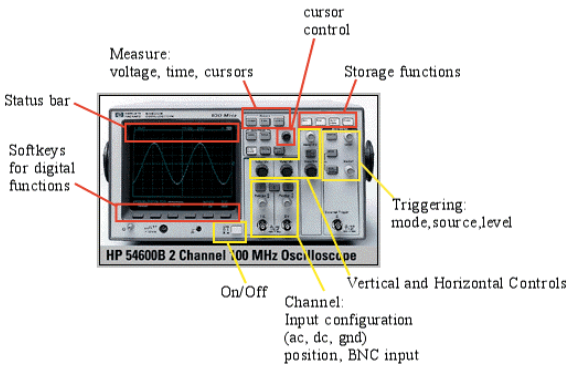
1. sz. mérés
Mérések digitális oszcilloszkóppal

A mérés célja, hogy megismerjük egy digitális oszcilloszkóp (DSO: *D*igital *S*torage *O*scilloscope) kezelését, *speciális* szolgáltatásait, mint pl.

- automatikus „kép” beállítás (Auto-scale) ... de NE szokjunk rá [1]
- automatikus jel-paraméter mérés
- PREtrigger
- hullámforma (Trace) és működési állapot (Setup) tárolás ill. előhívás
- zajszűrés (Display: `Average`) rekord-átlagolással
- zavar „tüske” detektálás (Display: `PeakDet`), stb.



és gyakoroljuk az *interaktív* jelanalízist.
A mérőeszköz a beépített 1K FFT (*F*ast *F*ourier *T*ransform) analizátorral a felvett hullámforma *spektrumát* (a periodogramot, azaz a harmónikus-modell [Fourier-sor felbontás] spektrum komponenseinek amplitúdóját) is megjeleníti.

Mérőeszköz: **Oszcilloszkóp** (HP 54600 **DSO + FFT**),
Scope *hátizsák*ban: **mérőfej** (HP 10071A **Probe, 10:1**)
Jelgenerátor: **saját** jelforrás (Scope – Probe adjust signal out),
Tesztjel generátor (HP 54654A)

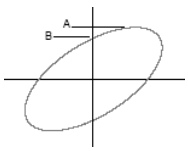
Mérési feladatok:

1. Stabil kép (nyomvonal) beállítással elemezzük a Tesztjel generátor egyes mérő-pontjain fellépő feszültség jelalakokat, mérjük meg a jellemzésükhöz szükséges paramétereket, *dokumentáljuk* az eredményeket

   Útm.**:** 1-2: jelkésleltetés (→ Time: `Delay`)
   3: trigger tiltás (→ Holdoff by time)
   4: végtelen utánvilágítás (→ Auto-store)
   5: kitöltési tényező (= pulzus-szélesség/periódusidő arány, →Time: `Duty Cycle`)
   6: kettős időalap (delayed sweep)
   7: jel-amplitúdó (→ Voltage: `Vp-p`)
   8: vonalíró üzemmód (→ `Roll`)
   ~~9,10: tranziens jel, túllövés~~
   11: átlagolás (→ Display: `Average`)
   12-13: fáziseltérés, **`XY`: Lissajous**-display
   13-14: burkoló és vivő


1822-1880

$$\varphi = \sin^{-1}\frac{B}{A}$$



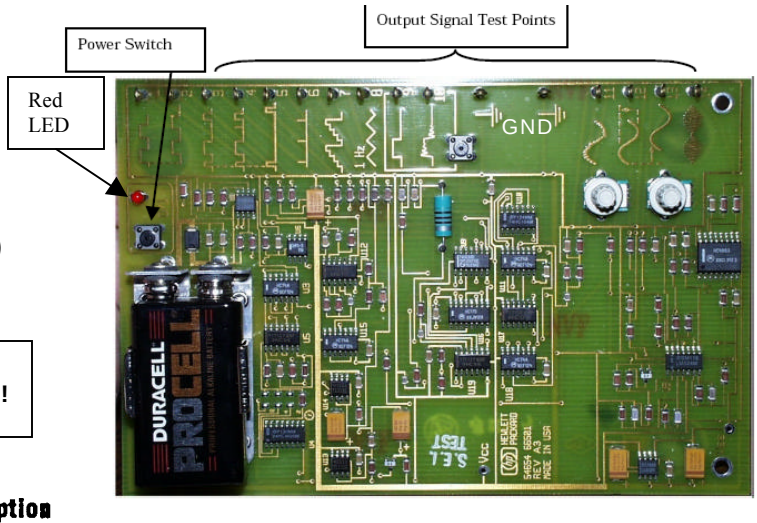
2. (a) Mérjük meg az oszcilloszkóp A/D átalakítójának max. mintavételi gyakoriságát
   Útm.**:** Ch1 - Probe adjust signal out, Auto-scale (Run), időalap: `50 ns/DIV`, trigger Mode `Single`, Display `Vectors: Off` és Cursors → mintapontok időtávolsága

   (b) Ezután, fedezzük fel az „ekvivalens idejű mintavétel (ETS)” működését
   Útm.**:** az előző beállításnál az Auto-store *ismételt* megnyomásával *sűríthetők* a mintapontok (repetitive signal, random Equivalent Time Sampling**:** ETS).
   Ezután *vissza*váltás: trigger Mode `Auto`

[1] MEG KELL TANULNI a **manuális** “kép”beállítást is: *stabil* nyomvonal (Trigger), *méretek* (amplitúdó, idő skála) és *helyzet* (vertikális, horizontális pozíció), valamint a méréseket **manuálisan** (Cursors) és „ránézéssel (Eyeballing)”

Függelék:

