBgen) ²
- Oszilloszkóp (Scope) ³
- Multiméter (DMM) ⁴

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

forma: Sine, Square, Ramp, Pulse, Noise, ARB, (DC)

$$u(t+T) = u(t), \min u(t) = -1, \max u(t) = +1$$

$$T = 1/F$$

$$A = V_{pp}/2 = CF \cdot V_{rms}, CF : \text{crest factor}$$

20 MHz sine, square
5 MHz pulse ...

V_{OUT}

Paraméter mérés: Oszilloszkóp *kontra* Multiméter
DC vagy AC csatolás

Scope: Ch1, Ch2, Math (source)

Select Measurement

Amplitude

$$Ampl = Top - Base!!$$

Average

$$Average = \frac{\sum x_i}{n}$$

Base

Counter

Delay

Duty Cycle

Fall Time

Frequency

Maximum

Minimum

Overshoot

Peak-Peak

$$RMS(dc) = \sqrt{\frac{\sum (x_i)^2}{n}}$$

$$Peak - Peak = V_{pp} = Max - Min$$

Rise Time

✓ RMS

Top

+ Width

- Width

X at Max Y

X at Min Y

V_{INPUT}



100 MHz;
8 bit / 200 MSPS

Math: 1-2(diff),
... 2K FFT

direkt *kontra* differenciális (Math: 1-2) mérés

"DMM: The Swiss Army knife of test"

DMM: „dual slope”

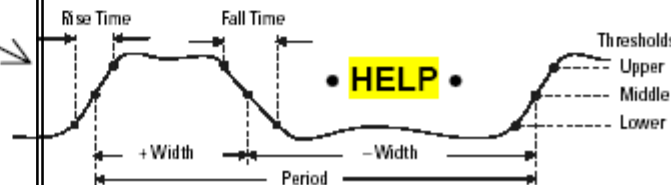
(analóg integrálás) **21 bit** (6 1/2 digit)

- V_{DC}
- V_{AC} - AC coupled true V_{rms}
- F
- T } reciprocal Counter
- ...

0.1V – 1KV
(dc, ac: 300KHz)

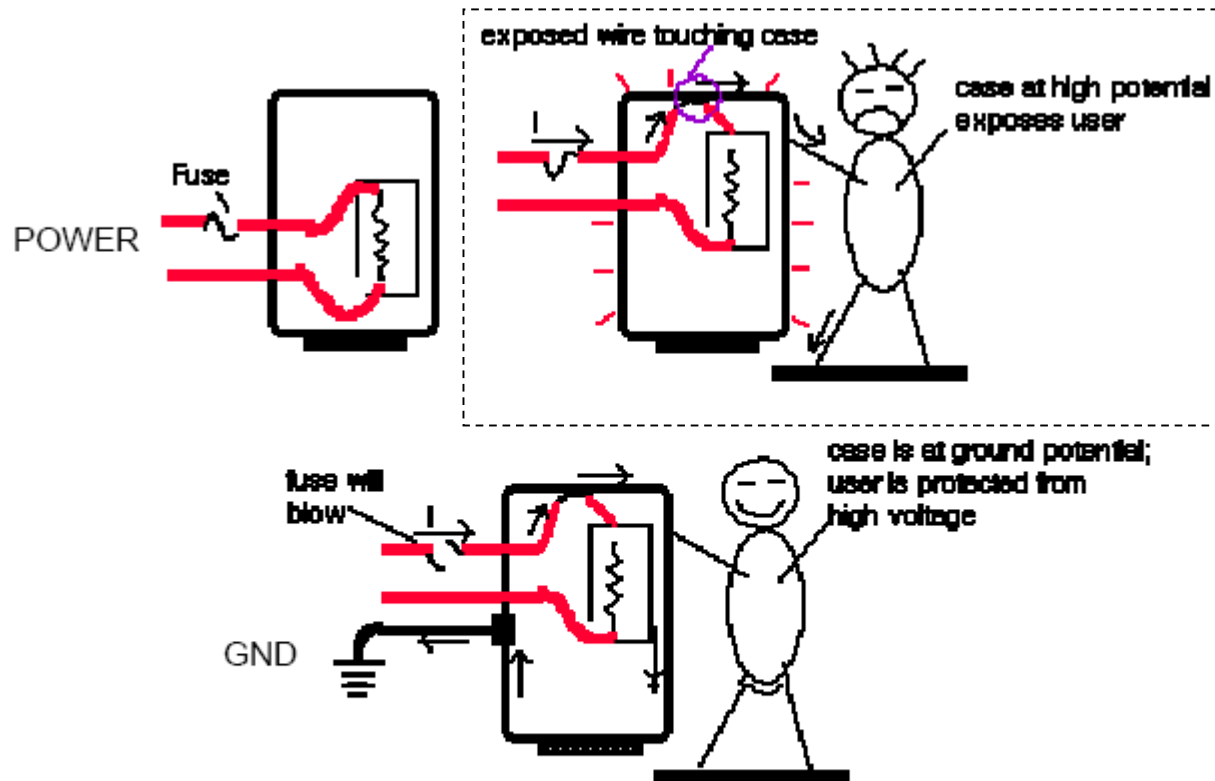
áram (I_{DC}, I_{AC} - AC coupled true RMS)
ellenállás (Ω 2W, 4W)

Math: Null, dB



Hi / Lo (= COM), GND

Minden mérőkészülék háza (biztonsági okból) az érintésvédelmi földre van kötve:



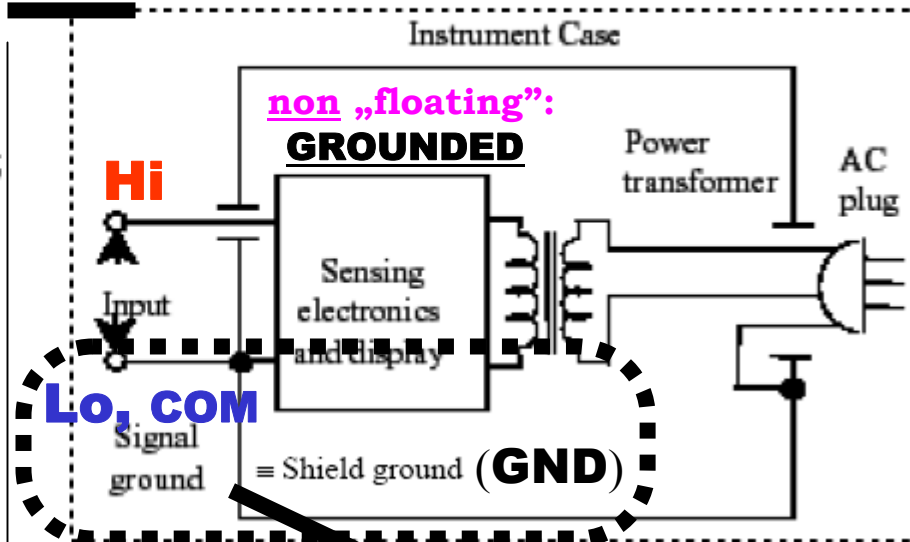
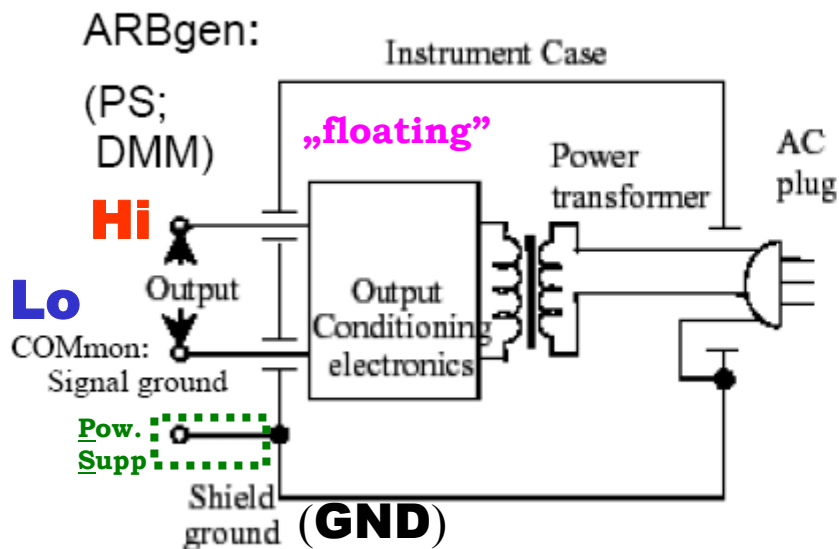
Ha a jelföld nincs hozzákötve az életvédelmi földhöz, akkor a készülék „lebeg” (a jelföld eltérő potenciálú az „igazi” föld-höz képest). Összekötés (COM \equiv GND) esetén a készülék „nem lebeg”.

- Csak az oszilloszkóp, lévén nagyfrekvenciás eszköz, „nem lebeg”.

Hi / Lo (= COM), GND

Mérőhálózat : „lebegő” műszer; érintésvédelmi föld (Shield ground)

Scope (High Frequency):



NEM lebeg →

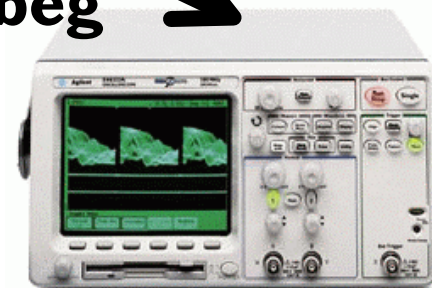


Power Supply

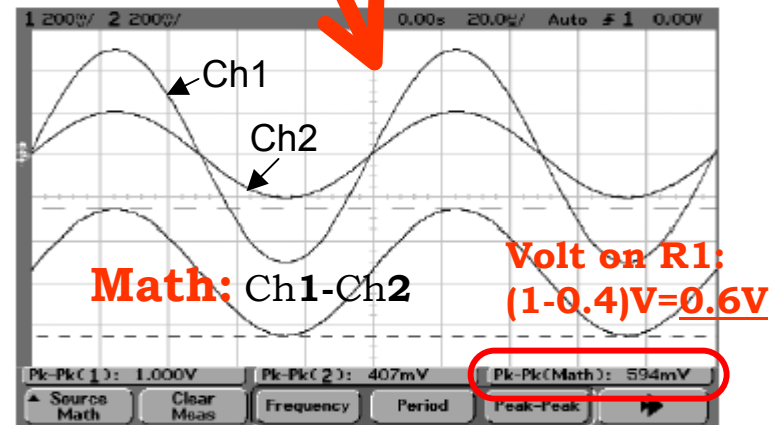
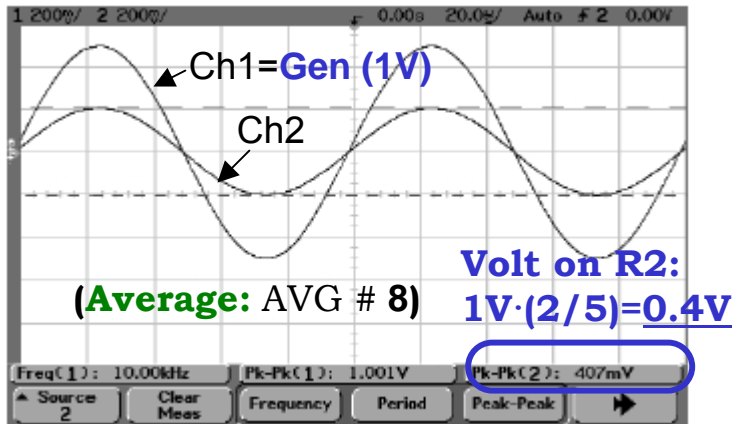
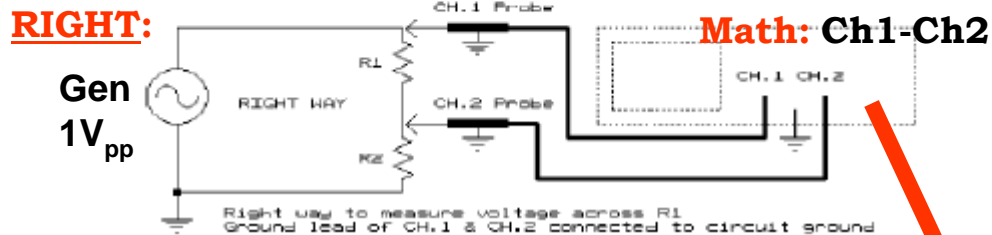
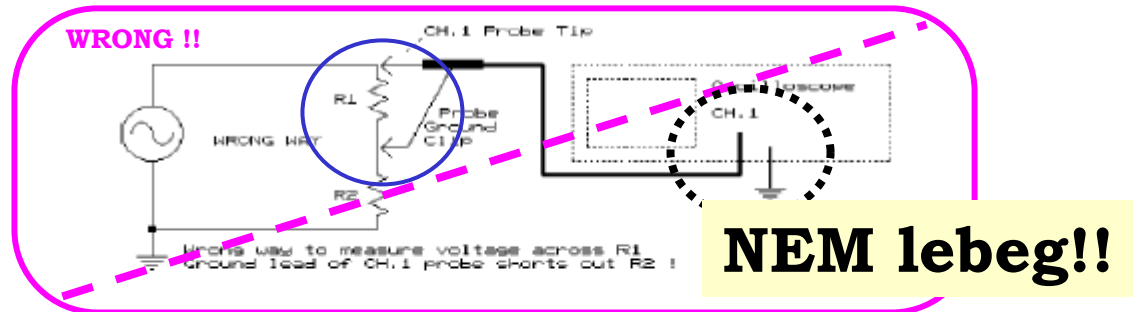


GND - NE használjuk

Lo (COM) ezt használjuk



Scope : Measure voltage across R1 ($R1 = 3K, R2 = 2K$) → **Math:1-2**



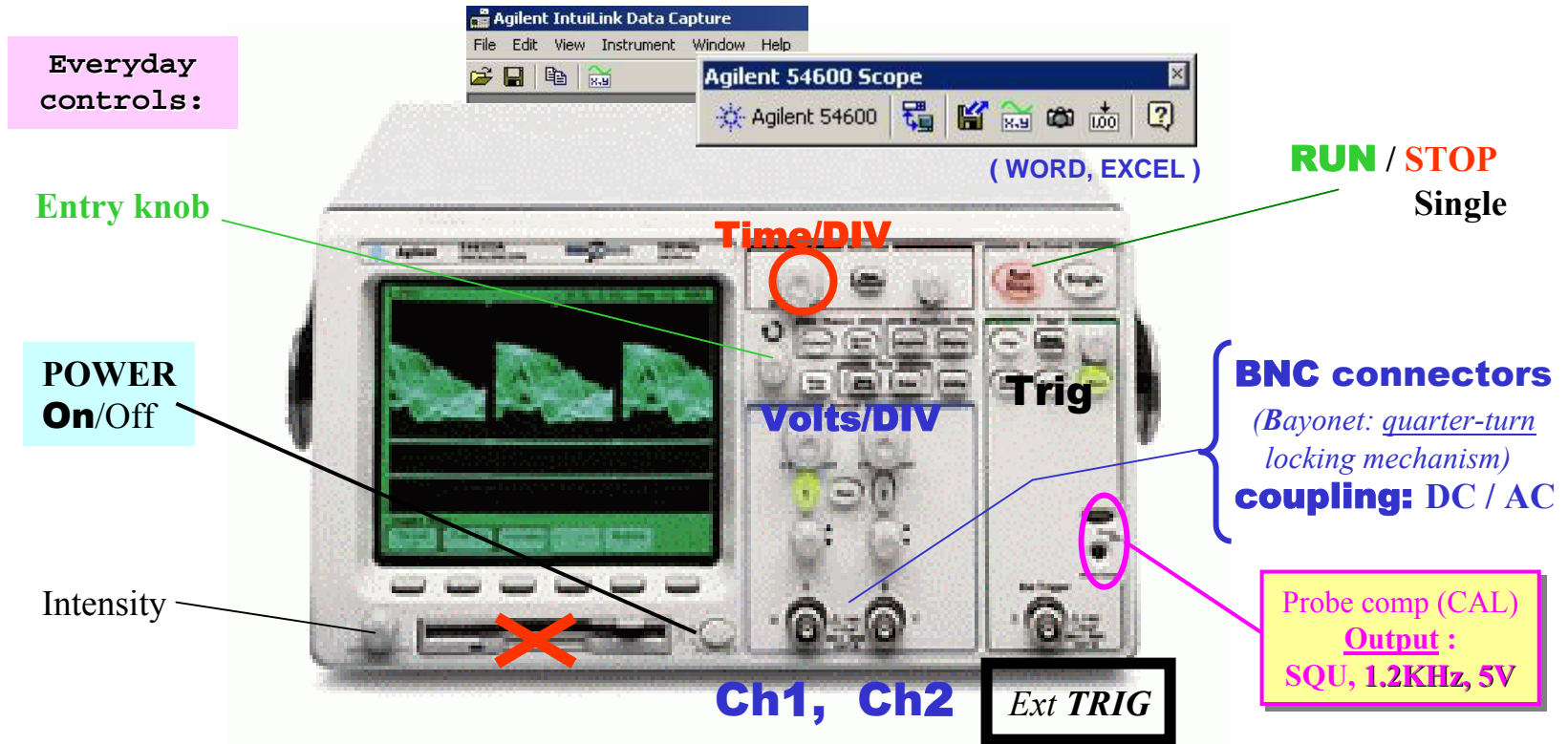
Agilent 54622A Portable Oscilloscope (DSO)

2 Ch, **100 MHz**; max 200 Msa/s, max 2 MB/ch (MegaZoom)

Hi-Def display, flexible Trig; autoMeas, **2K FFT**

~~floppy disk~~; **GPIB, IntuiLink: Toolbars**; Data Capture

*MOST nem
használjuk*



54622D MSO: Mixed Signal O'scope

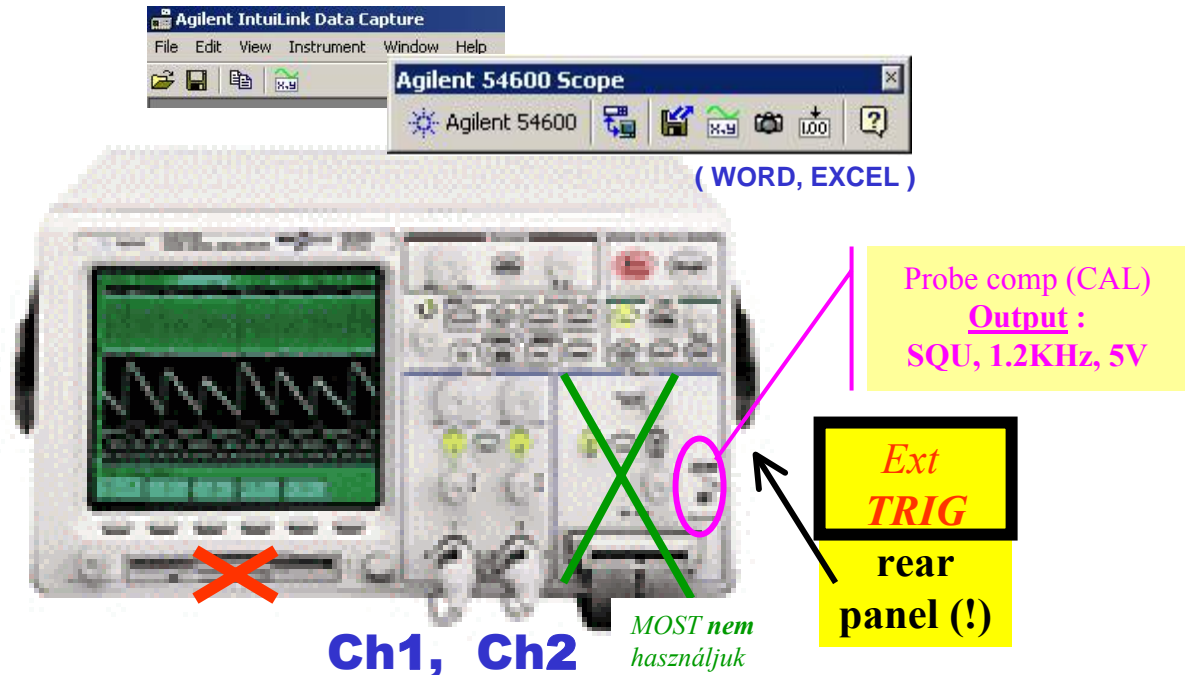
2 Ch, **100 MHz**; max 200 Msa/s, max 2 MB/ch (MegaZoom)

