Monolithic integrated galvanic isolation enabling energy management in Power over Ethernet applications

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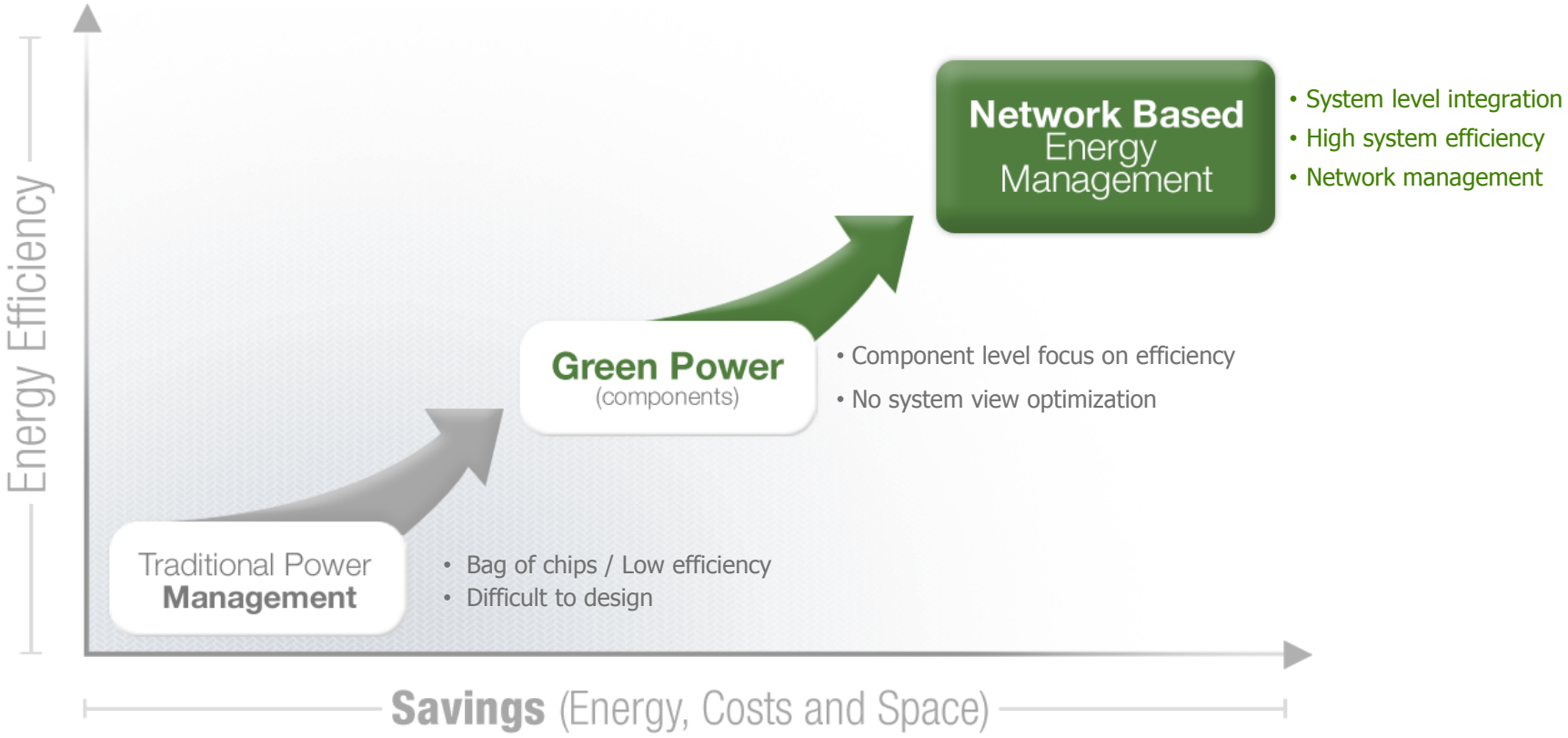
Power Management Evolution



Motivation for Network based Energy management

- **"Scalar" power management is producing diminishing returns**
  - Optimizing Vin/Vout efficiency and light load operation is no longer enough.
  - Communication is necessary between CPU and power supply system for further innovation
  - A system that can turn itself on/off when needed will always beat the best no-load architecture.
- **System controllability/observe-ability become much more valuable with energy management**
  - DC-DC power supply is usually a black box to the system architect.
  - Power supplies must have the ability to efficiently track the load conditions
- **Spatially distributed power supplies require isolation**
  - Ground loop: 600V of earth ground variation is possible within 100 meters
  - Safety: Cable cross/cable short to high voltage power cables
  - EMI

