Business from technology

Medium voltage fault current indication

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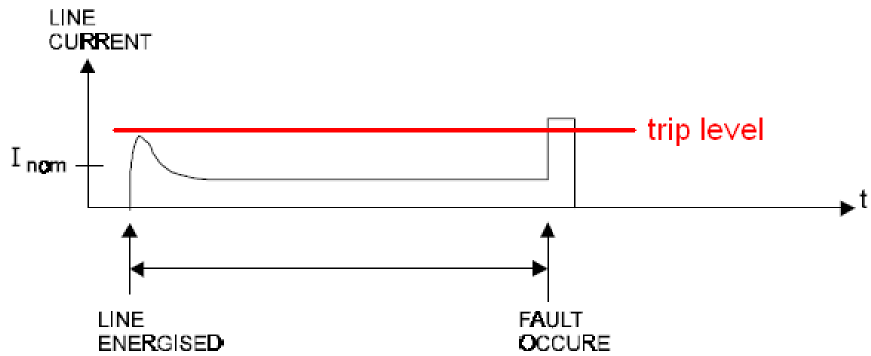
Technology available

- Linetroll from Nortroll
- Flite from Schneider Electric
- These devices detect rapid increases in the current by observing the magnetic field
- They also detect the absolute value of the current and compare it to a pre-defined trip level
- They usually include an electric field sensor for line voltage detection



The Linetroll 111K

- Suitable for 6-132kV distribution networks
- Mounted on the pole 3-5 m below the conductors
- Battery lifetime is 7-10 years
- 3.6V 13Ah Lithium battery
- Minimum trip level is 4 A
- Fault indication with xenon flash

The Flite 117

- Suitable for 20 kV to 69 kV distribution networks
- Clipped directly to the conductors
- Battery lifetime is ≈10 years
- Minimum trip level is 6 A
- Fault indication with high power LEDS

Disadvantages of common technology

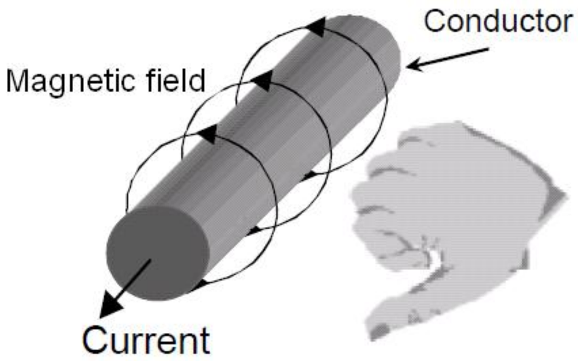
- 4 – 6 A trip levels may not be adequate for detecting small leakage or unbalance?
- The devices require battery changes
- The alarm method is based on visible light, which requires on-site work to locate the fault

Improvement possibilities

- 2D magnetic field measurement enables
  - recognition of the **fault type** and
  - Detection of **unbalance between the phases**
- MEMS based magnetometers together with coherent detection make the current measurement more **accurate** and enables observing the **waveform**
- Capacitive MEMS sensor is **low power** and **small** size
- **Energy harvesting** as a power source removes the need for changing the batteries
- Replacing the pulsing light with radio communications as the **alarm method**

Current sensing

- Magnetic flux density around the conductor is proportional to the current
- Depending on the schedule either MEMS or commercial AMR magnetometers can be used



