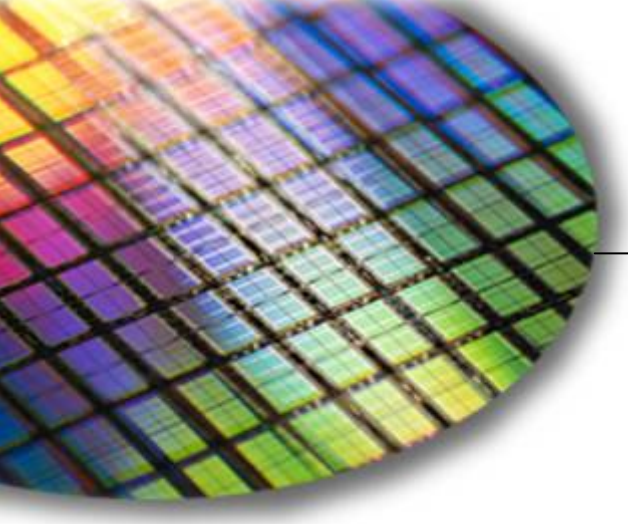


The World Leader in High Performance Signal Processing Solutions

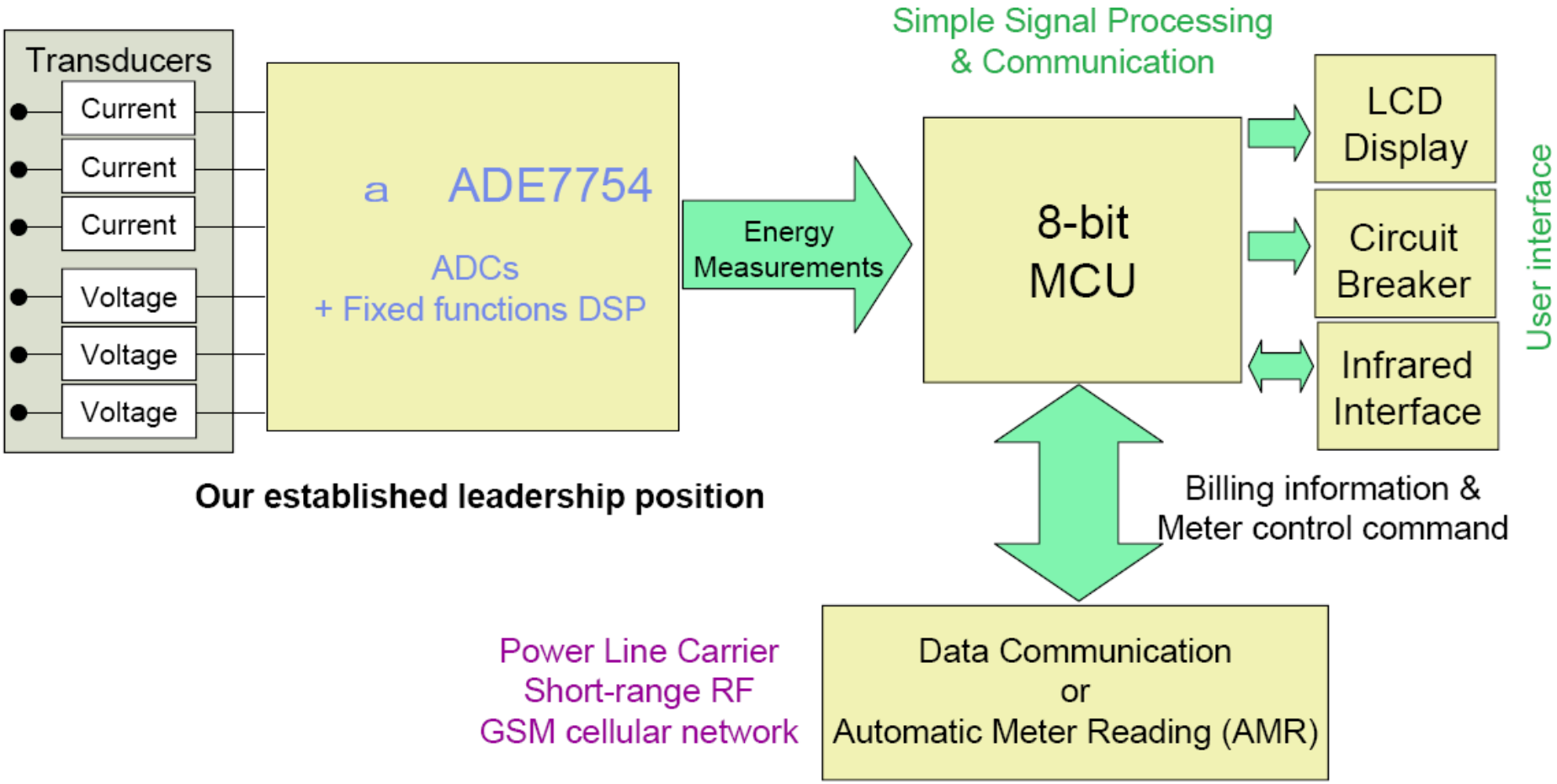
Multi-functional Polyphase Energy Metering IC with Serial Port Interface

