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Static Metering Technology

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A specifically designed program for

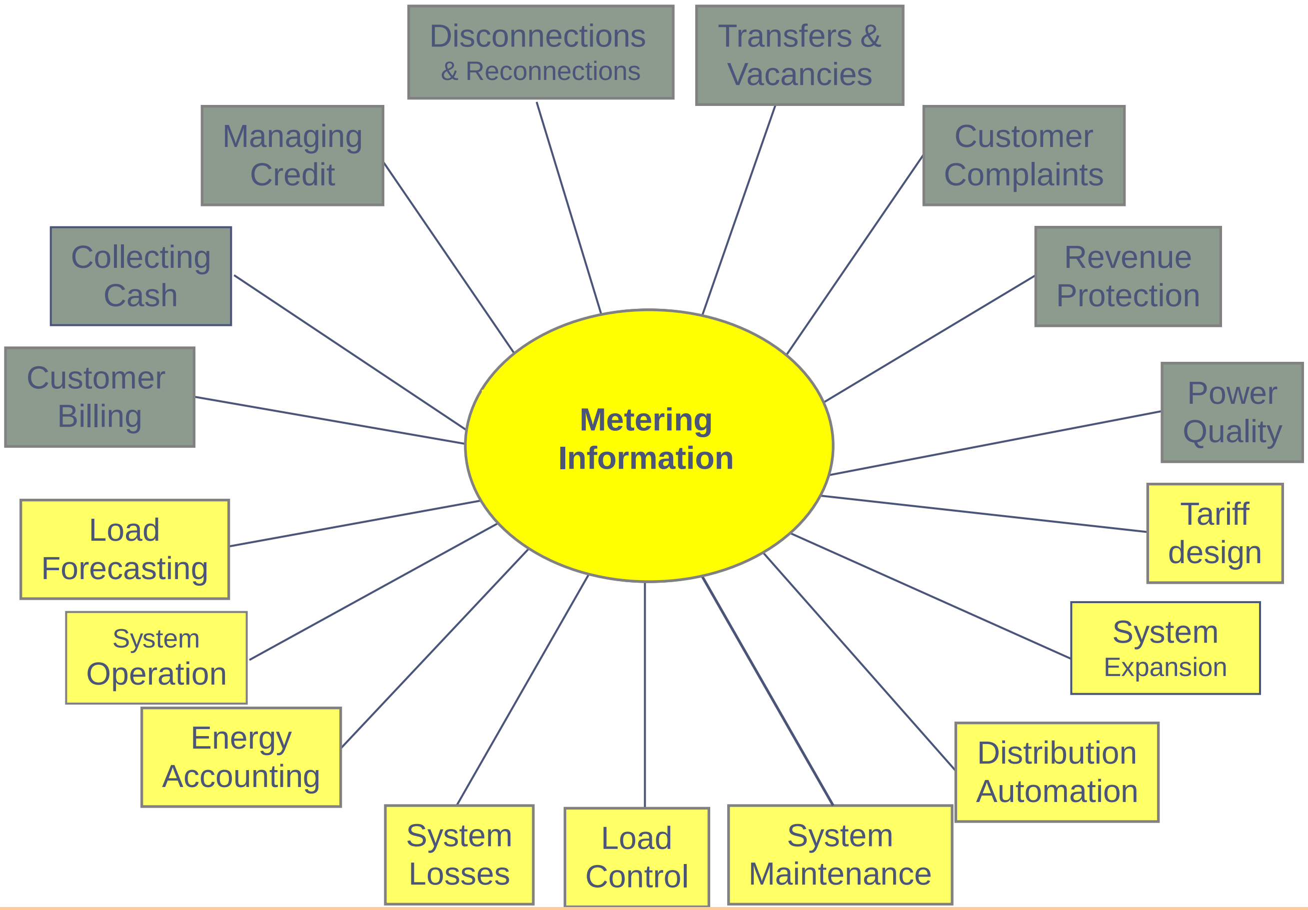
Da Afghanistan Breshna Sherkat (DABS)
Afghanistan

Evolution of Technology

Agenda

- Why electronic meters?
- What is an energy meter?
- What's inside?
  - Voltage and current sensing technologies
  - Multiplier Technologies
  - Electronic meter (typical)
  - Display types
  - Memories
  - Real time clocks
  - Power Supplies

Why electronic meters?



Electronic Meter information affects almost every aspect of distribution management business

Electronic Meters

- Electronic Meters provide the power of information
- Managing energy needs harnessing this information
- Real advantage of electronic metering can be harnessed by deploying appropriate IT infrastructure

Electrical power & energy

The instantaneous electrical power *P* delivered to a load is given by

$$P_{(t)} = V_{(t)}.I_{(t)} \quad \text{or} \quad p=v.i$$

where

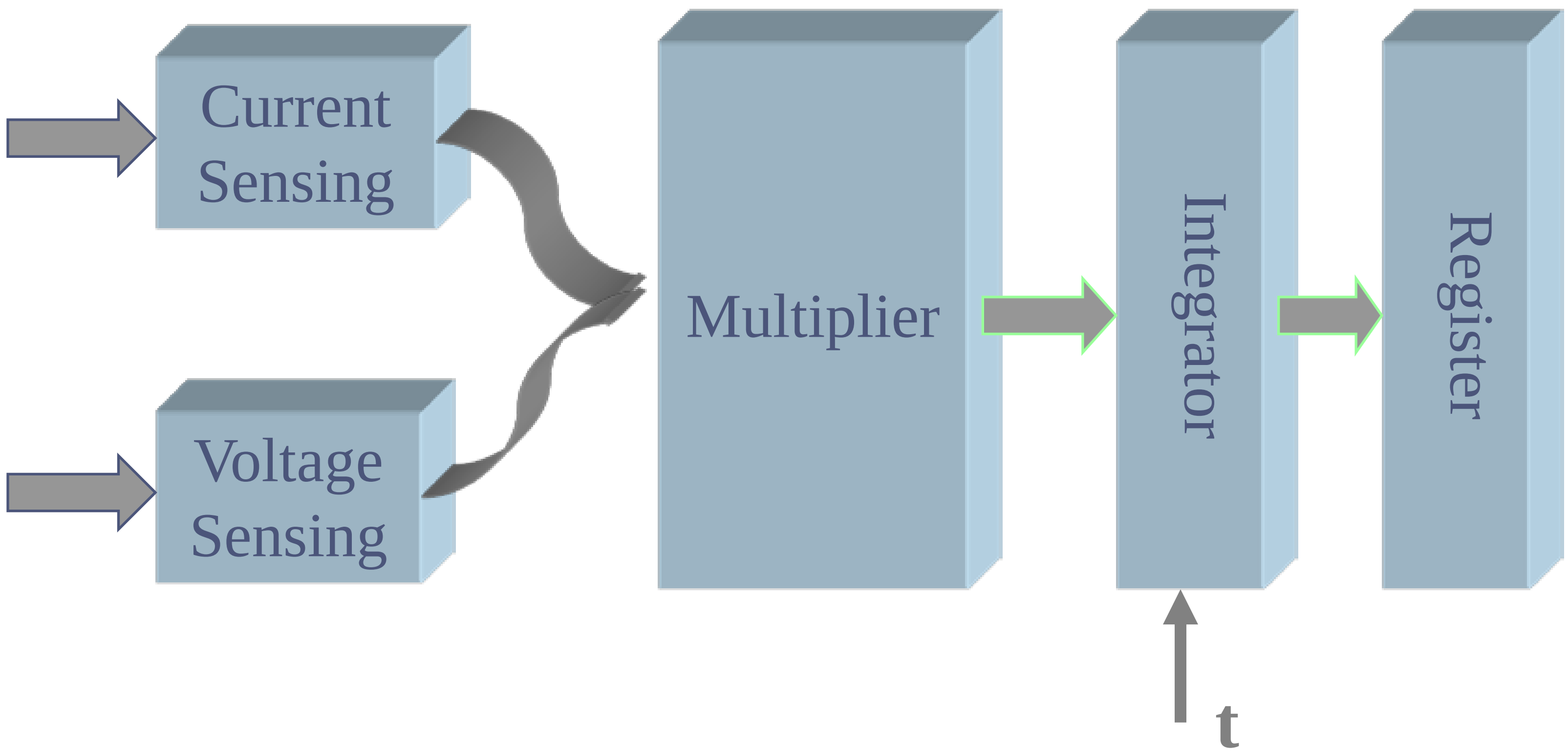
- *P*(*t*) is the instantaneous power, measured in watts (joules per second)
- *V*(*t*) is the potential difference (or voltage drop) across the component, measured in volts
- *I*(*t*) is the current flowing through it, measured in amperes