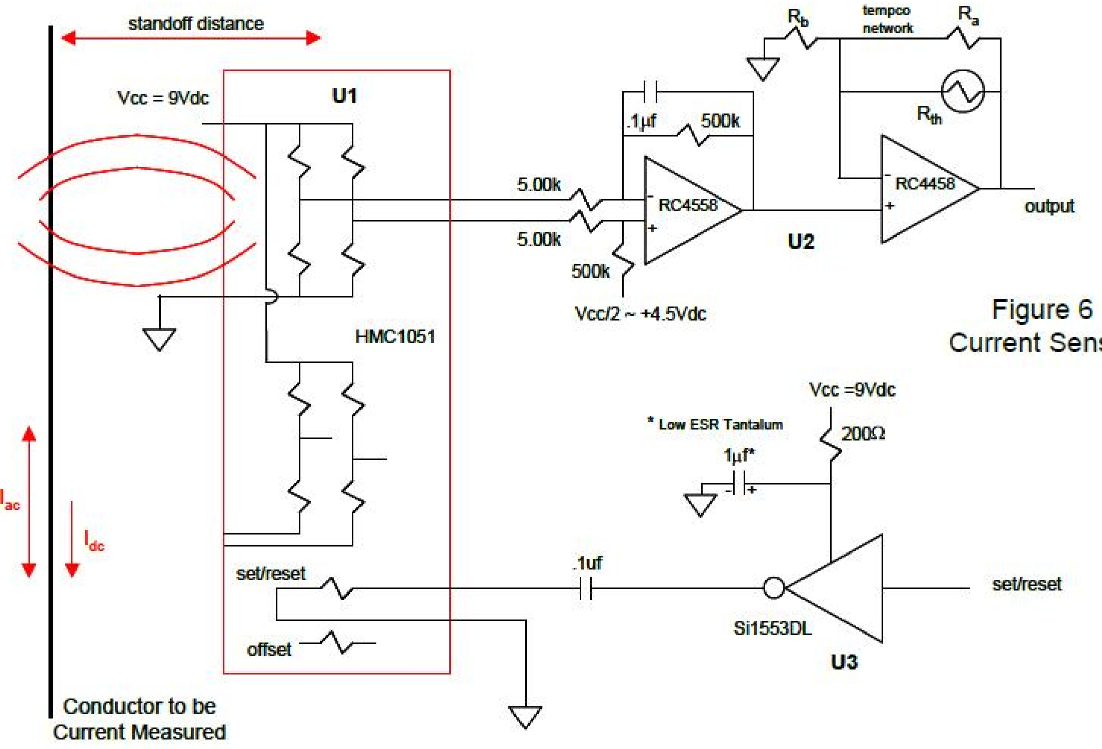
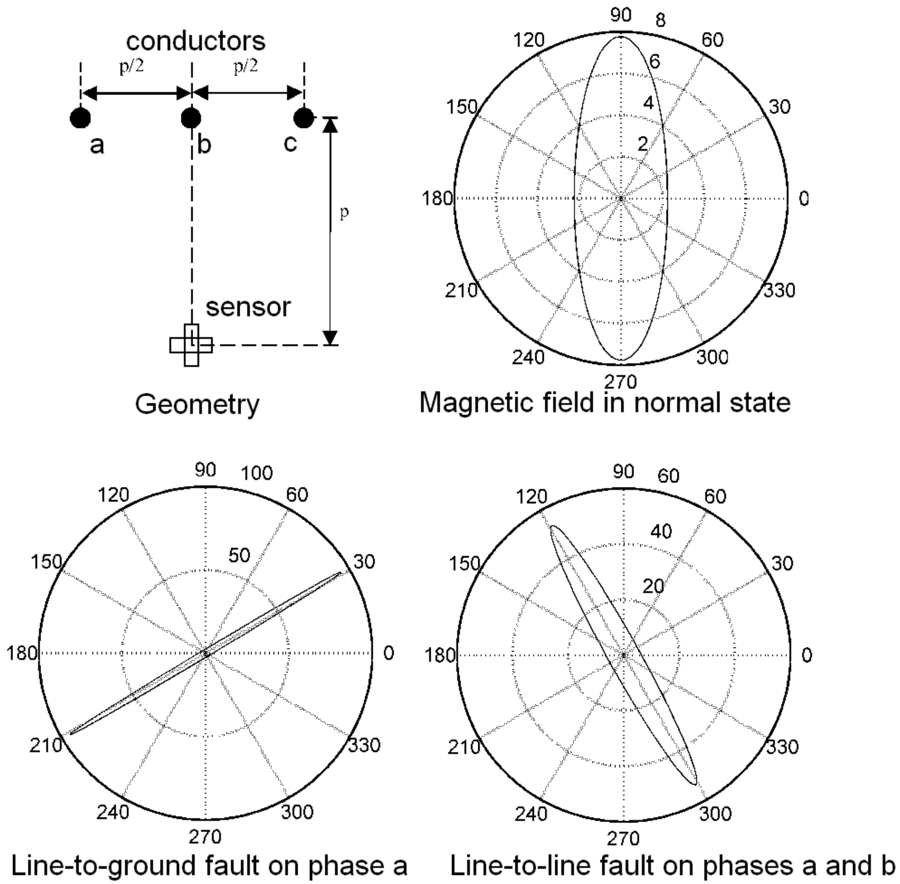