Tesztjel generátor (HP 54654A) jelalakok

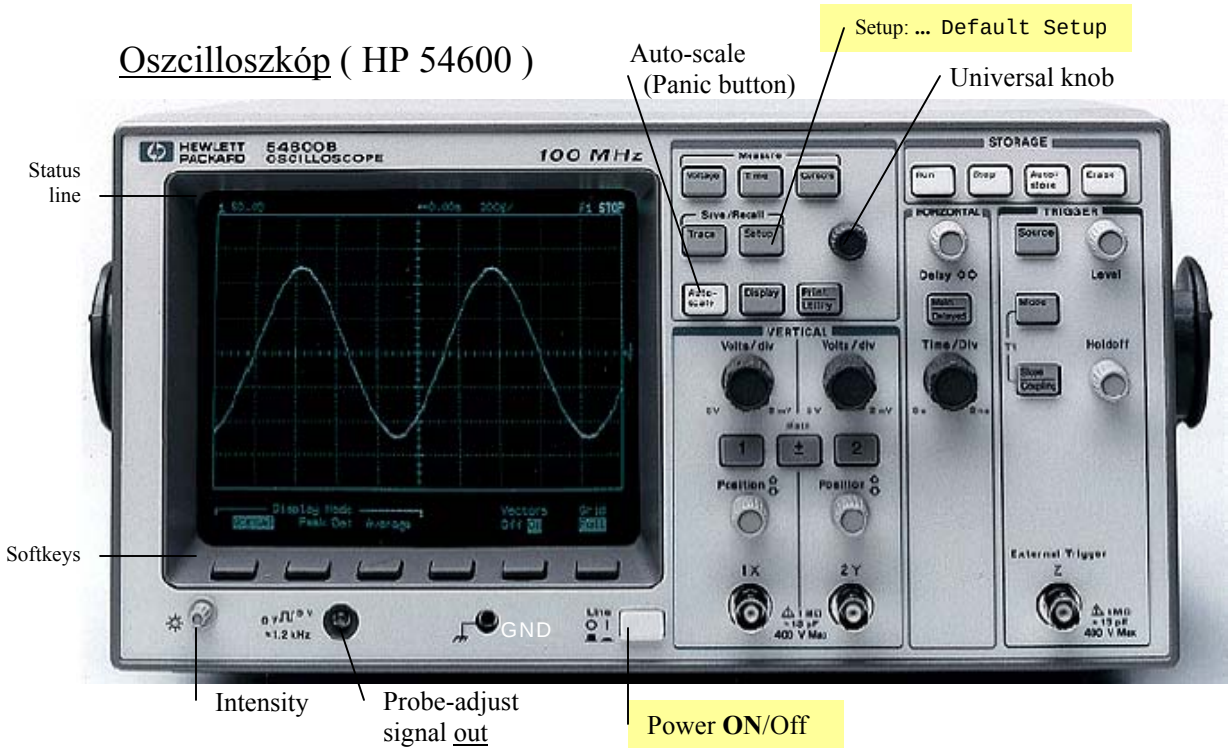


Connect the scope probe ground lead to the board's **ground (GND)** test point **first !**

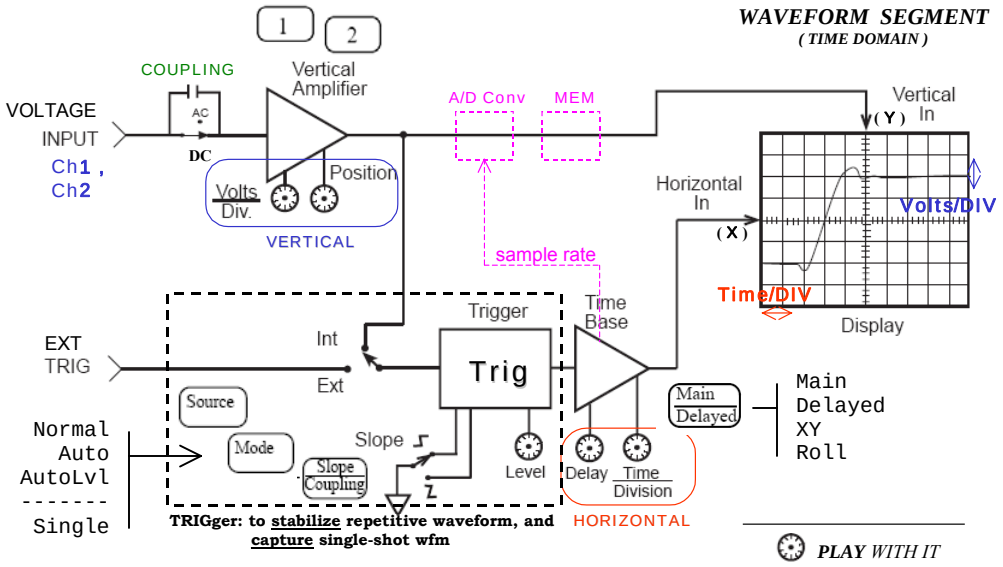
Test Point	Waveform	Description
1		Square wave, 500 kHz, 3.7 Vp-p.
2		Square wave, same as test point 1, but delayed in time by a partial period.
3		Complex pulse train with pulses of various widths and variable time spacing; pulse train repeats every 28.6 μs, 3.7 Vp-p.
4		Same as test point 3, but with an additional narrow glitch pulse occurring at a lower repetition rate.
5		Pulse with period of 28.2 μs, 3.7 Vp-p, and duty cycle of 6.6%.
6		Narrow pulse with low duty cycle, period 6.4 ms, width 325 ns.
7		Noisy stair step with glitches; height of each step is about 65 mV, period 7.5 μs.
8		Slow saw tooth waveform, period 1.6 s, 1.2 Vp-p.
9		Single-shot pulse activated by a momentary-contact pushbutton near the test point; width 90 μs, 3.6 Vp-p.
10		Single-shot pulse, similar to that on test point 9 but with ringing on the pulse top; ringing frequency about 190 kHz.
11		Noisy sine wave; frequency 1.1 kHz, 1.4 Vp-p.
12		Variable amplitude sine wave; frequency 1.1 kHz; amplitude is varied by turning a potentiometer near the test point.
13		Sine wave is similar to that available on test point 12, but with variable phase shift referenced to the test point 12 waveform. Phase shift is varied by turning a potentiometer near the test point.
14		Modulated carrier waveform; carrier frequency about 260 kHz, modulating frequency about 1.1 kHz.

