# On-Line Partial Discharge Measurement on Power Transformers


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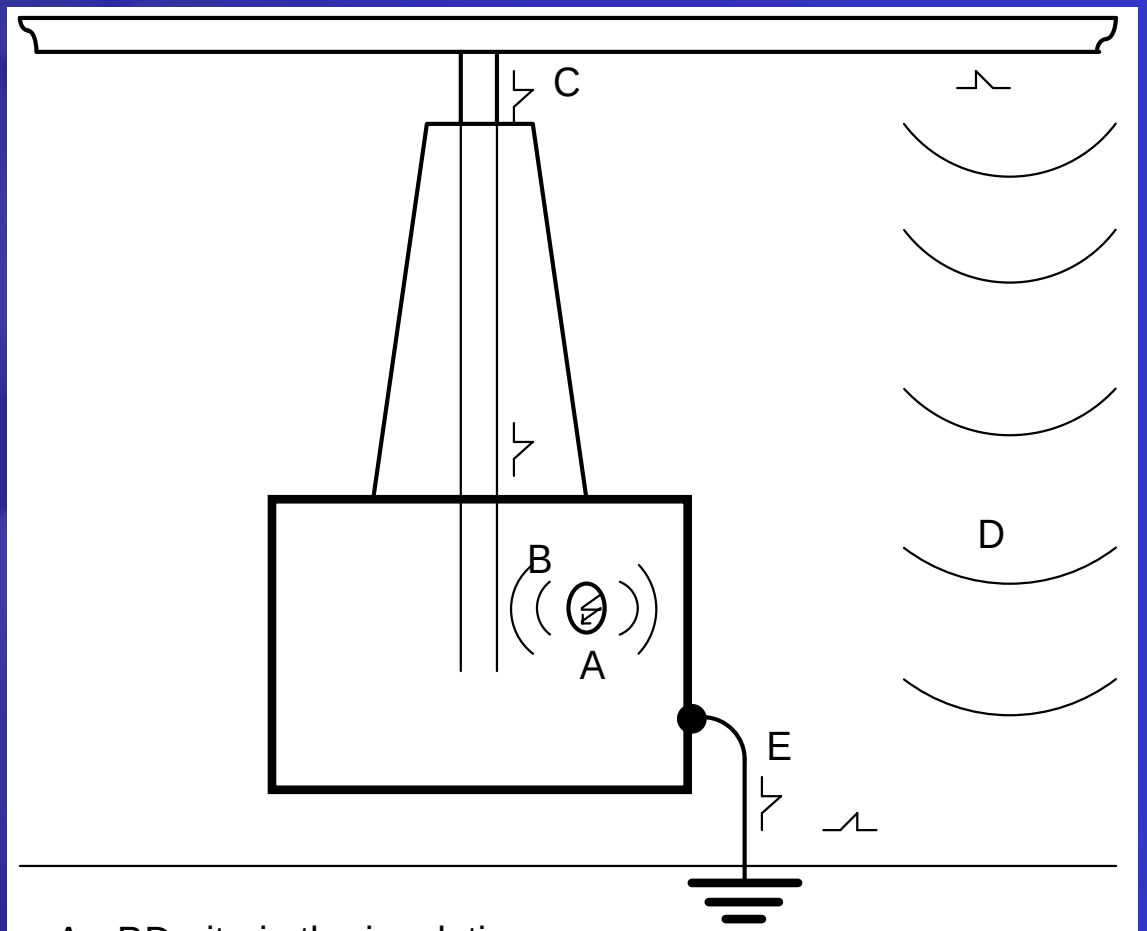
# Measurable Phenomena of PD

- Electromagnetic Field
  - Radiated from PD Event
- Voltage Drop
  - Decoupled via the Electrical Field (Coupling Capacitor, C-Sensor)
- Current Impulse
  - Decoupled via the Magnetic Field (L-Sensor)
- Acoustic Shock-wave
  - Ultrasonic Detector / Transducer
- Light Flash
  - Ultraviolet Detector / Camera
- Chemical Decomposition
  - “Gas in Oil Analysis”

# Electrical PD Phenomena



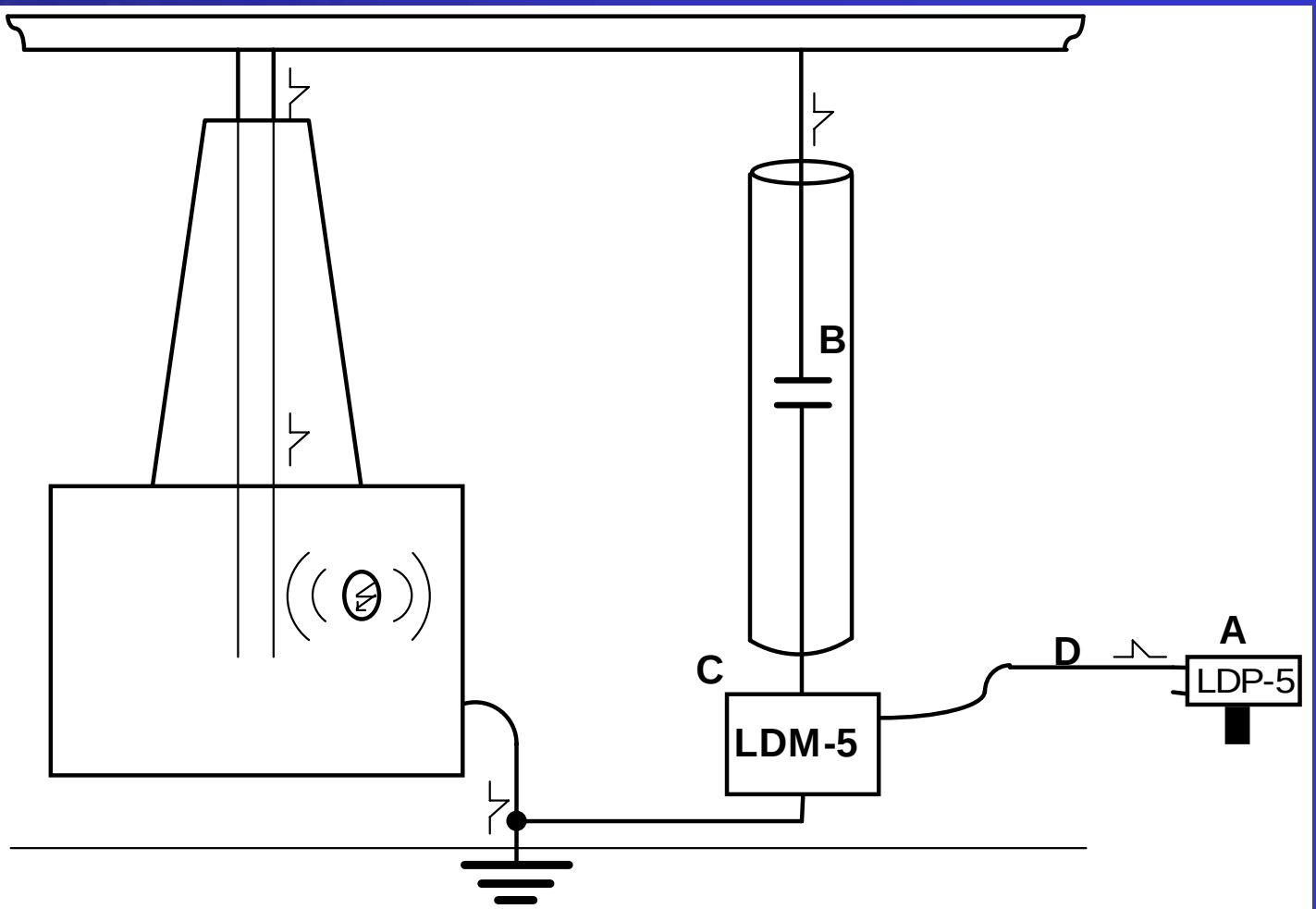

A - PD site in the insulation
B - Radiated electromagnetic field
C - Voltage drop at the HV side
D - Electric field via the stray capacitance to ground
E - Magnetic field by the current in the ground lead