Average power is $P = \int_0^{2\pi} P(t).dt =$

$$= \int_{n=1}^{n=N} V_{Sn}.I_{Sn} = VICos\theta$$

Energy is $E = \int_0^T P.dt$

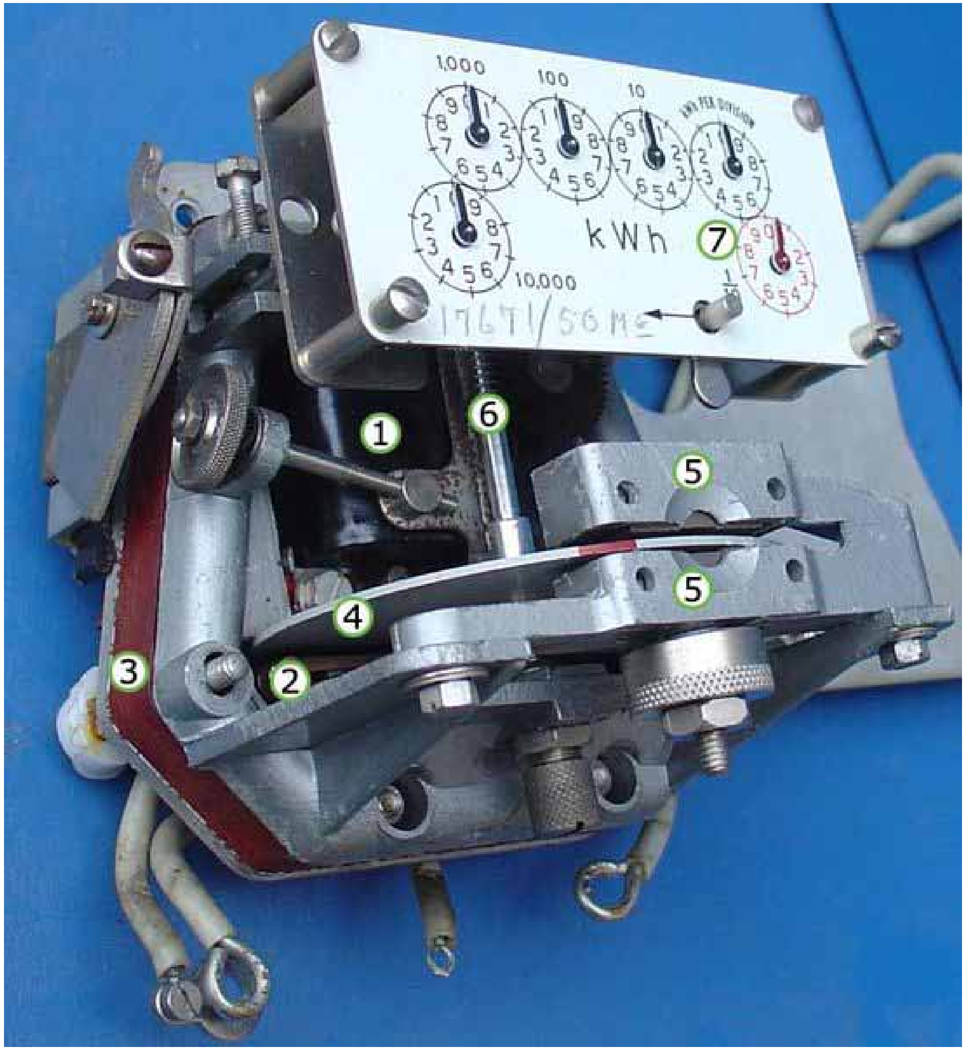
What is an energy meter?