Output impedance for **digital** waveforms is 316 Ω; output impedance for **analog** waveforms are as high as 50 kΩ. It is important that you use high impedance 10:1 probes, not 1:1 probes, to connect to the board. The 1:1 probes have high-input shunt capacitance which overloads the outputs, causing distortion.

Oszcilloszkóp (HP 54600)



Scope (graphic voltmeter) ... a "mental model"



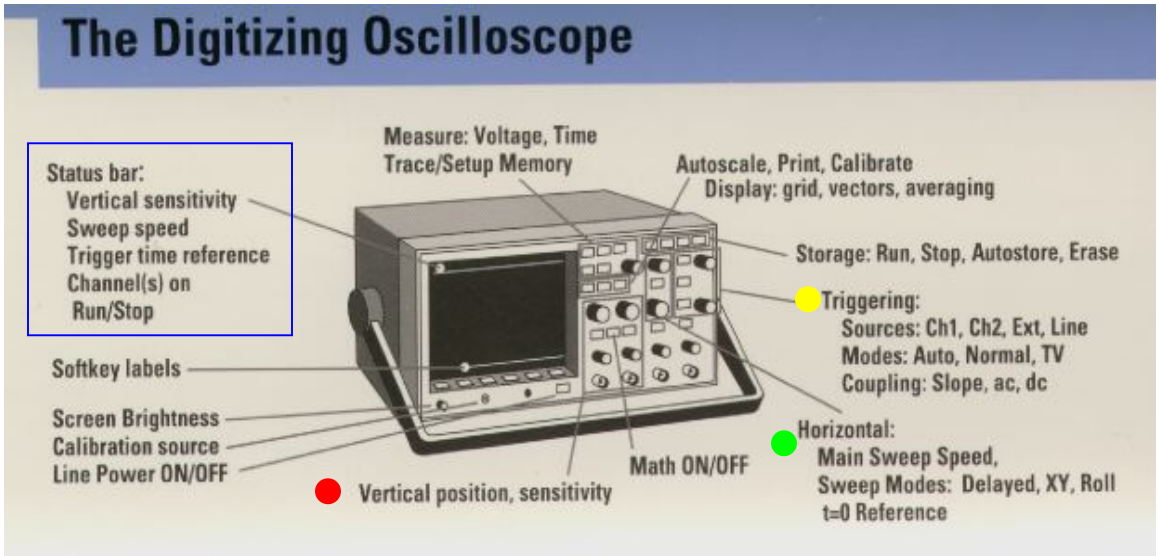
Kezelő szervek (**user interface**)

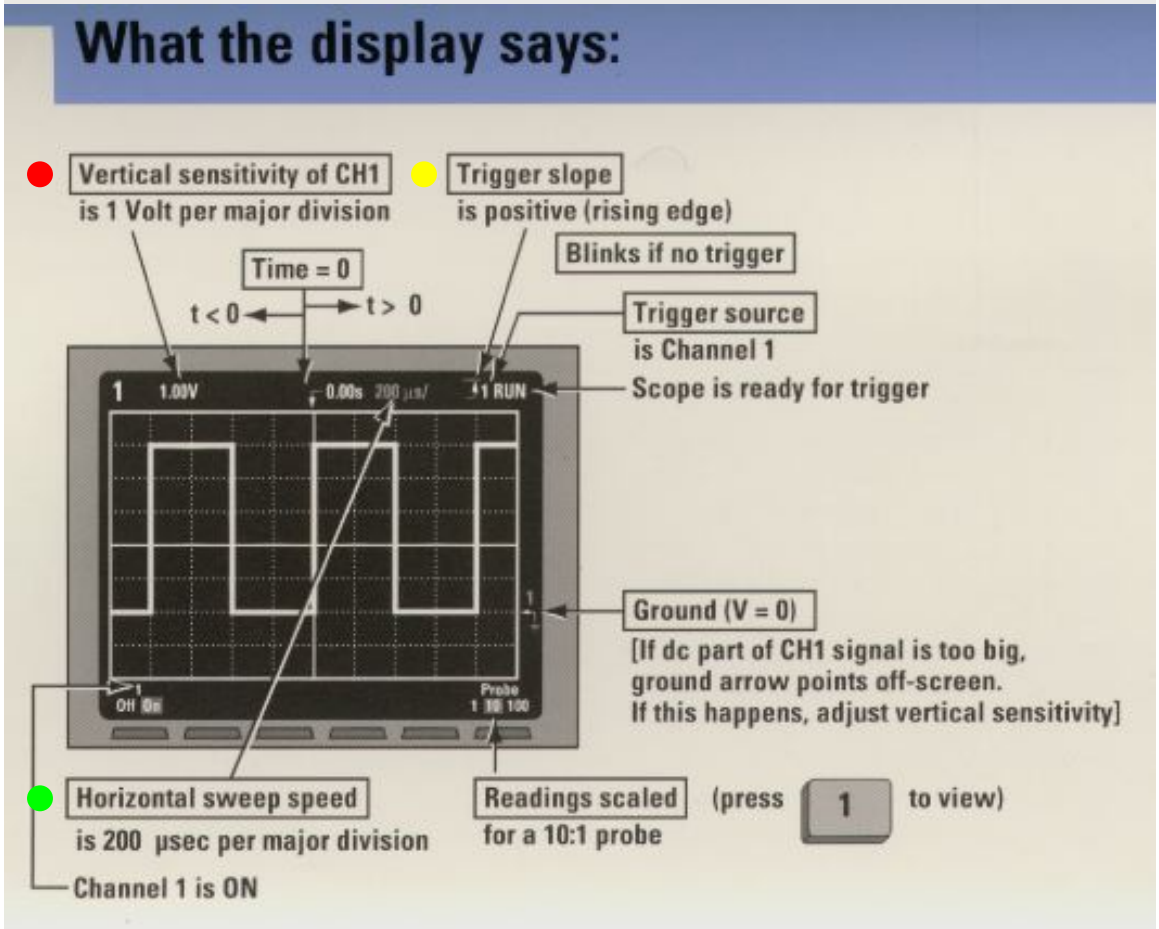
- Közvetlen vezérlés (**instant action**: *dedicated* buttons and knobs)
  - Fehér nyomógomb(ok), pl. Run, Stop, Auto-store ... ; Auto-scale
  - Forgatógomb(ok), pl. **`Volts/Div, Position`** ... **`Time/Div`** ...
- Menü vezérlés (**menu-button / softkey**)