# Standard Measuring Circuit (IEC-270)

- Standardized method of testing
- Readout can be calibrated and compared to other tests
- Best used in the manufacturer test field
- Can be used on-site for induced test after maintenance outage
- Transformer bushing tap can be used as coupling capacitor

- Requires direct connection to high voltage
- Connections should be done without HV applied
- Coupling capacitor or bushing tap required

# IEC-270 Standard Circuit Connections




A - Differential LEMKE probe LDP-5
B - Coupling capacitor
C - Measuring impedance LDM-5
D - Connection cable

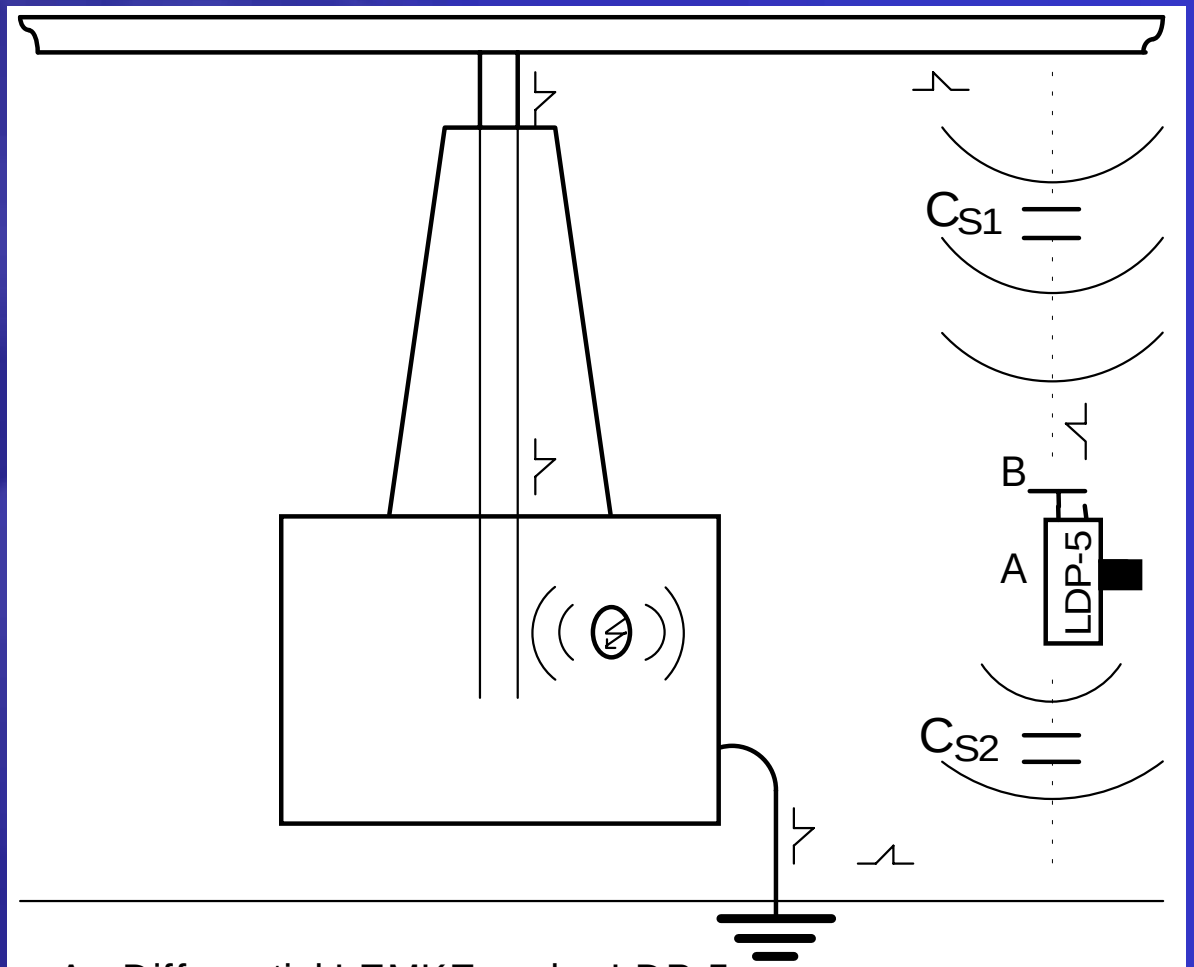
# Capacitive Sensor (C-Sensor)

- No direct connection to the high voltage, in service testing
- Easy test allows a quick scan of all substation equipment
- When put on a hot-stick, the LDP-5 is potential-free and can be moved near the high voltage.

- Requires direct “electrical line-of-sight”
- Does not work through electrical shields
- Not very sensitive (depending on sensor size)
- Not very directional

# LDP-5 with C-Sensor

# Using the C-Sensor




A - Differential LEMKE probe LDP-5
B - Capacitive sensor (electrical field sensor, C-sensor)
$C_{S1}$ - Stray capacitance between HV and LDP-5
$C_{S2}$ - Stray capacitance between LDP-5 and ground

# Differential Mode (C- Sensor)

Uses the positive and the negative input of the LDP-5, measures the difference in the signal strength

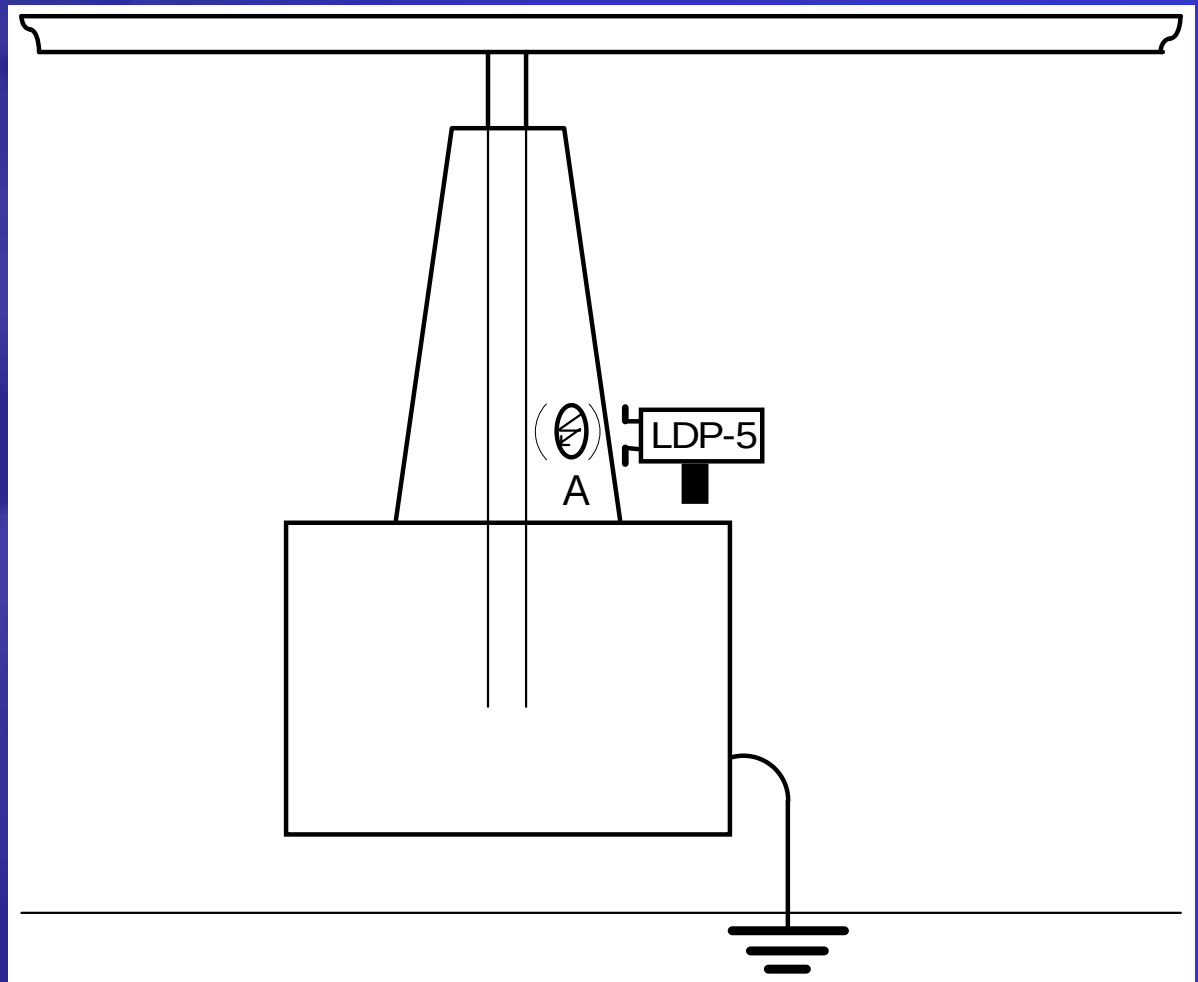
If both inputs see the exactly same signal, the resulting reading is Zero!