Communication across the isolation barrier is essential to create a network power supply

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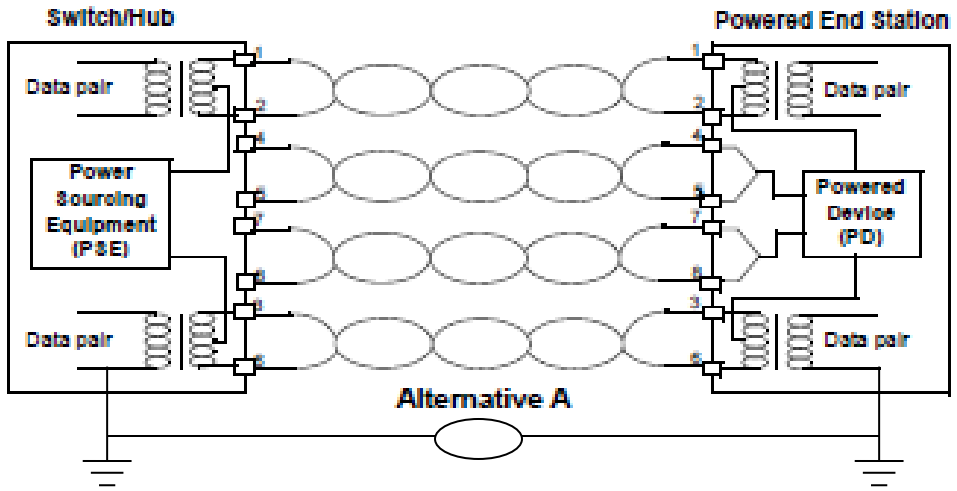
Power over Ethernet

IEEE 802.3AT
Power over Ethernet

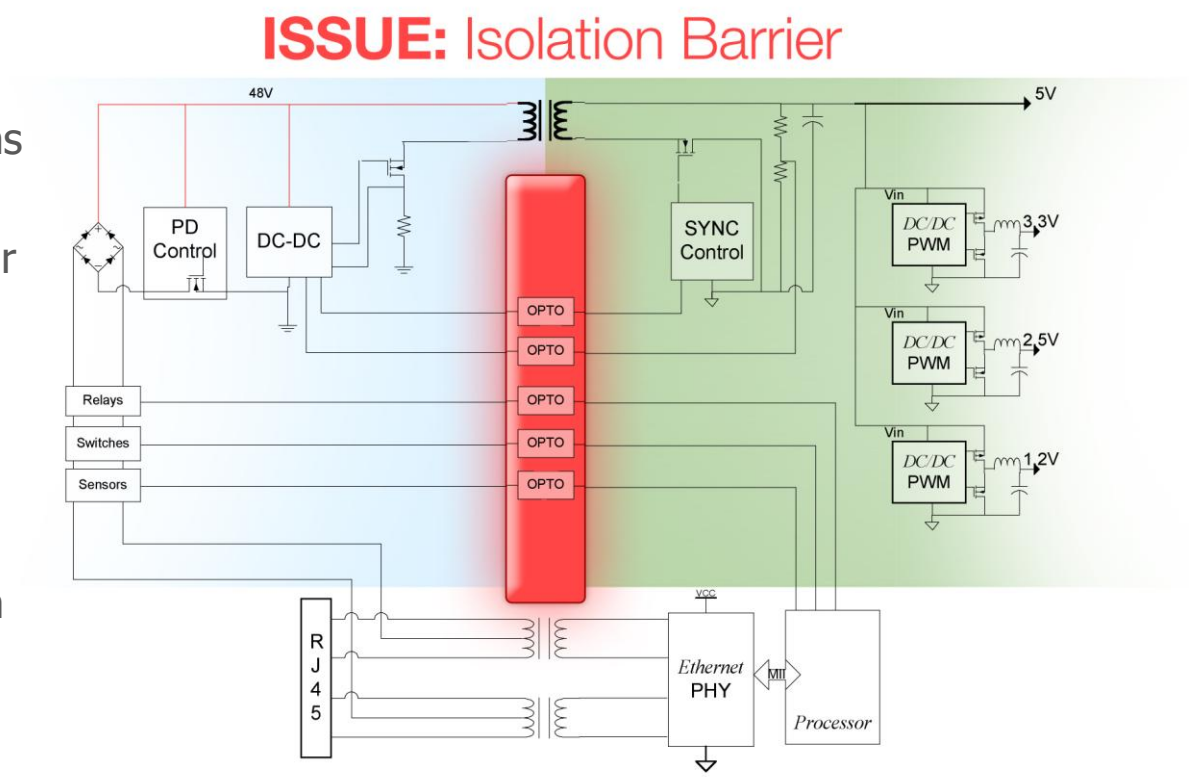
- Power supplied at the switch
- SELV
  - cable does not have to be installed by a licensed electrician
  - Existing cable plant can be used
- 100M cable can act as both a transmit/receive antenna
- 1500Vrms isolation required between Ethernet cable and switch or client circuitry
- Major applications are
  - IP phones
  - IP cameras
  - WLAN