  Szürke nyomógob(ok), az aktuális funkció a képernyő alján, a *felirat nélküli* nyomógomb (`softkey`) felett jelenik meg, pl. Display `Normal/PeakDet/Average` ...

  Aktív paraméter beállítás: univerzális forgatógomb (*felirat nélkül*, a Cursors nyomógomb közelében), pl. Cursors `Source:1 / ActiveCursor: … t2`

1. Front Panel

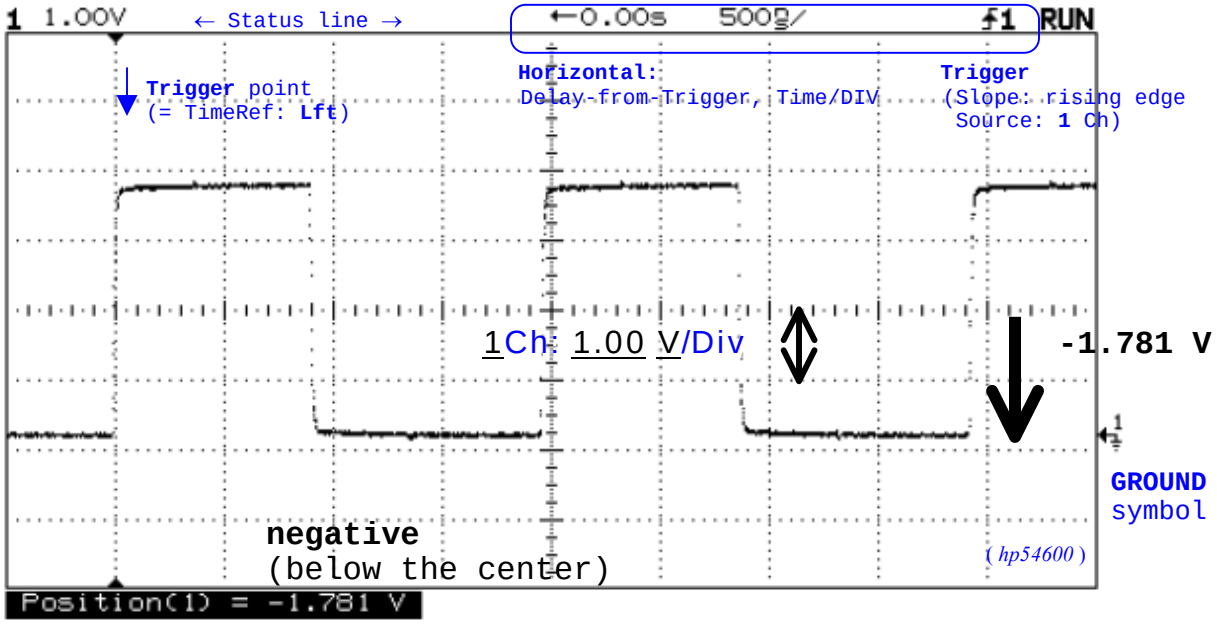




Auto-scale, Display `Grid:Full`, 1 `1:On, ... Probe:10` (@ `10:1` Probe!)

2. Trace Position

Vertical The **Position knob** moves the trace (displayed signal) vertically, and it is calibrated. Notice that as you turn the Position knob, a voltage value is displayed for a short time indicating **how far** the **ground** reference is located **from** the **center of the screen**. Also notice that the ground symbol [2] on the right side of the display moves in conjunction with the Position knob.

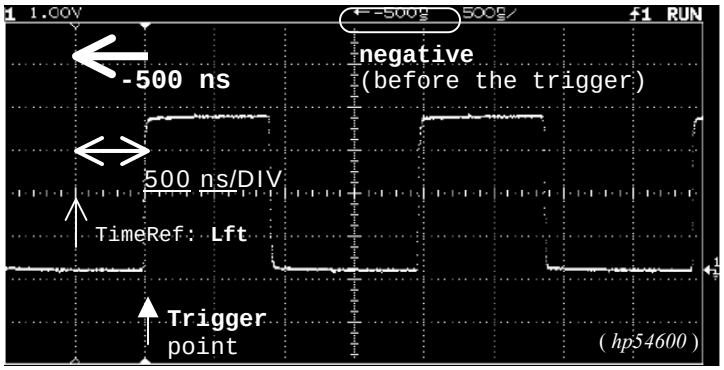


Horizontal Turn the **Delay knob** and notice that its value is displayed in the status line. The Delay knob moves the trace horizontally, and it pauses at 0.00 s, mimicking a mechanical detent.

At the top of the graticule is a **solid triangle** (▼) symbol and an **open triangle** (▽) symbol.
The ▼ symbol indicates the trigger point and it moves in conjunction with the Delay knob. The ▽ symbol indicates the time reference point [3]. If the `Main/Delayed`: `Time Ref` softkey is set to **Lft**, the ▽ located one graticule in from the *left* side of the display. If the `Time Ref` softkey is set to **Cntr**, the ▽ is located at the *center* of the display.

The delay number tells you **how far** the **reference** point is located **from** the **trigger** point.