$$Power = \int_0^{2\pi} P(t).dt = VI\cos\phi$$

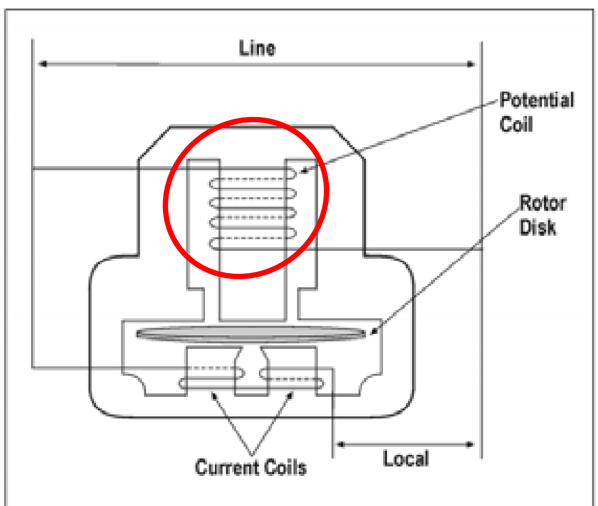
$$Energy = \int_{t1}^{t2} P.dt$$

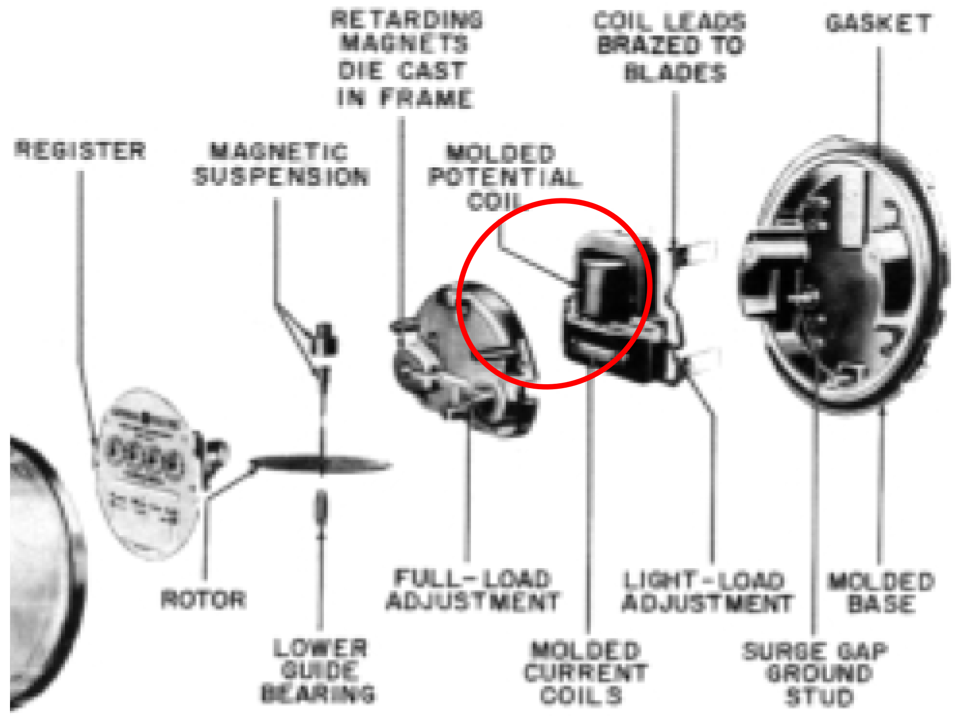
Functional blocks in energy meter



- Mechanism of electromechanical induction meter.
- (1) - Voltage coil - many turns of fine wire encased in plastic, connected in parallel with load. (2) - Current coil - three turns of thick wire, connected in series with load.
- (3) - Stator - concentrates and confines magnetic field.
- (4) - Aluminium rotor disc.
- (5) - rotor brake magnets.
- (6) - spindle with worm gear.
- (7) - display dials - note that the 1/10, 10 and 1000 dials rotate clockwise while the 1, 100 and 10000 dials rotate counter-clockwise.

Let us compare with EM meter





Potential Coil

Sensors

Voltage and Current sensors

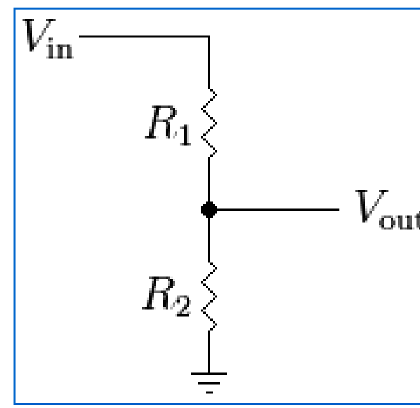
A good sensor …..

- **Should have**
  - Minimum Ratio Error
  - Minimum Phase Error
- **Should not be influenced by**
  - Temperature
  - Frequency
  - Magnetic Field (AC or DC)
  - Harmonics and distortions

Voltage sensing technologies
Potential Dividers

- Ü They are inexpensive
- Ü They are linear over long voltage ranges
- Ü They are not influenced by frequency
- Ü Very little influence of temperature variation
- Ü Do not introduce any phase error

ý They do not provide isolation



$$V_{out} = \frac{R_2}{R_1 + R_2} \cdot V_{in}$$

Voltage transformers

Ü **They provide isolation**

Û **However, HF transients tend to jump the coils**
Û **They are relatively expensive**
Û **They are non linear over long ranges**
Û **They introduce phase errors**
Û **They are frequency sensitive**
Û **They are influenced by temperature variation**

Generally only used where potential isolation is a key issue.

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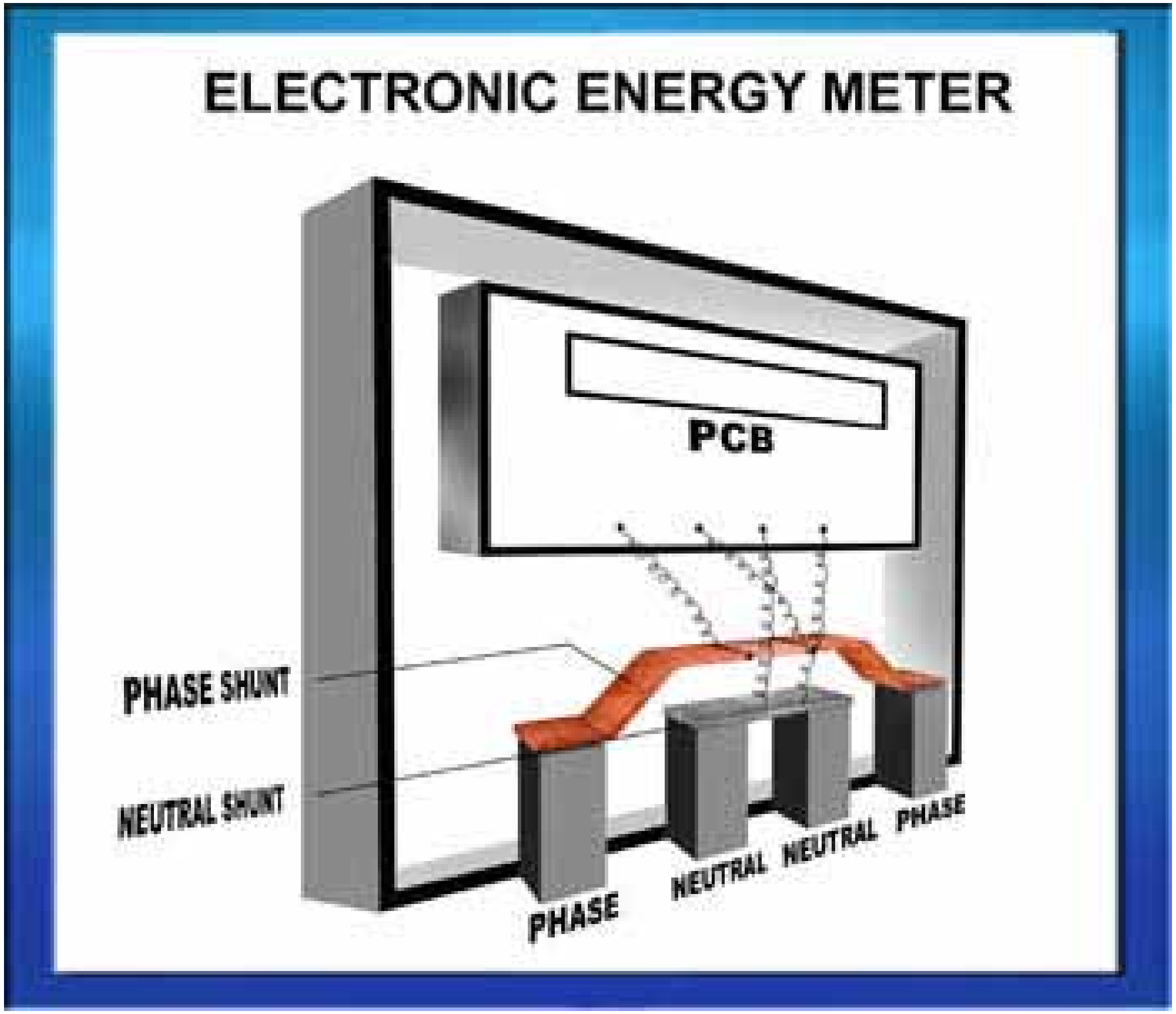
Current sensing technologies
Current shunts