Hi-Def display, flexible Trig; autoMeas, **2K FFT**

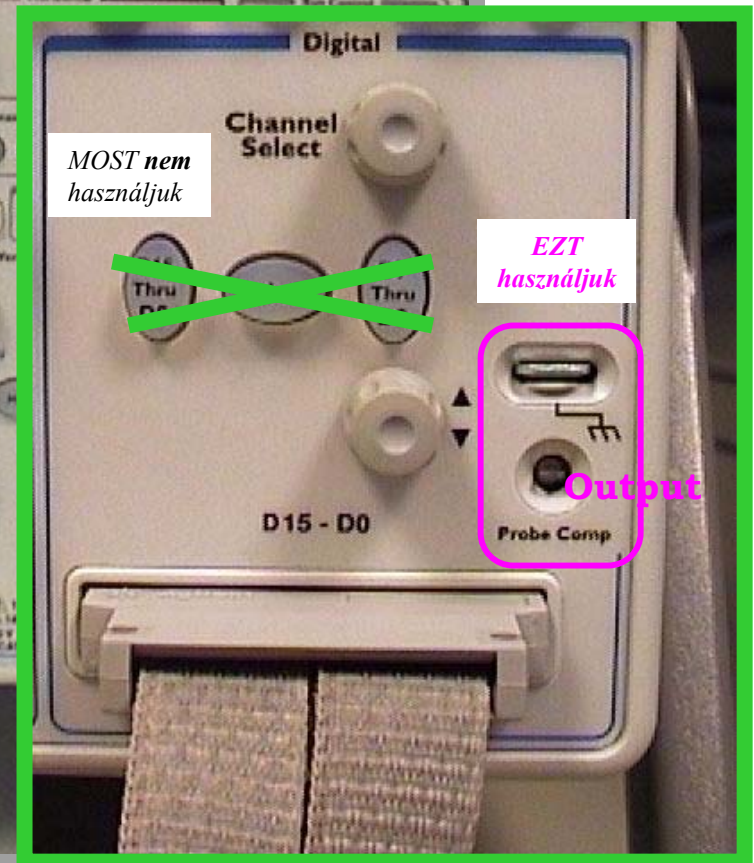
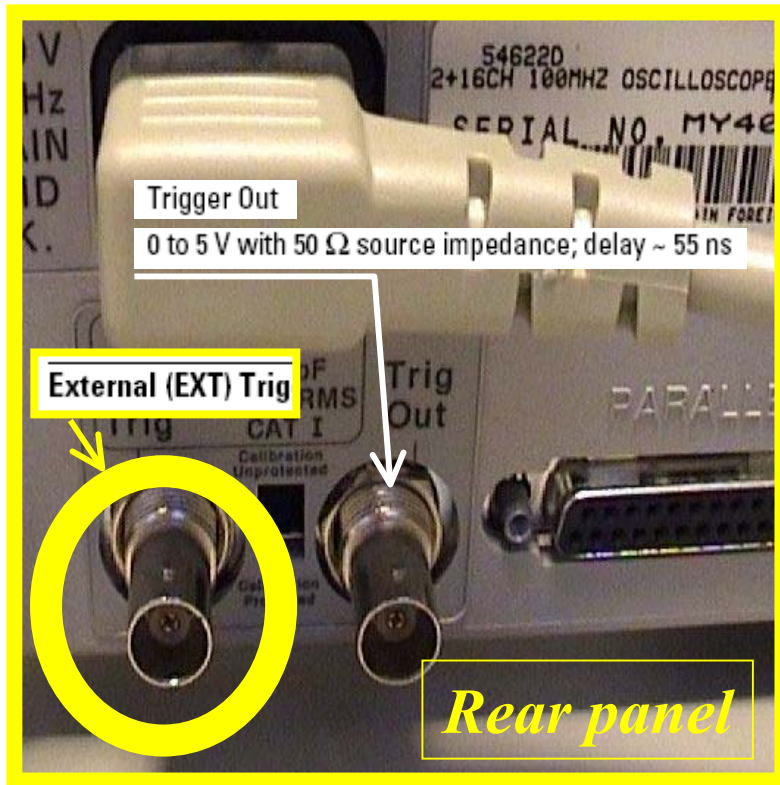
~~floppy disk~~; **GPIB, IntuiLink: Toolbars; Data Capture**

MOST nem használjuk

54622A DSO + **16 logic (digital timing) channels**

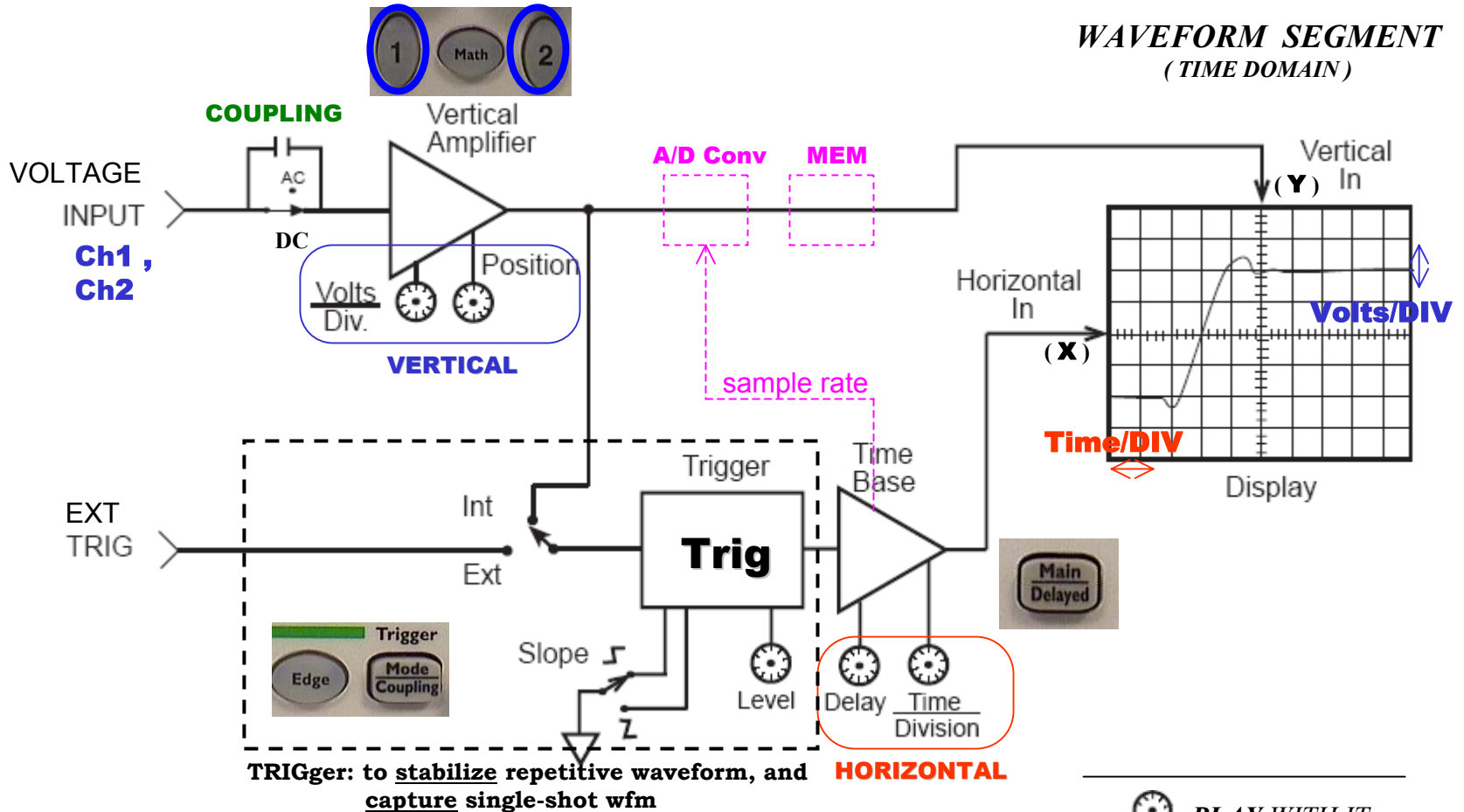


54622D Mixed Signal O'scope (MSO)

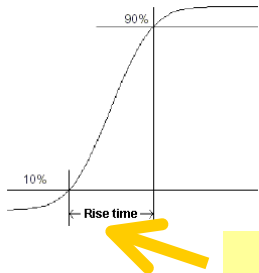


A mérésvezető segít,
ha **Ext Trig** kell ...
(BNC kábel bekötve)

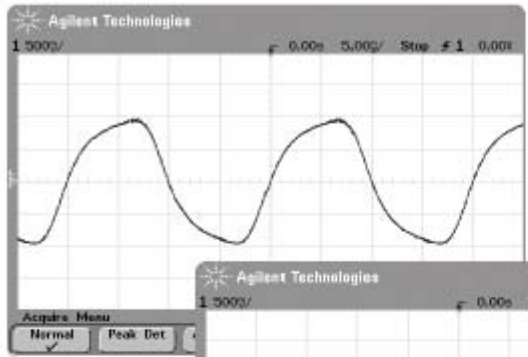
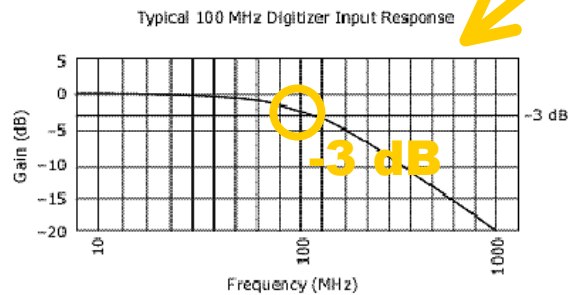
Scope (graphic voltmeter) ... a “mental model”



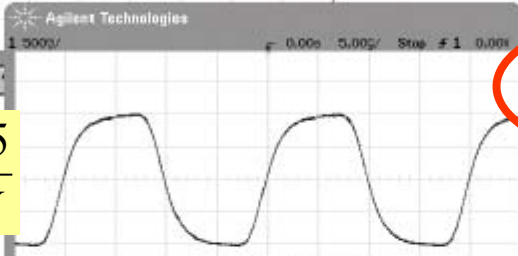
Scope Bandwidth (BW) ... the most important characteristic



$$RiseTime \approx \frac{0.35}{BW}$$

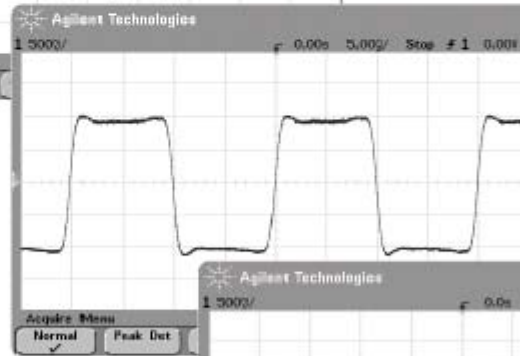


60 MHz scope

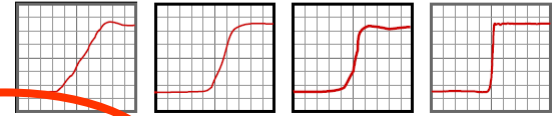
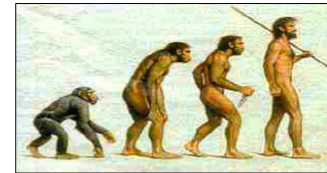
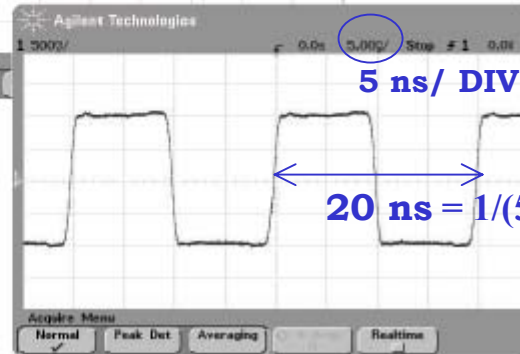


54622A/D
100 MHz scope

350 MHz scope



500 MHz scope



Saját felvétási idő \approx 3.5 ns

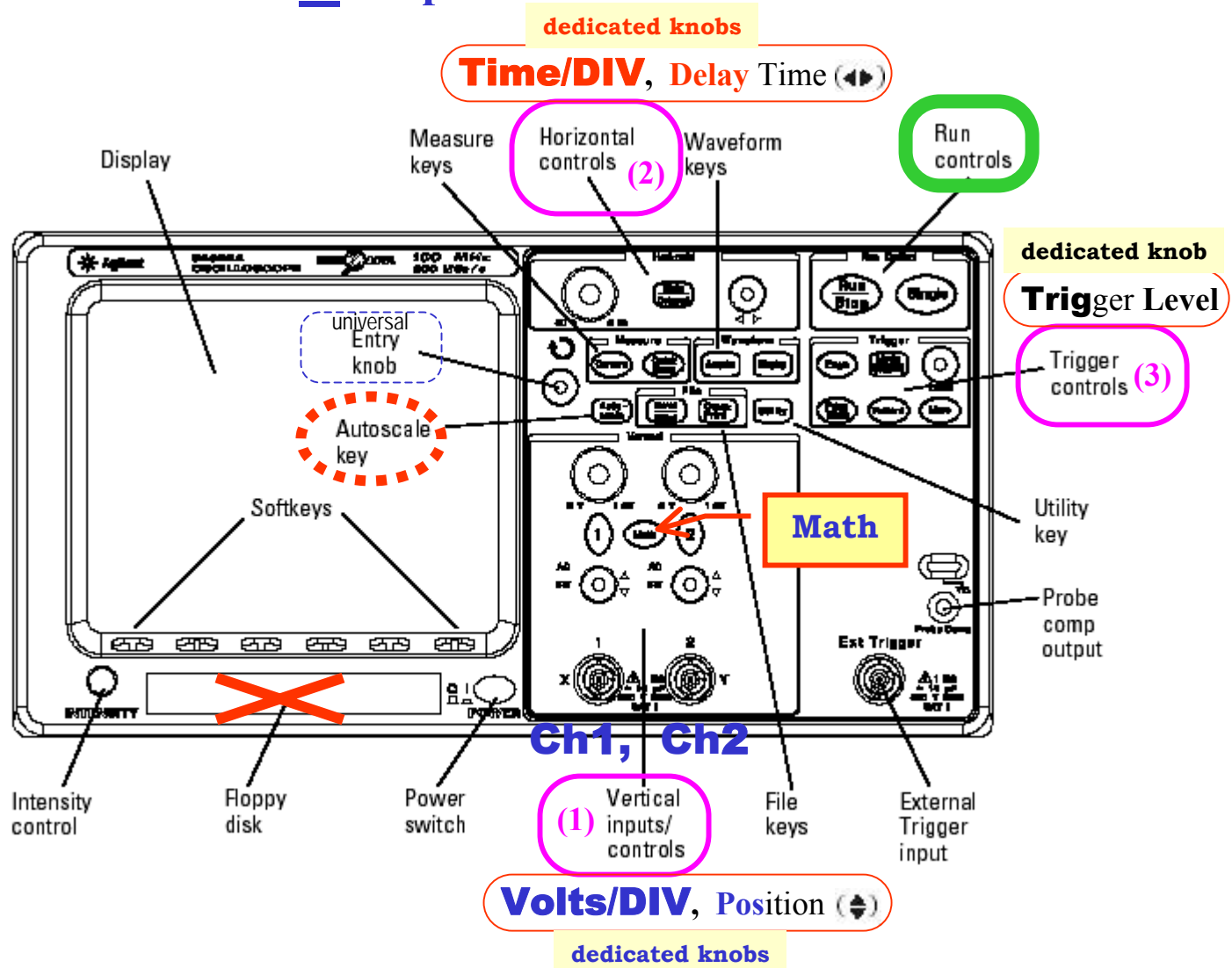
54622A Scope - Front Panel

 (1) **Vertical** (1,2)
 (2) **Horizontal**
 (3) **Trigger**
 [**AutoScale**]

Run/Stop
 [**MegaZoom**]

 Waveform
Measure
Math

 Utility
 File



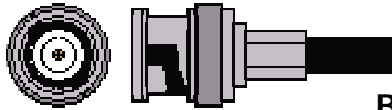
Scope - Display

Analog channels sensitivity
 Digital channel activity
 Trigger point, time reference
 Delay time
 Sweep speed
 Trigger mode
 Trigger type
 Trigger source
 Status line
 Analog channels and ground levels
 Digital channels
 Measurement line
 Softkeys (press **Quick Meas**)
 Trigger level or digital threshold
 Cursor markers defining measurement
 Duty cycle = Width / Period
 Circular arrow: use (universal) **Entry knob**
 or ▲ Press the softkey to display a pop up with a list of choices. Repeatedly press the softkey until your choice is selected.

Digital channels (54622D)
MSO: Mixed Signal O'scope

1 5.00V/ 2 5.00V/ 0.15 \uparrow \uparrow \uparrow \uparrow 0g
 0.00s 500ns/ Auto \uparrow 0g TTL
 Freq(1): 518.8kHz Pk-Pk(1): 4.1V Duty(1): 46.7%
 Source 1 Select: Duty Measure Duty Clear Meas Settings

Scope - Ch1, Ch2 input (BNC connectors)



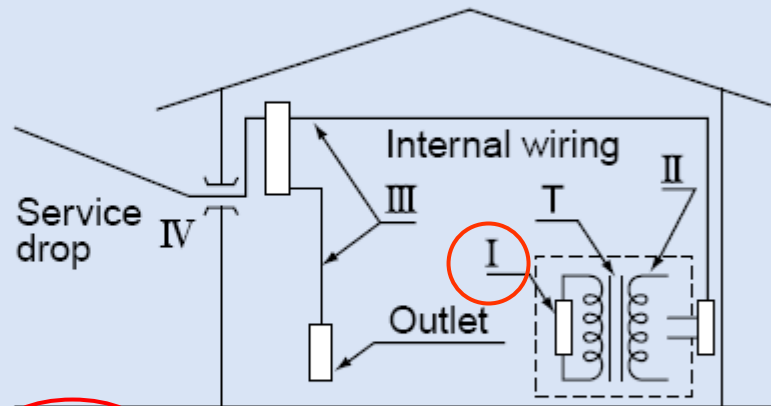
BNC: Bayonet Neill-Concelman (the inventors of the BNC connector)



GROUNDED (non „floating”)

Overvoltage categories (CAT)

In order to ensure the safety of the user, IEC 60664 defines the ranges of use of measuring instruments by classifying power levels into overvoltage categories I through IV. This is because the excessive impulse or surge levels induced in a power line vary depending on the location of measurement (category). Categories with higher numerals designate locations that include larger surge voltages. Instruments that are designed for category III can thus withstand higher surge voltages than instruments designed for category II.



Overvoltage category I (CAT I):

Secondary circuits connected to an outlet via a power transformer.

Overvoltage category II (CAT II):

Primary circuits of a device connected to an outlet with a power cord.