Figure 6
Current Sensor

2D magnetic field sensor



Modified from Ferreira, K.J.; Emanuel, A.E.; , "A Noninvasive Technique for Fault Detection and Location," *Power Delivery, IEEE Transactions on* , vol.25, no.4, pp.3024-3034, Oct. 2010

Coherent detector

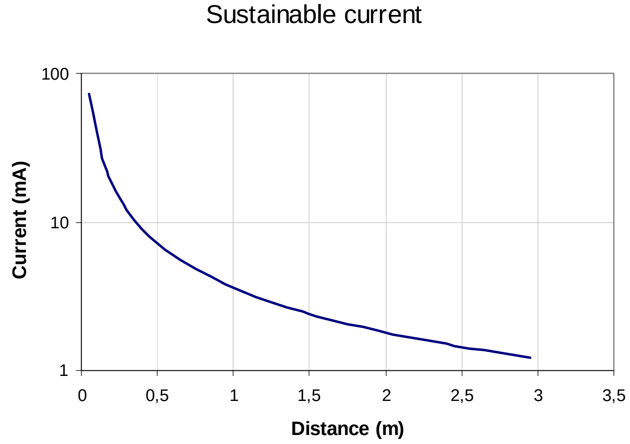
- Makes current measurement very accurate and tolerant to noise
- May enable reactive power indication

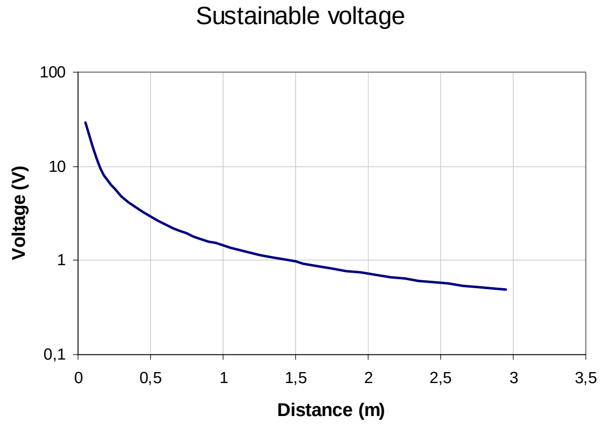
Energy harvesting

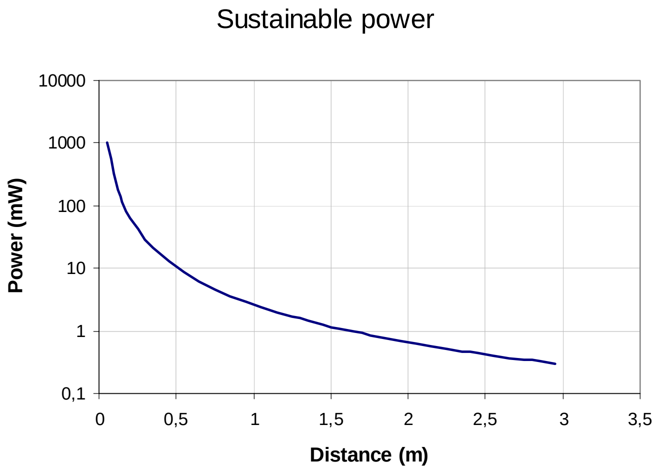
- The device could be powered by harvesting energy from the magnetic field surrounding the power lines
- Energy harvesting makes changing batteries unnecessary
- Reliability issues: Need for secondary power source?
  - No current → no harvesting
- Harvested power depends on the distance: smaller distance equals more power (see next slide)
- Can the device be mounted on the pole and how close?
  - At 1 meter below the conductor the power is more than adequate
  - At 3 meters problems may occur
- Can the device be clipped directly onto the conductor such as Flite 117?
  - The disadvantage of direct clipping is that the 2D field detection becomes difficult. This means that each conductor requires a separate device.