ELECTRONIC ENERGY METER
PCB
PHASE SHUNT
NEUTRAL SHUNT
PHASE
NEUTRAL
NEUTRAL
PHASE

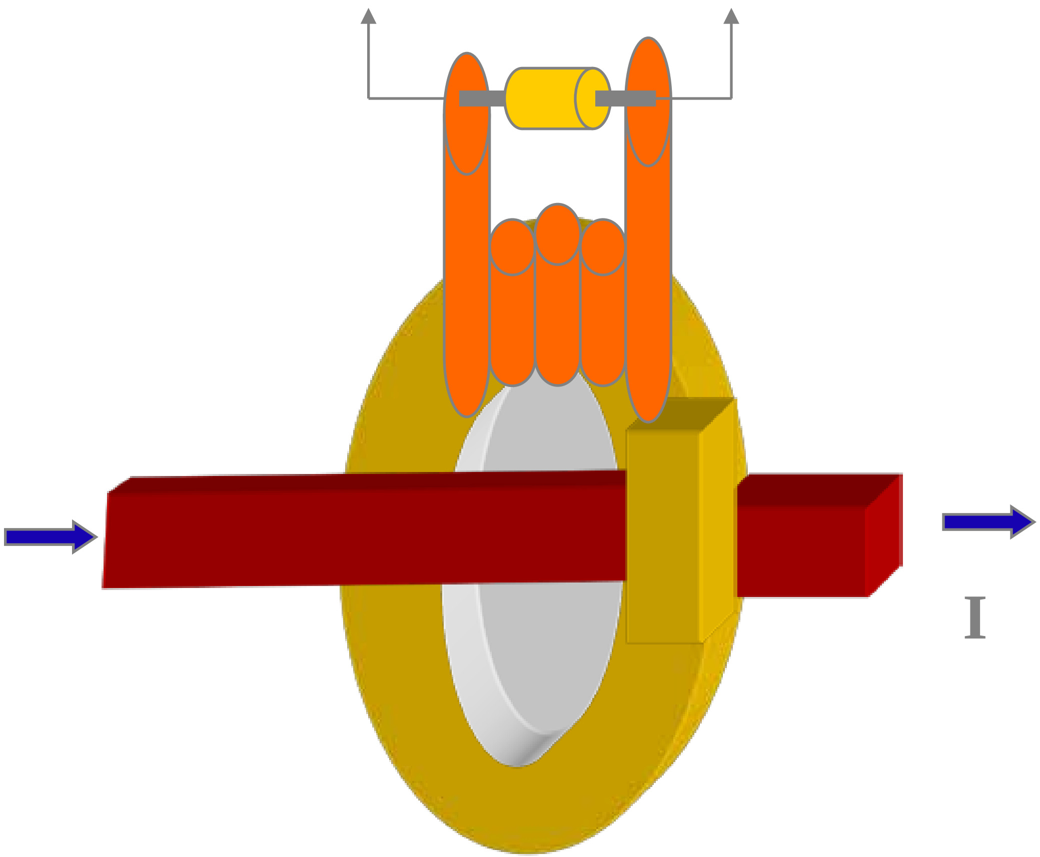
Current shunts

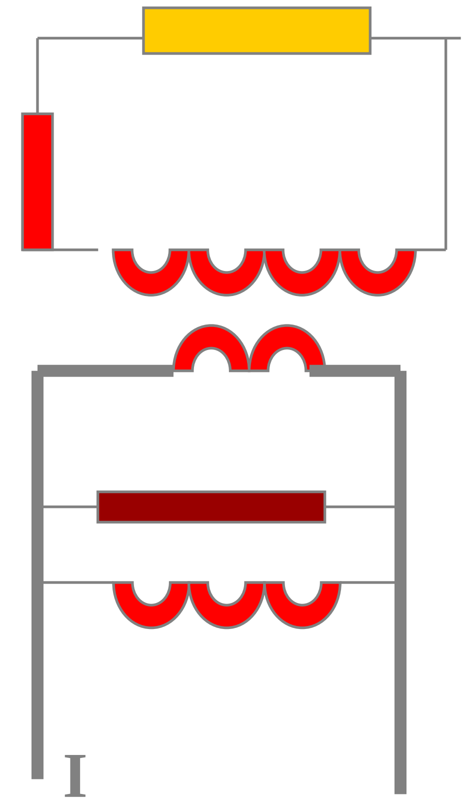
- Ü Shunts are relatively cheaper
- Ü They are fairly linear
- Ü They are not affected by frequency
- Ü They are not affected by magnetic fields
- Ü They do not introduce phase errors

- Û They are prone to temperature variations
- Û They are prone to junction ageing
- Û They do not provide isolation

They are generally more suited to single phase meters

Current sensor based on current transformers principle



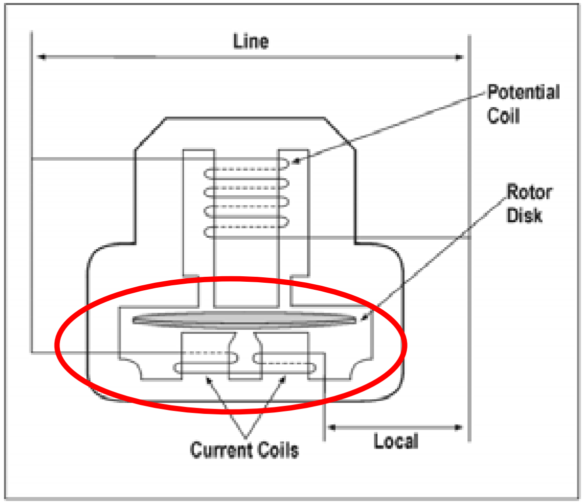


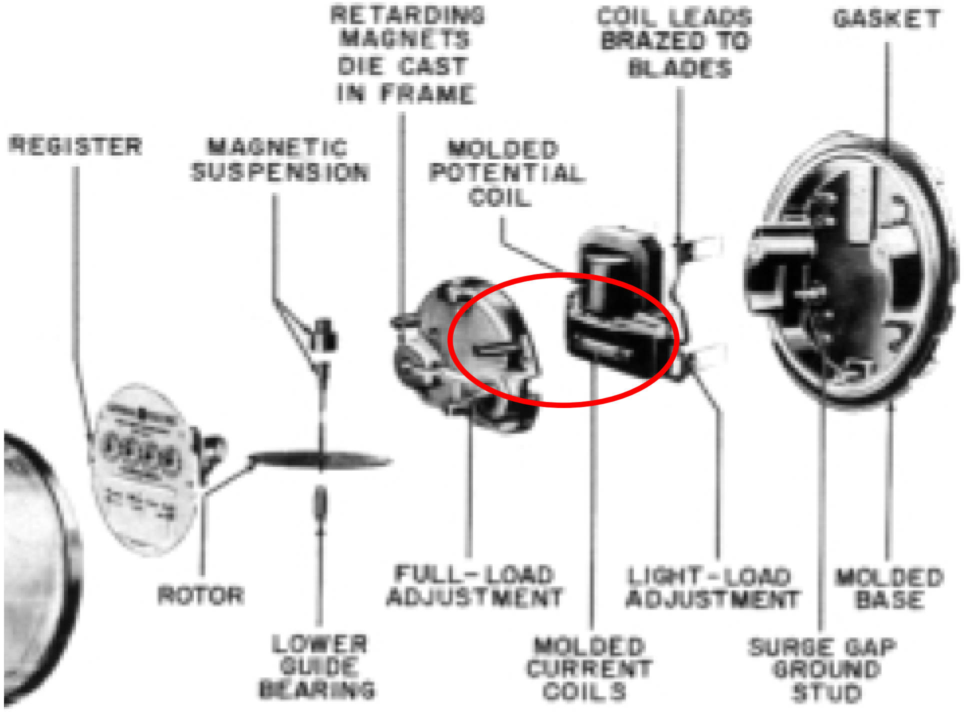
Current sensor (CT)