ADE7754

Energy Measurement Group
Precision Converters (PRC) Division

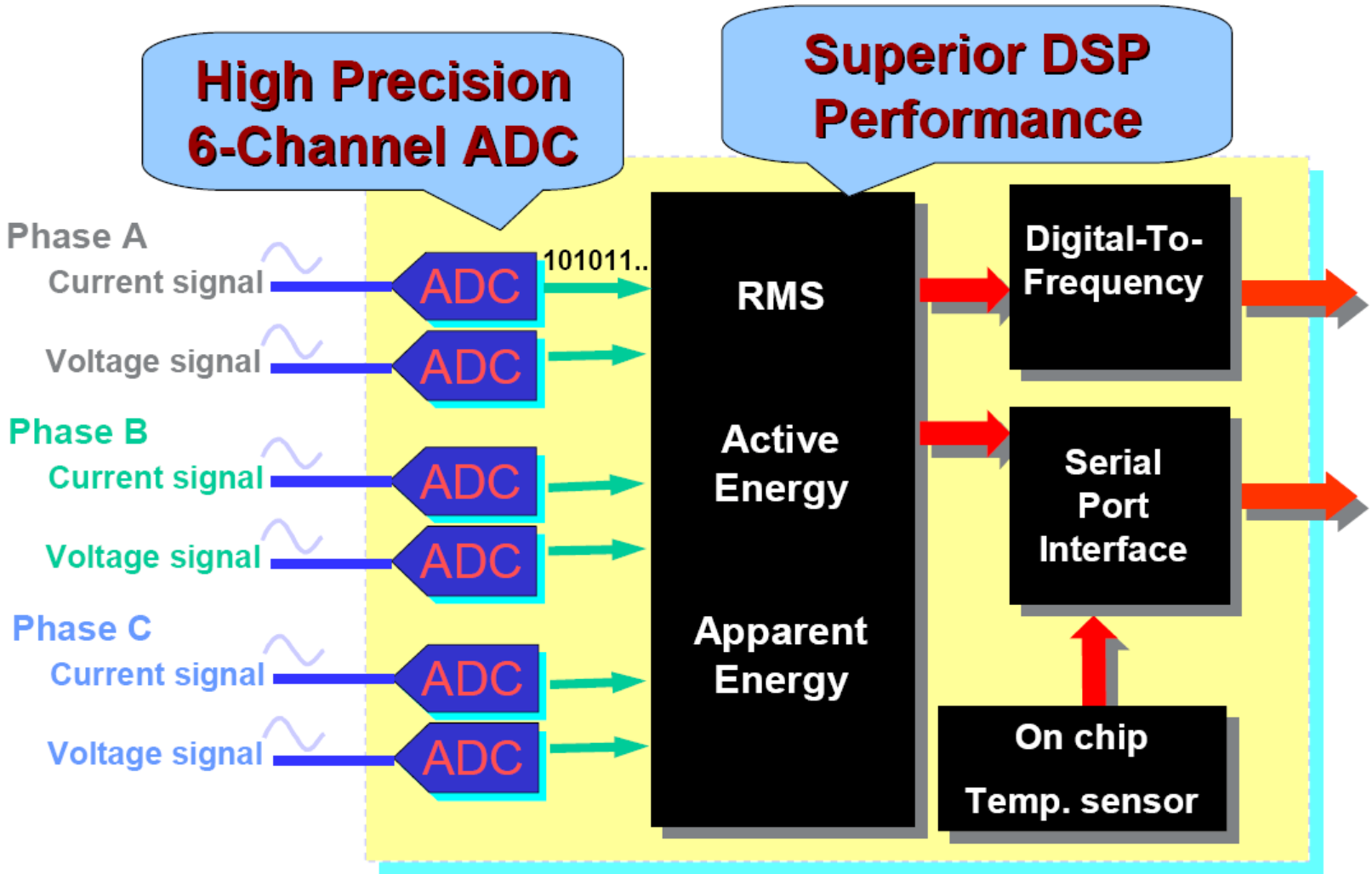
ANALOG DEVICES

ADE7754: A programmable solution for Polyphase Energy measurementTransducers



Our established leadership position

ADE7754: Technology at a glance



ADE7754: Overview of Functionalities

- **Surpasses IEC1036 requirement. Less than 0.1% error over wide dynamic range**

- **Supplies the following information:**
  - **Active energy**
  - **Sign of Reactive energy**
  - **Apparent energy**
  - **Simultaneous RMS calculation on the six analog inputs**
  - **Peak Voltage and Current detection**
  - **SAG Line Voltage detection**
  - **Line Period**
  - **Temperature**

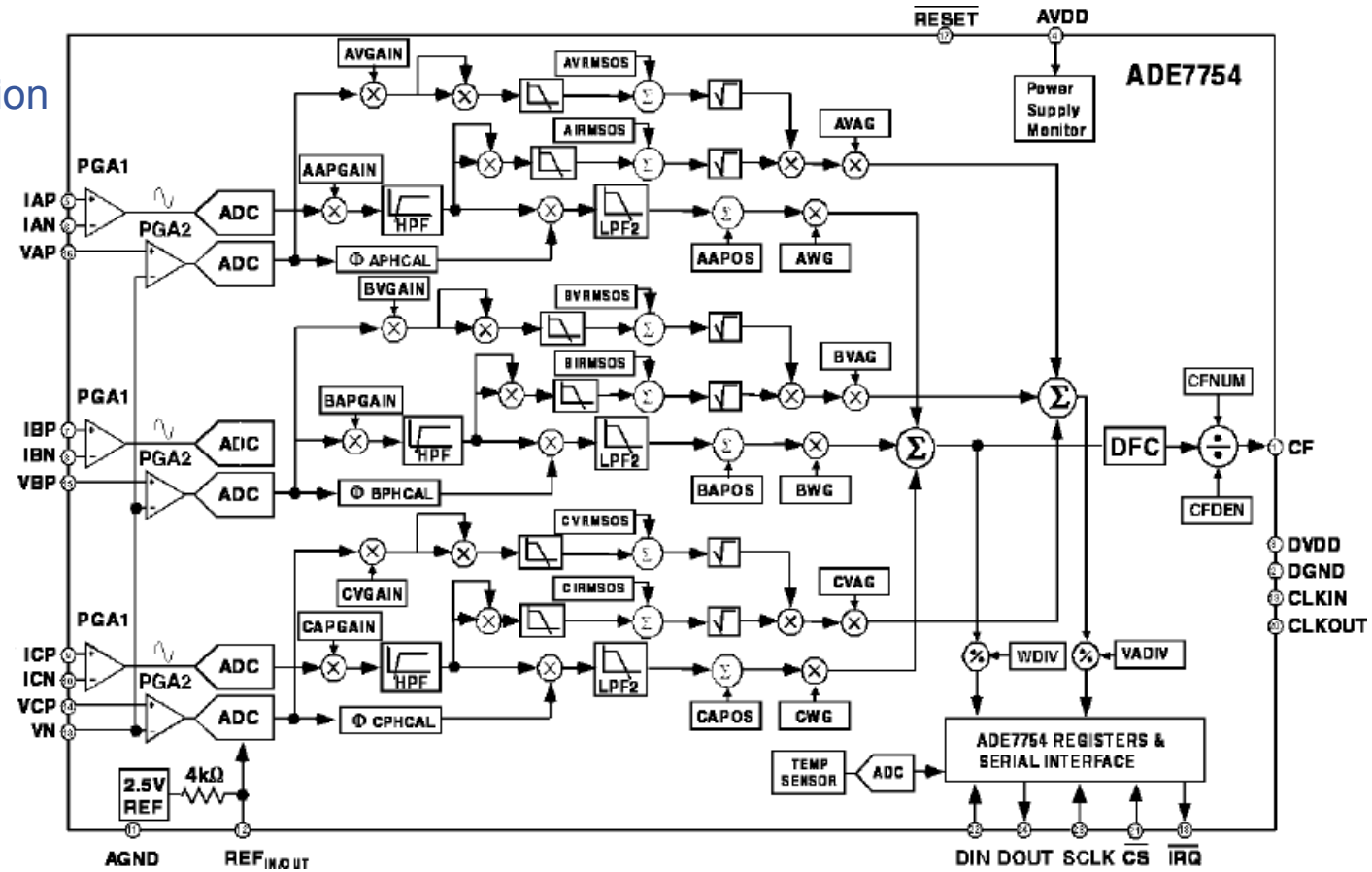
- **Digital calibration**

ADE7754: Characteristics

- 24-pin SOIC package
- 5V Power Supply
- [-40 C; +85 C] Temperature Operating range
- 500mV maximum analog input range with PGA of 1, 2 or 4 on all channels
- External Clock frequency = 10MHz

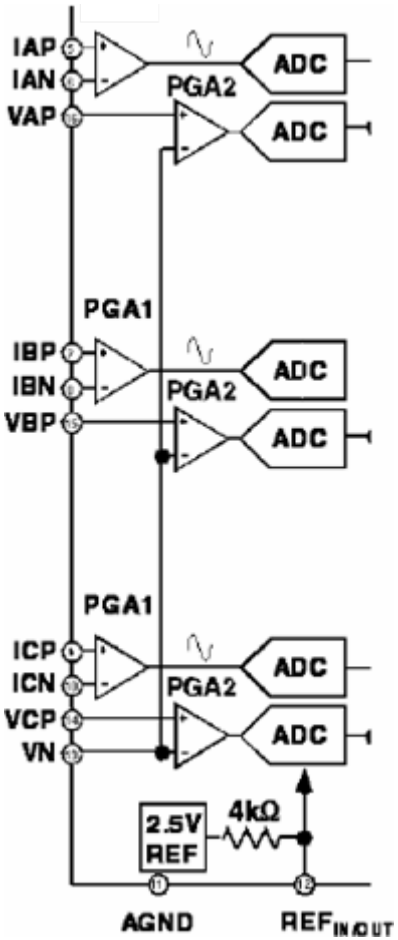
ADE7754: Block Diagram

- Analog Front end
- Current sensor connection
- Digital solution
- Active Energy
- Calibration Mode
- RMS measurements
- Apparent Energy
- Reactive Energy
- Power Line Quality
- Temperature sensor



ADE7754: A validated Analog front end

- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor



- 16-bit accuracy from 2nd order ΣΔ ADCs
- Linearity error < 0.1% over wide dynamic range (int. reference)
- Measurement Bandwidth 14 kHz