Legacy Approach: "Bag of Chips"

Traditional PD power supply circuit design

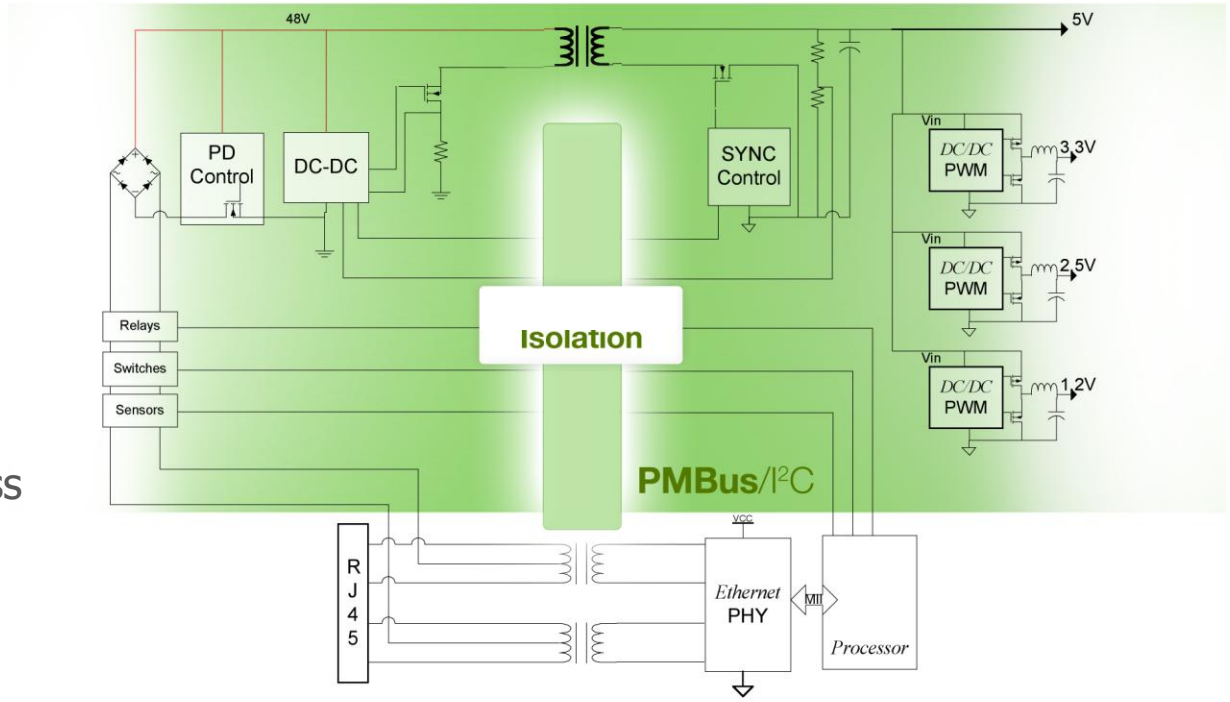
- Inefficient power design
  - Multiple power losses in components & interconnections
- Components loosely tied together
  - Limited functionality
- Additional power loss across isolation barrier
- Opto-couplers: reliability concern
- Isolation barrier prevents integration of primary and secondary side circuits