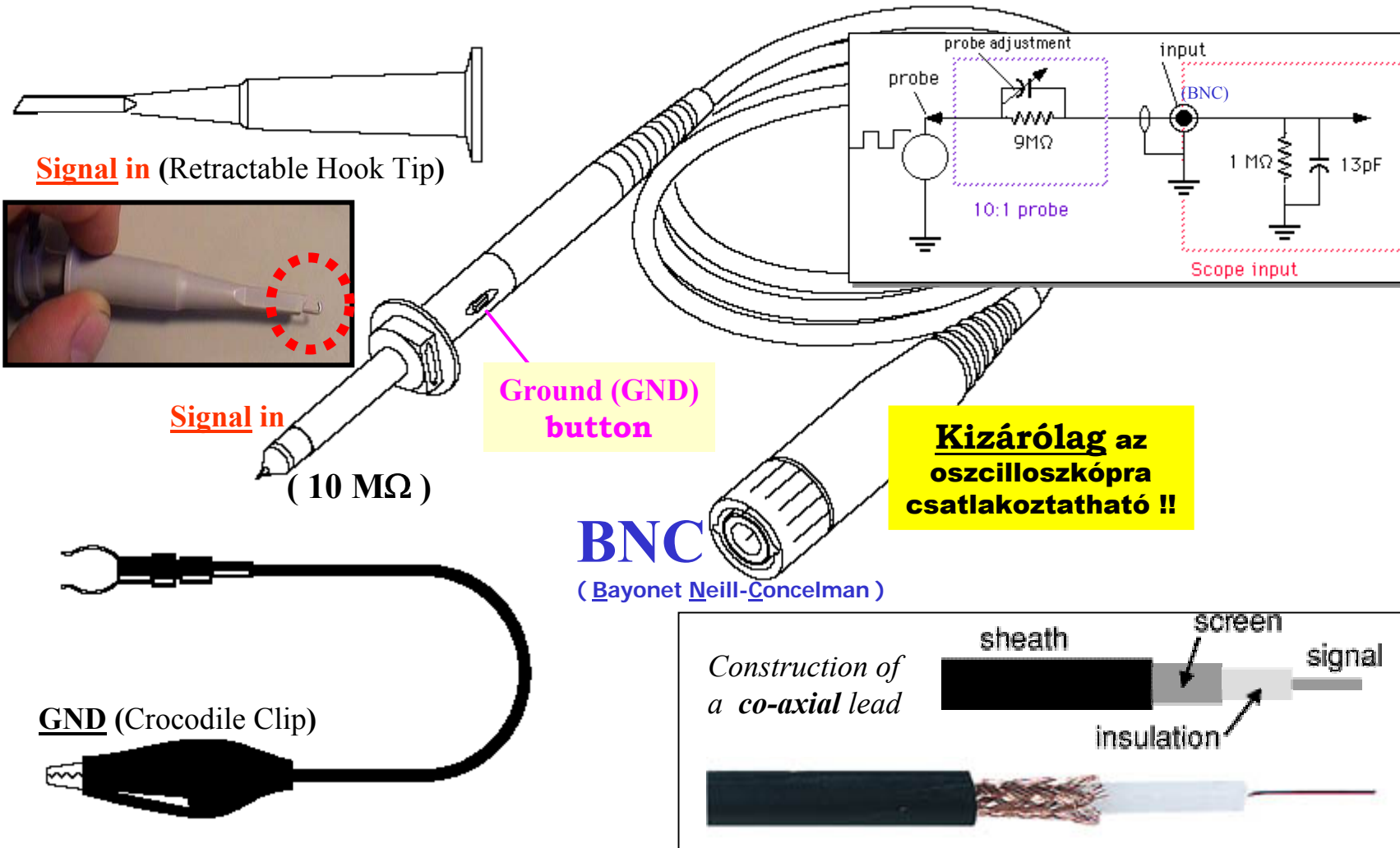
Overvoltage category III (CAT III):

Primary circuits of a device to which power is directly supplied from the power distribution panel, and circuits from the distribution panel to outlets.

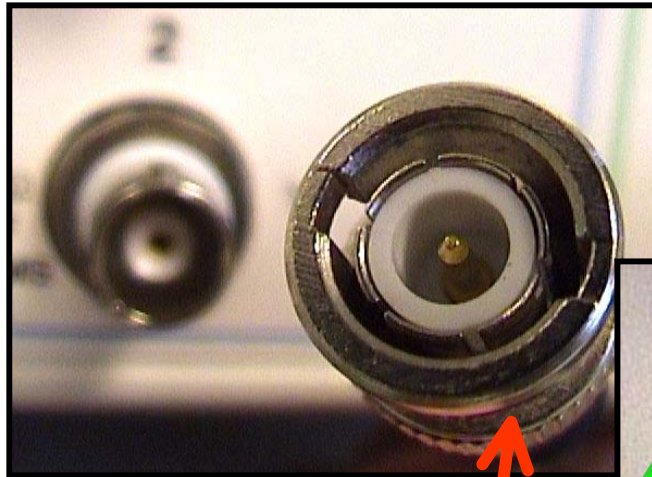
Overvoltage category IV (CAT IV):

All service line entrance circuits through the power distribution panel

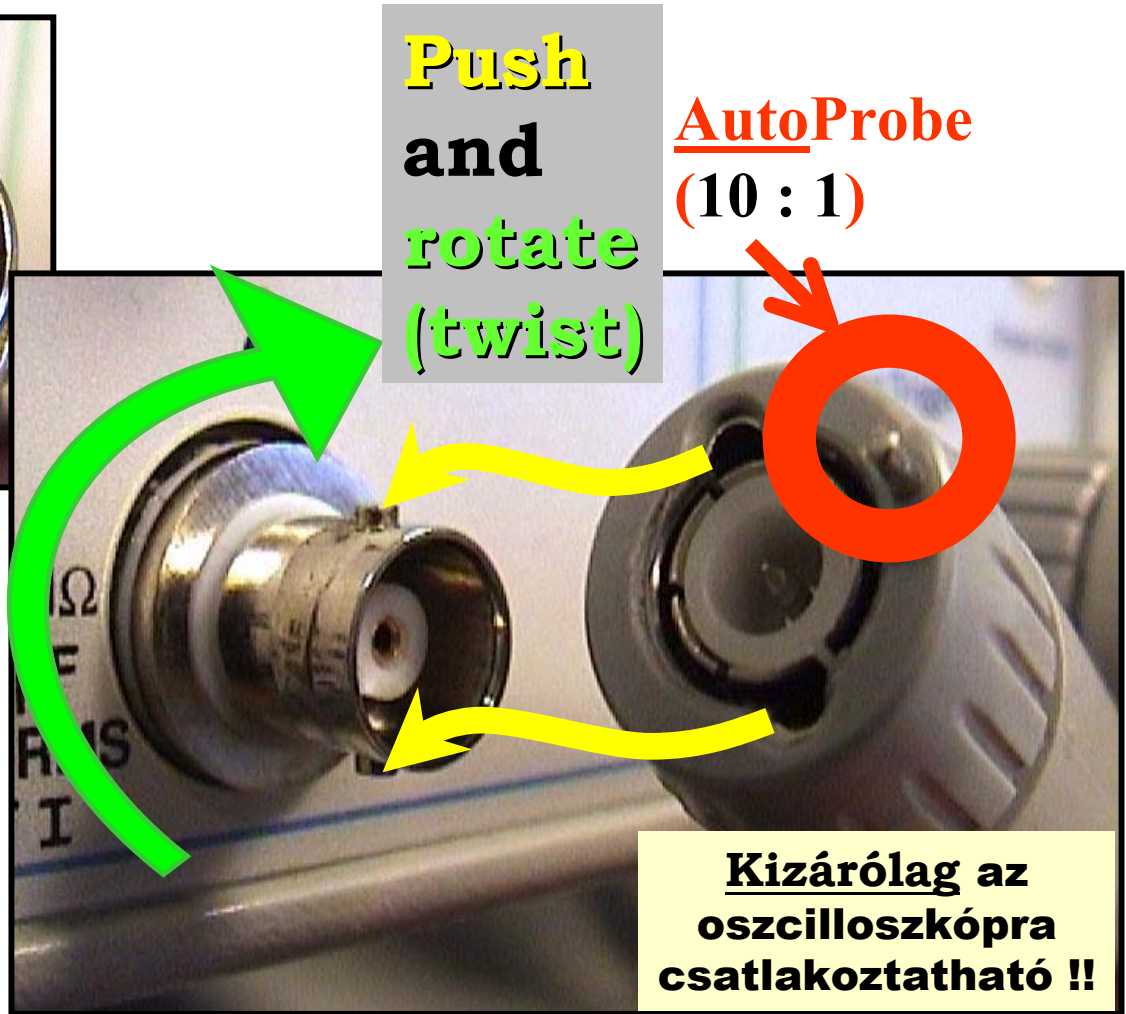
Oscilloscope Probe (10:1)



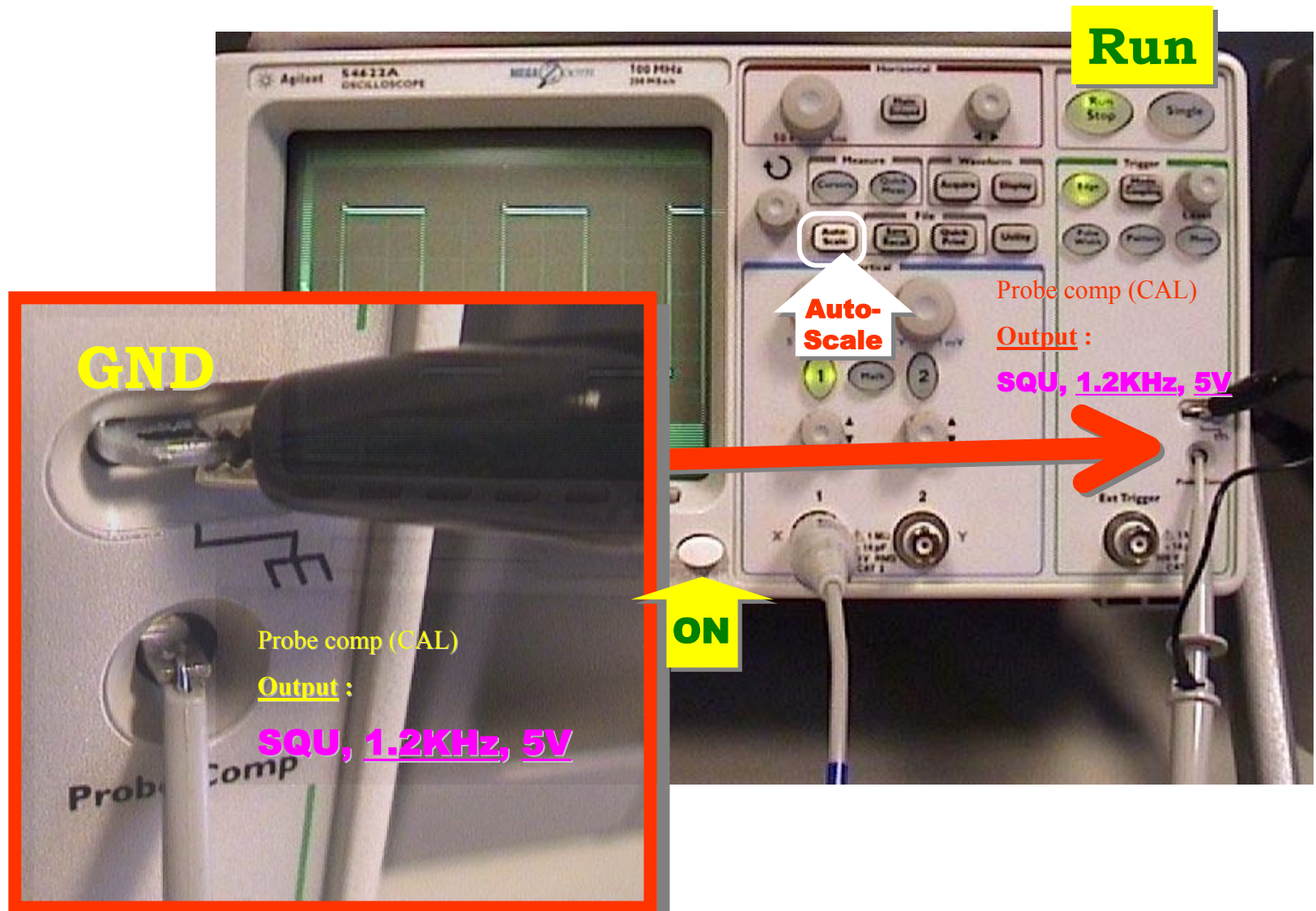
Scope: BNC



**Generátorra is,
oszilloszkópra
is
csatlakoztatható**



Scope: Auto Probe → Probe Comp (Out) / **ON** , Auto Scale



Scope - Measure

Quick Meas (“Let the scope do it: Select / Meas”)

Freq(1) = ?
PK-PK(1) = ?

Meas (and math functions) are performed on DISPLAYED data (fit signal on display) !!

1
2
Math (D15 ... D0)

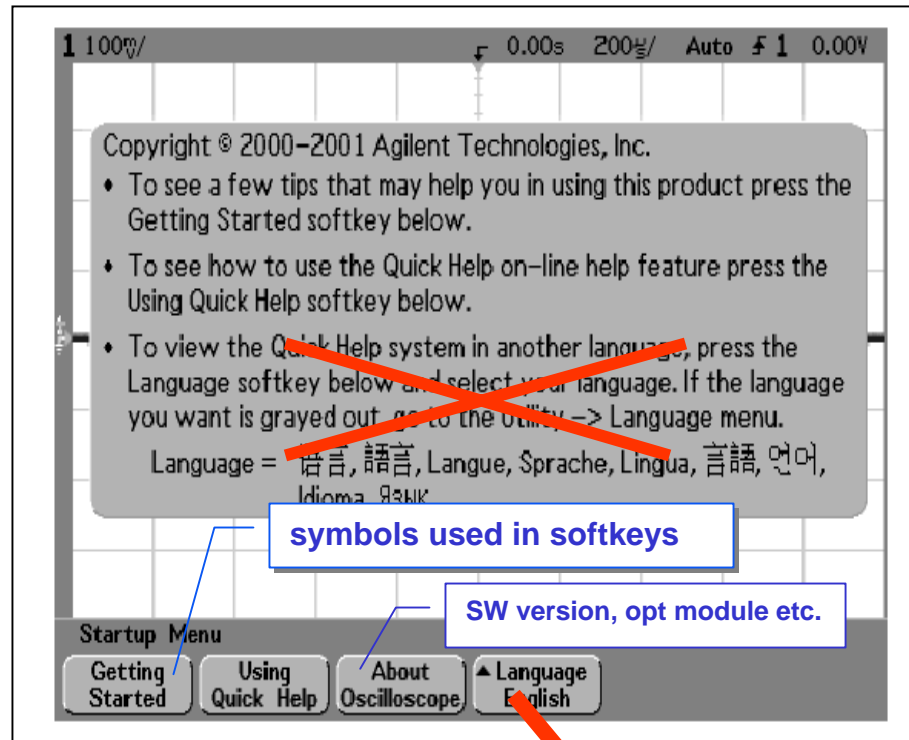
• HELP •

Source select Select measurement Press to make measurement Erase all measurements Additional settings Measurement Thresholds

Amplitude, Average ...

/ ne módosítsuk az alapértelmezést /

Scope: Getting started ... (@ Power ON)



**Please DO NOT
change (or delete)
the language**

54622A/D scope (@ Power ON)

The image shows the Agilent 54622A/D oscilloscope interface and physical device. The interface displays the Agilent Technologies logo, a startup menu with options like 'Getting Started', 'Using Quick Help', 'About Oscilloscope', and 'Language English', and a main display area with a grid and various settings (1 5.00V/, 0.0s, 100%/ Auto F 1 0.0V). A yellow arrow points from the 'Using Quick Help' button to a help box. Another yellow arrow points from the 'Getting Started' button to a second help box. A yellow dashed circle highlights the 'Entry knob' on the physical device's front panel.

Agilent Technologies

1 5.00V/ 0.0s 100%/ Auto F 1 0.0V

- All keys operate normally if pressed and immediately released.
- To get Quick Help information for any front-panel key or menu softkey:
 - **HELP**
 - Press and hold down that key.
 - Release the key after reading the message; releasing the key returns the oscilloscope to the previous state.

Startup Menu

Getting Started Using Quick Help About Oscilloscope Language English

Agilent Technologies

1 5.00V/ 0.0s 100%/ Auto F 1 0.0V

The following symbols are used in the oscilloscope menus:

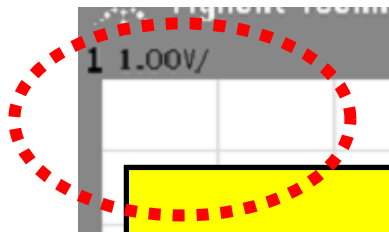
- ↻ – use the Entry knob labeled ↻ to adjust the parameter.
- ▲ – press the softkey to display a pop up with a list of choices.
- ↻ – use the Entry knob labeled ↻ or press the softkey to adjust the parameter.
- ✓ – option is selected and operational.
- – feature is on.
- – feature is off.
- – links you to another menu.
- ↕ – menu navigation softkeys.

Softkeys that display grayed-out text are not used in the current operating mode.

Startup Menu

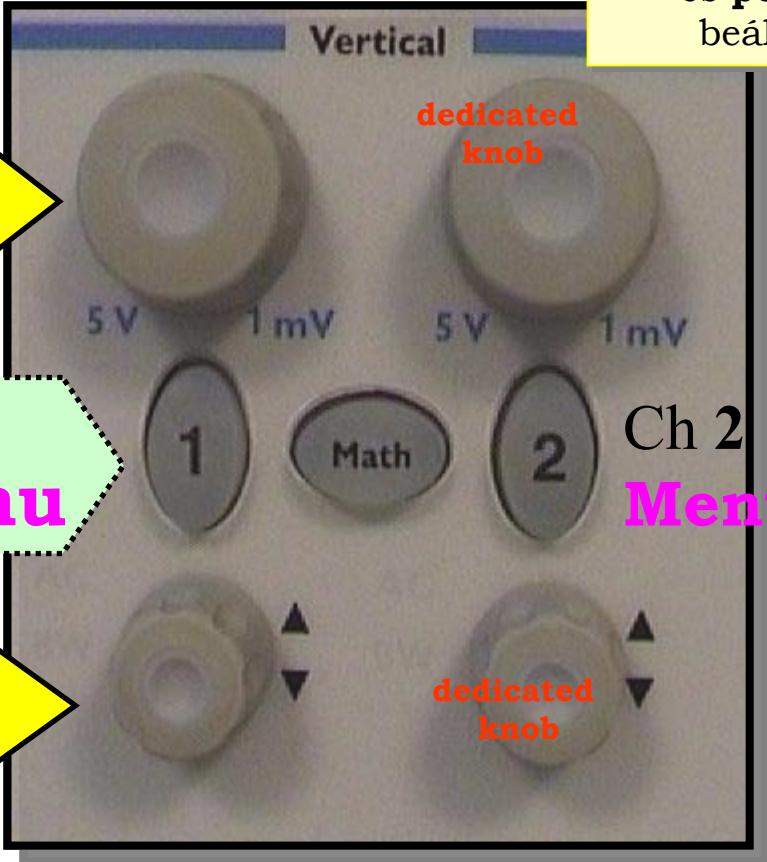
Getting Started Using Quick Help About Oscilloscope Language English

Scope - Vertical



Volts / DIV

**Különálló (!)
amplitúdó (skála)
és pozíció
beállítás**



Channel 1 Menu

Ch 2 Menu

Position (offset)

**“pop up”
voltage value**

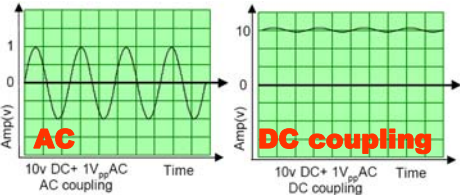
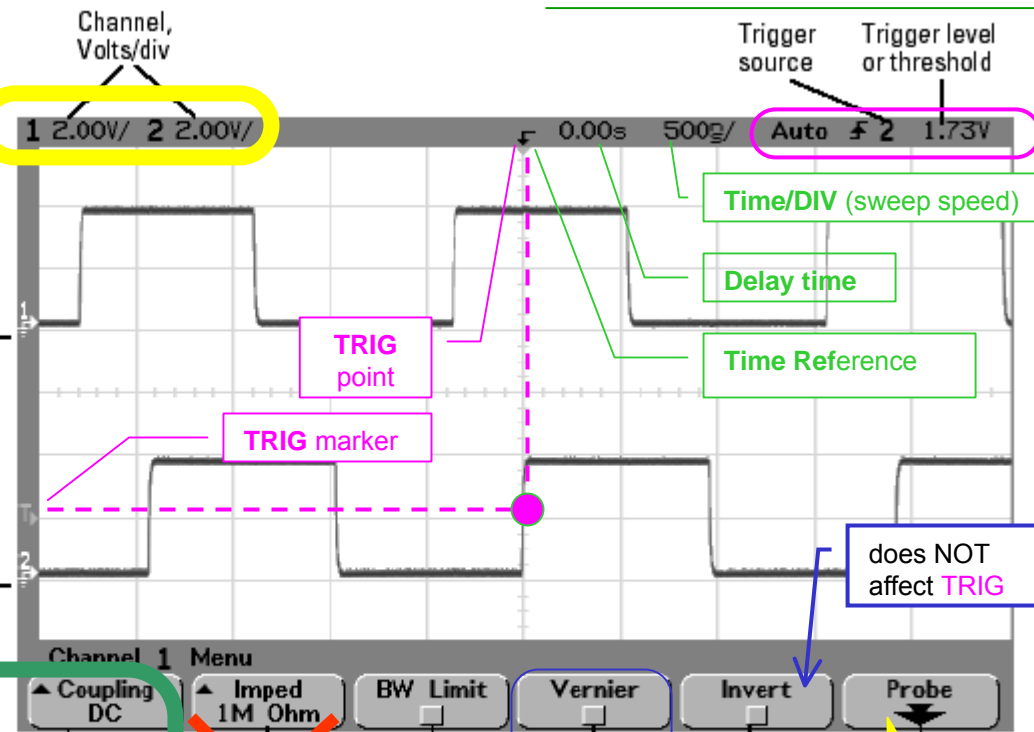
Scope - Vertical : press 1 [or 2]

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

**8 DIV
vertical**

Position

**Horizontal,
Trigger**



“Ground”

“AC” or **“BW” (20 MHz)**
is illuminated on front panel

Channel 1 Menu

- Coupling** DC (highlighted with a green box)
- Imped** 1M Ohm (crossed out with a red X)
- BW Limit** (crossed out with a red X)
- Vernier** (highlighted with a blue box)
- Invert** (crossed out with a red X)
- Probe** (highlighted with a yellow arrow)

Channel 1 Probe Menu

- AutoProbe** 10 : 1 (highlighted with a yellow box)
- Units** Volts
- Skew** 0.00s (crossed out with a red X)

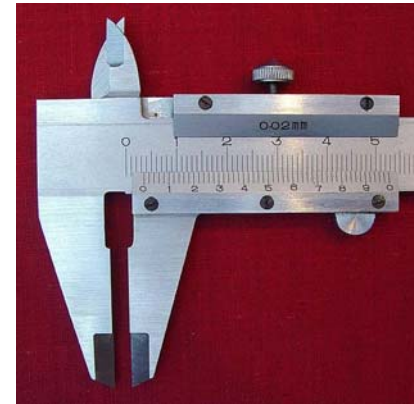
Labels for the menu items: Coupling, Input impedance (54640-series), Bandwidth limit, Channel vernier, Invert channel, Probe menu, Attenuation factor, Measurement units, Skew adjust (54640-series).