ADE7754: Easy use of Current sensors

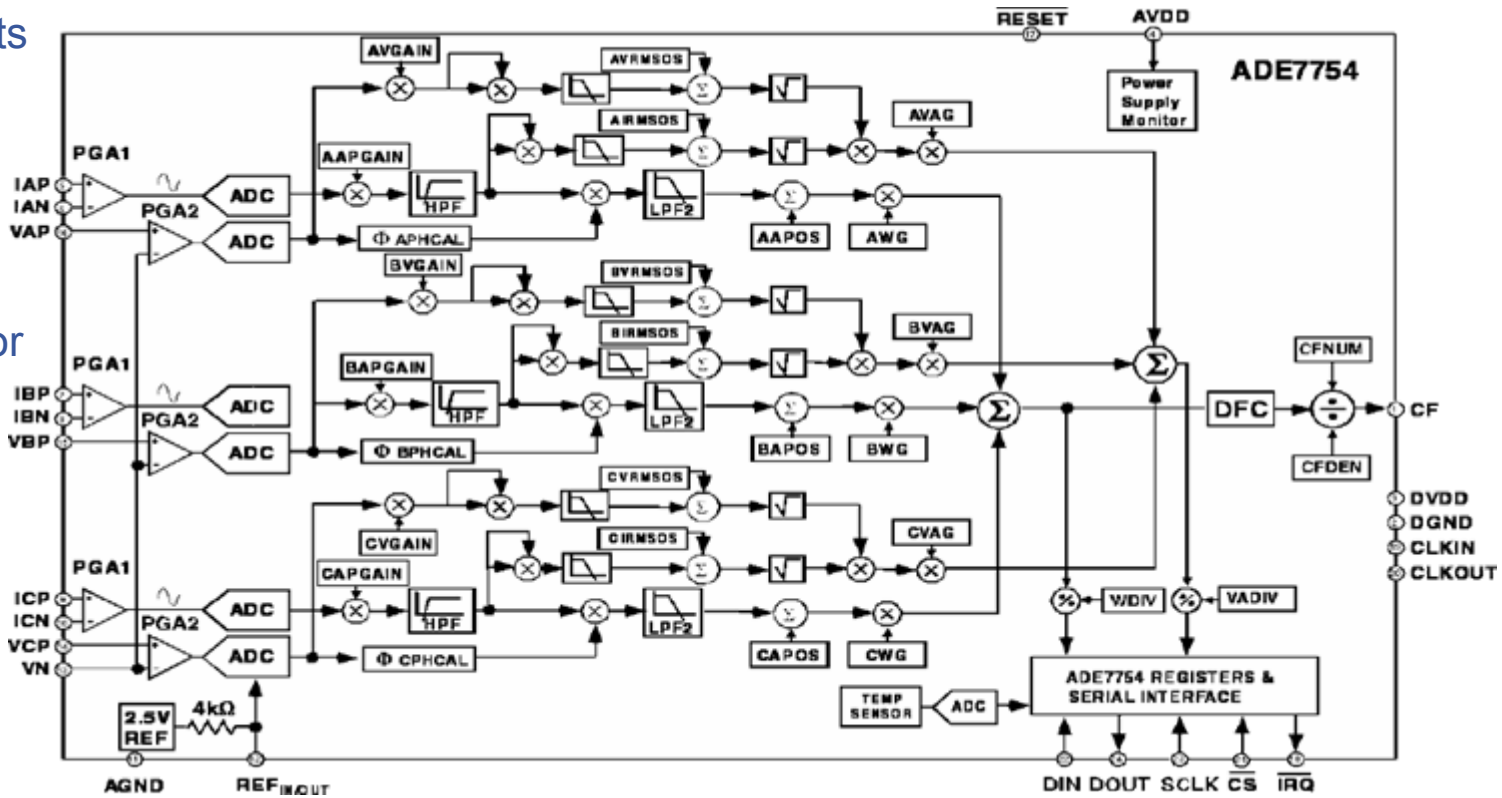
- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor

- Input Gain up to 4
- Phase compensation for CT connection
  ~ +/-0.5°max in 0.02°increment @ 50Hz

ADE7754: A Digital solution

- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor

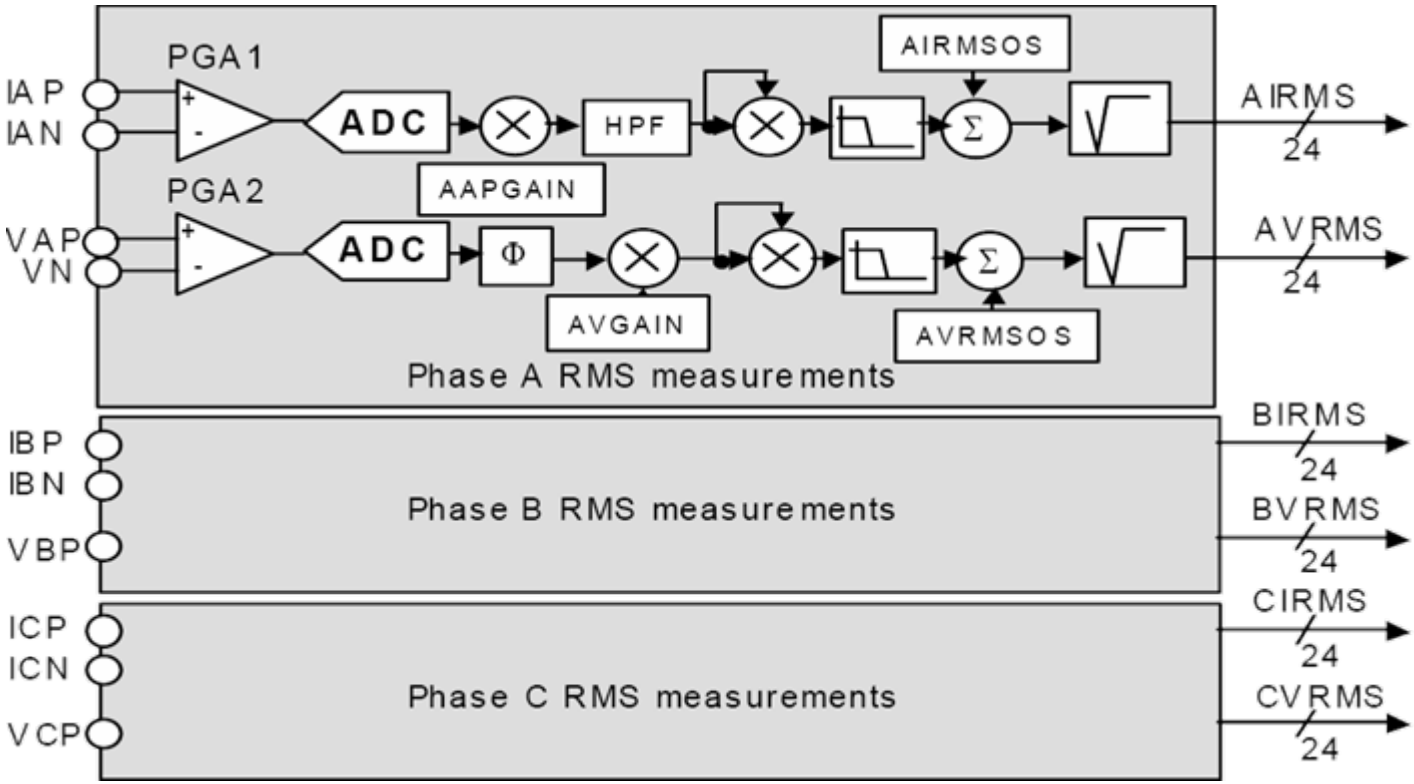
- Configuration done by writing ADE7754 registers at power up
- Only one point calibration to reach 0.5% accuracy for active energy
- CF output to drive LED