PD power supply circuit design using integrated galvanic isolation

Isolation in Silicon →

- Creates ability to **communicate over the Isolation** Barrier
- Enables end-to-end digital power control by the system architect
- Opens significant integration possibilities
  - Most functions can be implemented in one integrated circuit
- Eliminates significant power loss



No Opto or Pulse Transformer required for feedback

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Integrated Galvanic Isolation

Galvanic isolation implementation

- Requirements
  - POE: 1500Vrms isolation
  - Offline supplies 3000-5000Vrms
  - Medical > 5000Vrms
- Dielectric strength of SiO2 ranges from 200-1000V/um
  - Cost effective capacitors are in the fF range
  - Signaling levels are tiny

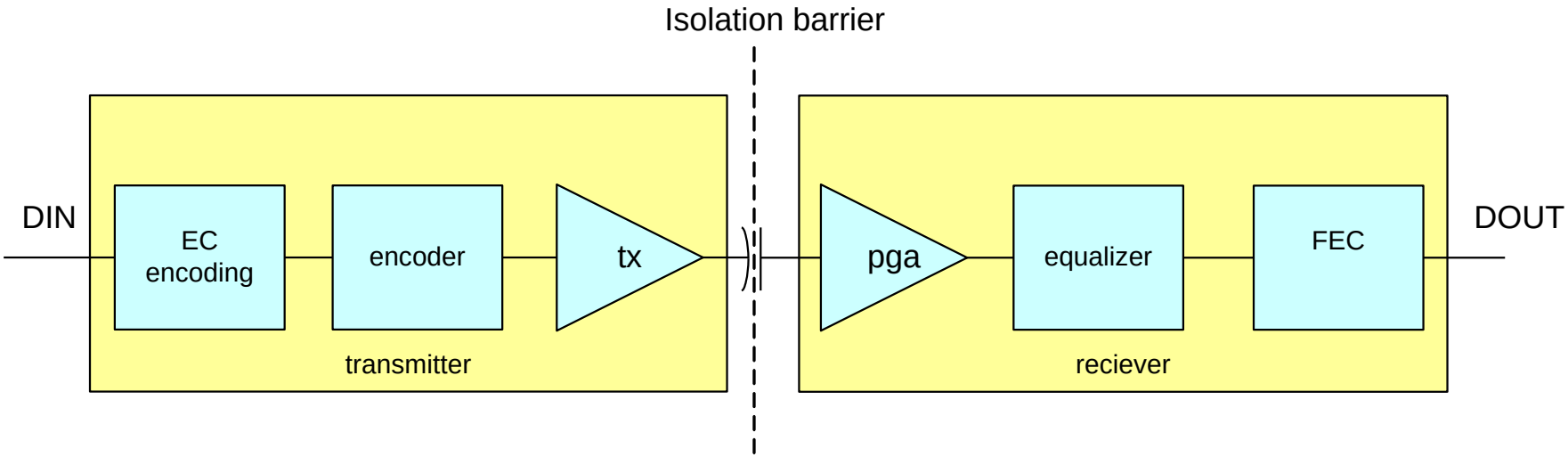
Noise Immunity

- Typical POE supplies can switch up to 20A
  - Causes large inductive switching events
  - Large voltage/current surges can be seen across the barrier
- Radiation
  - 100m cable forms a very effective receiving antenna
  - FM/AM/WLAN can and does couple very effectively into isolation circuitry
- Isolation modem must reject these noise sources
  - balanced circuitry
  - Active noise rejection circuitry
  - Error correction

Latency & Fault Protection

- Low latency is required for
  - Fault protection
  - Low phase margin degradation of control loop
- Bit error in the modem can translate into a broken power supply
  - Multiple redundant fault protection circuits