Scope - Vernier scale

A **vernier** scale lets one read more precisely from a measurement scale. It was invented in **1631** by the *French* mathematician Pierre Vernier (1584-1638).

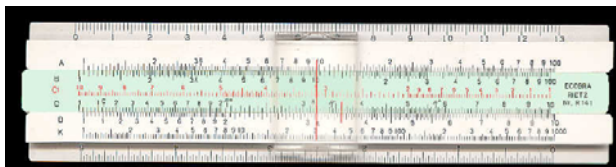


In some languages, this device is called **nonius**, which is the latin name of the *portugese* astronomer and mathematician Pedro Nunes (Lat. Petrus **Nonius**, 1502-1578).



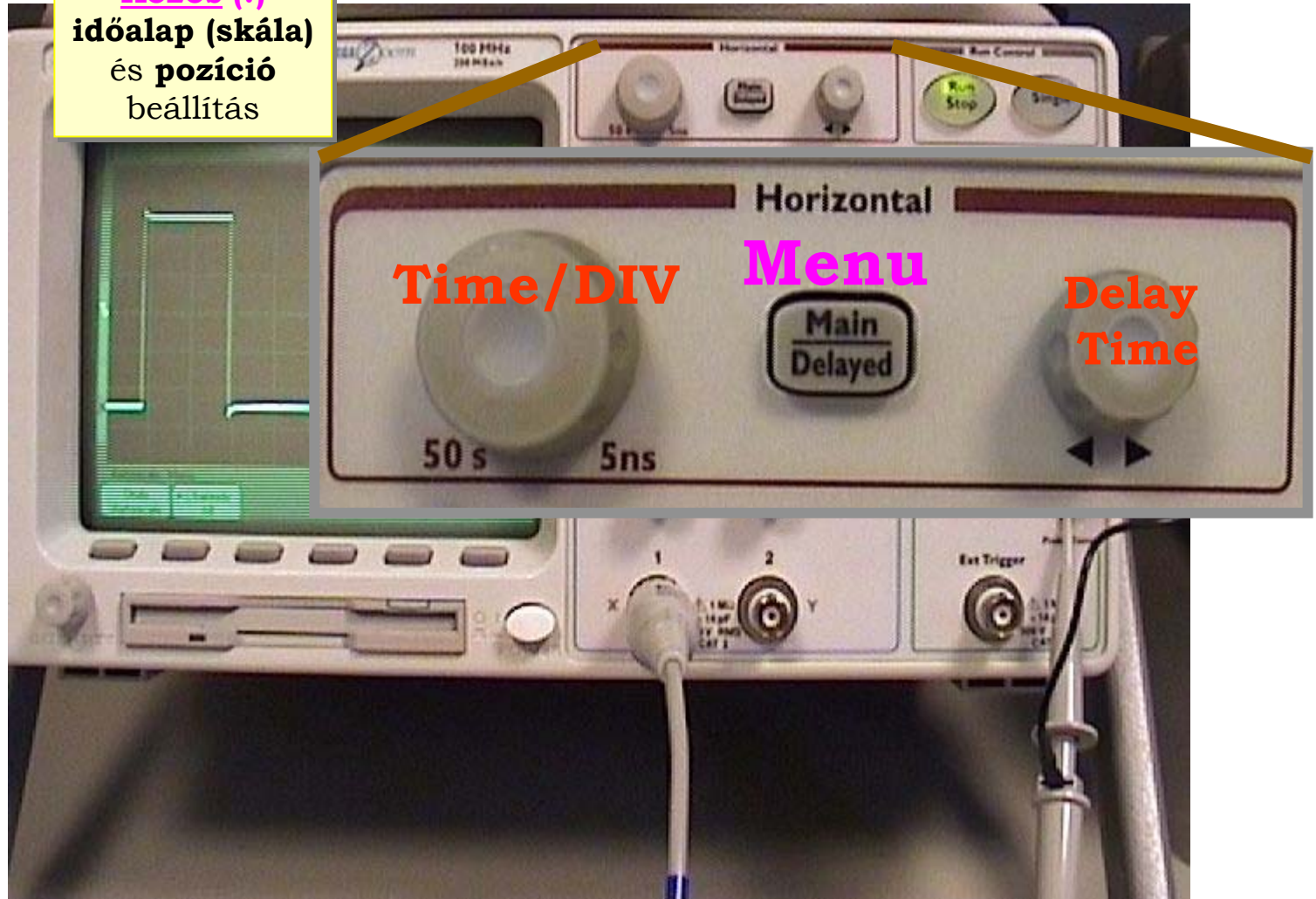
Verniers are common on sextant, machinists' measuring tools (all sorts, but especially **calipers** and micrometers) and on **slide rules**.

<http://www.phy.ntnu.edu.tw/ntnujava/viewtopic.php?t=69>



Scope - Horizontal

Közös (!)
időalap (skála)
és **pozíció**
beállítás



Scope - Horizontal : press **Main/Delayed**

5 ns/DIV to 50 s/DIV
(resolution: 25 ps)

10 DIV horizontal

Time reference:
Left, Center, Right

Chart recorder
(Roll, no trigger)
500 ms/DIV
or slower
(w/o TRIG)

X-Y plotter
(Time base: off)
Ch1: X
Ch2: Y
Note: Z (Ext Trig)

possible 1000 :1 zoom ratio

Delay Time (knob)

Trigger point

Time reference

Delay time

Sweep speed

Trigger source

Trigger level or threshold

Sample Rate = 500MSa/s

Main (checked)

Delayed

Roll

XY

Vernier

Time Ref Center

Main sweep mode

Delayed sweep mode

Roll mode

XY mode

Time base vernier

Time reference

These markers define the beginning and end of the delayed sweep window

Time/div for delayed sweep

Time/div for main sweep

Delay time momentarily displays when the delay time knob is turned

Time/DIV (window)

Delay Time (position)

Sample Rate = 500MSa/s

Main

Delayed (checked)

Roll

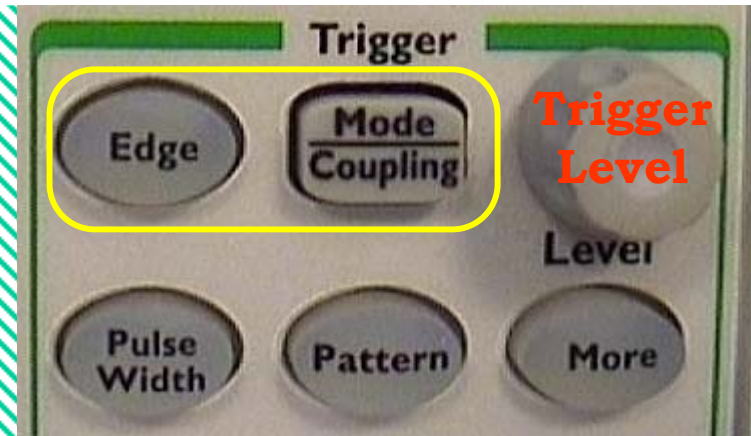
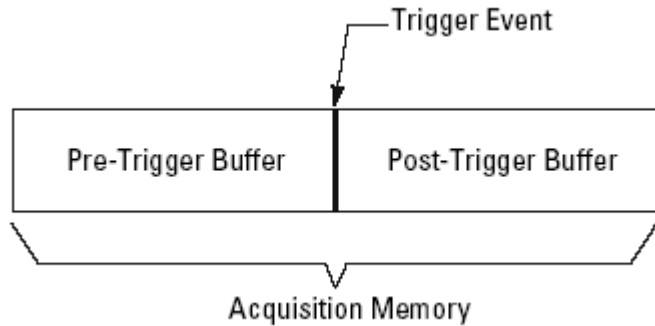
XY

Vernier

Time Ref Center

Select main or delayed sweep

Scope - Trigger : press **Mode/Coupling; Edge**



TRIG: to stabilize repetitive wfm, and capture single-shot wfm

TRIGGER [**Mode/Coupling** ...Holdoff; **Edge** ²⁰ ...Int/Ext] – Sweep „indítás”

! ANA szkóp működése bemutatható ('Auto' módban 'Trigger Level' hatása)!

DSO trigger: leállítja (!) az adatgyűjtést (Pre/Post trigger) ...

press **Mode/Coupling**

Auto Level
Auto
Normal

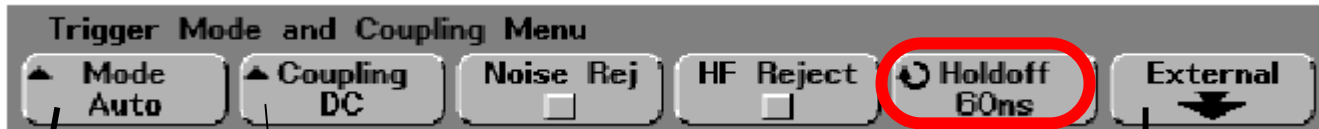
DC
AC
LF Reject (TV)

a sweep-et követő TRIG tiltás (álló kép beállításához)

press **Edge**

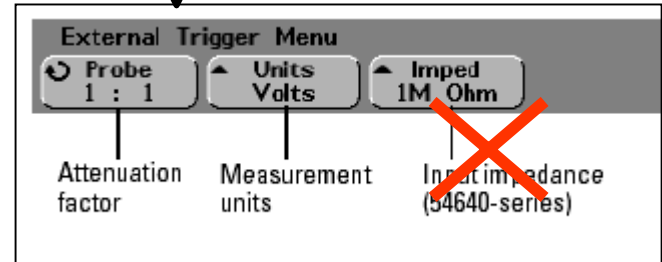
• „**TRIGGER Level** and ^{icon} **Tr** (if ANA Ch)” – dedikált (közvetlen beállítás)

Scope - Trigger mode



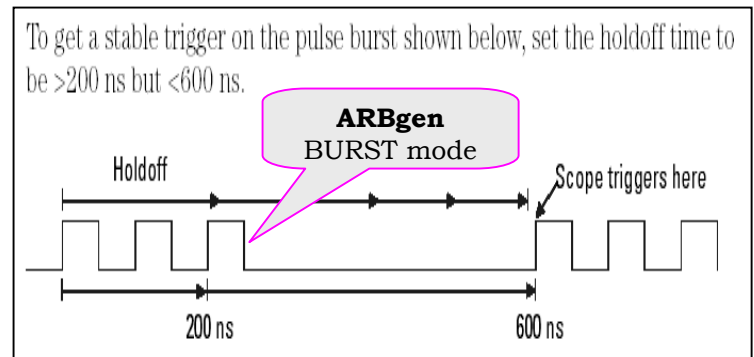
press
Mode/Coupling

DC, AC, LF Reject, (TV)



- **Normal** mode displays a waveform when the trigger conditions are met, otherwise the oscilloscope does not trigger and the display is not updated.
- **Auto** mode is the same as Normal mode, except it forces the oscilloscope to trigger if the trigger conditions are not met. ...as **ANALOG Scope**
- **Auto Level** mode (54620-series only) works only when edge triggering on analog channels or external trigger. The oscilloscope first tries to Normal trigger. If no trigger is found, it searches for a signal at least 10% of full scale on the trigger source and sets the trigger level to the 50% amplitude point. If there is still no signal present, the oscilloscope auto triggers. This mode is useful when moving a probe from point to point on a circuit board.

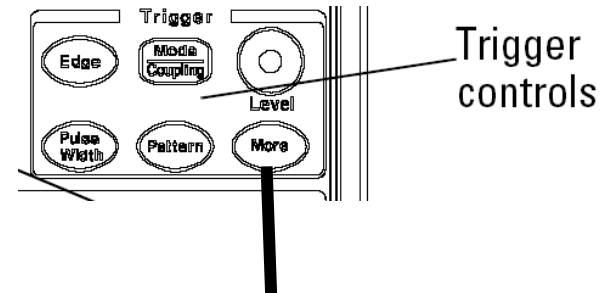
Holdoff Time ~60 ns to 10 seconds



Note: with *MegaZoom technology*, you can press **Stop**, then **pan and zoom** through the data to find where it repeats. **Measure** this time using the cursors, then **set Holdoff** to this number

Scope - Trigger types

- **Edge**
- **Pattern**
- **Pulse width** (glitch)



Pattern

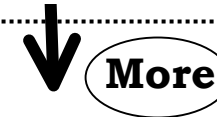
Trigger on a pattern of high, low, and don't care levels and a rising or falling edge established across any of the sources. The analog channel's high or low level is defined by that channel's trigger level.

Pulse Width

Trigger when a positive- or negative-going pulse is less than, greater than, or within a specified range on any of the source channels.

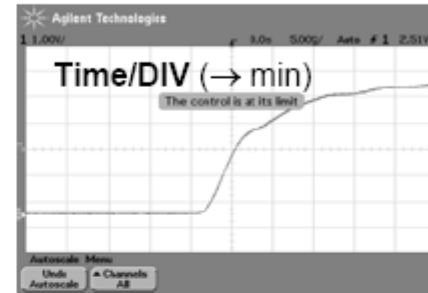
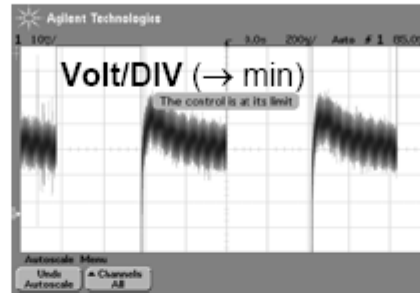
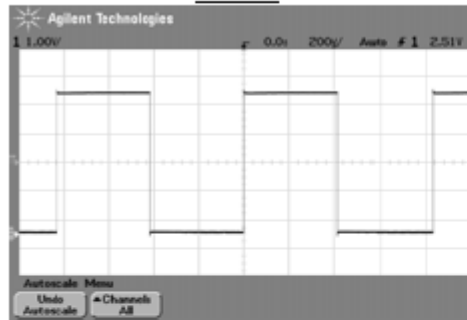
Minimum pulse width setting: 5 ns
Maximum pulse width setting: 10 s

- **CAN** (Controller Area Network)
- **Duration**: multi-channel pattern
- **I²C** (Inter-IC bus)
- **LIN** (Local Interconnect Network)
- **Sequence**: Find event A, trigger on event B, with option to reset on event C or time delay.
- **SPI** (2 & 3 Wire Serial Peripheral Interface)
- **TV**: Trigger on any analog channel for NTSC, PAL, PAL-M, or SECAM broadcast standards on either positive or negative composite video signals.
- **USB** (Universal Series Bus)



Scope:

- ♣ Szemléltető példa: saját forrás mérése (Scope Probe, Ch1, 10:1 mérőkábel) – Auto-scale
Fedezzük fel a skála változtatás és a dedikált gombok hatását (→ Status: Állapot sáv) ...