ADE7754: Voltage and Current RMS, and waveform samples

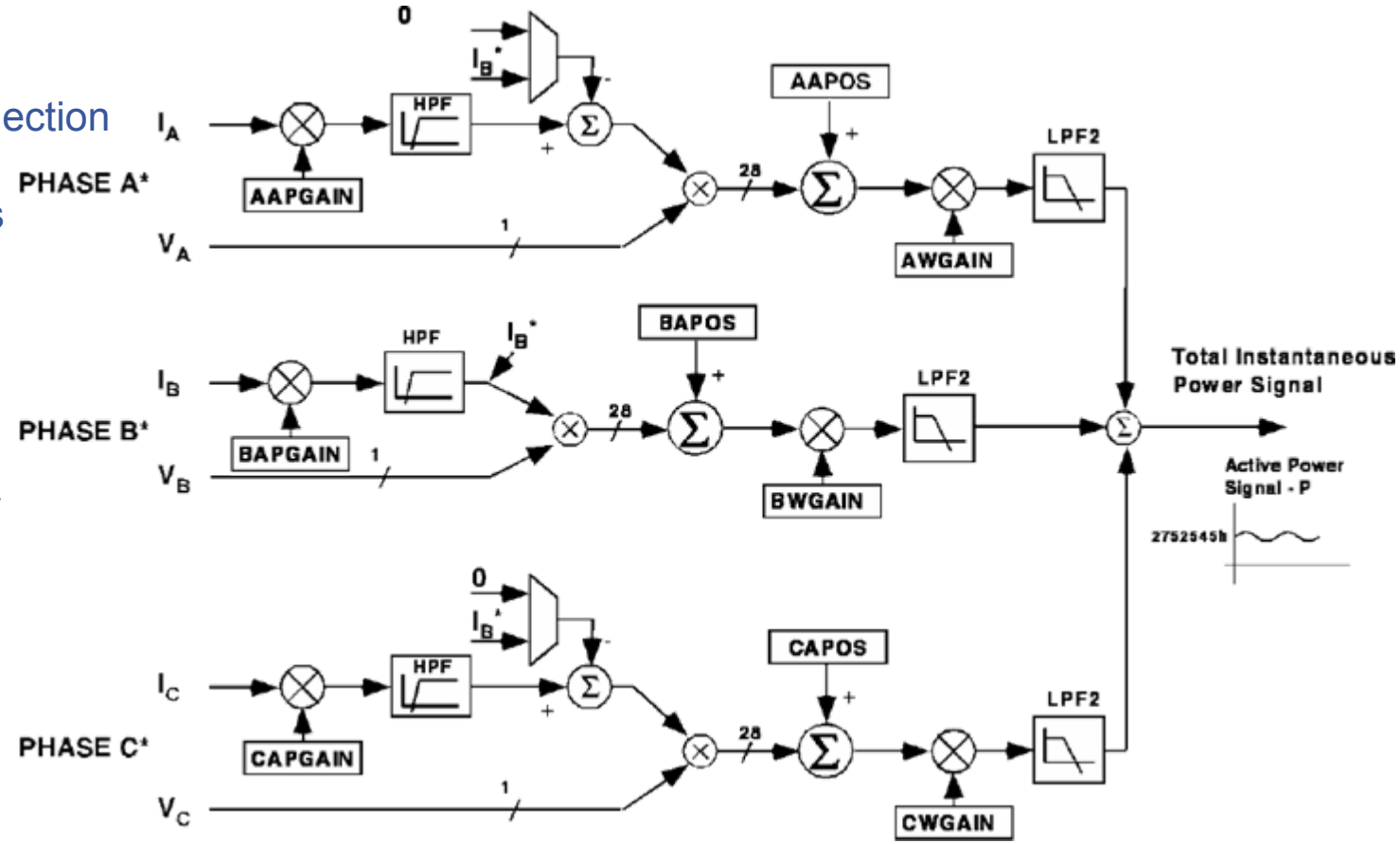
- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor

- Simultaneous Voltage and Current RMS values in 24-bit registers
- Offsets compensate RMS noise integration and improve accuracy
- Real-time voltage and current waveforms can be supplied in four different sampling speeds (up to 28ksps)



ADE7754: Active Energy – Signal Path

- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor

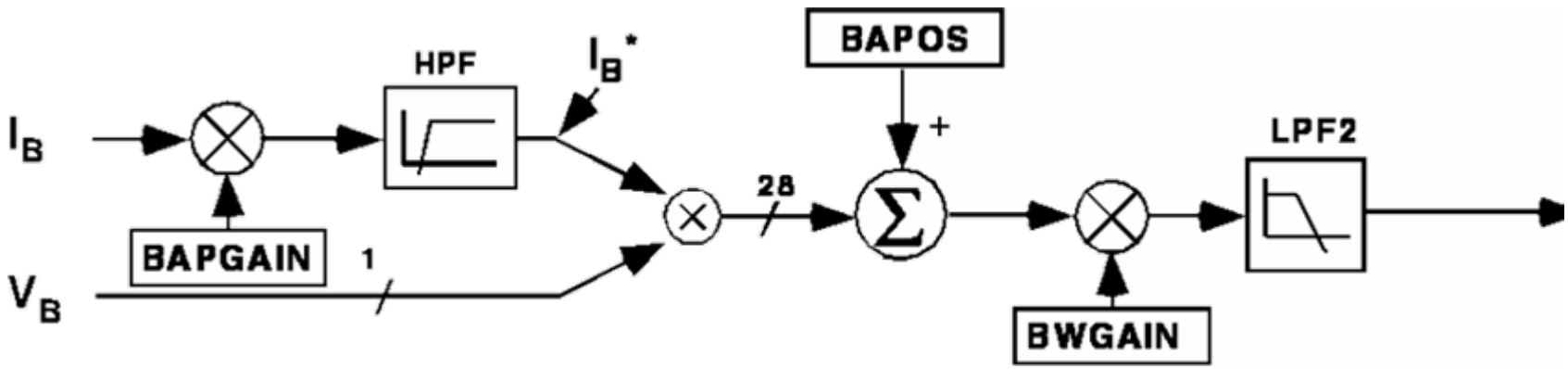


ADE7754: Active Energy – Description

- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor

- Accumulation of the Total Active Energy in a 24-bit register
  => Equivalent to 88s of Energy at Full scale
- HPF filter eliminates any DC offset
- Gain for calibration and multi-rate billing
- Different Modes to accumulate active energy in different meter configuration

  Mode 1. 3-phase 4-wire Wye service
  Mode 2. 3-phase 4-wire Wye service 2 Voltage sensors
  Mode 3. 3-phase 3-wire Delta service
  Mode 4. 3-phase 4-wire Delta service
  - See configurability