- Ü They provide isolation
- Û They are relatively expensive
- Û They are nonlinear – depending upon core material
- Û They introduce phase errors
- Û They are susceptible to magnetic fields
- Û They are influenced by frequency variations, temperature variations
- Û They can be saturated by DC content in current

Yet, in general, they are the best choices for 3 phase applications

Let us compare with EM meter





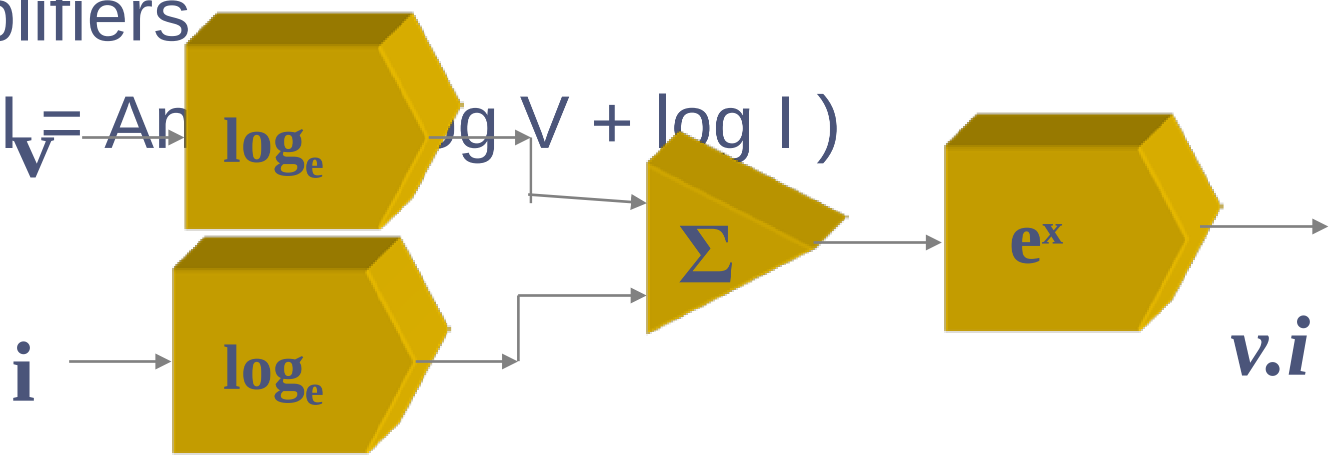
Current Coil

Multiplier Technologies

- Analog ‘log – antilog’ multipliers
- Mark space amplitude (MSA) multipliers
- Hall effect multipliers
- Direct digital sampling and multiplication

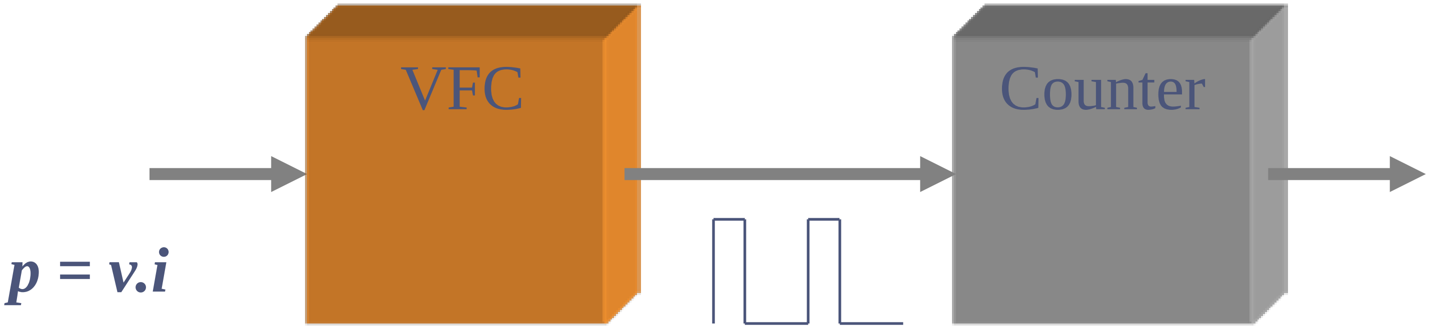
Analog Multipliers

- Analog multipliers are a combination of log – antilog amplifiers
- V x I = Antilog (log V + log I)

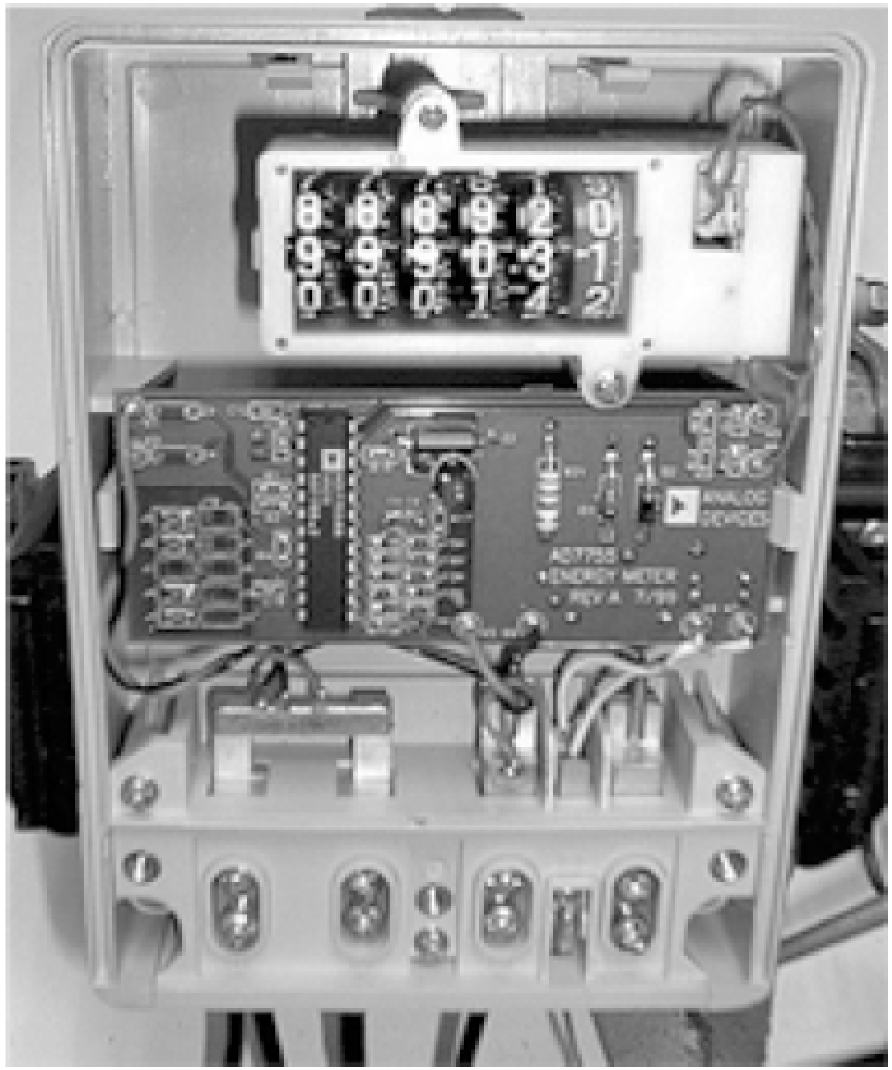


Integrator

- **Often the power signal is converted to frequency and counted to give “integrated” output.**