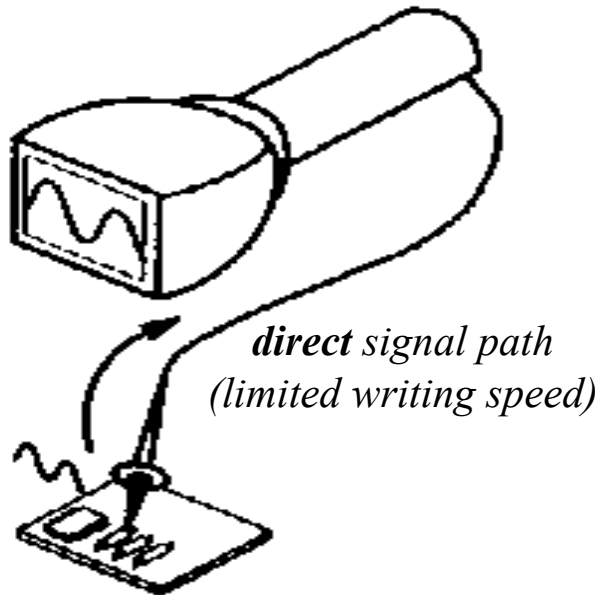


- VERT Position (↕): a rövid ideig megjelenő érték-kijelzés a mozgó icon ↗ (GND ref) távolságát adja meg a képernyő közép-vonalához képest
- HOR Delay time (◀▶): a trigger pontot (▼ symbol) mozgatja, és az érték-kijelzés azt adja meg, hogy a ▽ symbol (Time Ref, Zoom Ref) milyen távolságra van a trigger ponttól.
Megjegyzés: a ▼ symbol (trigger pont) előtt PRE-, utána POST-trigger információ
- TRIG Level: növeljük icon T (if ANA Ch) értékét a jel-csúcsérték fölé, ekkor ha TRIGger: Auto – megszűnik az álló ábra (→ nincs szinkron, mint ANA scope!!), (átváltva) Normal – „befagy” a kijelzés (→ mint DSO, villog a Trig'd)

Scope

ANALÓG :

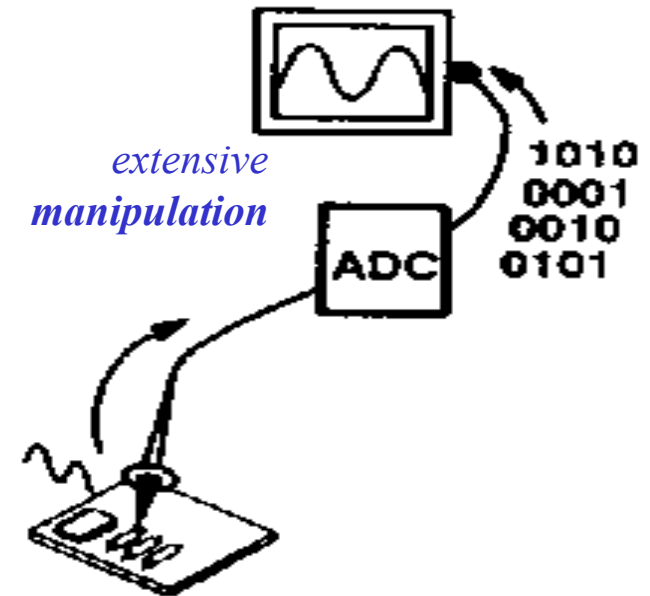
*közvetlen “rajzolás”
(képernyőre írás)*



**Analog Oscilloscopes
Trace Signals**

54622A/D DIGITÁLIS :

*numerikus “tárolás” (memóriába írás)
és virtuális nyomvonal “rekonstrukció”*

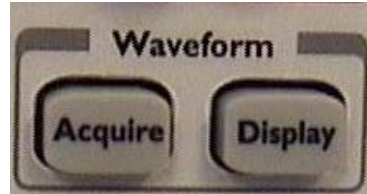


**Digital Oscilloscopes Sample
Signals and Constructs Displays**

Scope: Waveform – Rekord felvétel és megjelenítés

ACQUIRE:

digitalizálás (numerikus minták)
 → mintavétel és kvantálás



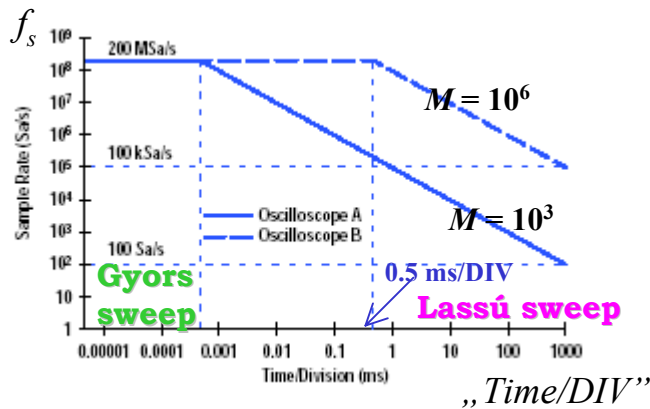
DISPLAY :

rekonstrukció („virtuális” nyomvonal)
 → pixel-ek

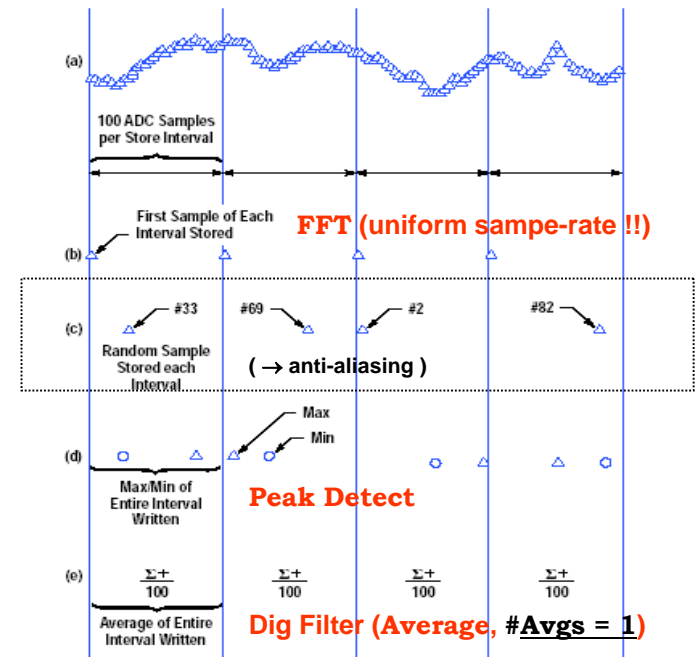
A memória kapacitás (M) **korlátozza**
 a minta-gyakoriságot (f_s , *sample rate*):

$$f_s = M / (10 \cdot \text{Time} / \text{DIV}) \leq 200 \text{MSa} / \text{s}$$

a DSO sávszélessége tehát változik (!!)
 az **időalap (Time/DIV)** módosításával
 (→ **Peak Detect**: glitch detect)



max **1-2(4)•10⁶** (Mega) point memória
 kontra
1•10³ (Kilo) pixel display (**compression !**)



Scope - Why is long Memory important

1a



2a



3



1b



10 kpts

2b



100 kpts

1 Mpts
Full resolution of
entire image

... finally you know why Mona Lisa is smiling
(listening to Leo's new music player)

Scope - Waveform : press **Acquire**



Lassú sweep

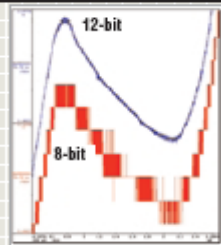
1 ms/DIV or slower
(10 ms/5 ns = 2M)

#AVG resolution

1	8 bit
4	9
16	10
64	11
256	12

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

12-bit versus 8-bit



#AVG = 1 HiRes

- 2 us/DIV 8 bit
- 5 us/ 9
- 20 us/ 10
- 100 us/ 11
- 500 us/ 12 bit

**OS: oversampling &
DF: decimation filter**
(@ one TRIG)

Gyors sweep

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**



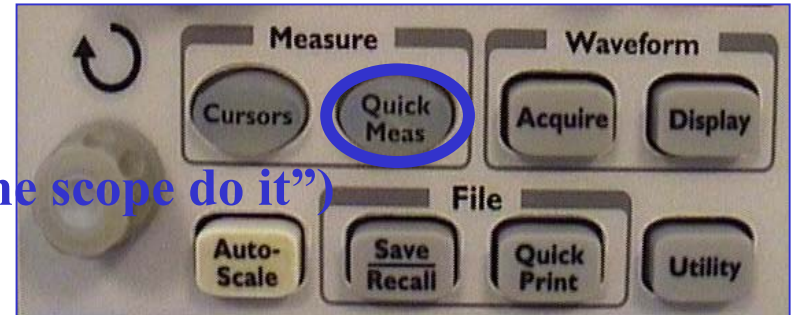
OFF

ON ("connect the dot":
LIN interpolation)

Scope - Measuring methods

Auto: **Quick Meas** (“Let the scope do it”)

Manual: **Cursors**



“Eyeballing”: graticule markings – **Display** / Grid [20%]
counting the (minor) divisions, and
multiplying by the readout sensitivity
... like *Analog Scope*

Maximizing measurement Accuracy, the first rule :
set the highest resolution (→ scale; **Vernier; Delayed**)

Scope - Measure : press **Quick Meas; Cursors**

MEASURE [**Quick Meas**, **Cursors**] – Paraméter mérések

- ! (Display) **Grid** : „hagyományos (ANA szkóp) mérés” is lehetséges !
- Egyidejűleg **három auto** param. mérés:

Meas (and math function) are performed on DISPLAYED data (fit signal on display) !!

NE módosítsuk az alap-
értelmezést (csak ha
célszerű

Measurement line →

1
2
Math (D15... D0)

• **HELP** •

press **Quick Meas**

Amplitude, Average ...

• **Manuális** mérővonalak (kurzorok):

Normal (Binary Hex)

1, 2, Math

press **Cursors**

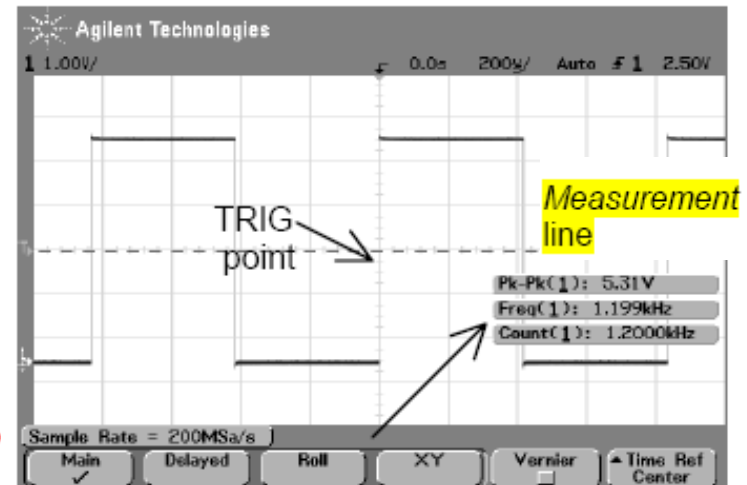
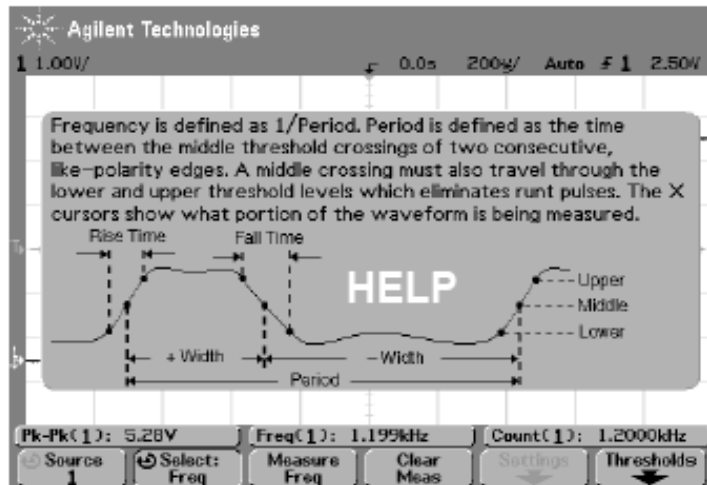
X: relative to TRIGger point
Y: relative to GND point

Measurements made with **Quick Meas** may give incorrect results, particularly on noisy signals.

Look at the cursor lines to see if **you** agree that the cursor lines are showing what you want to measure. If your displayed signal is noisy for any reason, try using **Averaging** to clean it up.

Scope:

♣ Szemléltető példa: (folytatás, *egységes* alap-helyzethez: **Auto-scale**)



Quick Meas: Vpp, Freq [Select: **HELP**], Counter

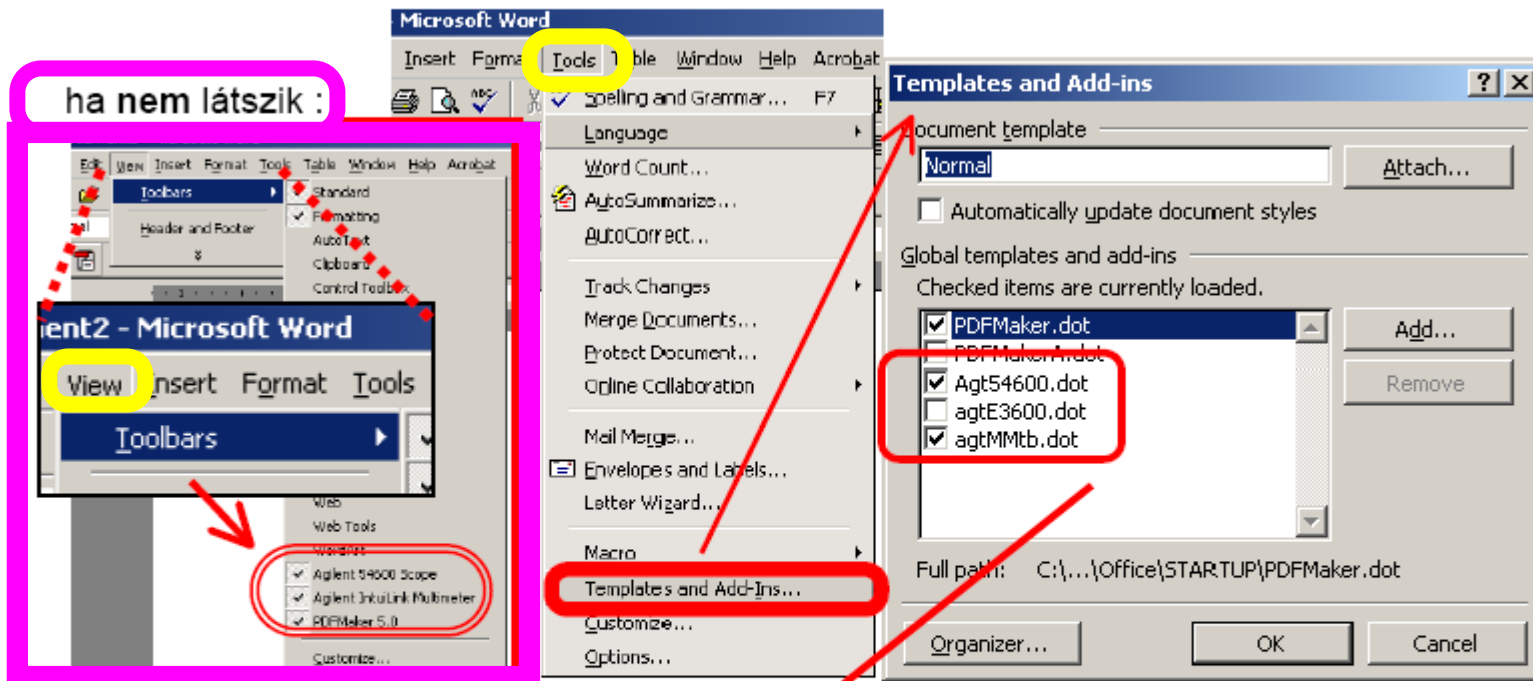
Main/Delayed (→display: **'Sample Rate'**)

Módosítsuk a skálákat, és figyeljük meg a hatásokat. (Pl. ha *nincs* egy teljes periódus a képernyőn, akkor Freq: *No edges*, de Counter: továbbra is működik!)

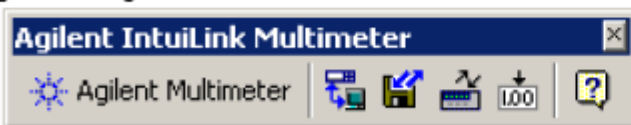
Dokumentálás:

„IntuiLink” Word Toolbar

Tools | Add-Ins... (ha nem látszik → View | Toolbars ...)



agtMMtb: Agilent MultiMeter Toolbar



Agt54600:



Scope - dokumentálás:

e-Jegyzőkönyv: Word **Save as ... (G: drive)!!**
A jegyzőkönyv **ékezetes** betűkkel készül!




Word **Toolbar** (*IntuiLink* tasakból), vagy

Tools | **Add-Ins...** **Agt54600.dot** (ha nem látszik → **View** | **Toolbars** :).

● **Connect to Scope: GPIB address – 7**

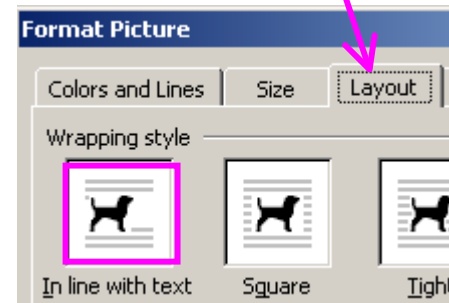
Get waveform data (N° of points: 100 | 250 | 500), and *make a graph*

 Get Screen Image (Scope display) → **Format Picture** / **Layout**, Size ...

 Get single measurement

WORD
Right click
on picture

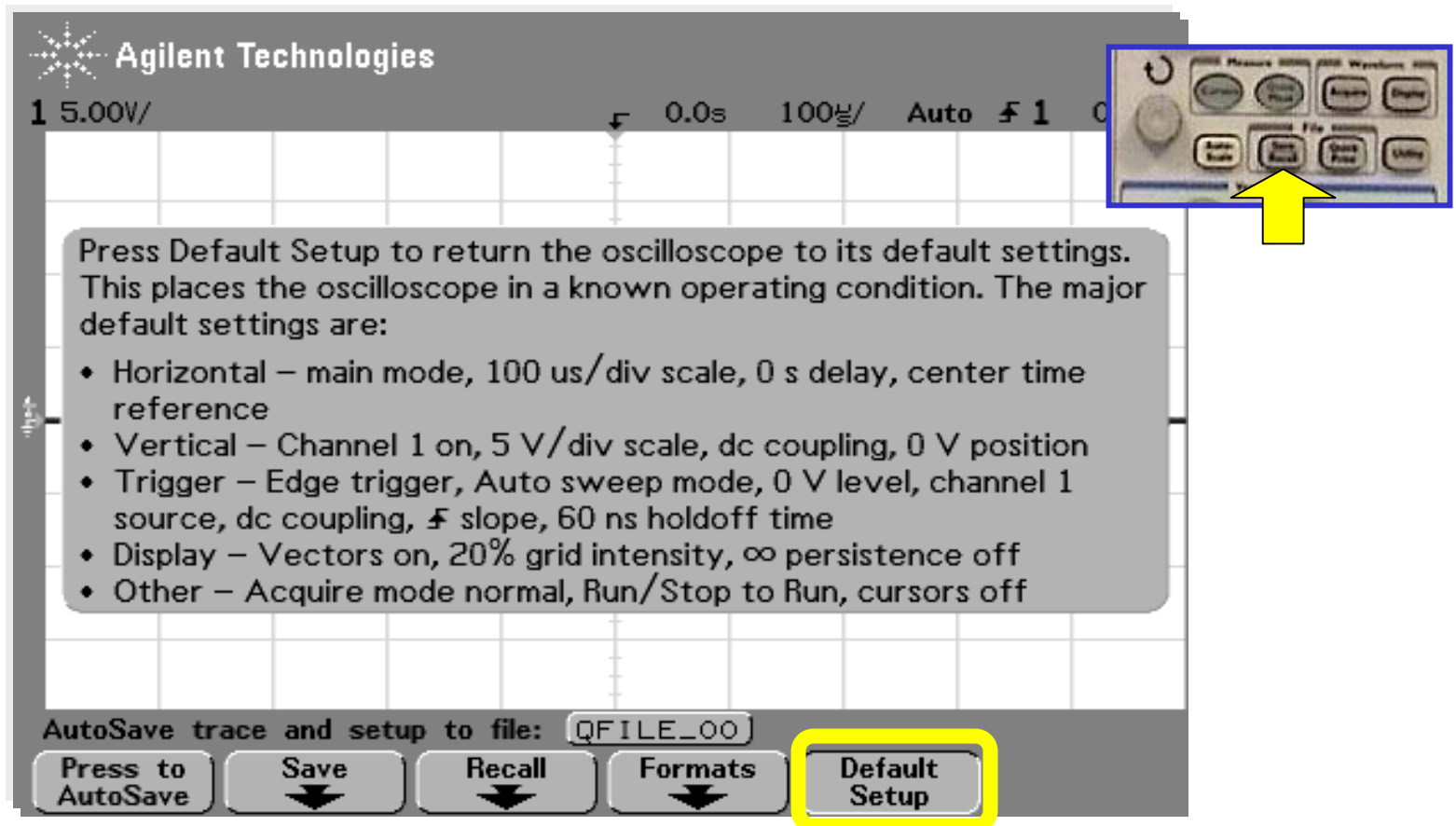
“bal Kutya” ...



nagyobb (2K)
mintaszám **Excel**
Toolbar-ral,

a **teljes** memória
„Data Capture”
SW-rel érhető el
(és az FFT is !)
NEM használjuk

Scope - File : press **Save/Recall** – Default Setup



The screenshot shows the Agilent Technologies oscilloscope interface. At the top, the logo and name "Agilent Technologies" are visible. Below it, the display shows "1 5.00V/" on the left and "0.0s 100µs/ Auto F 1 0" on the right. The main display area is a grid with a vertical cursor. A text box in the center provides instructions and default settings:

Press Default Setup to return the oscilloscope to its default settings. This places the oscilloscope in a known operating condition. The major default settings are:

- Horizontal – main mode, 100 us/div scale, 0 s delay, center time reference
- Vertical – Channel 1 on, 5 V/div scale, dc coupling, 0 V position
- Trigger – Edge trigger, Auto sweep mode, 0 V level, channel 1 source, dc coupling, \uparrow slope, 60 ns holdoff time
- Display – Vectors on, 20% grid intensity, ∞ persistence off
- Other – Acquire mode normal, Run/Stop to Run, cursors off

At the bottom, the "AutoSave trace and setup to file:" field shows "QFILE_00". Below this are five buttons: "Press to AutoSave", "Save", "Recall", "Formats", and "Default Setup". The "Default Setup" button is highlighted with a yellow border. In the top right corner, a physical button panel is shown with a yellow arrow pointing to the "Default Setup" button.