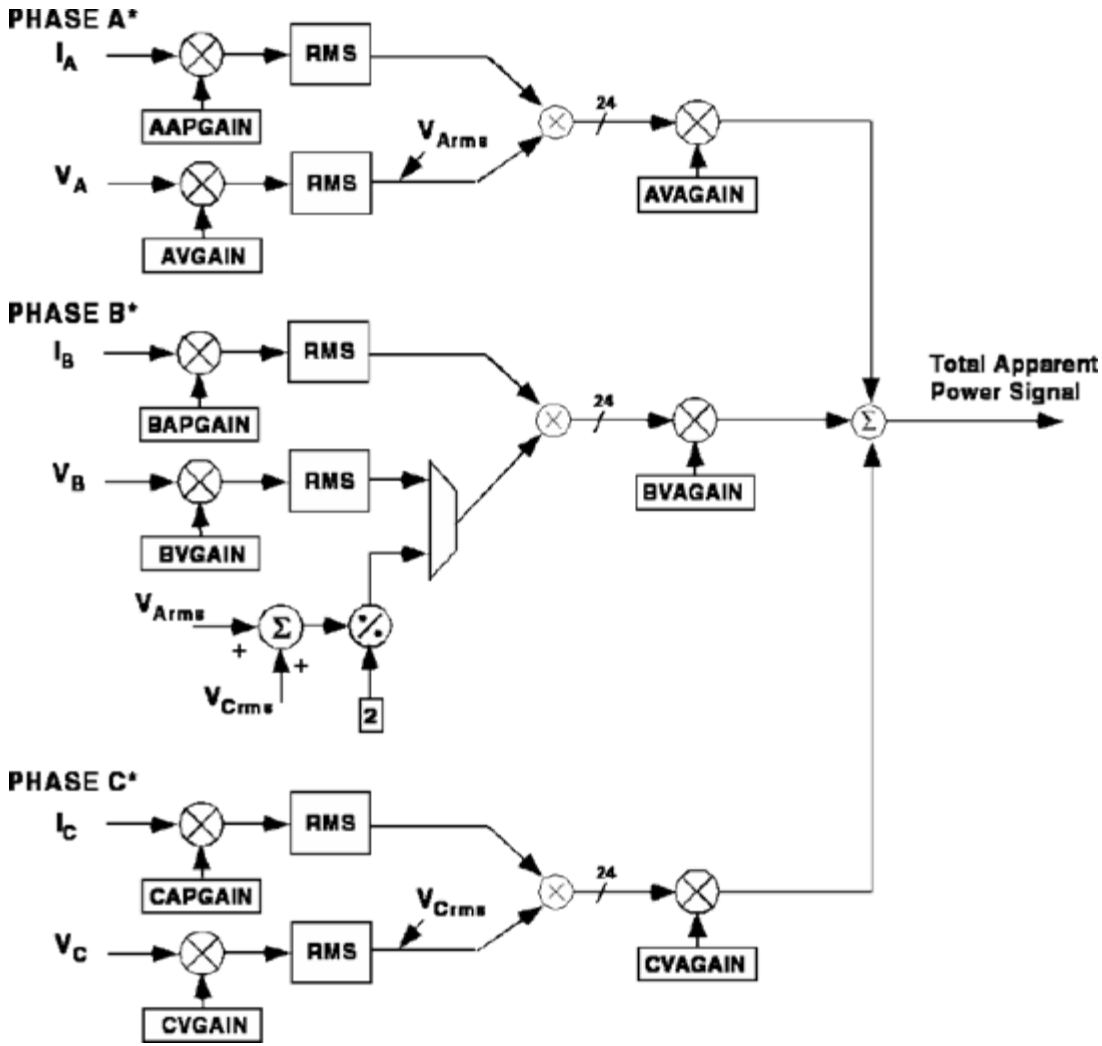
ADE7754: Active Energy – Description

- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor

- No-load threshold per phase for anti-creep 0.005% of Full scale
- Sum of absolute energies for anti-tampering Option selectable
- Instantaneous Reverse Active Power per phase

ADE7754: Apparent Energy (VAh) – Signal path

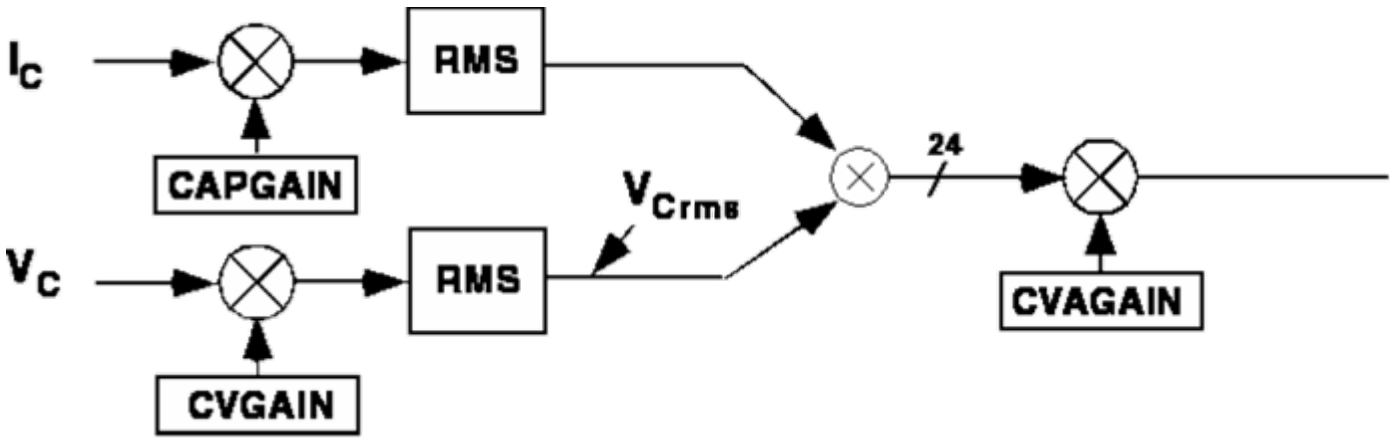
- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor



ADE7754: Apparent Energy (VAh) – Description

- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor

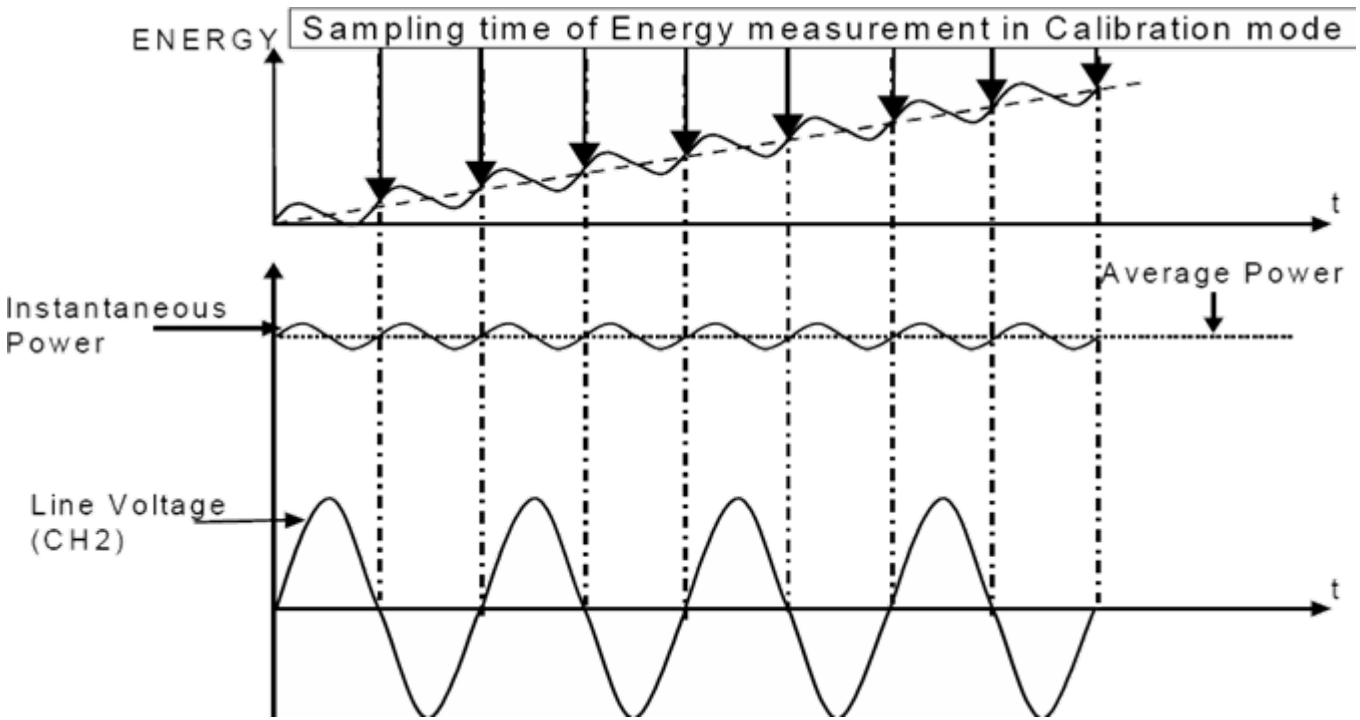
- Apparent power is calculated using: VA = Vrms x Irms
- Accumulation of the Apparent Energy in a 24-bit register
  => Equivalent to 131s of Energy at Full scale
- Gain for calibration and multi-rate billing
- Different Modes to accumulate apparent energy in different meter configuration
  - Mode 1. 3-phase 4-wire Wye service
  - Mode 2. 3-phase 4-wire Wye service 2 Voltage sensors
  - Mode 3. 3-phase 3-wire Delta service
  - Mode 4. 3-phase 4-wire Delta service
  - See configurability