Modem Architecture



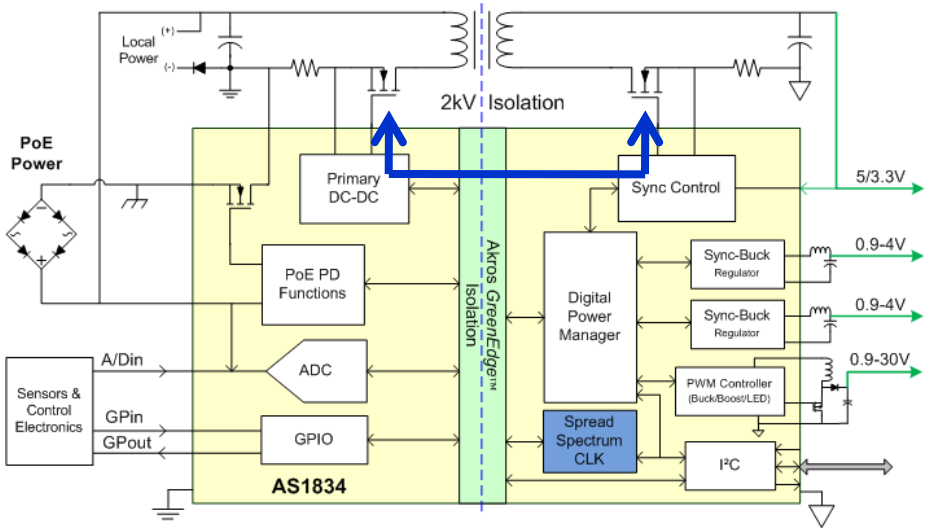
- Embedded error correction
- Encoding/decoder
- Driver/reciever

Architectural improvements

Full control of primary/secondary FET's

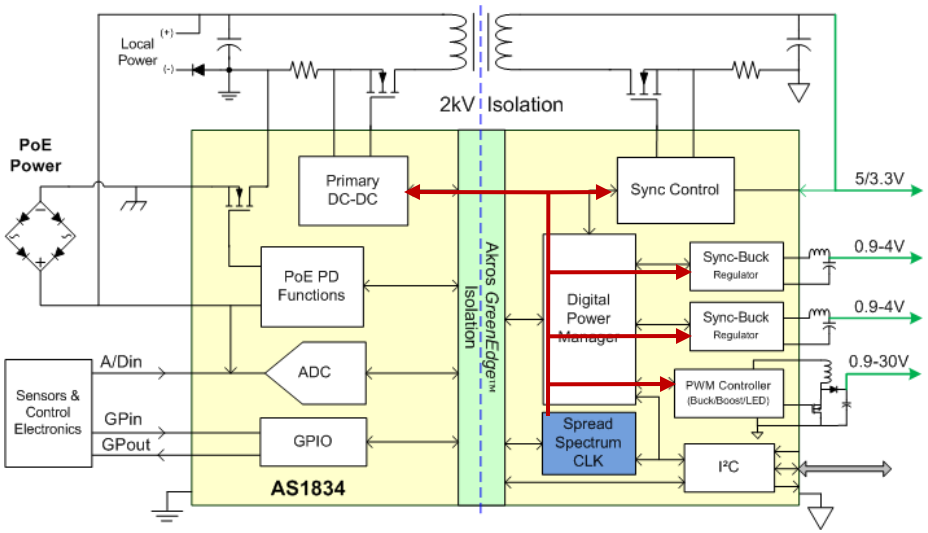
Superior Efficiency across varying loads

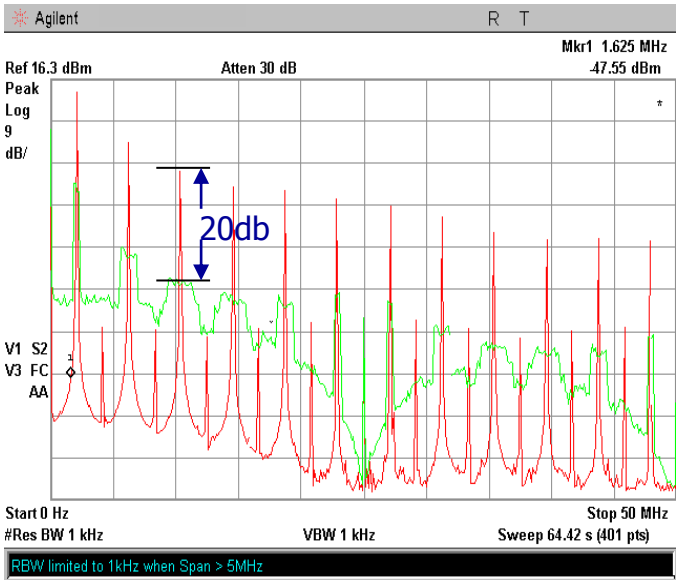
	Diode Rectification	Winding-based Sync. Rectification	Sync. Rectification
Light Loads Efficiency	**Good** performance	**Poor** performance due to FET overlap	**Good** performance
Heavy Loads Efficiency	**Poor** performance due to diode conduction losses	**Good** performance	**Good** performance >90%