Agilent 33220A Function/**AR**bitrary waveform generator

20 MHz sine and square, ARBs; / modulations /
14-bit, 50 MSa/s, 64K-point **DDS**; variable-edge pulse
GPIO (USB, LAN), **IntuiLink: Waveform Editor**

MOST nem használjuk

The image shows the Agilent 33220A Function/ARbitrary waveform generator. The front panel features a digital display showing 20.000 000 MHz and various control buttons. The back panel shows connectors for 50 MHz In/Out, Modulator, Est Top / Freq Select, LAN, USB, GPIB, and a power input. A software window titled 'Agilent IntuiLink Waveform Editor' is overlaid on the top right, showing a menu with options like 'Equation Calculator', 'Agilent FIR Filter', and 'Import Waveform'. Callouts point to specific features: 'built-in HELP' points to the 'Help' button on the front panel; 'Go to Local' points to the 'Local' button; 'POWER On/Off' points to the power button; 'BNC Connectors (SYNC - always ON OUTPUT - On/Off)' points to the BNC connectors on the back panel; 'OUTPUT On/Off switch' points to the 'Out' button on the front panel; and 'LAN, USB, GPIB' points to the corresponding connectors on the back panel. A yellow box at the bottom left contains the text 'FOP: Fifty Ohm [50-Ω] Party' with an arrow pointing to the 50 Ohm connectors.

built-in HELP

Go to Local

POWER On/Off

Pwr on
default state:
Sine, 1 KHz
0.1Vpp @ $R_L=50\Omega$
Out: Off

FOP:
Fifty Ohm [50-Ω] Party

BNC Connectors
(*SYNC - always ON*
OUTPUT - On/Off)

OUTPUT On/Off switch

~~LAN, USB,~~ **GPIB**

ARBgen - DDS: Direct Digital Synthesis

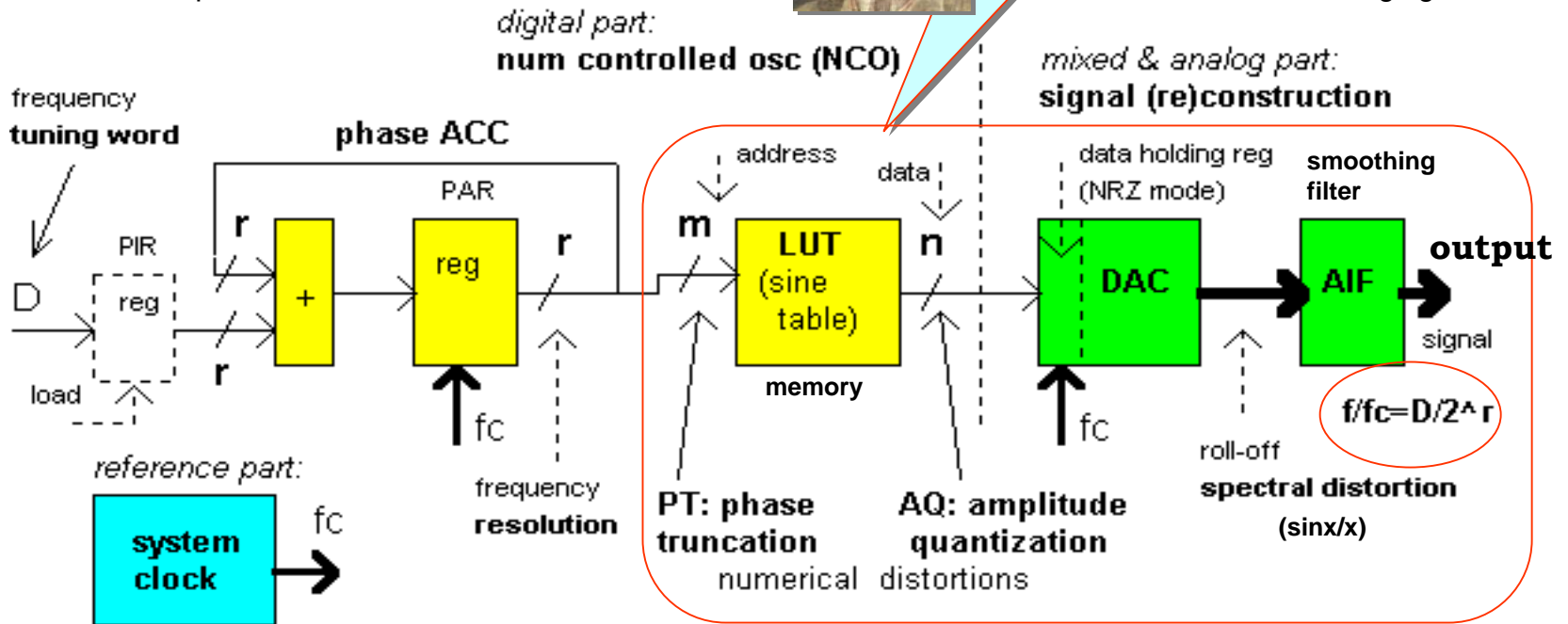
(@ constant f_c clock-rate)

PIR : phase increment register
 Phase **ACC** : accumulator
LUT : look-up table



... mint a CD lejátszó !!

NRZ : non return to zero
DAC : digital to analog converter
AIF : anti imaging filter

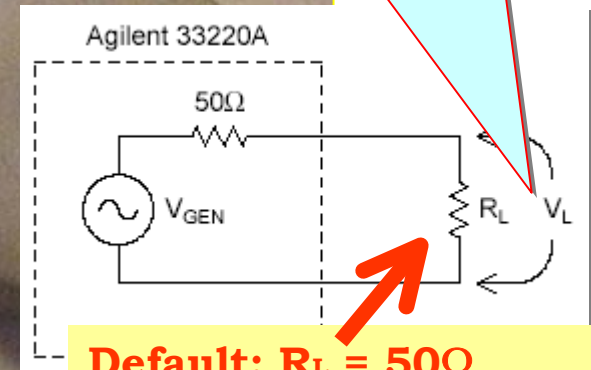


33220A : $r = 64$ bit, $m = 16$ bit (64K memory), $n = 14$ bit, $f_c = 50$ MHz
 14 bit (16K memory)

FREQ resolution (int): 2.7 pHz ($2^r = 2^{64} = 2^{4+10+10+10+10+10+10} = 2^4 \cdot 10^{3+3+3+3+3}$)

ARBgen Output - 50Ω source impedance

Displayed Ampl !!



Default: $R_L = 50\Omega$
Setup: „Utility/Output”

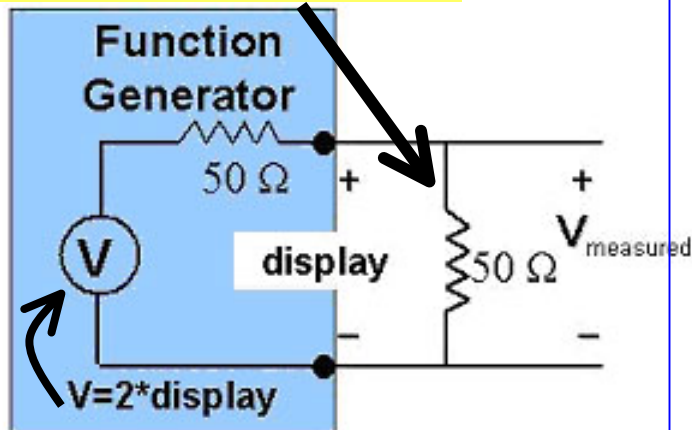
FOP: Fifty Ohm [50-Ω] Party



Why your function generator outputs **twice (!!) the programmed voltage?**

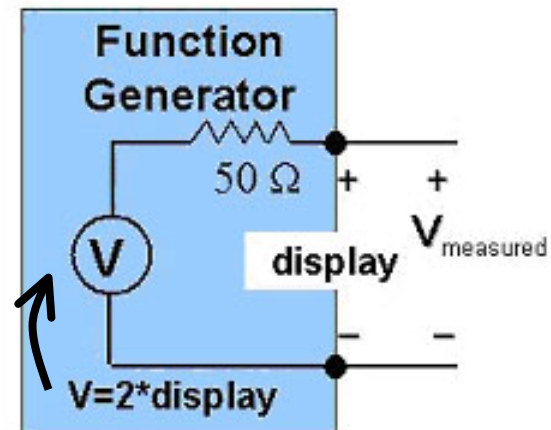
The **default setting** for Agilent function generators is to display the desired voltage as though terminated into a 50 Ohm load.

FOP:
Fifty Ohm [50-Ω] Party



$$V_{\text{measured}} = \frac{1}{2} V = \frac{1}{2} (2 * \text{display})$$
$$V_{\text{measured}} = \text{display}$$

When a high impedance device, such as an **oscilloscope** is used to measure the output of the function generator, the waveform appears to be **twice** the voltage set on the display of the function generator.

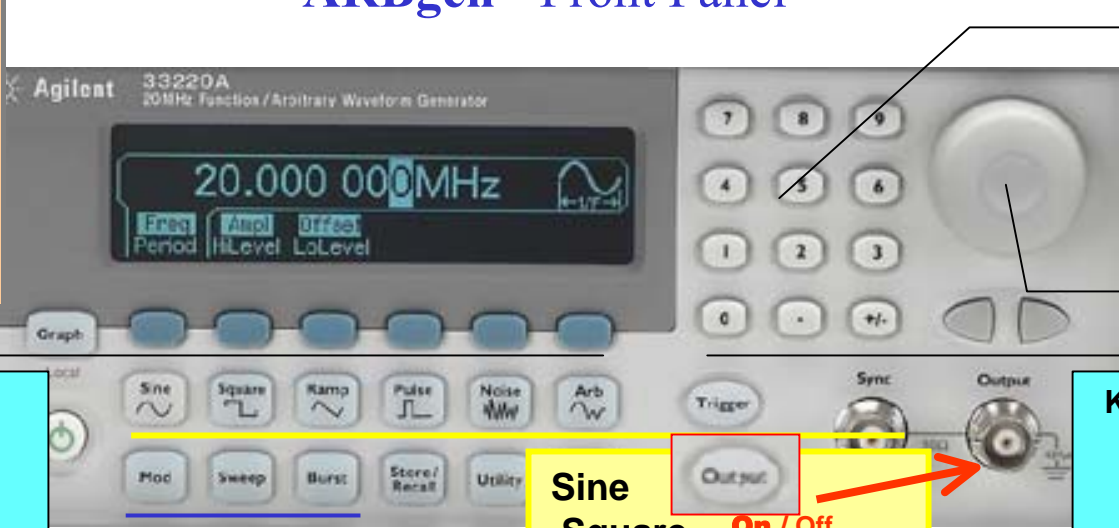


$$V_{\text{measured}} = V = \underline{2 * \text{display}}$$
$$V_{\text{measured}} \neq \text{display}$$

The Agilent 33220A function generator includes a feature that allows the output termination to be **set** to any impedance from **1 to 10 k Ohm**, or **infinite**.

ARBgen - Front Panel

-
- 1. Function**
- 2. Parameters**
-
- 3. Output**
- On / Off**
-



Setting

Tuning

Graph or Menu mode

Softkeys to configure the Parameters

...always adjust Parameters from left to right

Knob and cursor keys to modify the displayed number

Keypad to enter numbers, and **Softkeys** to select units

Mod
Type: AM
FM
PM
FSK
PWM
Source: INT
EXT

Sweep
LIN or LOG

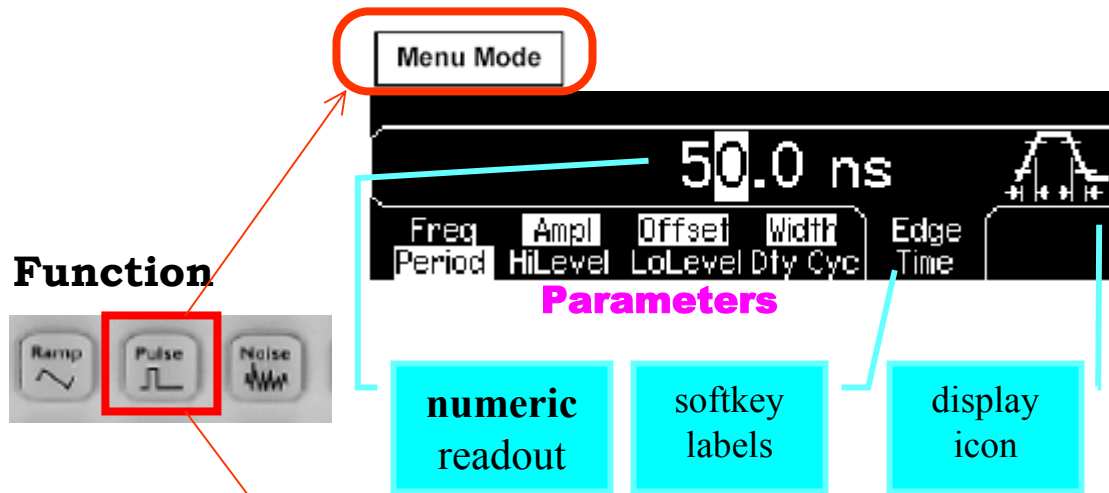
Burst
N cycle or
EXT-gated

Sine
Square **On / Off**
Ramp
Pulse
Noise
Arb (currently selected)
DC ('Utility' key | DC on)

	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.

ARBgen Display: numeric vs. graphical views



Methods:
 Frequency / Duty Cycle
vs.
 Period / pulse Width
 (Let the ARBgen perform the calculation ...)

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.

Period	HiLevel	LoLevel	Width	Edge
--------	---------	---------	-------	------

Parameters

To exit the Graph Mode, press **Graph** again.

Scope / ARBgen :

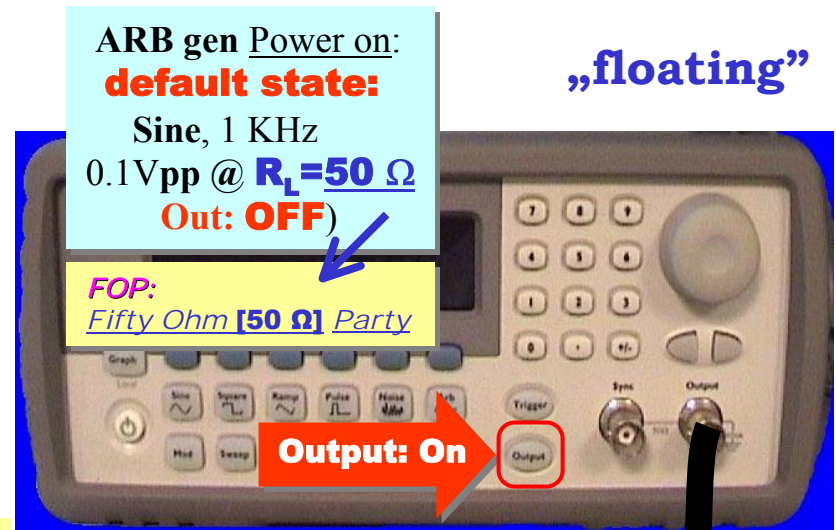
GROUNDING
(non „floating”) !!



Scope
QuickMeas
Peak-Peak: ?

Auto-Scale

BNC
(in, 1 MΩ)



ARB gen Power on:
default state:
Sine, 1 KHz
0.1Vpp @ $R_L=50 \Omega$
Out: **OFF**

FOP:
Fifty Ohm [50 Ω] Party

Output: On

„floating”

BNC
(out, 50 Ω)

BNC/BNC cable (50 Ω)

ARBgen:



♣ a terhelés hatása: a **legfontosabb**, amire **figyelni** kell !

- **ARBgen:**

Ampl: **1** Vpp, Output: **ON**

Scope: Auto-scale, QuickMeas: Peak-Peak: \approx **2** Vpp (?!)

(Az ok: *alap-beállításnál* a generátor **50Ω** terhelést tételez fel, valójában 1 MΩ a terhelés: az oszcilloszkóp bemenete.)

ARBgen: Utility: **Output Setup:** Load ↓ **High Z** . Ampl = **2** Vpp !

(Ahhoz, hogy fix 50Ω forrás-impedanciával 1 Vpp legyen 50Ω terhelésen, a generátor forrás-feszültsége: **2** Vpp . Átdefiniálva a terhelést a valóságos helyzetre („közel ∞ impedancia: High Z”), az ARBgen display most már a (*változatlan*) forrás-feszültséget mutatja.)

Output key

a kimenet bekapcsolása előtt (a **fix** 50Ω forrás-ellenállás miatt) – **gondoljuk át** a feltételezett **terhelő ellenállás** (Output setup) és ahova kötjük a kimenetet: a tényleges **terhelés** hatását !!

ARBgen - Utility/Output Setup: High Z

- **SINE**



- Freq: **8** KHz
- Ampl: **3 V_{pp}**
- Offset: **0 V**

- *RMS = ?*

- **SQUARE**



- Freq: **1.5** KHz
- **HiLevel: 3.2 V**
- **LoLevel: 0 V**

**TTL,
CMOS 3.3V**

- *RiseTime = ?*

ARBgen:

Sync (out) – a generált jel periódusával megegyező **négyszög** jel

Sine, Ramp, Pulse: 50% - os, Square: a jellel *azonos* a kitöltési tényező ...

Modulációnál a *referencia* a moduláló jel (mod source: INT), vagy a (belső)vivő (EXT)

ARBgen / Scope:

♣ Szemléltető példa: **két csatornás** oszcilloszkóp-mérés, Output: **Ch1**, Sync: **Ch2**,

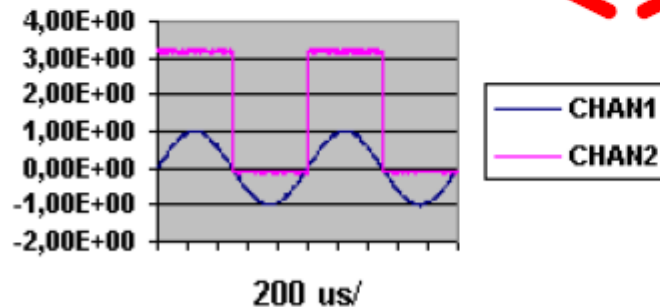
ARBgen: Store/Recall: Set to Defaults: YES ; (→ **Sine**) Set: Ampl: **1 Vpp**, Output: **ON (!)**

Scope: Auto-scale

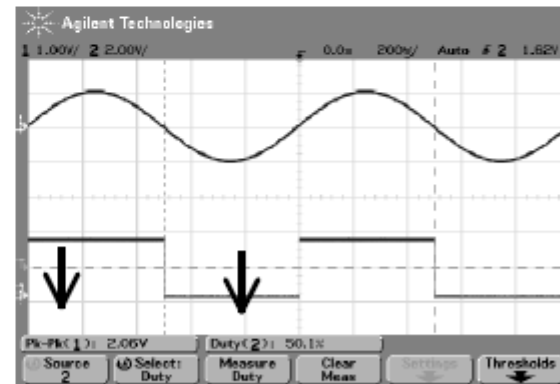
(a) Auto-scale után vegyük le Ch2 kábelt, és *magyarázzuk meg* a jelenséget
(Scope ...[Auto-scale miatt] **Trig Source**: Ch2, és megszűnt a szinkron!)