ADE7754: Active and Apparent Energy

- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor

- Principle: Accumulation of the Active and Apparent Energy over N half line cycles (<16384) => Drive IRQ when finished
- Benefits:
  - Cancels the ripple frequency effect (2 x line freq) in Energy Measurement
  - Shorten calibration time



ADE7754: Reactive Energy (VAR) – 1

- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor

- Sign of Reactive Energy can be directly read from the LVARENERGY[23:0]
- The sign of LVARENERGY indicates inductive or capacitive loading
- LVARENERGY is updated synchronous to a programmable number of voltage half-cycles to improve accuracy

ADE7754: Reactive Energy (VAR)-2

- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor

- **Proposed Method to measure Reactive Energy and Power Factor including harmonics:**

  Using synchronous VAh and Wh data

Varh = √(VAh2–Wh2) = √(LVAENERGY2-LAENERGY2)
PF = sign(LVARENERGY) * LAENERGY/ LVAENERGY

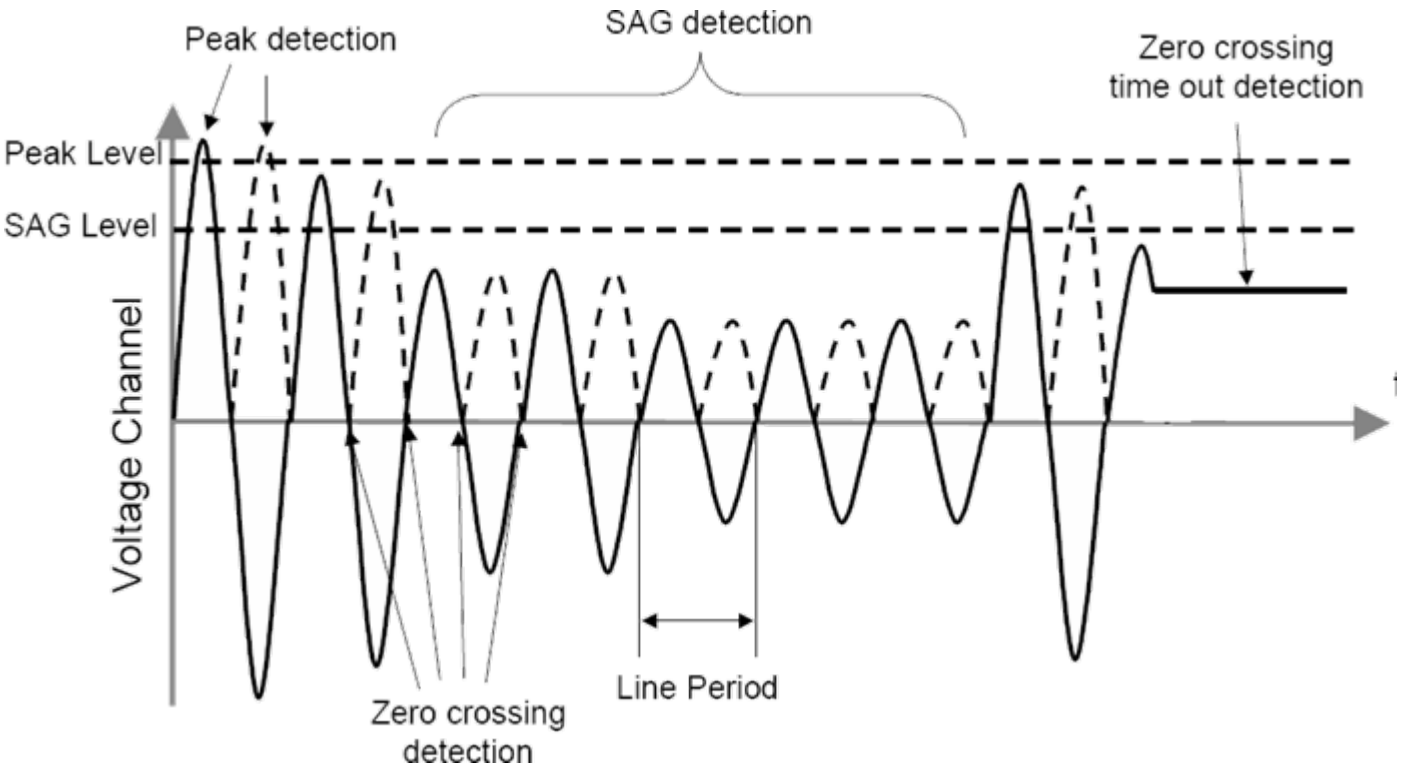
The nature of the load (inductive or capacitive) is determined by the sign of LVARENERGY register

ADE7754: Power Line Quality Supervisory

- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor

- Period Measurement of any Voltage channel
- Configurable SAG and Peak detections of the Voltage channels
- Zero crossing of the Voltage channels

➢ General supervisory of each lines' Voltage quality



ADE7754: Temperature Measurement

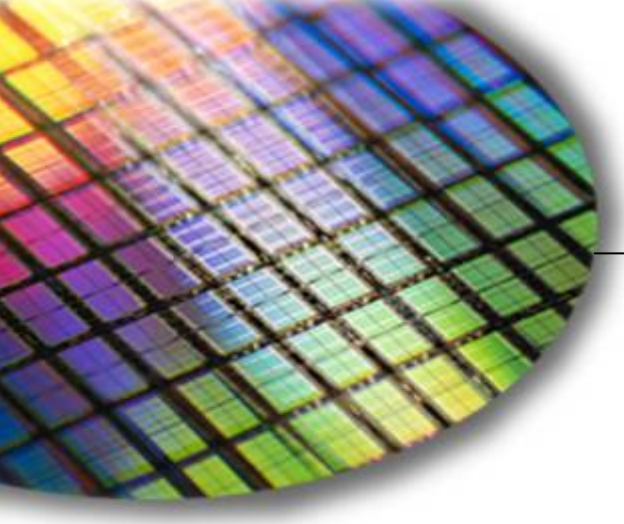
- Analog Front end
- Current sensor connection
- Digital solution
- RMS measurements
- Active Energy
- Apparent Energy
- Calibration Mode
- Reactive Energy
- Power Line Quality
- Temperature sensor

8-bit register : 1LSB/°C

- Temperature compensation of external components
- Temperature supervisory of the system