Rough estimates of harvested energy

- Assumptions: current on line is 100 A, frequency is 50 Hz, load resistance of the device is 200 Ω, no saturation in the ferrite core of the harvester
- To obtain the highest precision, the power dissipation of the MEMS sensor is roughly 150 µW excluding the readout electronics
    - Lower precision reduces power consumption



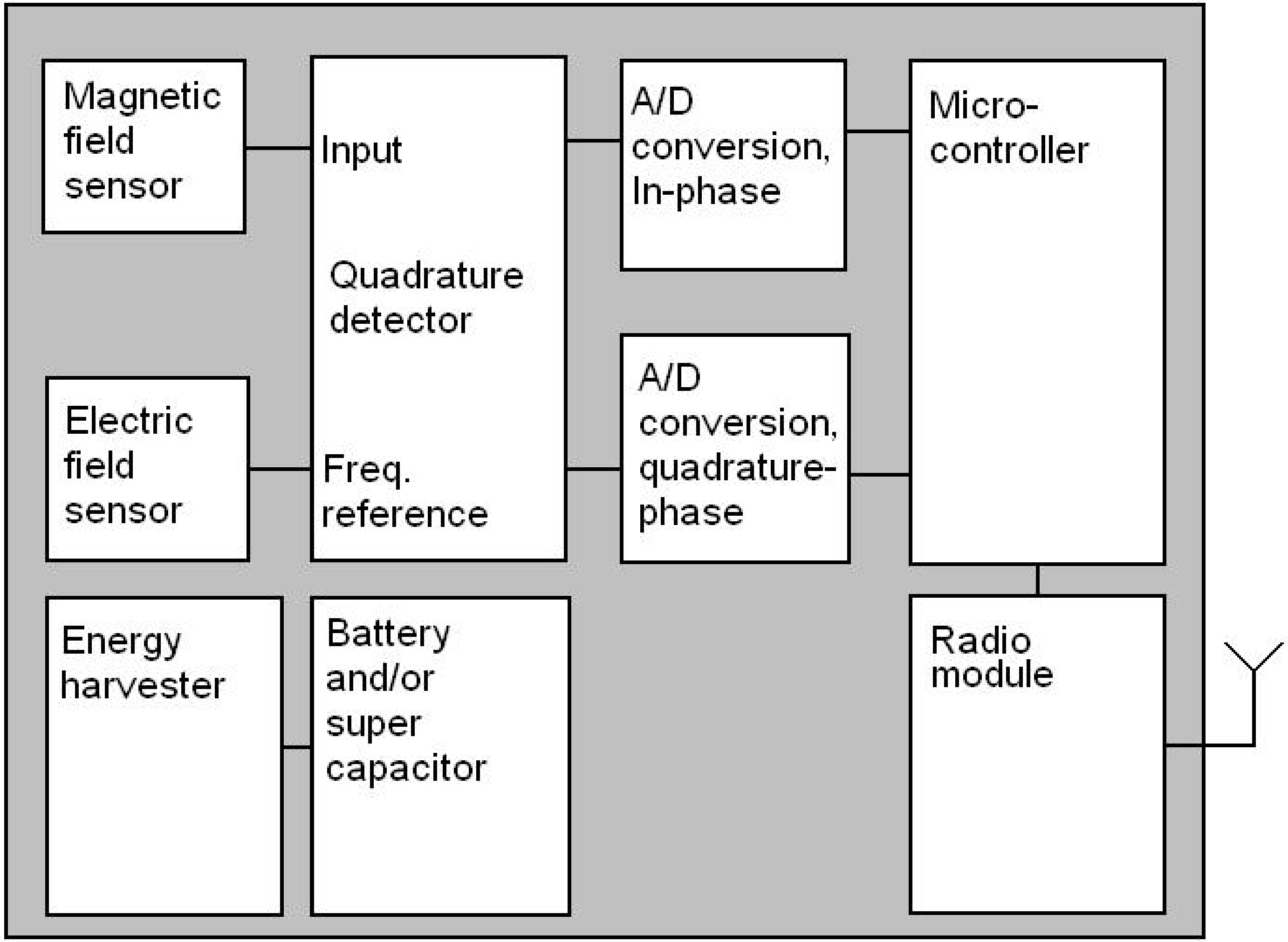




Alarm indication

- Alarms would be transmitted by radio
  - Configuration may also be possible via radio
- Radio transmission could be based on cell-phone networks or by using some other radio network

Proposed block diagram



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