- Very accurate (Pinpointing in less than 1/2 inch)

- Requires direct access to the insulator surface
- Does not work through shields
- Safety distances to HV electrodes can prevent the use

# LDP-5 in Differential Mode

# Differential Mode




A - PD site in the insulation (not shielded, e.g. Bushings)
B - Differential LEMKE probe LDP-5 with
two small C-sensors at the differential inputs

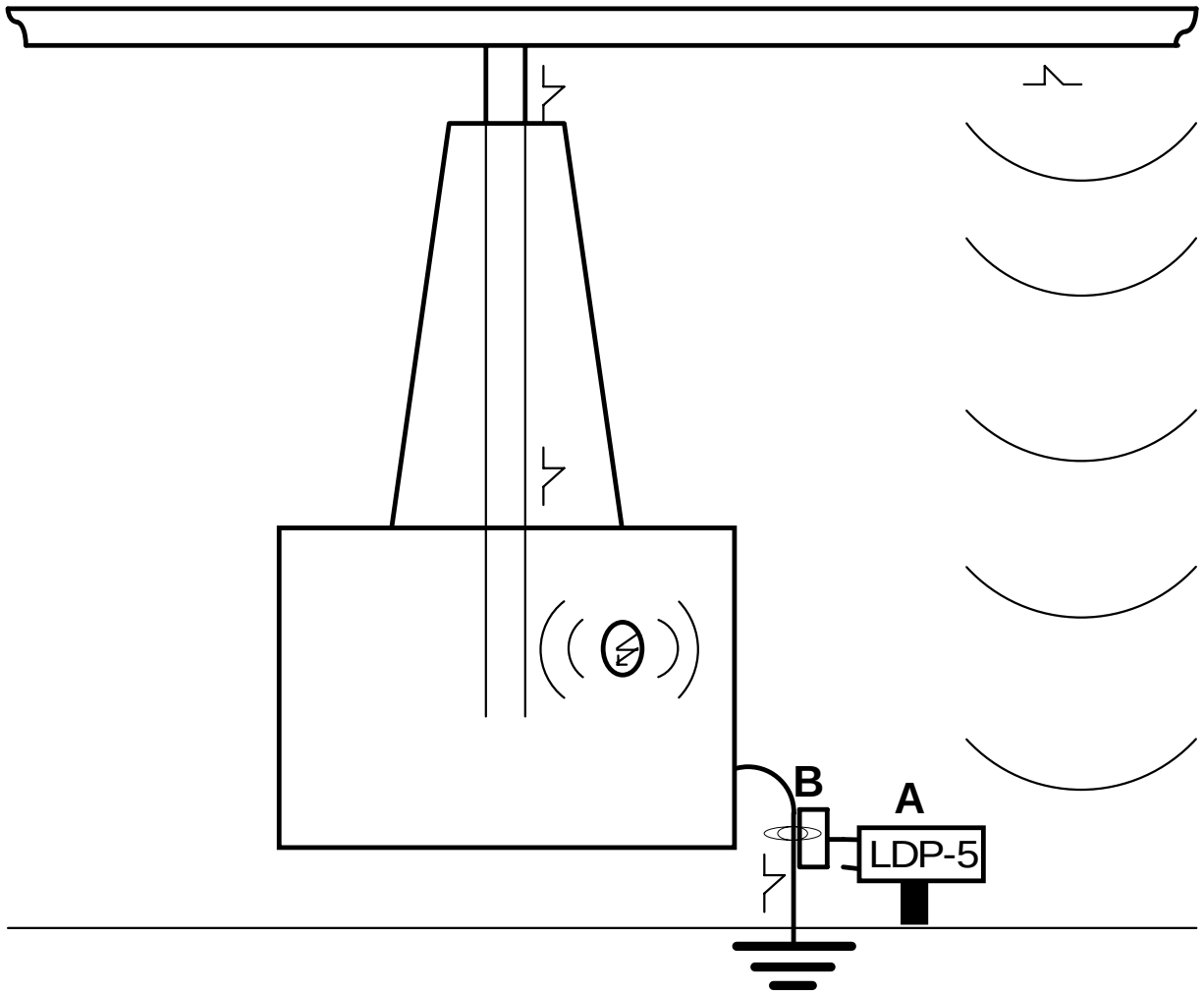
# Inductive Sensor (L- Sensor)

- No direct connection to the high voltage, in service testing
- Easy test allows a quick scan of all substation equipment
- Very sensitive

- Has no directional selectivity
- Does not work through shields
- Requires direct access to e.g a grounding wire

# LDP-5 with L-Sensor

# Using the L-Sensor




A - Differential LEMKE probe LDP-5
B - Inductive sensor (magnetic field sensor, L-sensor)

# On-Site PD Test with L-Sensor

# Noise Reduction

On-Site tests are affected by electromagnetic noise.

Noise reduction is necessary to increase the sensitivity of the measurement.

Two general kinds of noise:

- Narrowband noise (Continuous, e.g. AM Radio)
  - ☞Use “RIV Red” or LDF-5 to reduce this noise
- Wideband impulse noise (e.g. Switching, Triacs)
  - ☞Use LDK-5 to reduce this noise