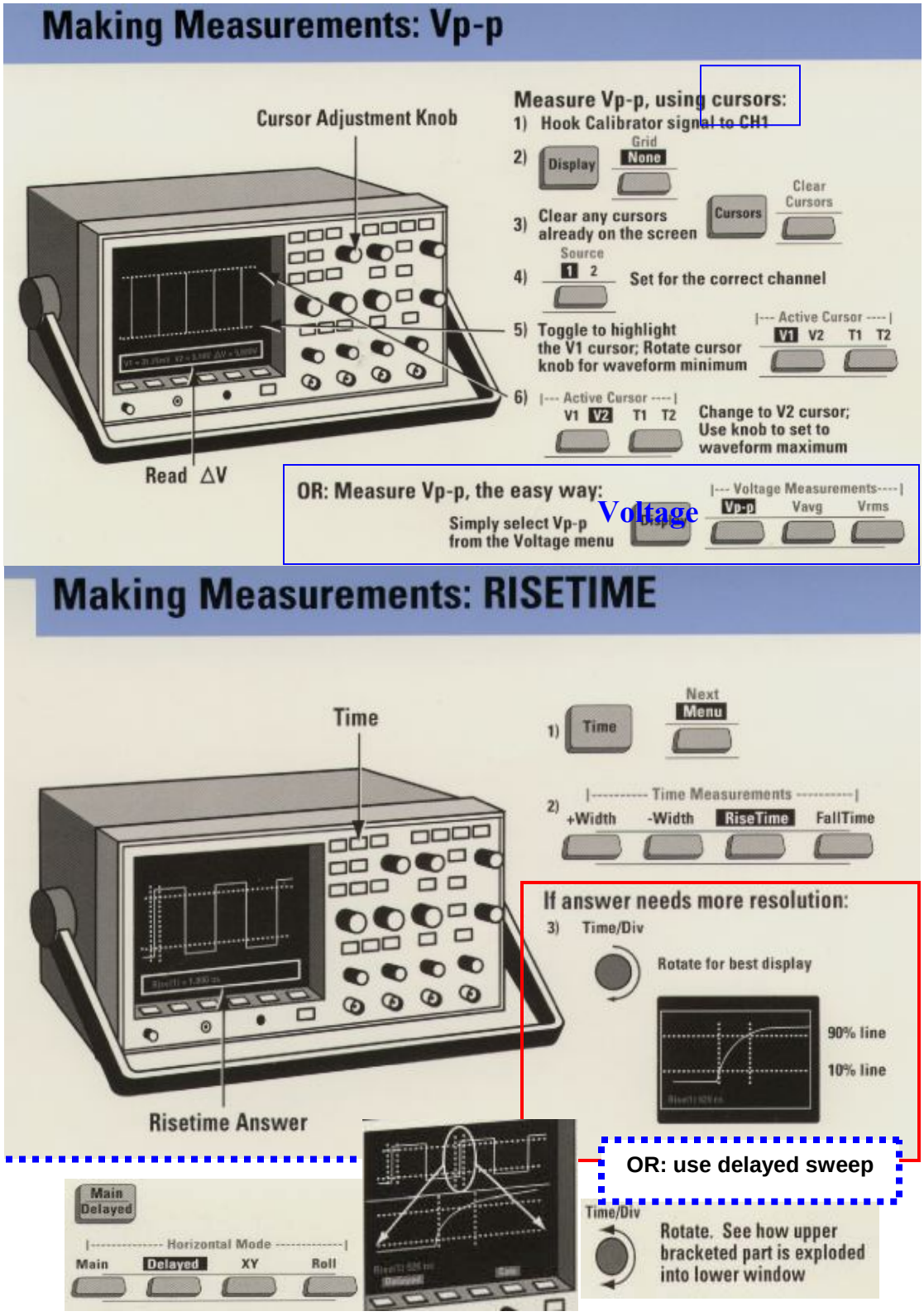
All events displayed left of the trigger point ▼ happened before the trigger occurred, and these events are called *PREtrigger* information. You will find this feature very useful because you can now see the events that led up to the trigger point. Everything to the right of the trigger point ▼ is called *POSTtrigger* information.



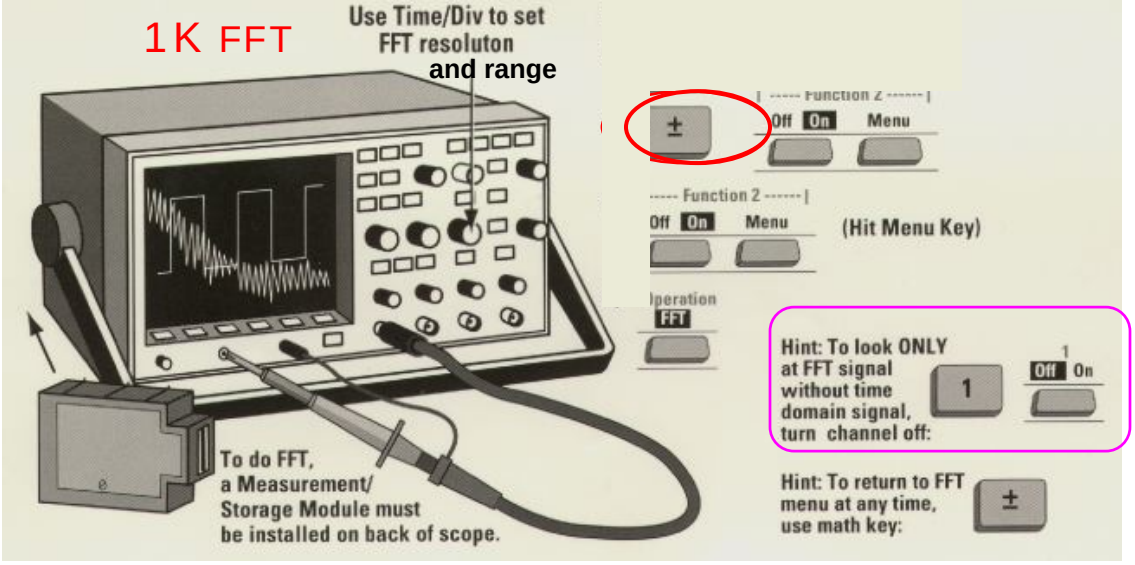
[2] When the ground reference moves **off screen**, the GROUND symbol changes to an arrow and points in the direction (up or down) where the ground reference is