- V = 240, I = 5A, P = 1200 W, Energy = 1.20 kWh
- Counter to increment 1.20 or 120 steps or 2 pulses per minute.
- Calib LED to blink at the rate of 1200 pulses per kWh (every 3 sec)


ANALOG DEVICES
AD7755
ENERGY METER

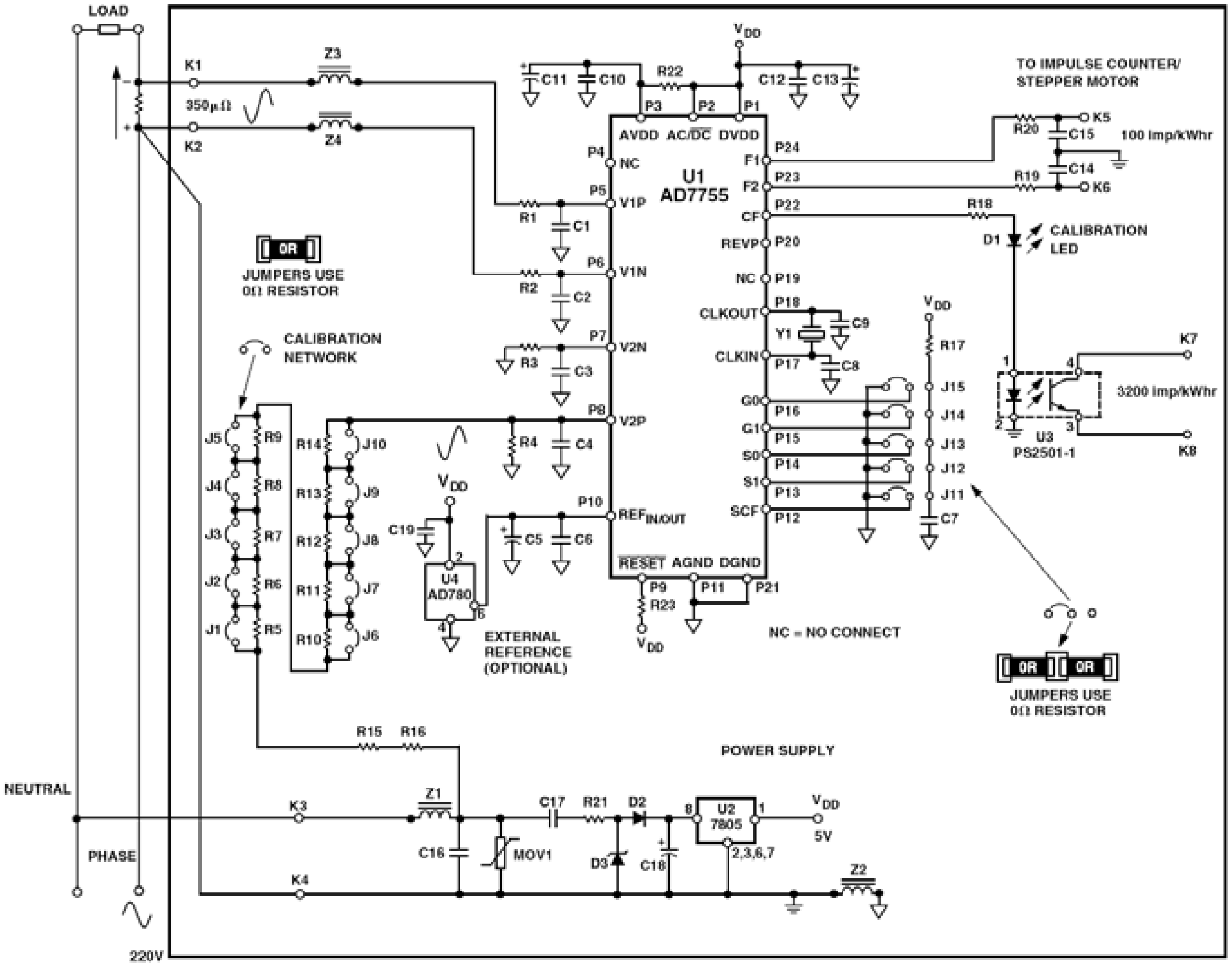


Figure 1. Simple Single-Phase Watt-Hour Meter Based on the AD7755

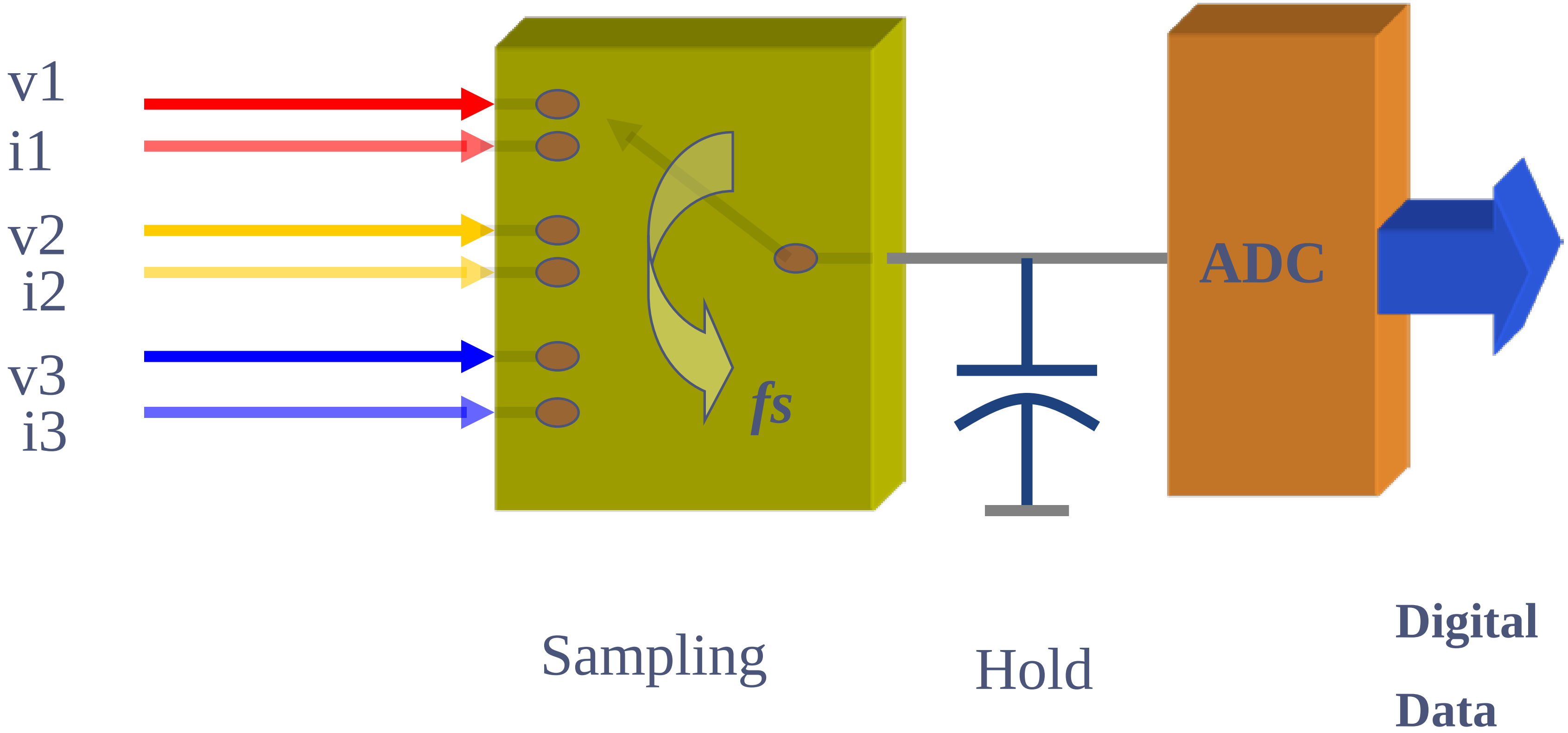
Direct Digital Sampling

- Analog voltage and current signals converted into digital values
- Sample and hold circuits are employed
- Sampling frequency (f_s) is important
- Signals up to frequency component of $f_s/2$ are measured accurately