# Noise Reduction Filter LDF-5

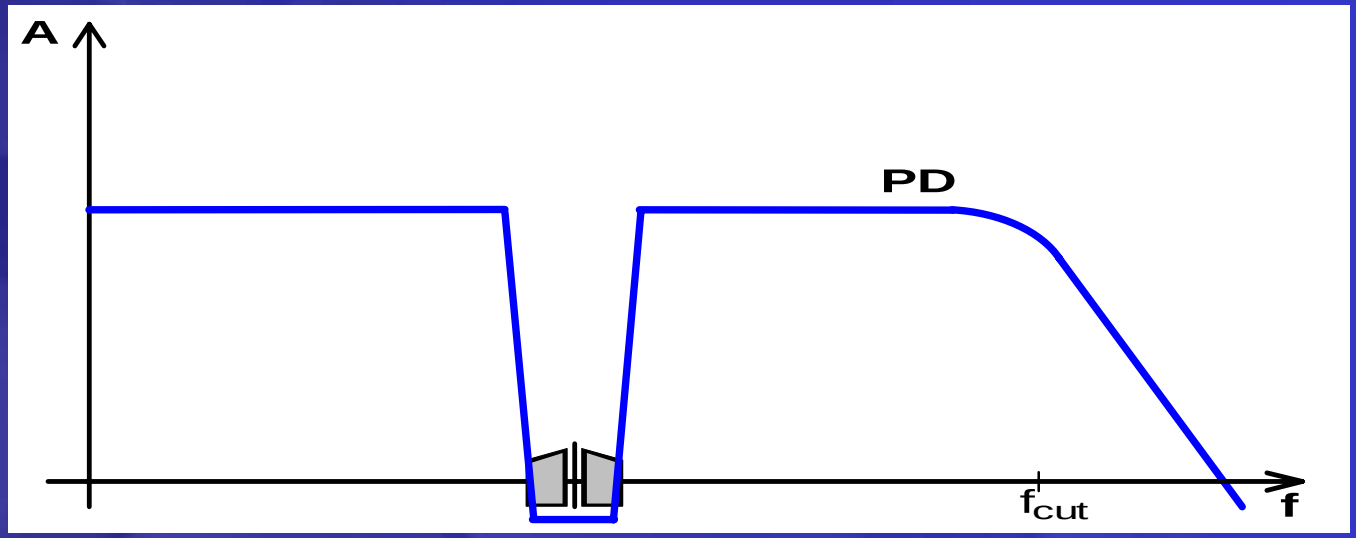
Special adjustable Band-Stop filter to reduce narrow-band noise

- Improves signal to noise ratio
- Affects only narrow-band continuos signals (AM Radio stations)
- Negligible influence on wide-band PD signals (compensated by Calibration)

- Manual adjustment required
- Heavy multiple noise frequencies require two or three LDF-5 filter in series

# Noise Reduction Filter LDF-5

# Operating Principle of the Filter LDF-5



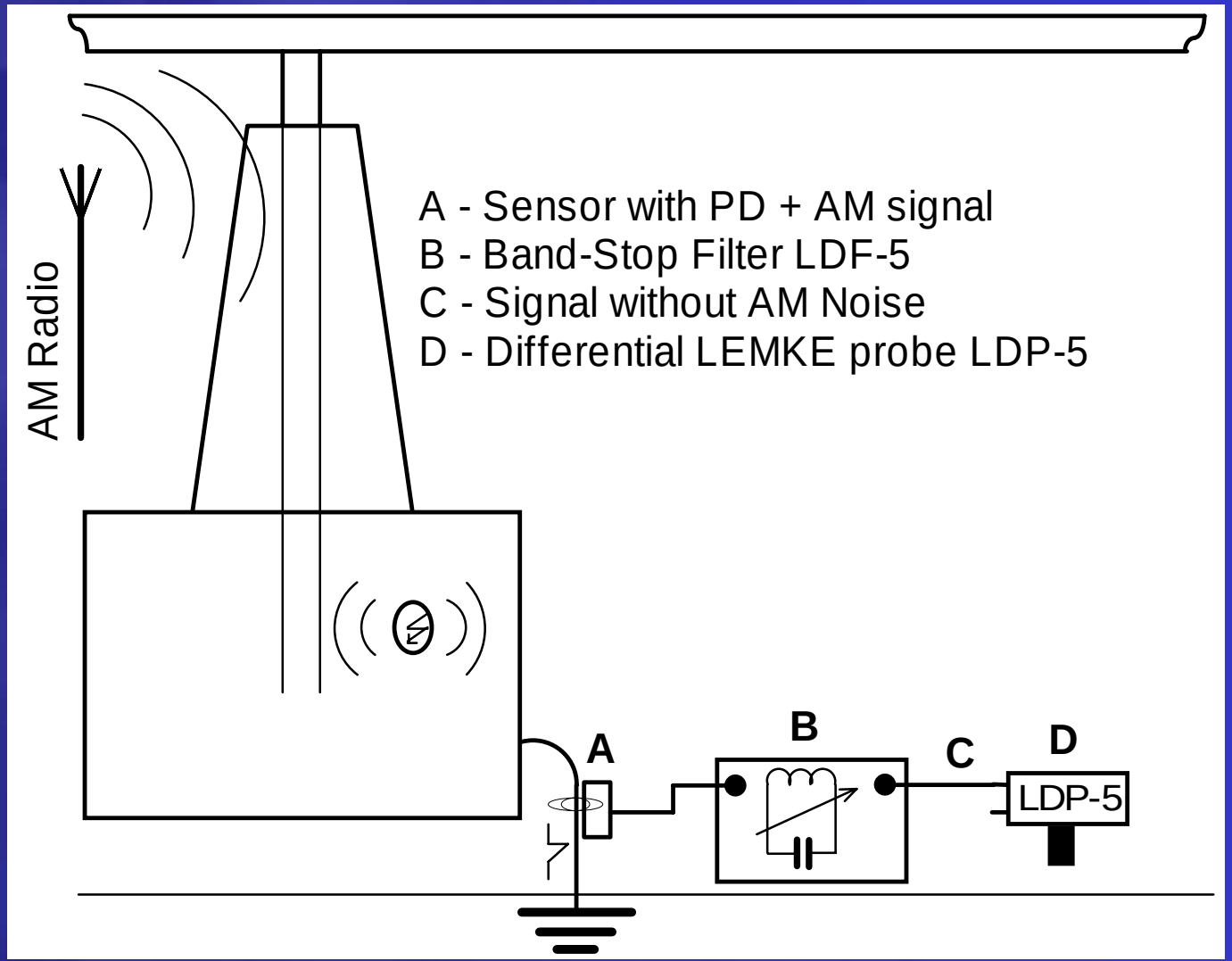

PD signals are wide-band,
from 0 to several MHz or GHz

An AM signal has much higher energy only at a narrow band (Center frequency ±5kHz)

The Filter stops only the noise frequency area

The resulting signal has the AM noise much stronger attenuated than the PD signal

# Using the Noise Filter LDF-5



# Noise Impulse Comparator LDK-5

Impulse noise can be created by:

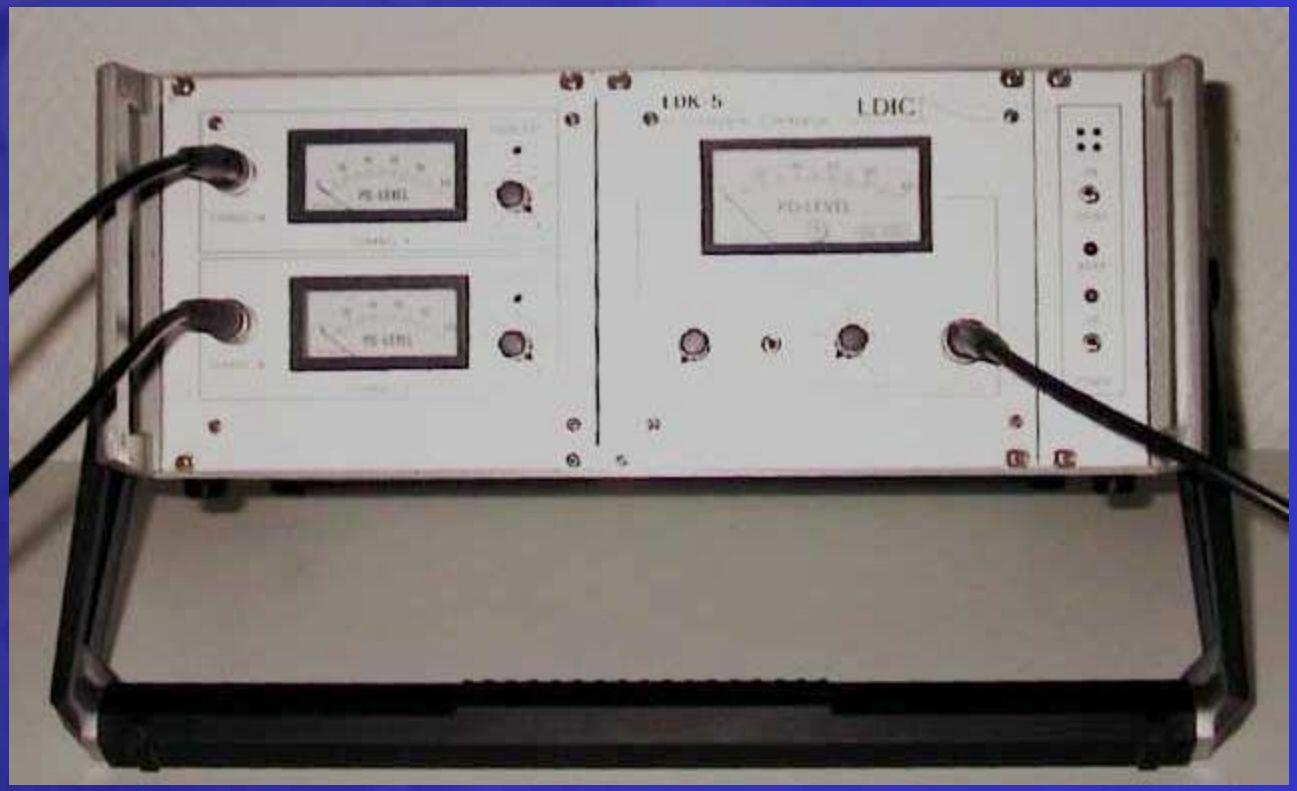
- Network switching events
- Variable frequency drives
- PD sources in adjacent equipment

The Noise Impulse Comparator LDK-5 uses two LDP-5:

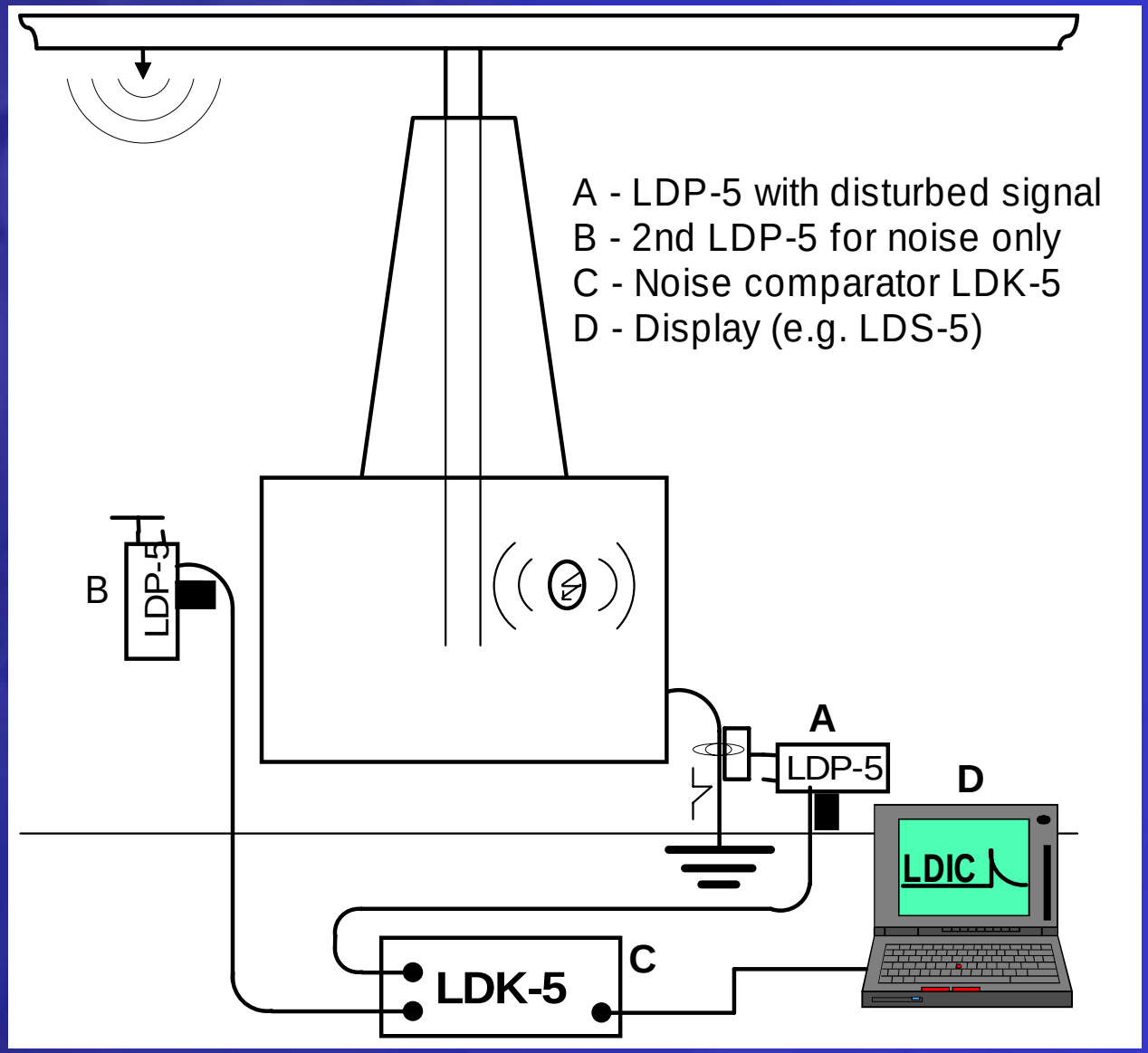
- The first LDP-5 receives the PD with the noise
- The second LDP-5 receives the noise only
- The LDK-5 subtracts the noise (Ch2) from the mixed PD and noise (Ch1)
- The PD remains and will be recorded

👍 PD measurements in heavy noisy systems possible (Substations, Power plants)