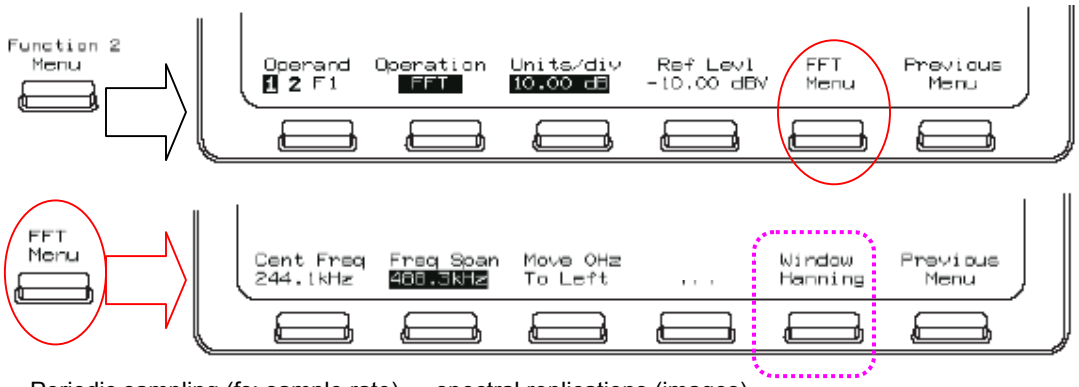
[3] The time reference point is the trigger point when **zero** (0.00s) delay is selected

3. Measurements

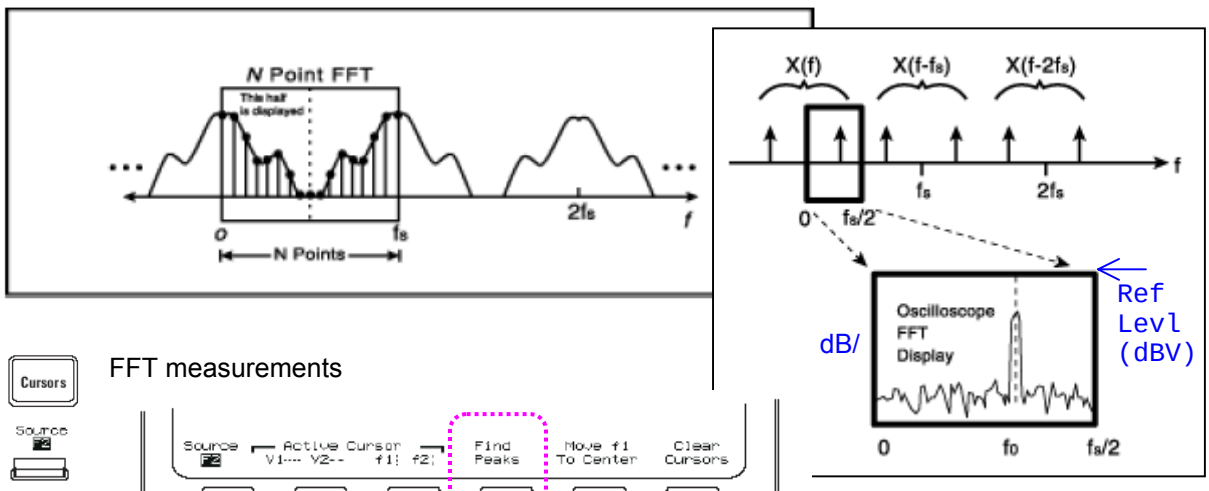


Making Measurements: FFT (Frequency Domain)



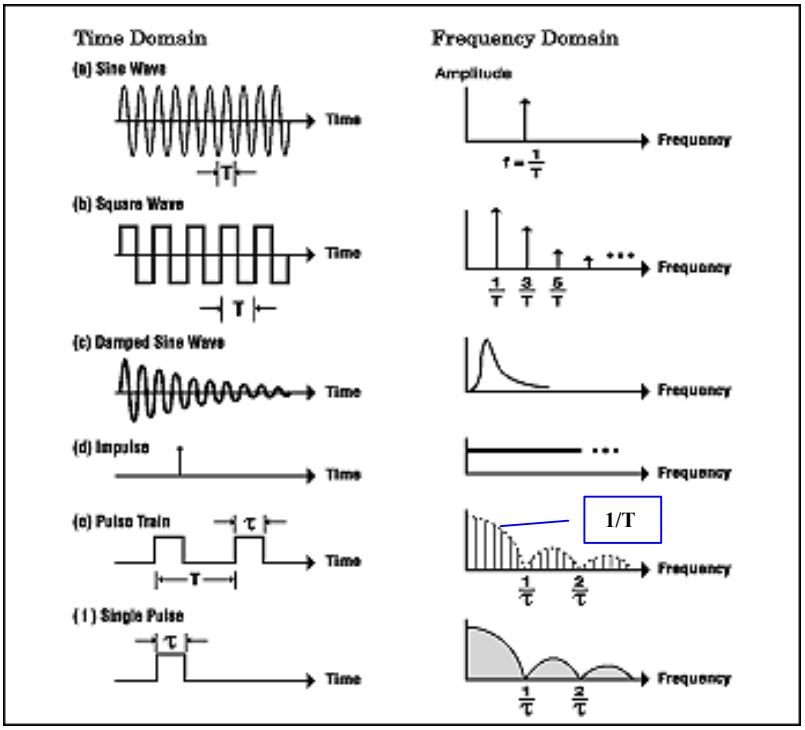


Periodic sampling (fs: sample rate) → spectral replications (images)