Digital sampling

- Most commonly deployed technology
- Important parameters –
  - ADC linearity
  - ADC conversion speed
  - Sampling speed
  - ADC effective bits
- Allows easy integration to digital systems
- Digital calibration and compensation is possible
- Basic parameters are available for computation

Digital sampling



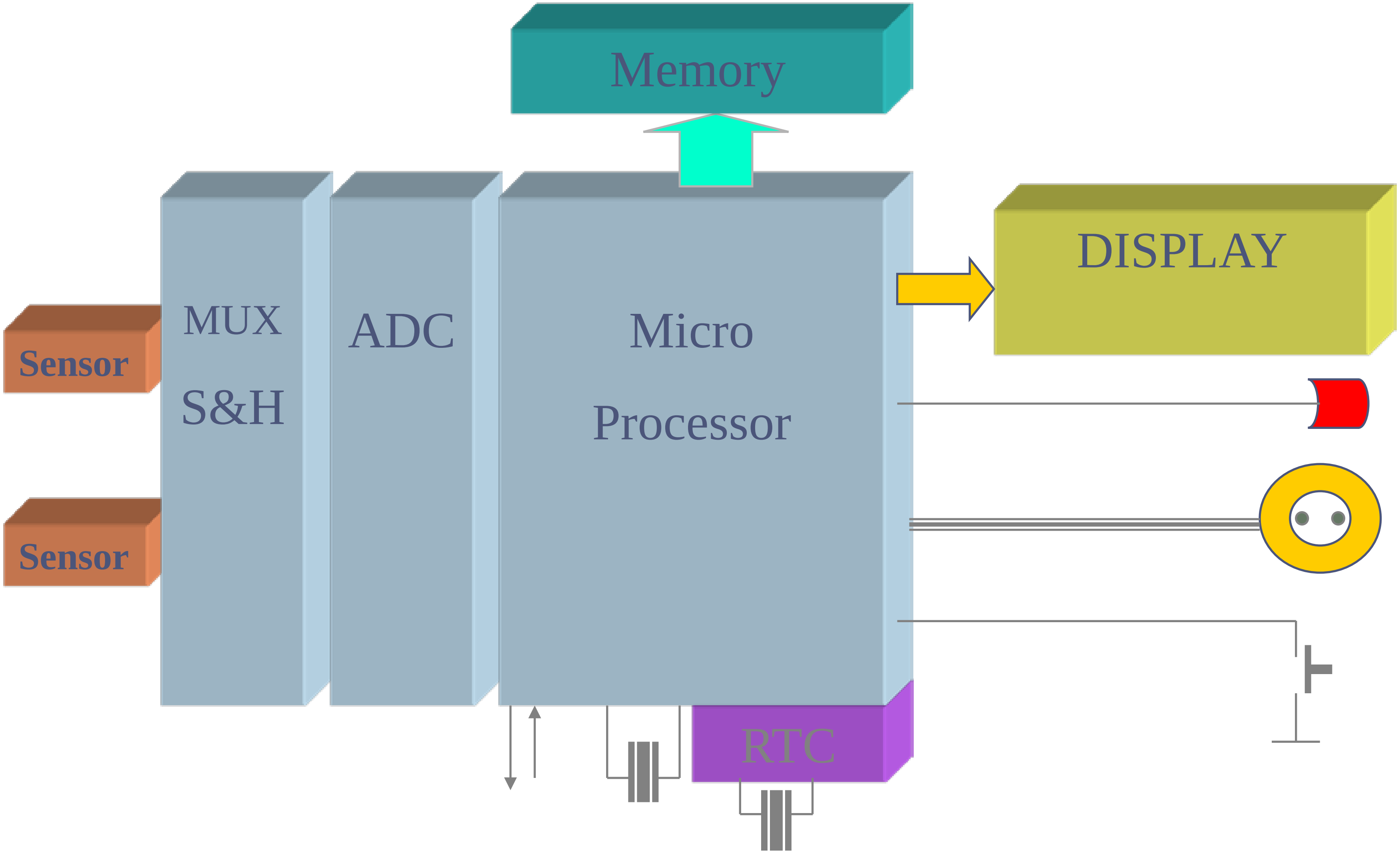
Integrators

- Digital systems deploy discrete integration in digital domain

$$P = (1/N) \sum_{n=1}^{N} \{V_n \cdot I_n\}$$

Some meters do Fourier Analysis to get V, I , Cosθ, and then numerically compute Power and energy.

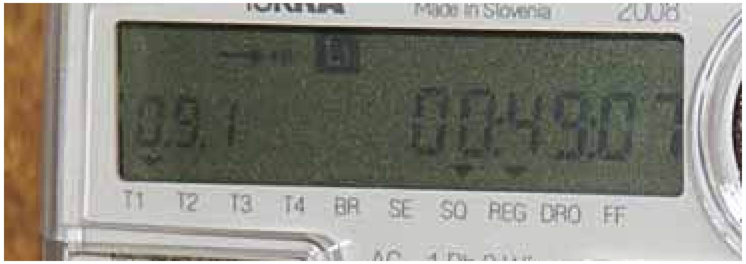
Electronic Meter (Typical)



Display types

- **Impulse Counter**
  - Influenced by magnetic fields
  - Mechanical wear and tear – short life

- **Light emitting diodes (LED)**
  - Good visibility in low ambient light
  - Difficult to customize icons and symbols
  - Higher power consumption



- **Liquid Crystal Displays (LCD)**
  - Temperature is an important issue
  - TN / STN displays
  - Often used with backlight

- **Vacuum fluorescent display (VFD)**
  - Excellent visibility
  - High power consumption
  - Expensive

Memories

- Program memory (Non volatile)
  - ROM (Mask, OTP, OTP Flash)
- Data memory
  - RAM (battery backed)
  - EEPROMs
  - FRAM
- Scratch pad memory
  - RAM
- Registers
  - RAM (battery backed)
  - EEPROMs
  - FRAM

Real Time Clocks

- **What are RTC's** ?
  - Oscillator (32768 Hz), frequency dividers, counters and RAM
- **High stability crystals**
  - RTC time accuracy depends on crystal stability
  - Crystal frequency varies as negative square of temperature
  - Therefore time will always get slower with change of temperature from nominal
  - Time has to be periodically set
- **Mains frequency based time**
- **GPS time synchronization**