# Noise Impulse Comparator LDK-5



# Using the Noise Impulse Comparator LDK-5



# UHF Adapter LDA-5/U

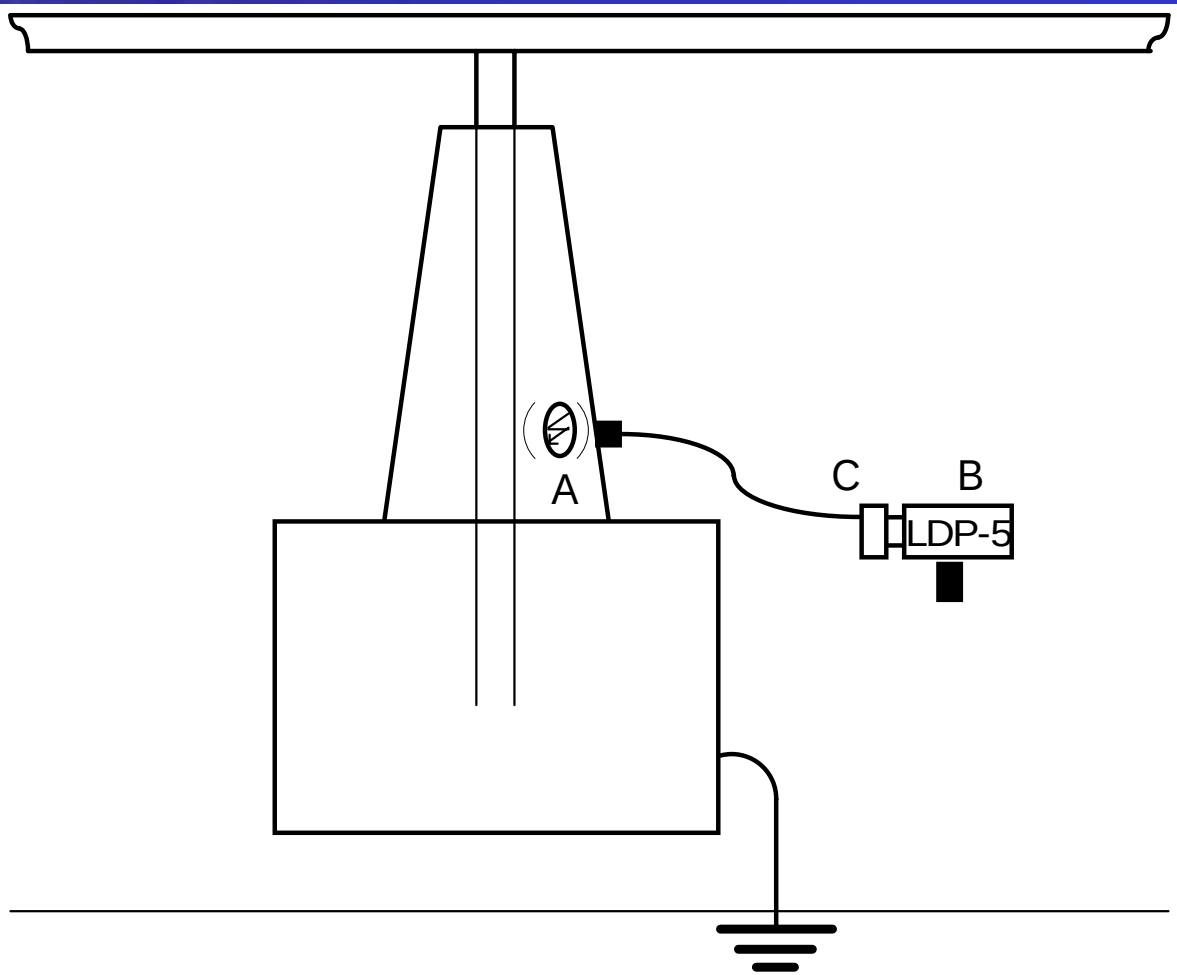
Special add-on adapter for the LDP-5.

- Very accurate for pinpointing
- Low noise signal level
- Works through some shields
- Optimal for testing of “Gas-insulated Switchgear” (GIS) and shielded cable and cable joints

- Requires direct access to the insulator surface
- Strong signal attenuation in solid and liquid insulation prevents the detection of defects farther away
- Keep safety distance to HV electrodes
- No Calibration possible (except for GIS)

# UHF Adapter LDA-5/U

# Using the UHF Adapter




A - PD site in the Insulation (e.g. dry-type, epoxy insulated)
B - Differential LEMKE Probe LDP-5
C - UHF adapter LDA-5/U

# On-Site Test with the UHF Adapter

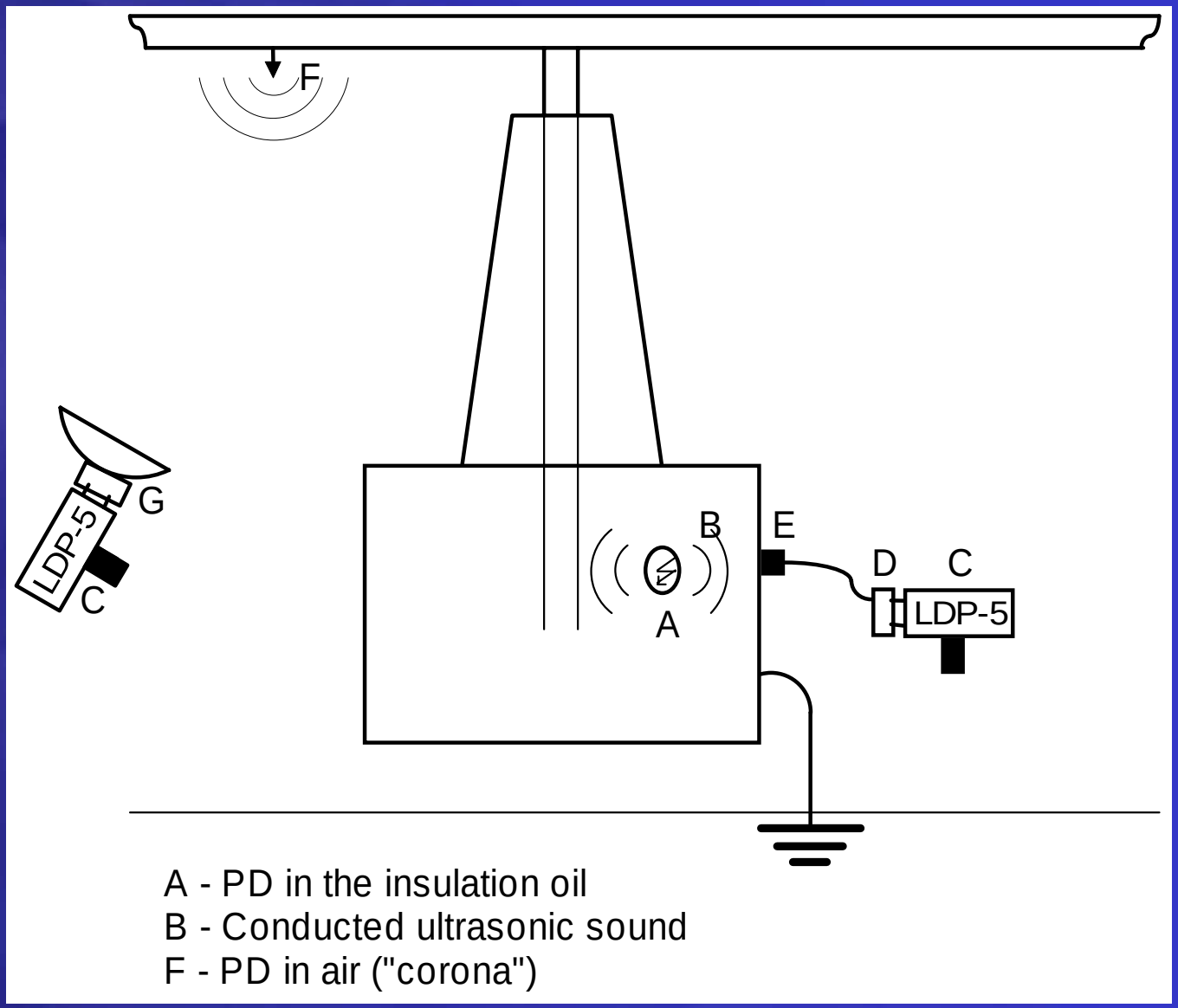
# Ultrasonic Adapter LDA-5/S

Special add-on adapter for the LDP-5.

The principle is well-known for transformer testing.