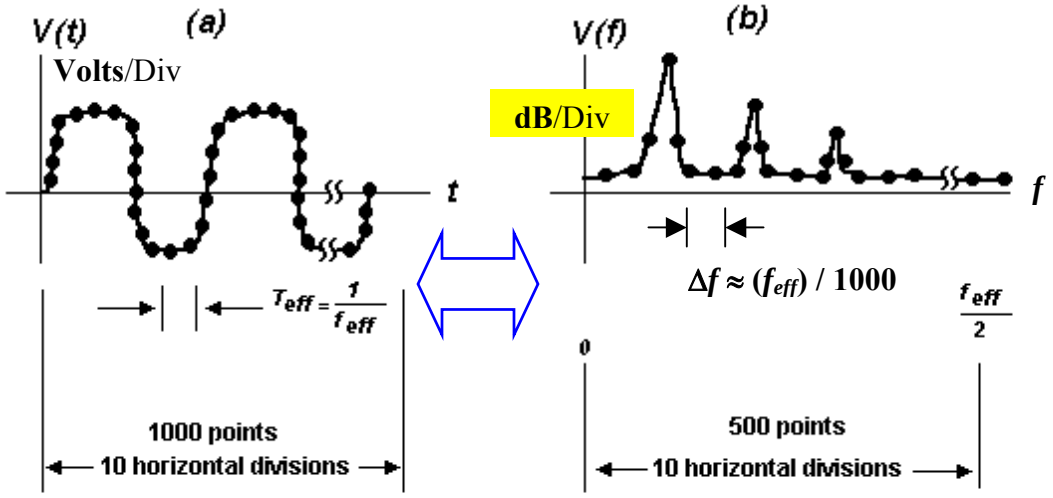


FFT measurements

Példák: **jelalak** (időtartomány) ⇔ **spektrum** (frekvencia-tartomány)



Megjelenítés: (a) **idő**tartomány: **DSO** ⇔ (b) **frekvencia**-tartomány: **FFT**

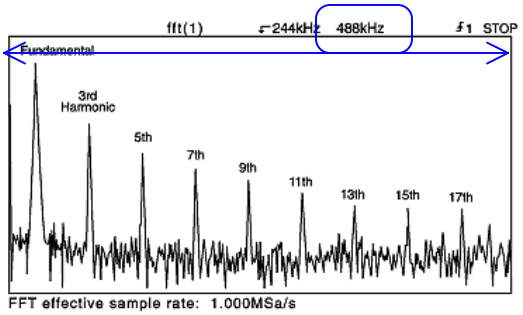


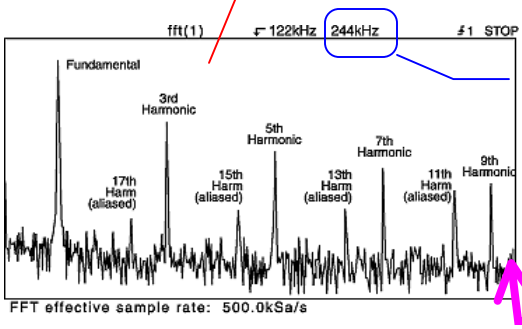
f_{eff} ≈ 1000 / (10."Time/Div") = 100 / (Time/Div) ... effective **sample rate**

Hasonmás (**aliasing**): f = (k. $\mathbf{f_{eff}} \pm \mathbf{f_A}$) > $\mathbf{f_{eff}/2}$, k = 1,2, ... frekvenciájú komponens az **alap**sávba (0, $\mathbf{f_{eff}/2}$) "lapolódik" át (!) és $\mathbf{f_A}$ (< $\mathbf{f_{eff}/2}$) frekvenciájú komponensként jelenik meg az FFT kijelzésen (amely csak az amplitúdó értéket jeleníti meg, a fázist *nem*)!

Ablak (**window**): lecsökkenti az ún. nem-koherens mintavétel miatt fellépő "spektrum-szivárgás" (**leakage**) hatását. Frekvencia-méréshez → `Hanning`, amplitúdó-méréshez → `FlatTop`

Hasonmás (ALIASING): **háromszög-jel** spektruma





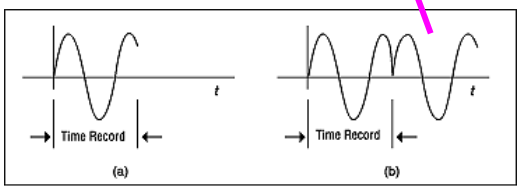
miért rossz a sorrend? (alias)

milyen a skála?

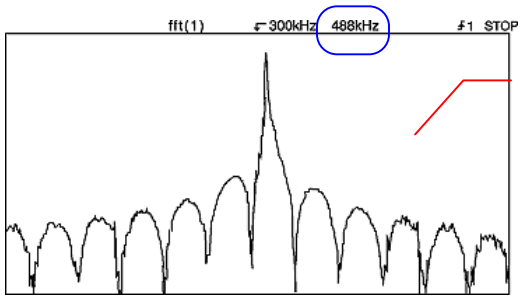
„Nyquist wall": fs/2

Ablak (WINDOW) a spektrum szivárgás (leakage) csökkentéséhez: **szinuszos jel**

"nem-periódikus" folytatás



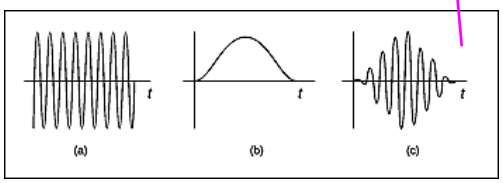
"nem-koherens" mintavétel



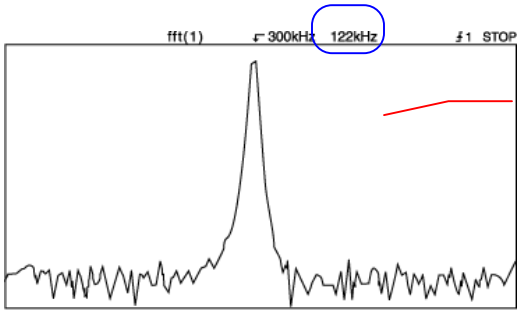
FFT - "Rectangular" window

miért nem vonal? (leakage)