3-phase Product Comparison

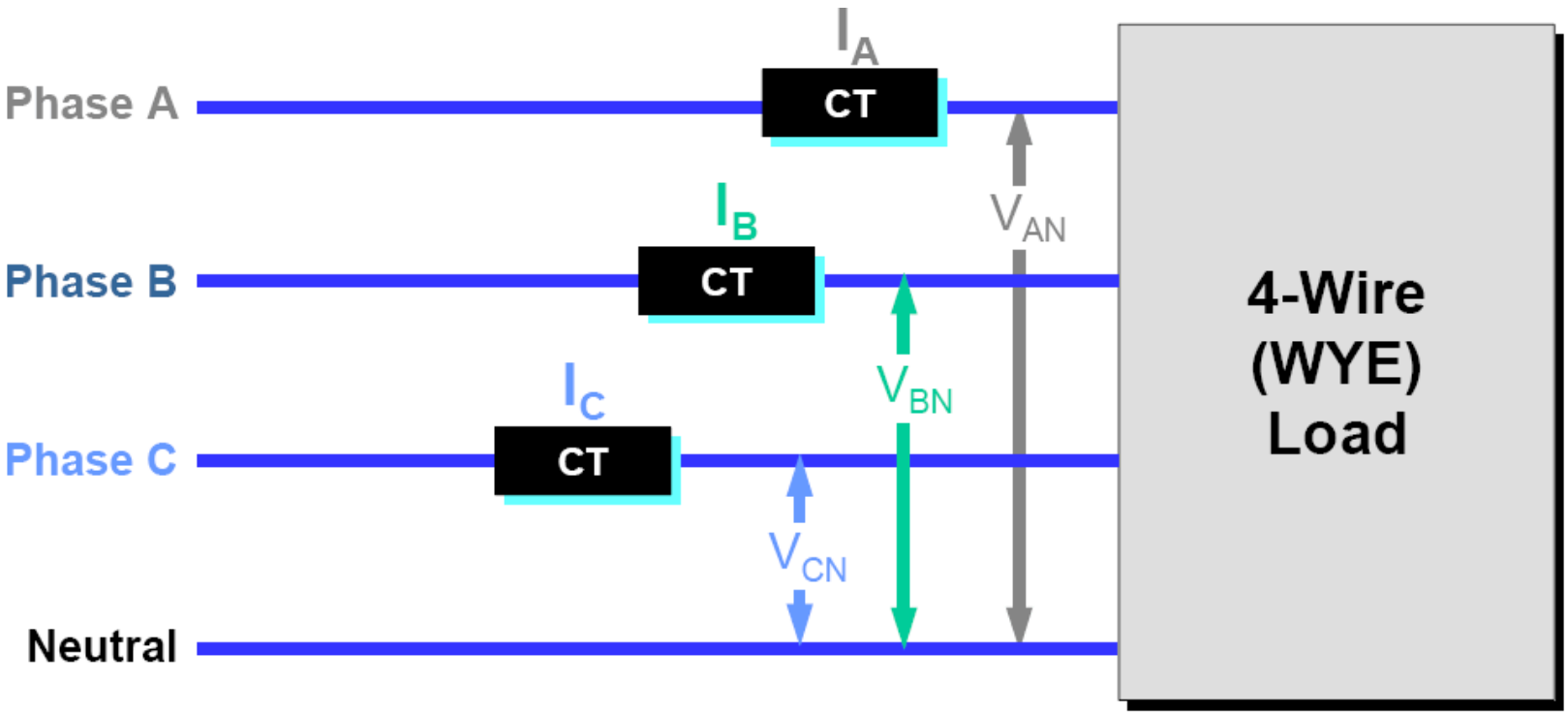
	Competitor	ADE7752	ADE7754
Meter architecture	Single chip meter + Analog calibration	Single chip meter + Analog calibration	Micro-processor based meter + Digital calibration
AC Linearity	1%	0.5%	0.5%
Energy Measurements	Watt Hour	Watt Hour	Watt + VA + RMS + Sign of VAR
Other Measurements	-	-	Line Period + Temperature sensor + SAG and PEAK detections
Power Service compatibility	3-Φ 4-wire or 3-Φ 3-wire	3-Φ 4-wire or 3-Φ 3-wire	Any
Interface	1 Pulsed output for calibration + 1 pulsed output for Impulse counter	1 Pulsed output for calibration (CF) + 2 pulsed outputs (F1/F2) for Impulse or Stepper motor counter	1 Pulsed output for calibration of Watt + SPI interface for DIGITAL CALIBRATION
Output rates	1 rate for CF + 3 rates for F1	2 different rates for CF + 5 rates for F1/F2	Any rate possible for CF
Reverse power	Detection + Display per phase	Detection per phase + General Display	Any detection and display possible
No Load threshold	No spec.	0.0007% of max current	Can easily be done by the micro-processor



APPENDIX: Meter Configurations

Mode 1: 3-phase 4-Wire Wye service
Mode 2: 3-phase 4-Wire Wye service 2 voltage sensors
Mode 3: 3-phase 3-Wire Delta service
Mode 4: 3-phase 4-Wire Delta service

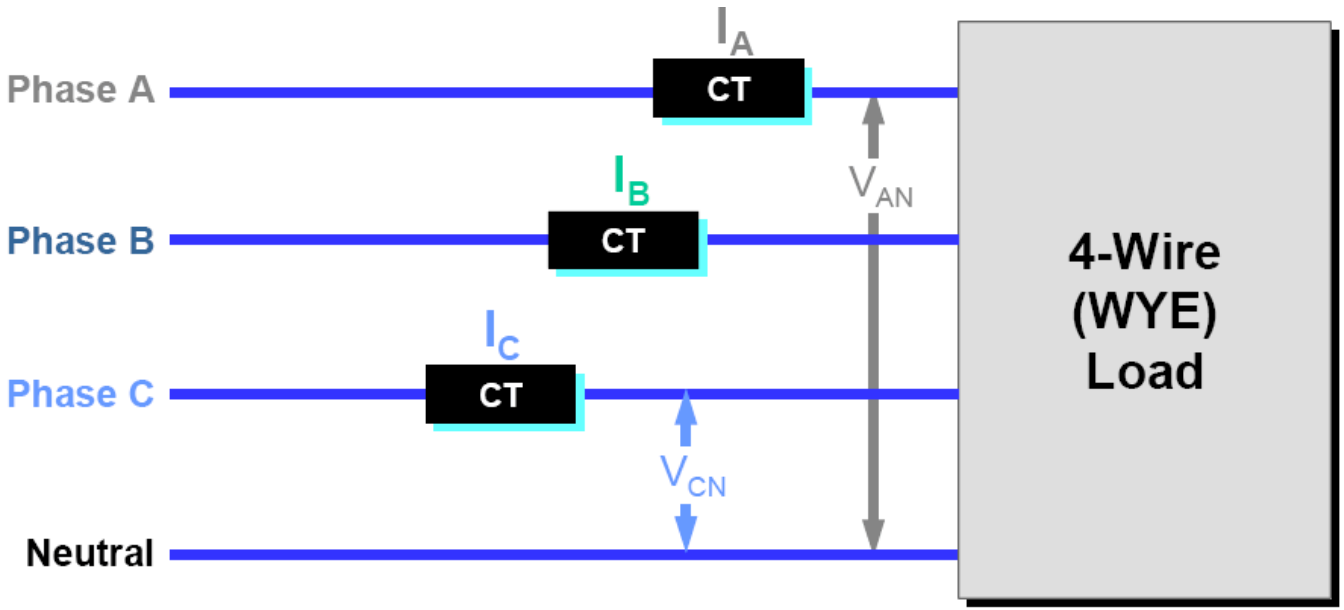
Mode 1: 3-phase 4-Wire Wye service



Total Active Power = $V_{AN} * I_A + V_{BN} * I_B + V_{CN} * I_C$

Total Apparent Power = $V_{AN_{rms}} * I_{A_{rms}} + V_{BN_{rms}} * I_{B_{rms}} + V_{CN_{rms}} * I_{C_{rms}}$