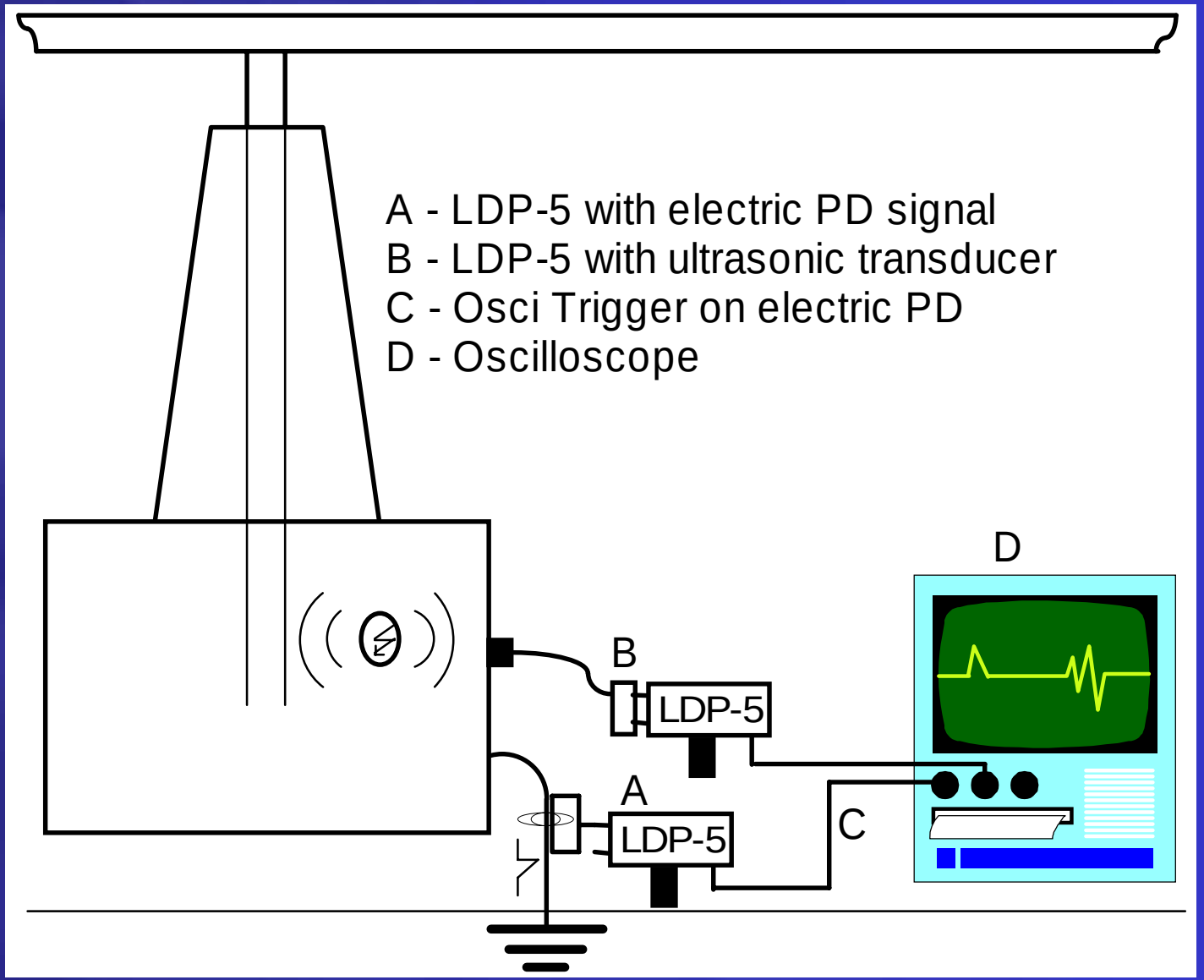
- For locating of PD in air (Corona) and power transformers
- No connection to the high voltage, in service testing
- Transducer works through steel tank
- Can be up to 100ft. away from “Corona” source
- Best used together with electrical measurement
- Requires acoustic line-of-sight between PD and sensor
- No Calibration possible
- No PD detection possible within winding, bushing...

# Using the Ultrasonic Adapter




A - PD in the insulation oil
B - Conducted ultrasonic sound
F - PD in air ("corona")