a széleken "nullára simított" időrekord: **periódikus** folytatás



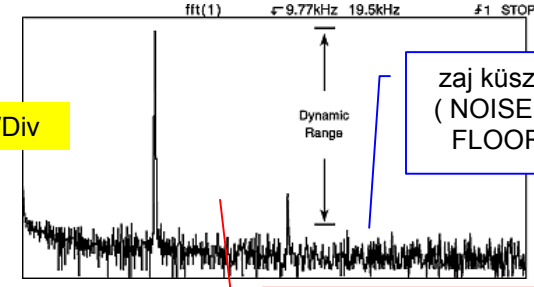
nem-koherens mintavétel **és ablak**



FFT - **„Hanning"** window

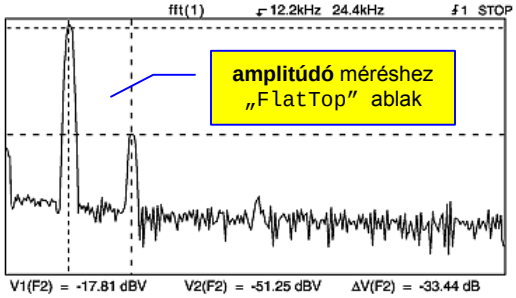
milyen szűrő?

A spektrum mérés (FFT) dinamika tartománya tipikusan 60 dB (HP54600) és a két legnagyobb spektrum "vonal" **automatikus** méréséhez: Cursors → Find Peaks



10 **dB**/Div

zaj küszöb (NOISE FLOOR)



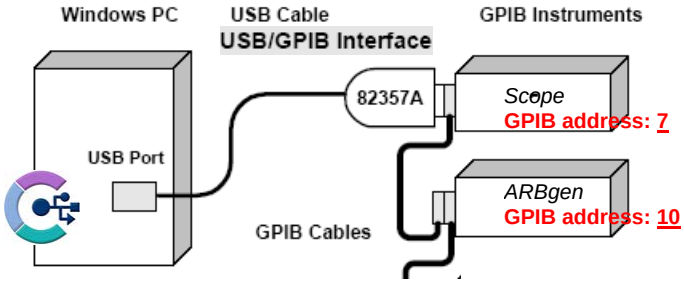
amplitúdó méréshez „FlatTop" ablak

miért nem egy vonal? (→ torzítás)
miért zajos? (8 bites A/D átalakító → kvantálási zaj)

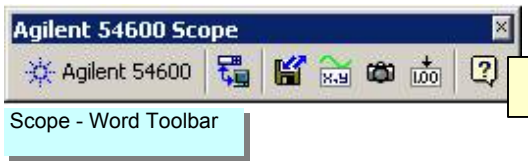
Számítógépes kapcsolat (*transparent* IO interface)

GPIB: General Purpose Interface (Instrument) Bus
[IEEE488/IEC625, HPIB]

IO driver: IO Libraries Suite 14.1



IntuiLink szoftver (Word Toolbar)

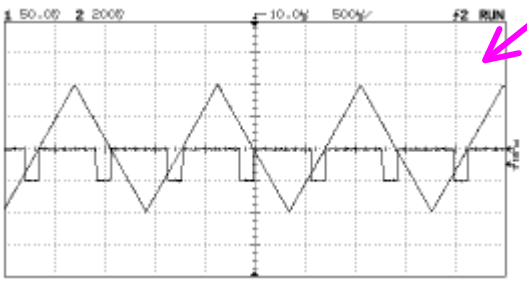


?

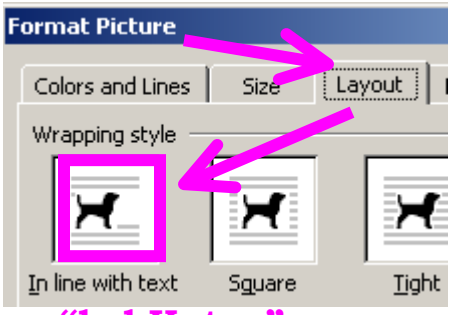
1. ~~Select the local language~~
2. **Connect** to the Scope and verify communication
3. ~~Save the current Scope settings to a file | Download previously stored settings to the Scope~~
4. Get **waveform data** from the Scope and make a graph
5. Insert an **image** of the Scope display in the document
6. Capture a **single measurement** from the Scope

Adding the toolbar in Word
Word: **Tools** | Templates and **Add-ins:** ☑ **Agt54600.dot**
(View | Toolbars: ☑ Agilent 54600 Scope **)**

Insert an **image** in Word:



RIGHT click:



"bal Kutya" ...

Részletes, angol nyelvű leírások

Scope**:** Agilent [=HP] 54600 **Scope manual** (condensed)
http://www.hit.bme.hu/people/papay/edu/Lab/54600_Manual.pdf
Scope probe (HP 10071A)
http://www.hit.bme.hu/people/papay/edu/Lab/54600_Probe.pdf
FFT**:** 54600 Scope **FFT manual**
http://www.hit.bme.hu/people/papay/edu/Lab/54600_FFTmanual.pdf
Aliasing**:** Random decimation in **anti-aliasing**
http://www.educatorscorner.com/media/Exp66.pdf
Lissajous and his **figures**
http://www.hit.bme.hu/people/papay/edu/Lab/Lissajous.pdf
IntuiLink connectivity software**:** 54600 Scope **Toolbar for Word**
http://www.hit.bme.hu/people/papay/edu/Lab/ScopeToolbar.pdf
IO driver**:** Agilent E2094P **IO Libraries** Suite 14.1 **Data sheet**
http://cp.literature.agilent.com/litweb/pdf/5989-1439EN.pdf