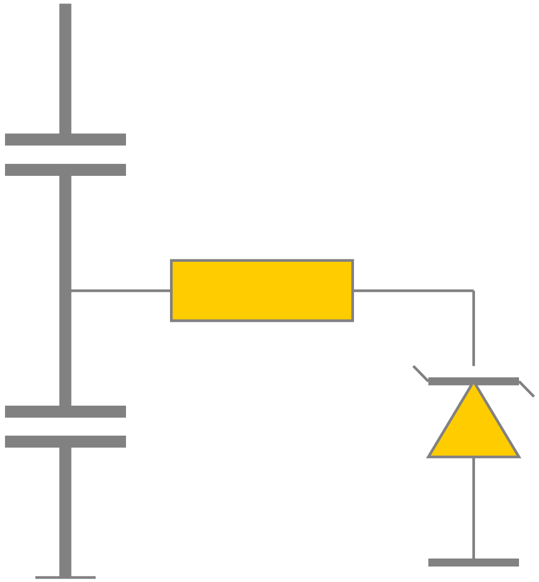
Power Supplies

- The most critical component of an electronic meter
- Key issues to consider are:
  - Output voltages and isolation levels
  - Voltage range of operation
  - Immunity to magnetic fields
  - Surge immunity
  - Fast transient burst immunity
  - Conducted and radiated emissions
  - Sustained long term performance
  - Burden delivered to the load
  - Burden of the supply itself
  - Efficiency

Power Supply

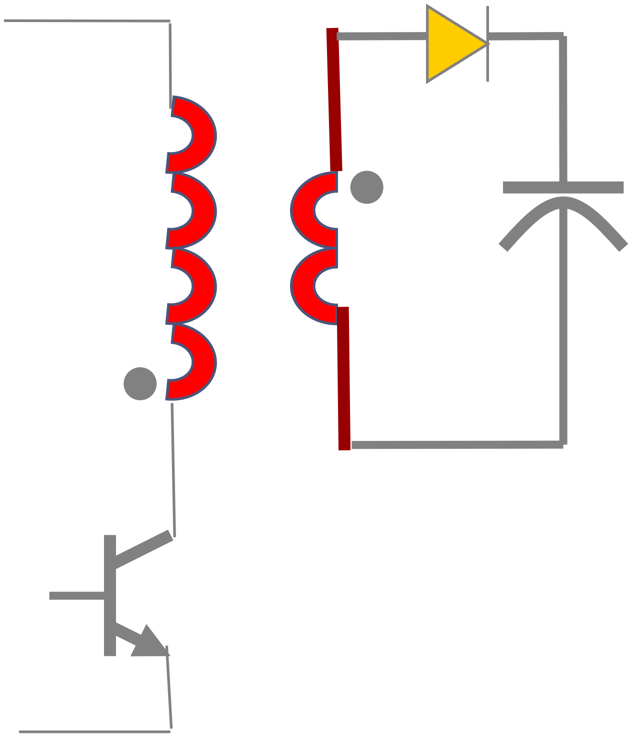
Capacitive dividers

- Low cost designs
- No conducted and radiated emissions
- Low burden power delivery
- High burden to source (capacitive)
- Low voltage variation withstand
- Capacitor ageing problem!

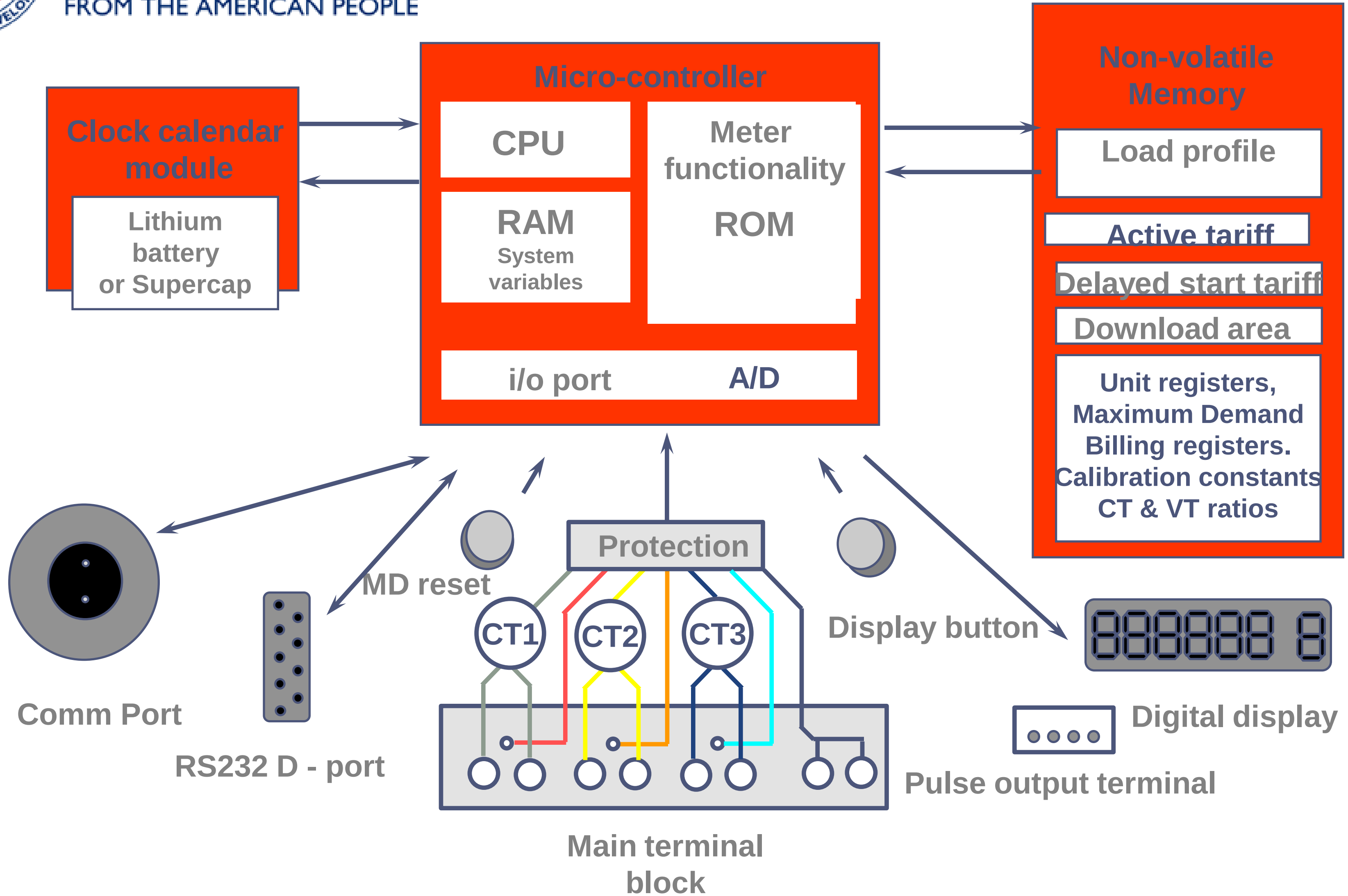


Power supplies
Switched mode power supply (SMPS)

- More expensive
- Very good line and load regulation
- Very high efficiency
- Higher conducted and radiated noise
- Low source burden
- Multi voltage output
- Full bridge configuration in 3 phase circuits



Energy meter …intelligence



Applications of Electronic Meters

- Billing and AMR
- Payment Systems
- Load Control and Demand Response
- Load profiling
- Revenue Protection (Detect, prevent and create evidence against fraud)
- Power Quality and Event logging
- Energy Accounting
- Energy Monitoring and management

Questions please??

Thanks