# Combined Electric and Acoustic Measurement

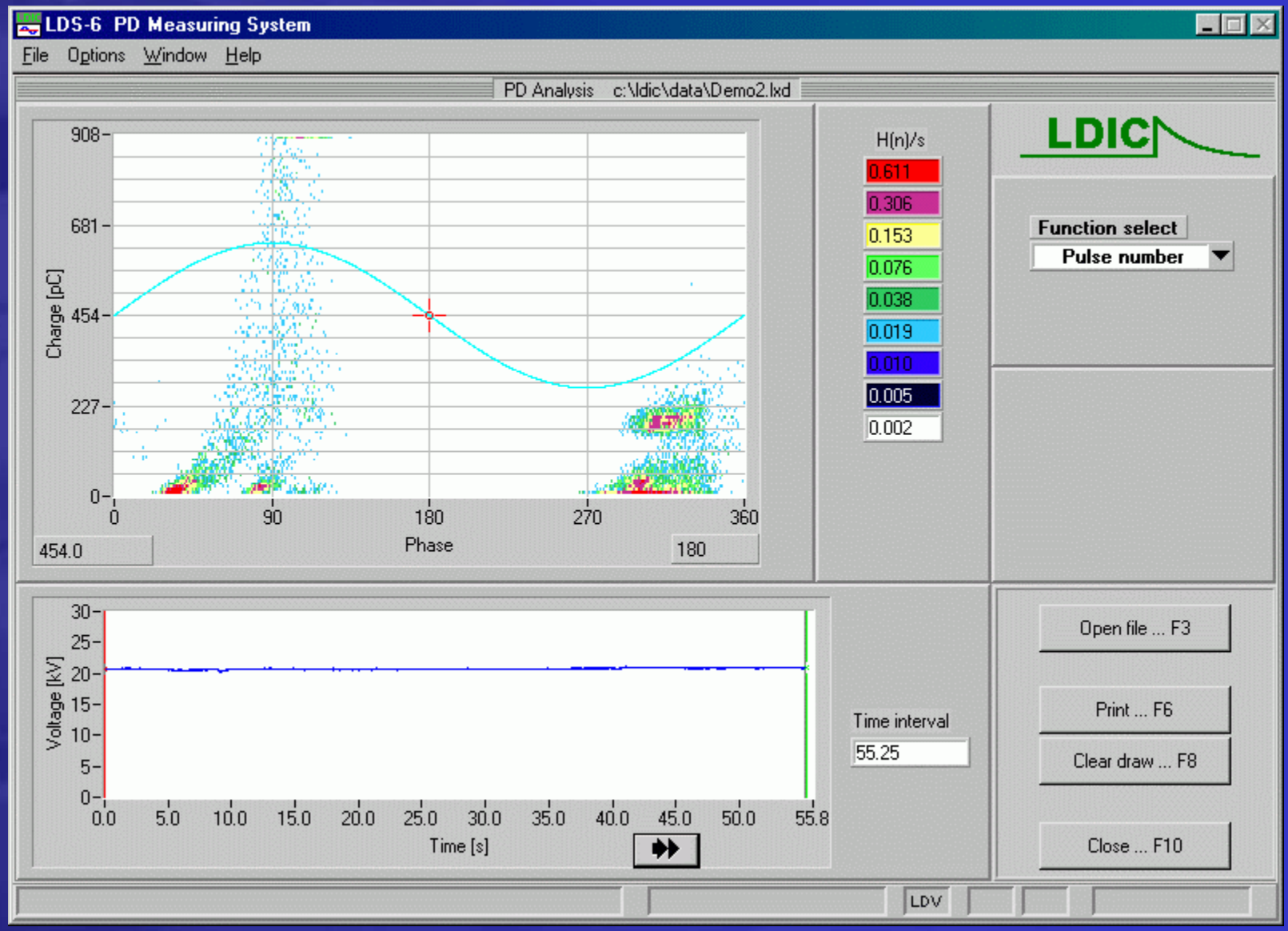


# Digital Measuring System

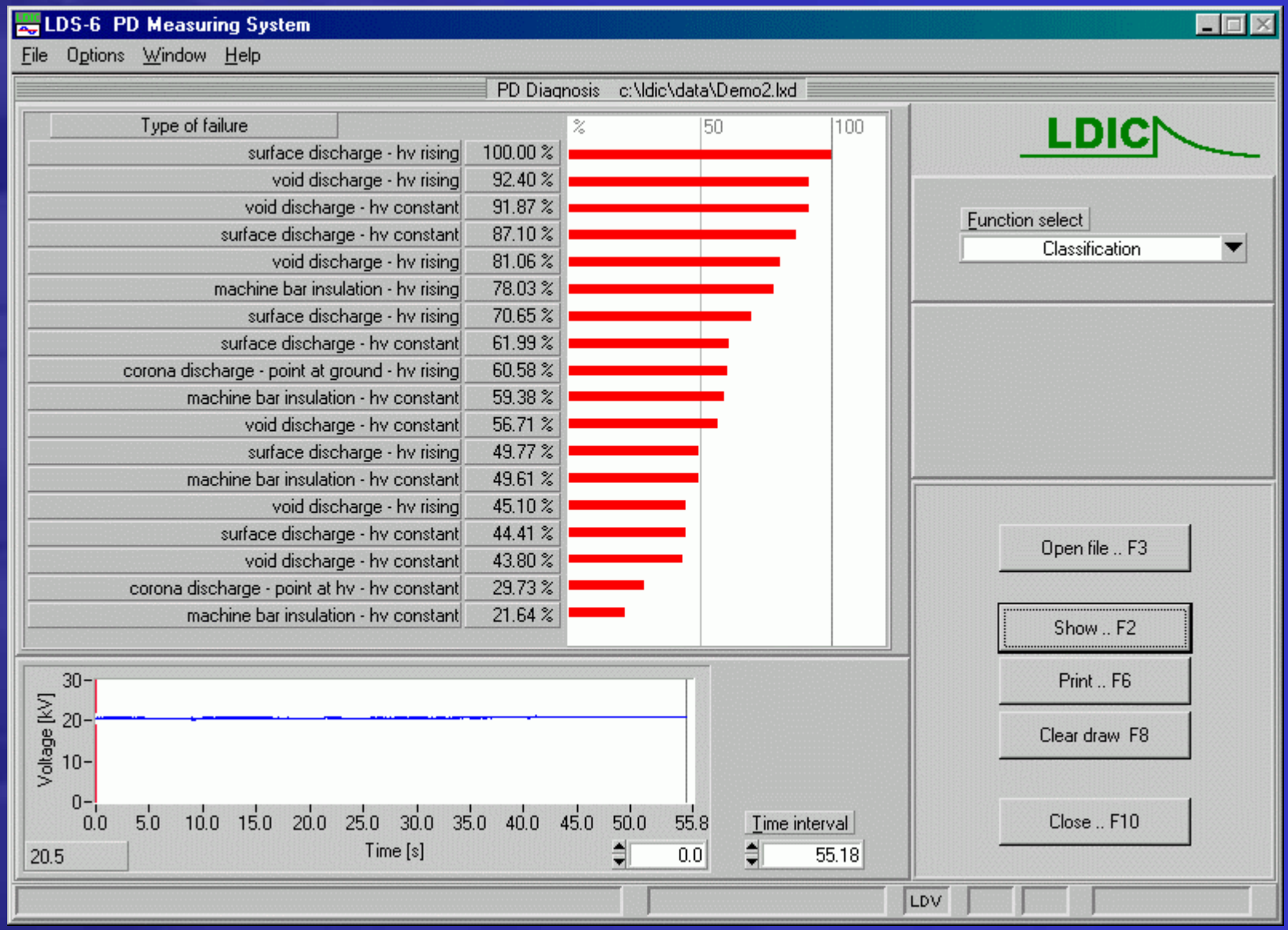
- Real-time display of the PD events
- Saving of all PD events on the hard disk
- Comparison with previous measurements (trend recognition)
- Powerful Analysis functions
- Expert system on the PC helps in failure analysis

# Digital PD Measurement On-Site

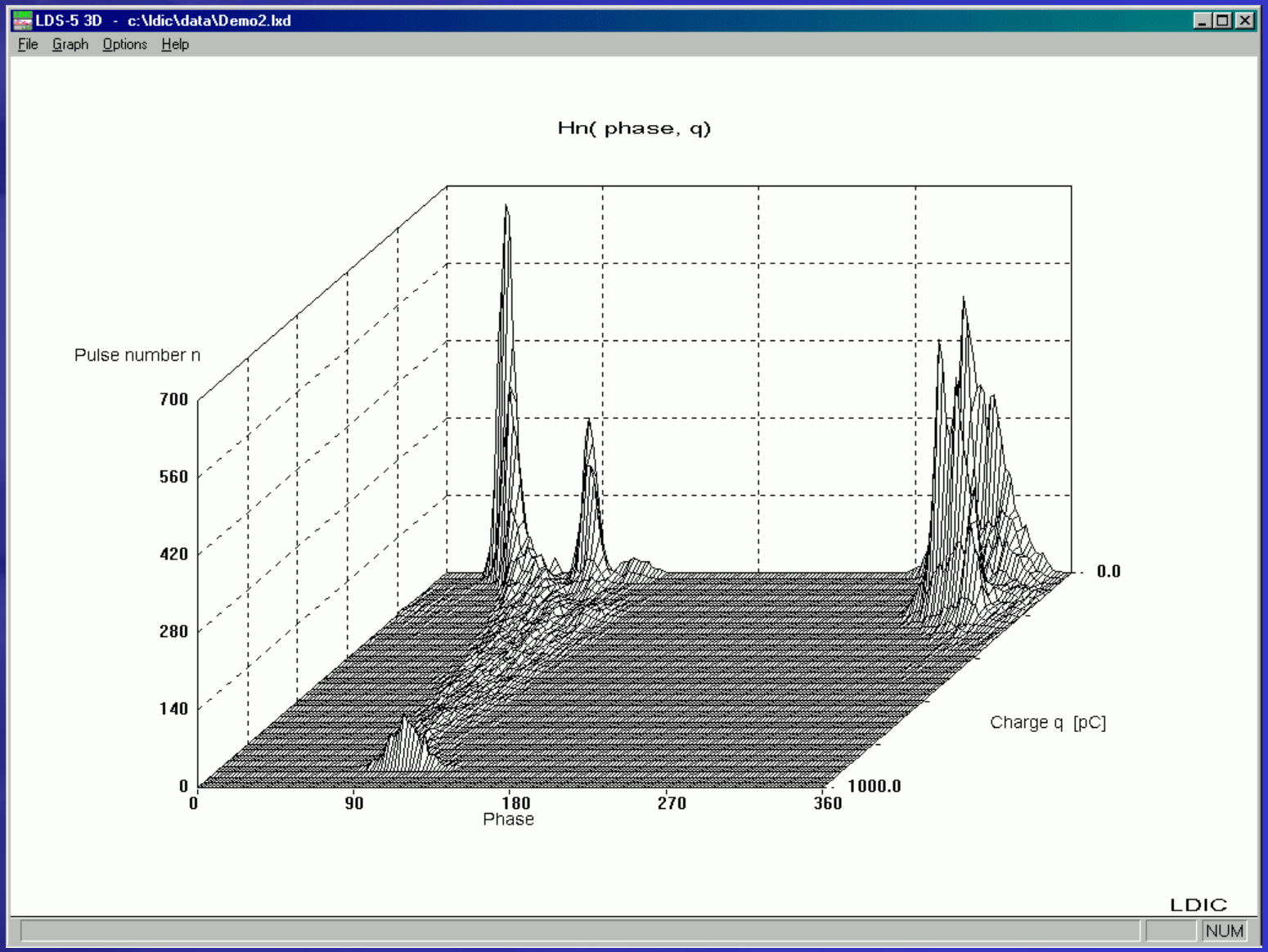
# Digital PD Recording - Pattern Analysis



# Automatic PD Classification



# Digital 3-D PD Data Representation



# Thank You for Your Attention!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