Mode 2: 3-phase 4-Wire Wye service 2 voltage sensors

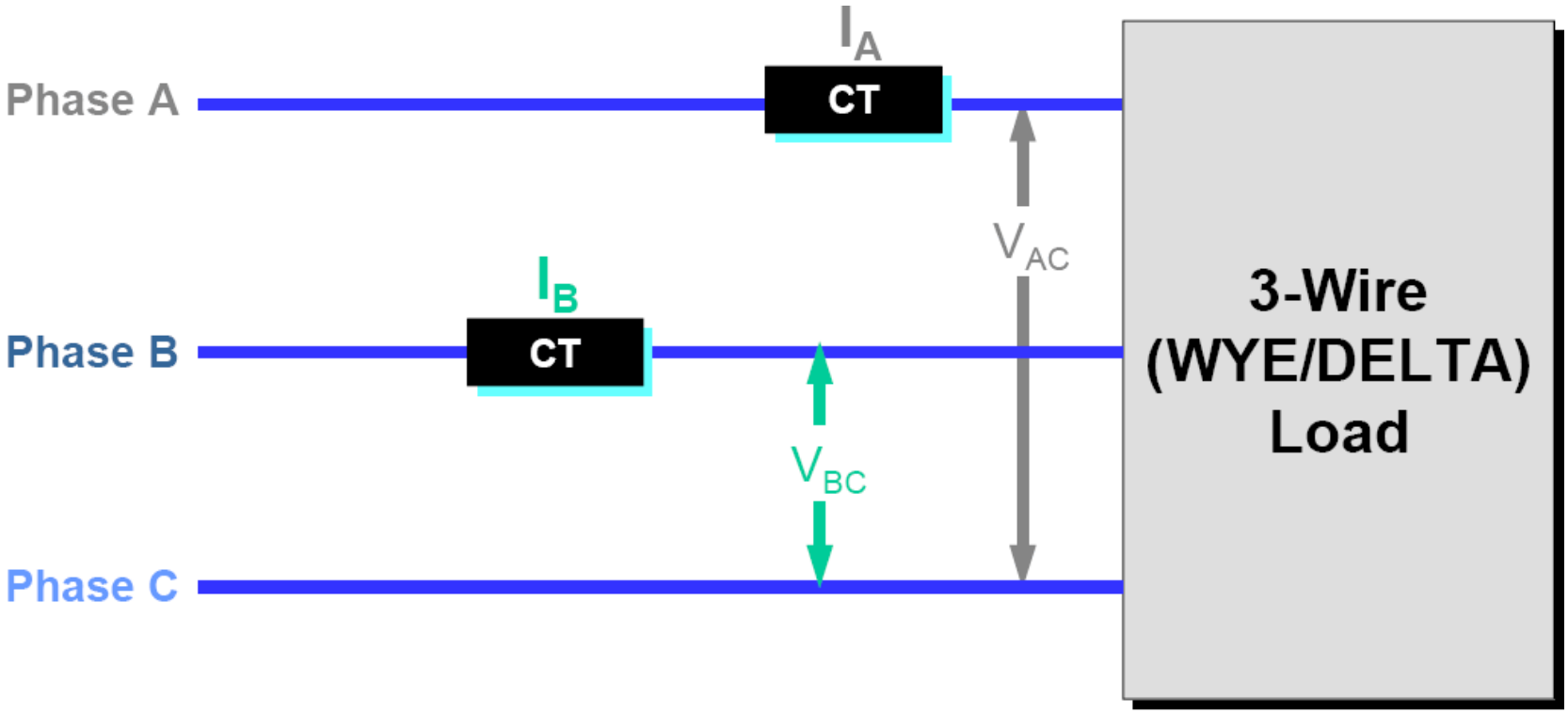


Total Active Power = $V_{AN} * (I_A - I_B) + V_{CN} * (I_C - I_B)$

Total Apparent Power = $V_{AN_{rms}} * I_{A_{rms}}$

$+ (V_{AN_{rms}} + V_{CN_{rms}}) / 2 * I_{B_{rms}} + V_{CN_{rms}} * I_{C_{rms}}$

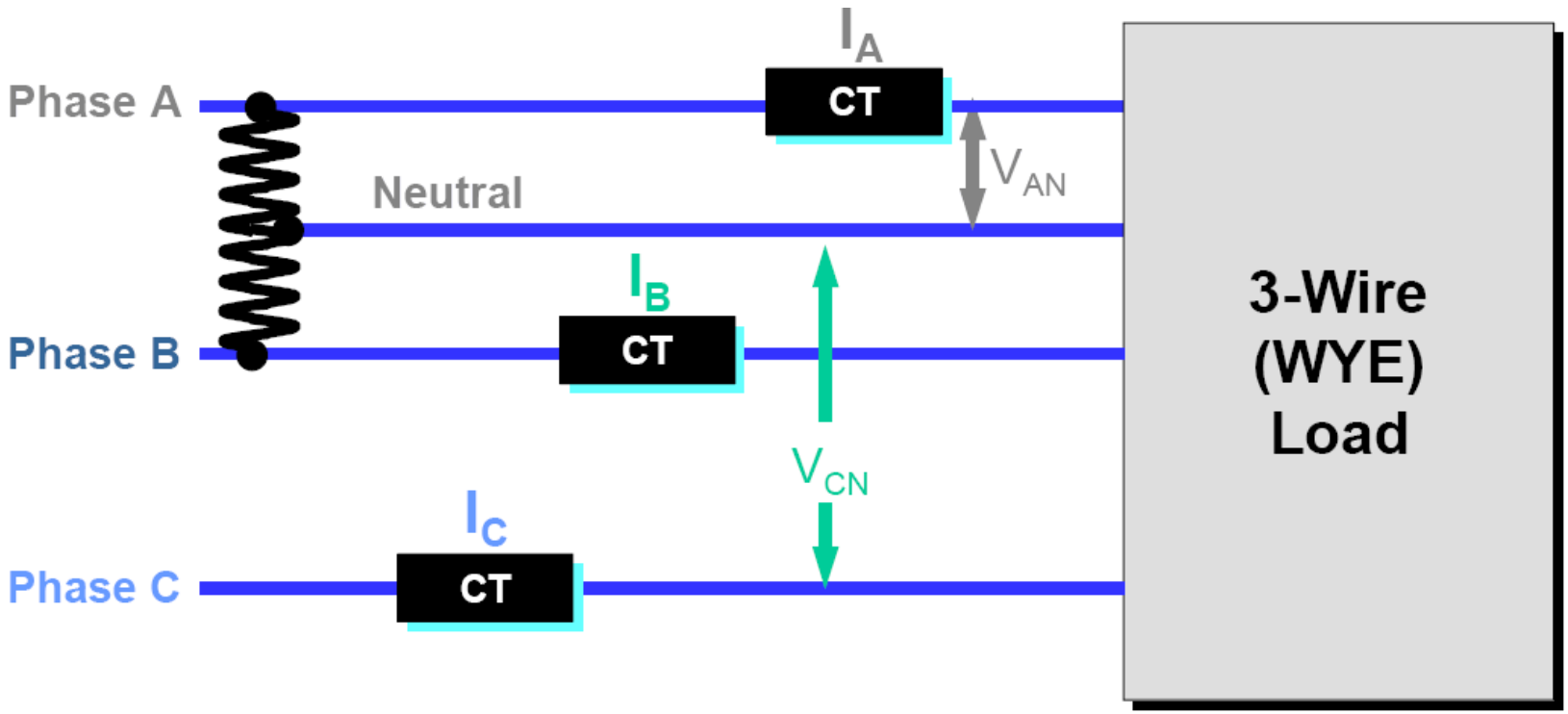
Mode 3: 3-phase 3-Wire Delta service



$$\text{Total Power} = V_{AC} * I_A + V_{BC} * I_B$$

$$\text{Total Apparent Power} = V_{ACrms} * I_{Arms} + V_{BCrms} * I_{Brms}$$

Mode 4: 3-phase 4-Wire Delta service



$$\text{Total Power} = V_{AN} * I_A - V_{AN} * I_B + V_{CN} * I_C$$

$$\text{Apparent Power} = V_{AN_{rms}} * I_{A_{rms}} + V_{BN_{rms}} * I_{B_{rms}} + V_{CN_{rms}} * I_{C_{rms}}$$