(b) Visszatéve a kábelt, *dokumentálás* (Scope):

Get waveform data (N^o of points: 500),
and make a graph :



Get Screen Image :



Get single measurement :

Ch1 :Volts Peak-to-Peak (1) = 2,063 V (... mert 1MΩ a terhelés 50Ω helyett)

Ch2: Duty Cycle (2) = 49,9 % (... más időpont, ezért eltér Screen Image adatától)

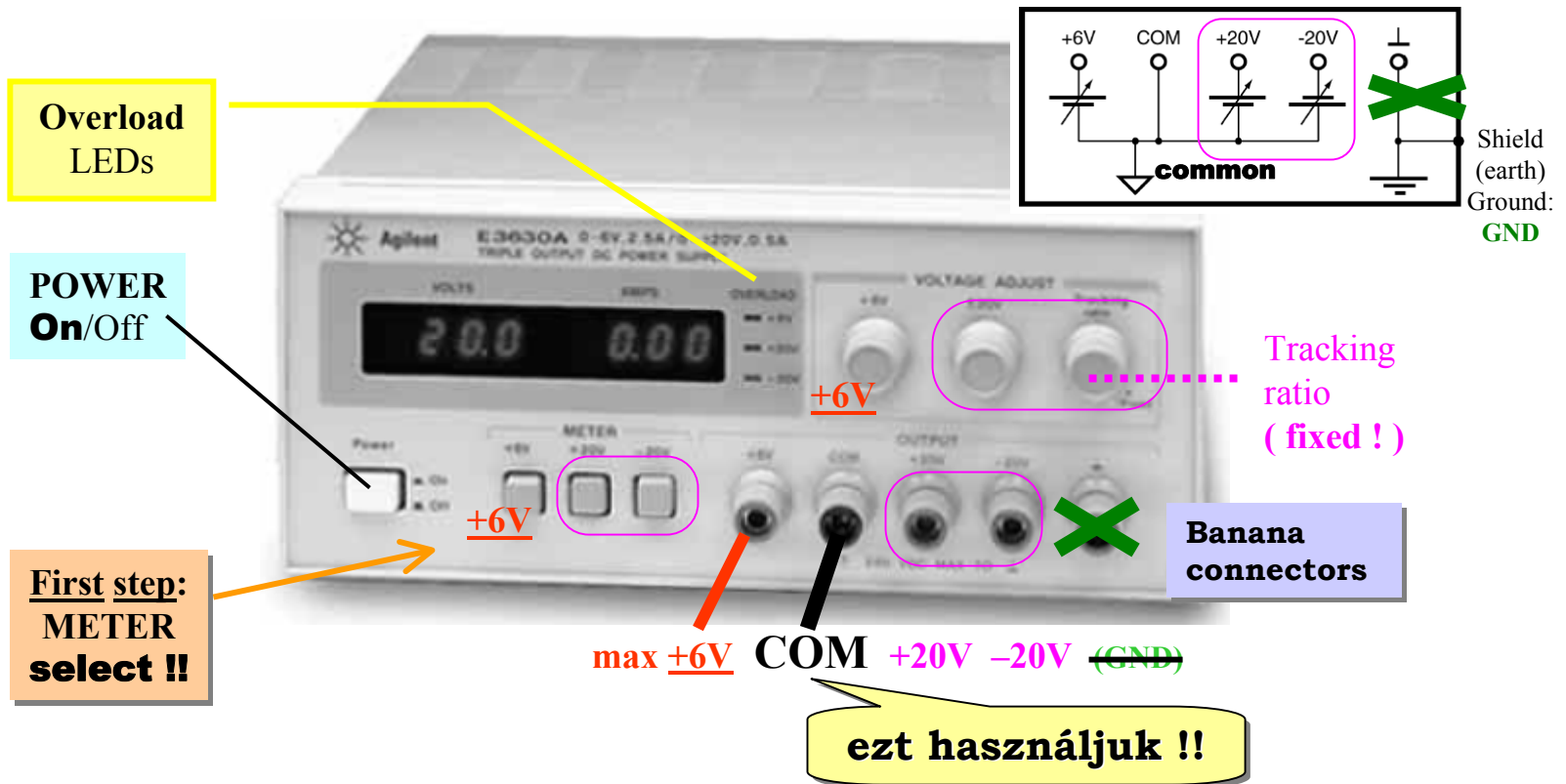
Agilent 3630A triple-output **Power Supply**

max **6V**, 2.5A; max $\pm 20V$ 0.5A (output tracking)

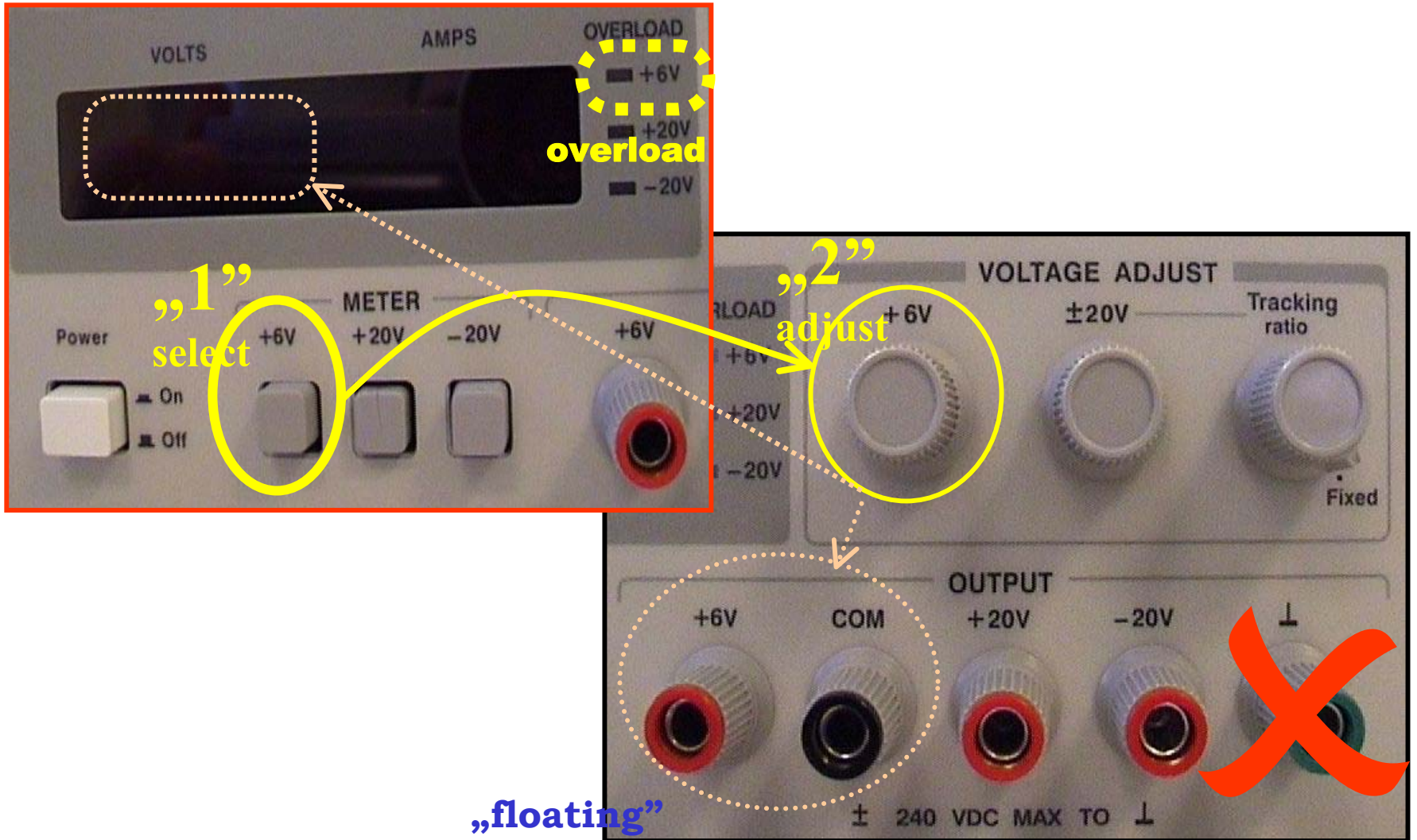
Constant voltage (CV)

and **current foldback (CF, +6V)** / **current limit (CL, $\pm 20V$)** modes

Digital voltage and current METERS



Power Supply - **max** +6V output



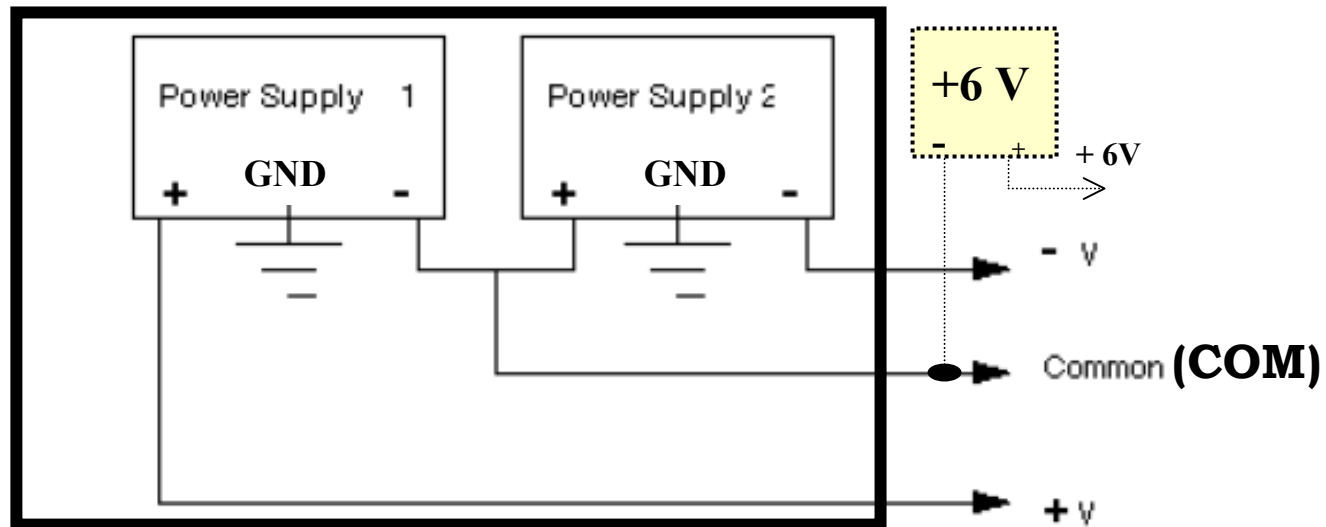
Power Supply: $\pm 20V$ output “tracking”

- The $\pm 20V$ 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 $\pm 20V$ 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* : $\pm 15V$

“1” METER
“2” ADJUST

“3” Connect
(COM, V)



- 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 $\pm 20V$ control still controls both outputs and maintains a *constant ratio* between their voltages.

Agilent 34401A digital **Multimeter (DMM)**

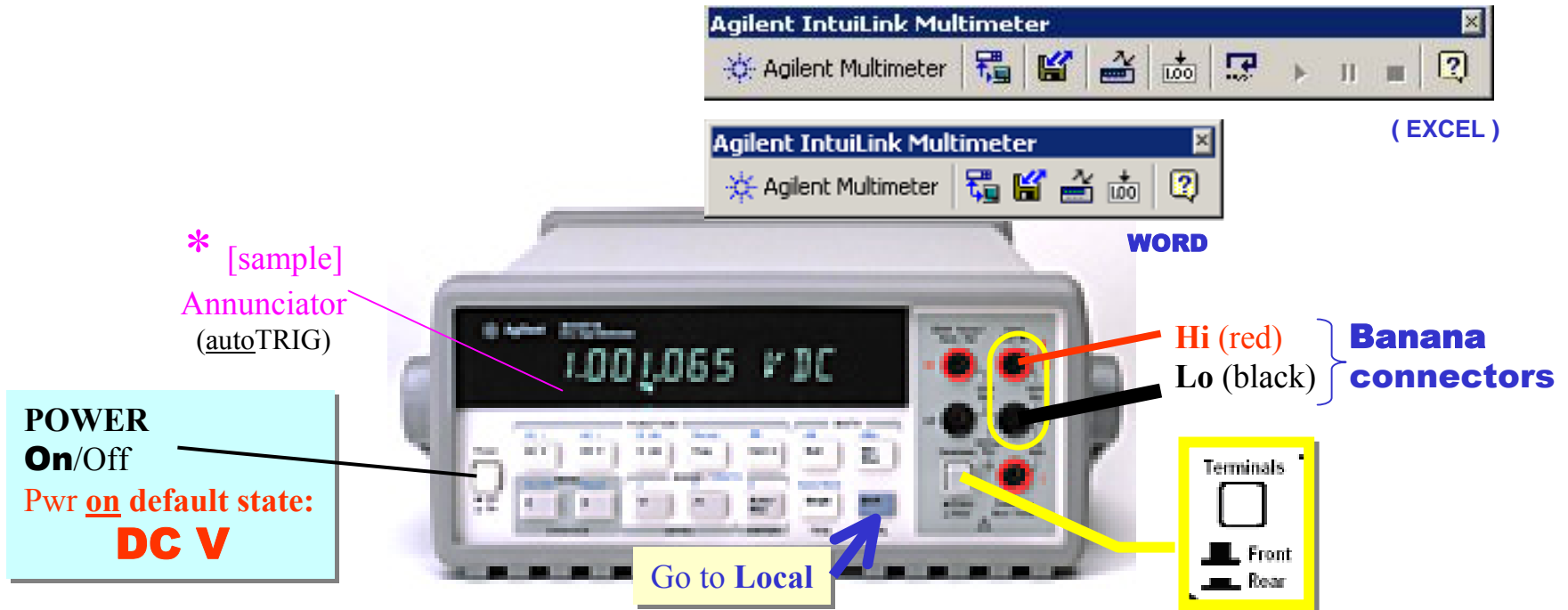
6.5 digit resolution (!); **auto**Ranging; **auto**Trig

Voltage: V, Current: I, **Resistance: Ω** (2Wire, NULL feature, 4W)

True RMS AC volt and current (**ac coupled !**)

Frequency, period; **Math**, Data logging

GPIB, IntuiLink: Toolbars



DMM - Front panel

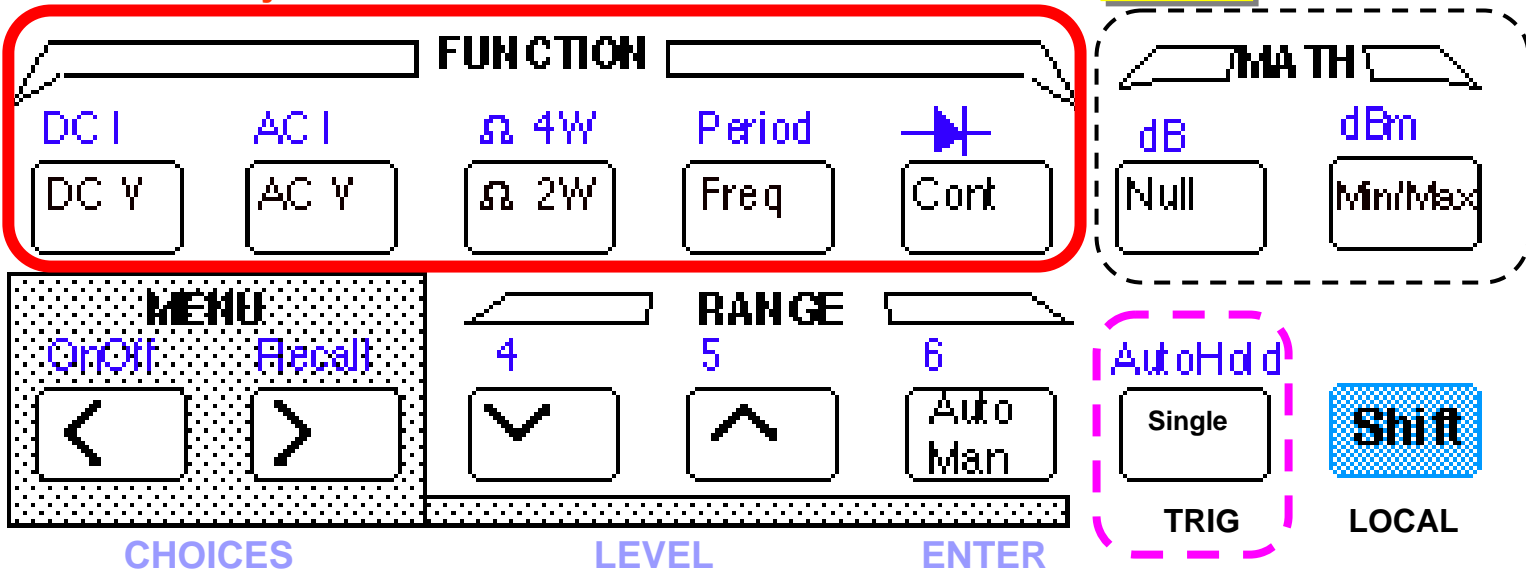
① **FUNCTION** (default state: **DC V**)

② **RANGE** (Auto/Man \wedge \vee), ③ **DIGITS** (Shift 6/5/4; masking: < >), ④ **TRIGger** (Auto)

⑤ *Connection*



“DMM - The Swiss Army knife of test”



DMM - Basic functions

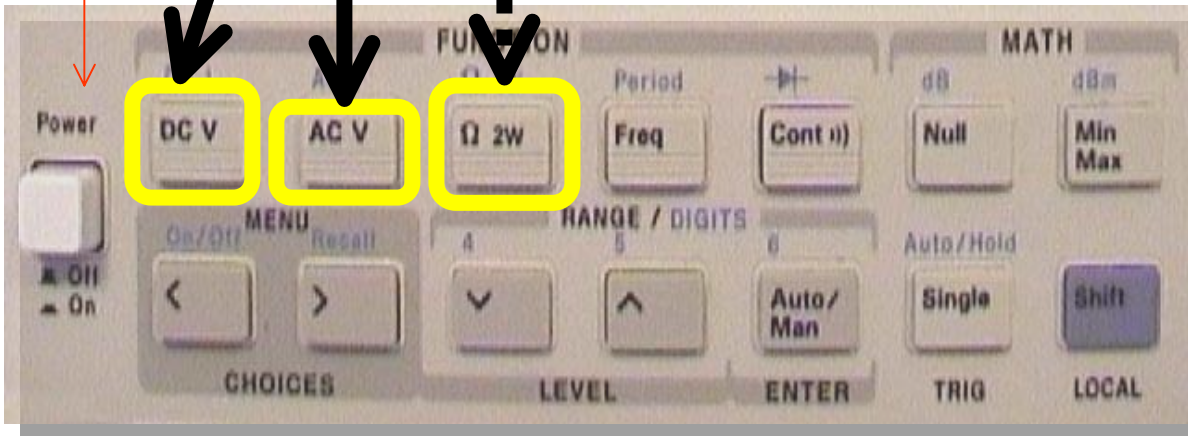
Egyenkomponens

DC: „direct current”
AC: „alternating current”
V: volt (!!)