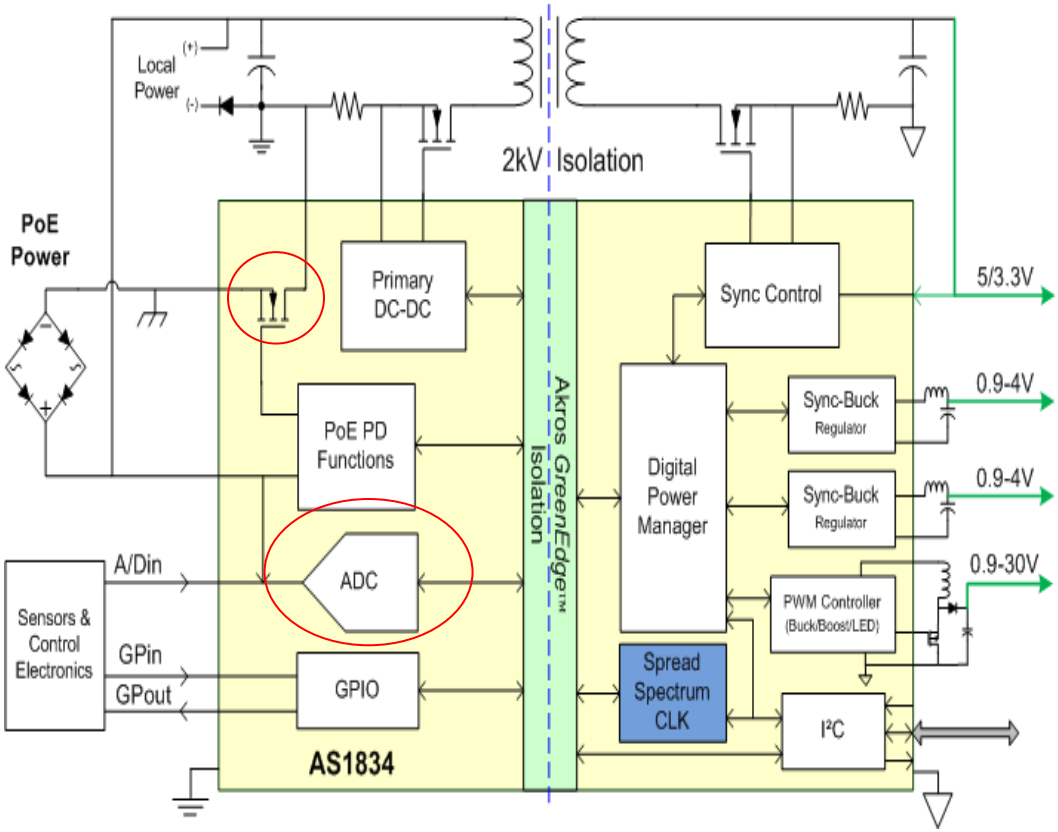
EMC & Noise Control

- Selectable Spread-spectrum clocking on all PWMs
  - Primary & Secondary PWM synchronization across Isolation barrier
  - Reduces Power Supply Spectral Noise >15dB
- Deterministic PWM Clock phasing for lower di/dt
- External SYNC clock capability – to all Primary/Secondary PWMs





Monitoring



- Installation & maintenance costs are often more than the total HW cost
- Early replacement is often much cheaper than line down
- Line Voltage monitoring
  - Early brownout detection w/ controlled shutdown
- Line current monitoring
  - Early detection of failing HW
- Temperature sensing
  - Early detection of failing HW
- Monitoring/control also offers remote power throttling, sleep & shutdown

Network based Energy management

- There is a clear industry trend towards system/network wide power management
  - DCDC -> PMIC ->
    - » POE
    - » Network lighting control
    - » Home appliance control
- Galvanic isolation is an enabling technology for full network control
- Much larger gains can be had at the network level than at the component level
- From designer perspective this means that the "little features" enabling power supply control and monitoring can be as important as the architecture of the power supply itself
- It is no longer sufficient for the power supply to be a black-box
  - System architect must have full control

The world is going IP, so must the power supply