POWER
(Pwr on:
default
state:
DC V)

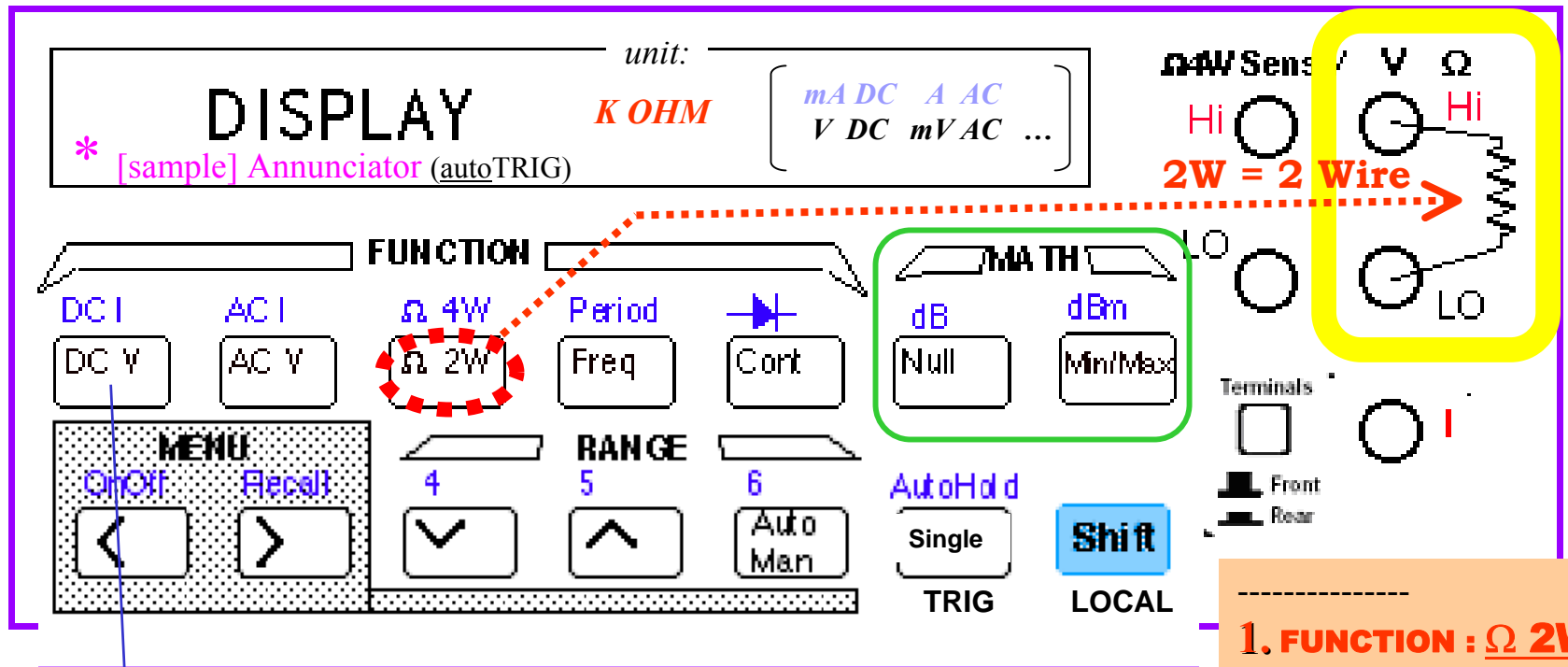
Egyenkomponens nélküli váltakozó jel valódi effektív értéke

Ellenállás (2Wire)



“DMM - The Swiss Army knife of test”

DMM - Ω 2W meas



**BEkapcsolásnál
ez aktív: DC V
(most meg kell
váltogatni !!)**

**a BEkapcsolási alaphelyzet
maradjon !!**

- 1. FUNCTION : Ω 2W**
- RANGE (*auto*)
- Digits (**Shift** 4/5/6)
- TRIGger (*auto*)
- 2. Connection**

♣ DMM - Szemléltető példa: Ω 2W

1. Két összekötött mérővezeték ellenállásának mérése ... ($\approx 45 \text{ m}\Omega$),

ezután

Math: **Null** (*Math* annunciator turns on):
 Ω **2W** mérésnél a mérővezeték hatásának kompenzálása

- (2. Saját *test-ellenállás* mérése ...)

3. **Dokumentálás:** e-Jegyzőkönyv (**Word**)

egyszerűbb KÉZZEL
begépelni az adatot ...

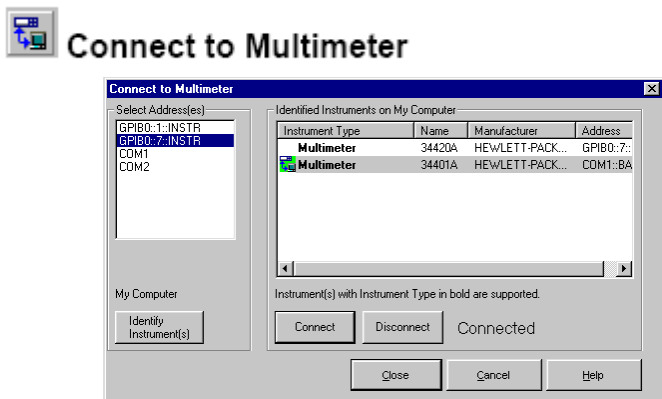


DMM - WORD: Tools | Templates and Add-Ins... AgtMMtb.dot

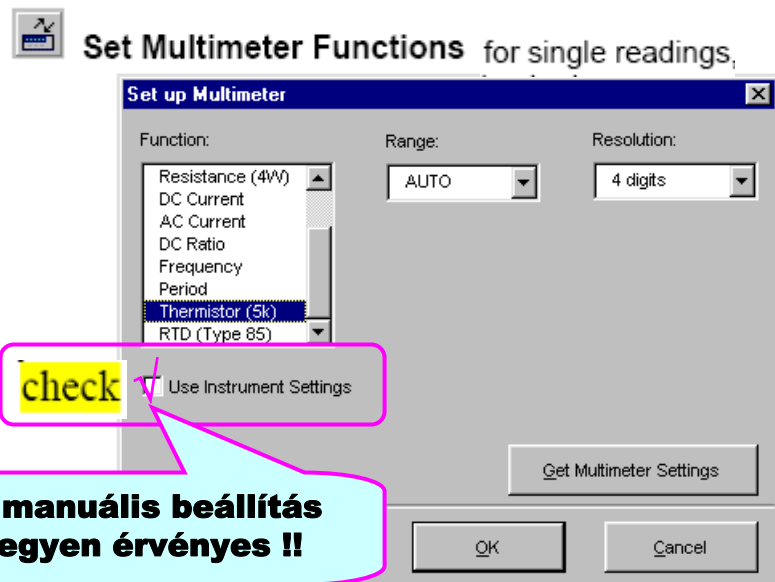
(ha nem látszik → View | Toolbars : √)



Agilent MultiMeter toolbar



GPIB address - 22



Get Single Measurement

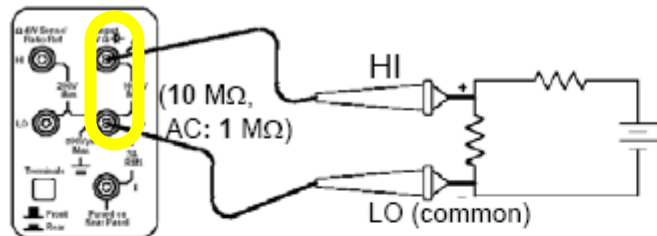
check 'With Engineering units',
do NOT check 'Do not show this dialog' !!

WORD
Save as ... **G:** drive !!

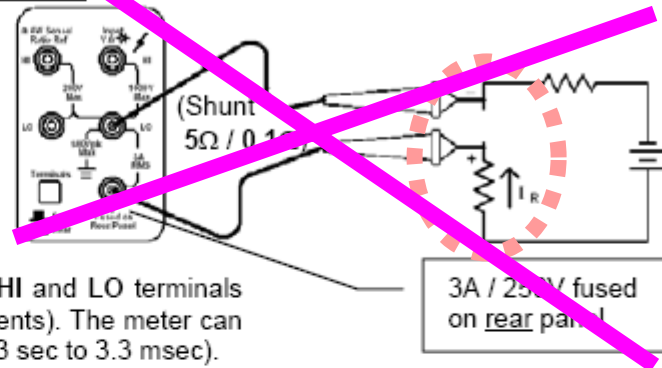
DMM Functions – Banana connectors

DC V, AC V:

Voltage measurement:



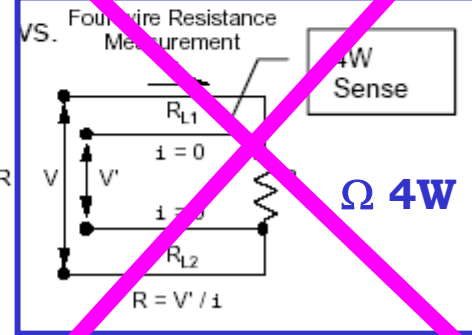
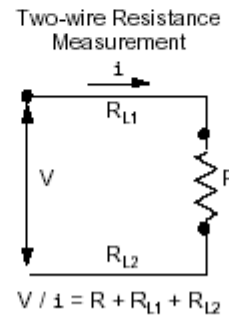
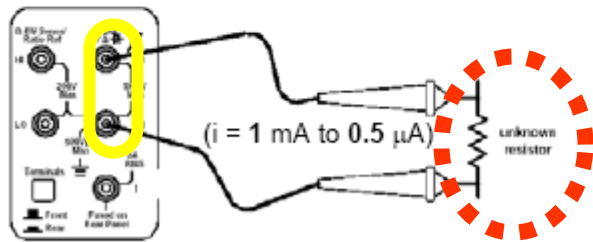
Current meas:



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!

Ω 2W: 2 wire (2W) Resistance meas:



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

Üzem mód váltás előtt: vezeték bontani (kivéve: DC V, AC V) !!

DMM - DC V (dc coupled)

Range (DIGITS) vs. Integration (**AVG**) time in PLCs

Resolution Choices	Integration Time
Fast 4 Digit * Slow <u>4 Digit</u>	0.02 PLC ← Fastest , least accurate 1 PLC
Fast 5 Digit * <u>Slow 5 Digit (default)</u>	0.2 PLC ← 10 PLC
* Fast <u>6 Digit</u> Slow 6 Digit	10 PLC 100 PLC ← Slowest, most accurate

Do not provide power-line noise rejection

* These settings configure the multimeter just as if you had pressed the corresponding "DIGITS" keys from the front panel.

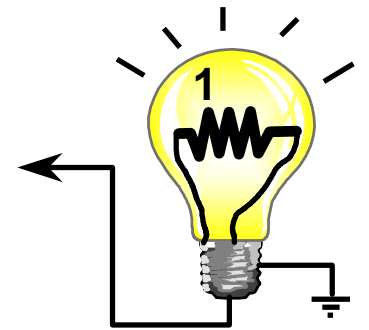
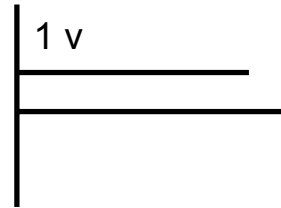
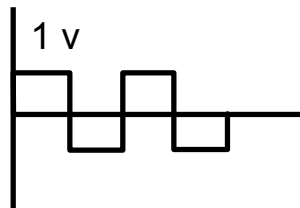
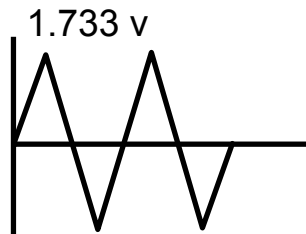
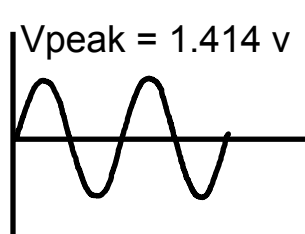
Integration time is specified in *number of power line cycles* (NPLCs). The choices are 0.02, 0.2, 1, **10**, or 100 power line cycles. *The default is 10 PLCs.*

DMM - AC V (true RMS: Root-Mean-Square, ac coupled)

* **RMS** is a measure of a signal's average power

$$V_{rms} = \sqrt{\frac{1}{T} \int_0^T V^2(t) dt} = \sqrt{AVG(v^2)}$$

- An **AC Voltage** with a given **RMS** value has the same heating (power) effect as a **DC Voltage** (with that same value)
- All the following voltage **waveforms (wfm's)** have the *same* **RMS** value: 1.000 VAC on an RMS meter

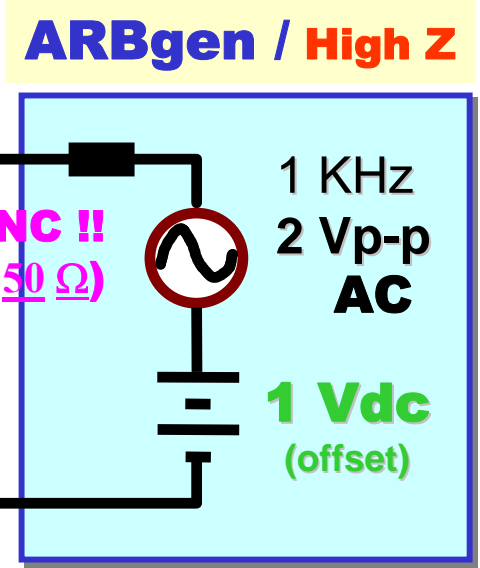
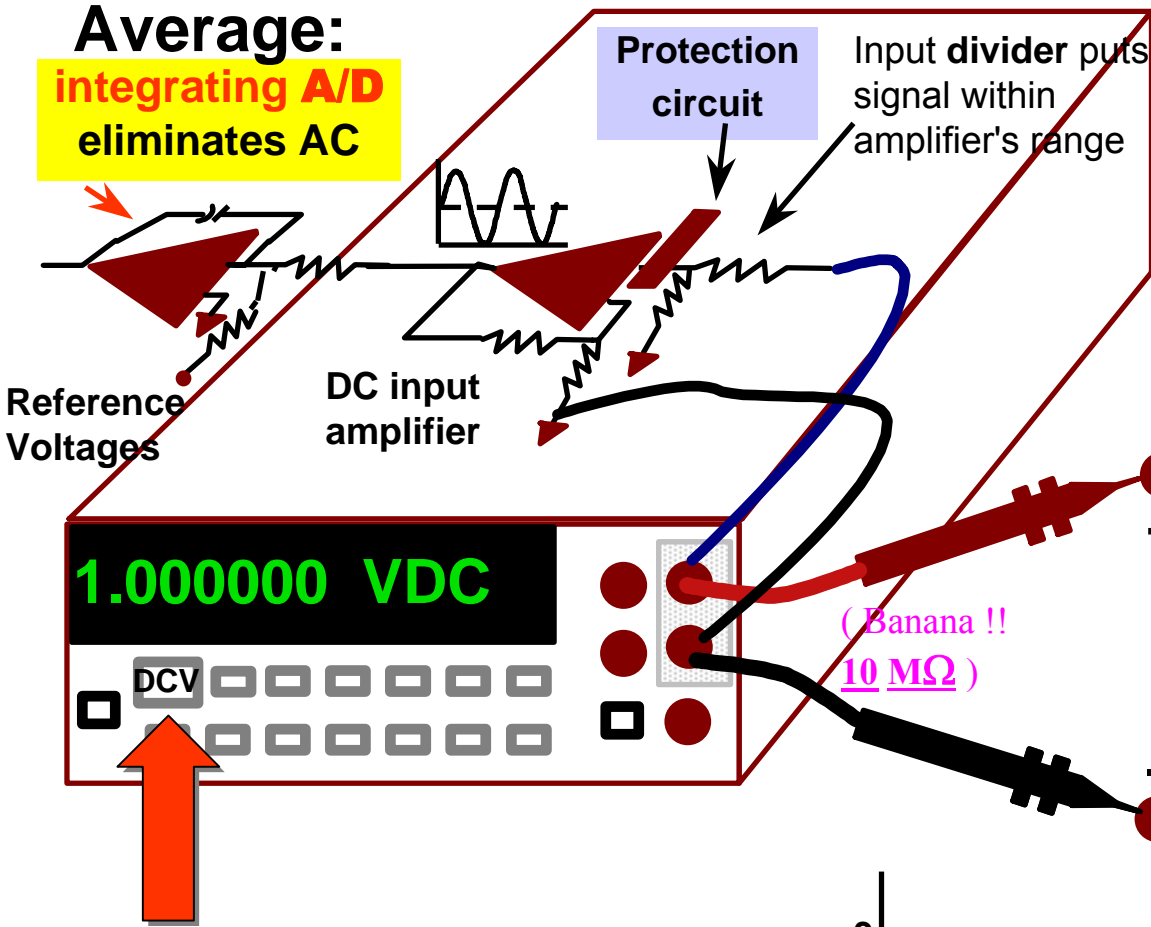


All = 1 WATT

Sine	Triangle	Square	DC	wfm
1.414	1.733	1	1	Vpeak
1	1	1	1	Vrms

ARB gen / DMM (1): Measuring **DCV** (dc coupled)

CAUTION:
Do not exceed the **maximum** allowable voltage input (1000V DC).
(Also, **never** apply a voltage over the **current** input terminal (I) of the DMM.)



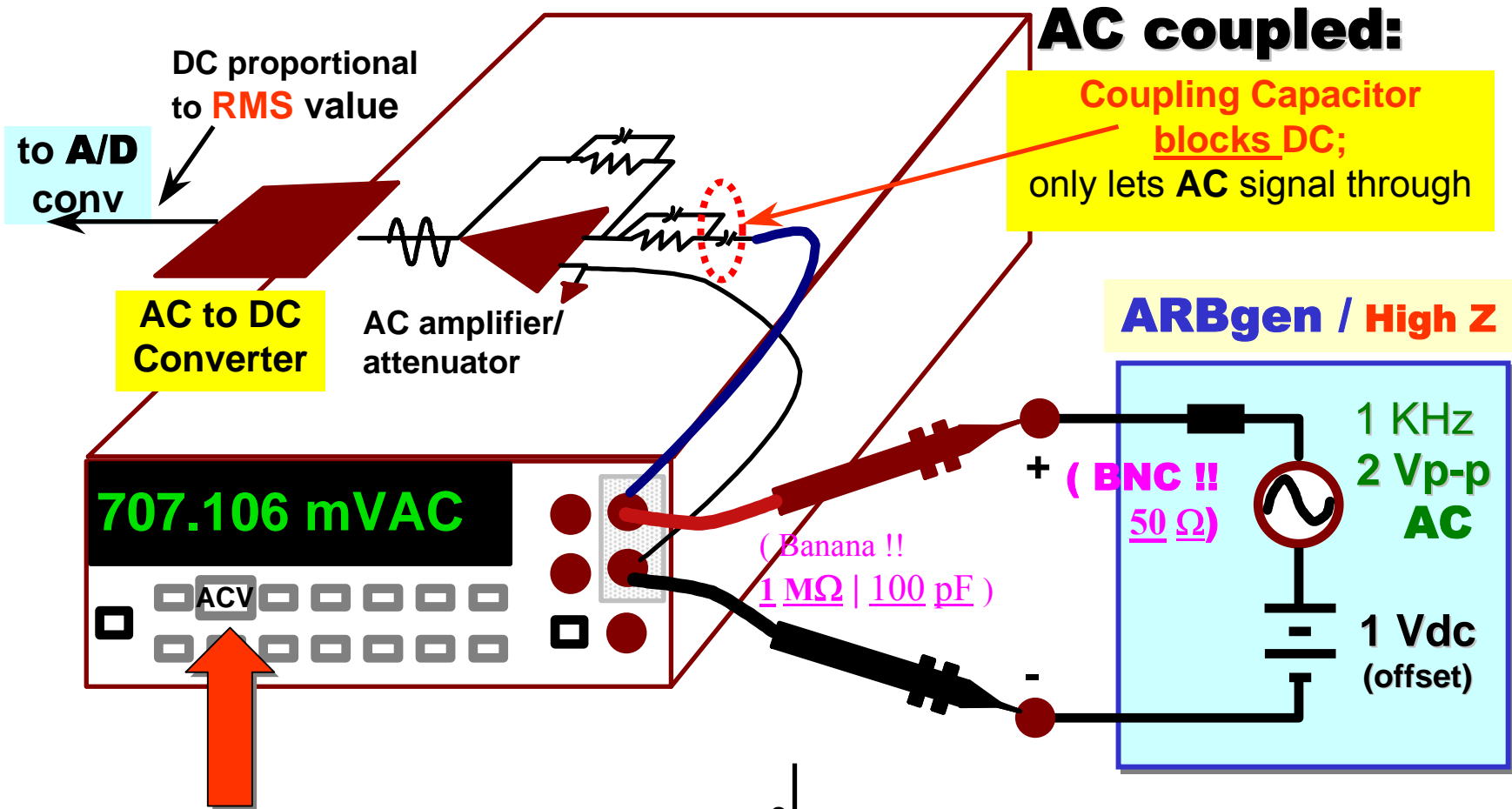
1.000000 VDC

DCV



Signal

ARBgen / DMM (2): Measuring **ACV** (true RMS, ac coupled)



mérőhely kikapcsolás

1. **Műszer(ek)** – *K*/kapcs.

2. **Számítógép** (Win2K) – *Shut Down ...*

... és **megvárjuk (!)** , amíg az
aut. kikapcsolás lefut

3. Mérőhely **táp-elosztó** – *K*/**I**

... és **rendet rakunk** (kábelek, stb.)

A mérőkártyák adapterei
NE maradjanak a **(!)**
konnektorban
a mérés után
(ne melegedjen a trafó)

"I hear...I forget; I see...I remember; I do...I understand." - Confucius, c. 500 BC

**In theory, there is no
difference between theory
and practice.**

But, in practice, there is.

Jan L. A. van de Snepscheut