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**Enhanced Poly-Phase High-Performance Wide-Span
Energy Metering IC**

DATASHEET**FEATURES****Metering Features**

- Metering features fully in compliance with the requirements of IEC62052-11, IEC62053-22 and IEC62053-23, ANSI C12.1 and ANSI C12.20; applicable in class 0.2S, 0.5S or class 1 poly-phase watt-hour meter or class 2 poly-phase var-hour meter.
- Accuracy of $\pm 0.1\%$ for active energy and $\pm 0.2\%$ for reactive energy over the dynamic range of 6000:1.
- Temperature coefficient is 6 ppm/ °C (typical) for on-chip reference voltage.
- Single-point calibration on each phase over the whole dynamic range for active energy; no calibration needed for reactive/apparent energy.
- ± 1 °C (typical) temperature sensor accuracy.
- Electrical parameters measurement: less than $\pm 0.5\%$ fiducial error for V_{rms} , I_{rms} , mean active/ reactive/ apparent power, frequency, power factor and phase angle.
- Active (forward/reverse), reactive (forward/reverse), apparent energy with independent energy registers. Active/ reactive/ apparent energy can be output by pulse or read through energy registers to adapt to different applications.
- Programmable startup and no-load power threshold, special designed of startup and no-load circuits to eliminate crosstalk among phases achieving better accuracy especially at low power conditions.
- Dedicated ADC and different gains for phase A/B/C and Neutral line current sampling circuits. Current sampled over current transformer (CT) or Rogowski coil (di/dt coil); phase A/B/C voltage sampled over resistor divider network or potential transformer (PT).
- Programmable power modes: Normal mode (N mode), Idle mode (I mode), Detection mode (D mode) and Partial Measurement mode (M mode).
- Fundamental (CF3, 0.2%) and harmonic (CF4, 1%) active energy with dedicated energy and power registers.
- Total Harmonic Distortion (THD) and Discrete Fourier Transform (DFT) functions for 2 ~ 32 order harmonic component. THD and DFT results available in SPI accessible registers. Both voltage and current of all phases processed within the same time period.
- Event detection: sag, phase loss, reverse voltage/ current phase sequence, reverse flow, calculated neutral line current I_{NC} overcurrent sampled neutral line current I_{NS} overcurrent and THD+N over-threshold.

Other Features

- 3.3V single power supply. Operating voltage range: 2.8V~3.6V. Metering accuracy guaranteed within 3.0V~3.6V.
- Four-wire SPI interface with Direct Memory Access (DMA) mode to stream out 7-channel ADC raw data.
- Parameter diagnosis function and programmable interrupt output of the IRQ inter-

rupt signals and the WarnOut signal.

- Programmable voltage sag detection and zero-crossing output.
- CF1/CF2/CF3/CF4 output active/ reactive/ apparent energy pulses and fundamental/ harmonic energy pulses respectively.
- Crystal oscillator frequency: 16.384 MHz. On-chip two capacitors and no need of external capacitors.
- TQFP48 package.
- Operating temperature: -40 °C ~ +85 °C .

APPLICATION

- Poly-phase energy meters of class 0.2S, 0.5S and class 1 which are used in three-phase four-wire (3P4W, Y0) or three-phase three-wire (3P3W, Y or Δ) systems.
- Data Acquisition Terminal.
- Power monitoring instruments which need to measure voltage, current, THD, DFT, mean power, etc.

GENERAL DESCRIPTION

The M90E36A is a poly-phase high performance wide-dynamic range metering IC. The M90E36A incorporates 7 independent 2nd order sigma-delta ADCs, which could be employed in three voltage channels (phase A, B and C) and four current channels (phase A, B, C and neutral line) in a typical three-phase four-wire system.

The M90E36A has an embedded DSP which executes calculation of active energy, reactive energy, apparent energy, fundamental and harmonic active energy over ADC signal and on-chip reference voltage. The DSP also calculates measurement parameters such as voltage and current RMS value as well as mean active/reactive/apparent power.

A four-wire SPI interface is provided between the M90E36A and the external microcontroller. In addition, DMA mode can be used for 7-channel ADC raw data access, offering more flexibility in system application.

The M90E36A is suitable for poly-phase multi-function meters which could measure active/reactive/apparent energy and fundamental/harmonic energy either through four independent energy pulse outputs CF1/CF2/CF3/CF4 or through the corresponding registers.

With the on-chip THD and DFT engine, all phases' THD and DFT results can be directly accessed through related registers, thus simplifying hardware design in Data Acquisition Terminals.

The proprietary ADC and auto-temperature compensation technology for reference voltage ensure the M90E36A's long-term stability over variations in grid and ambient environment conditions.

BLOCK DIAGRAM

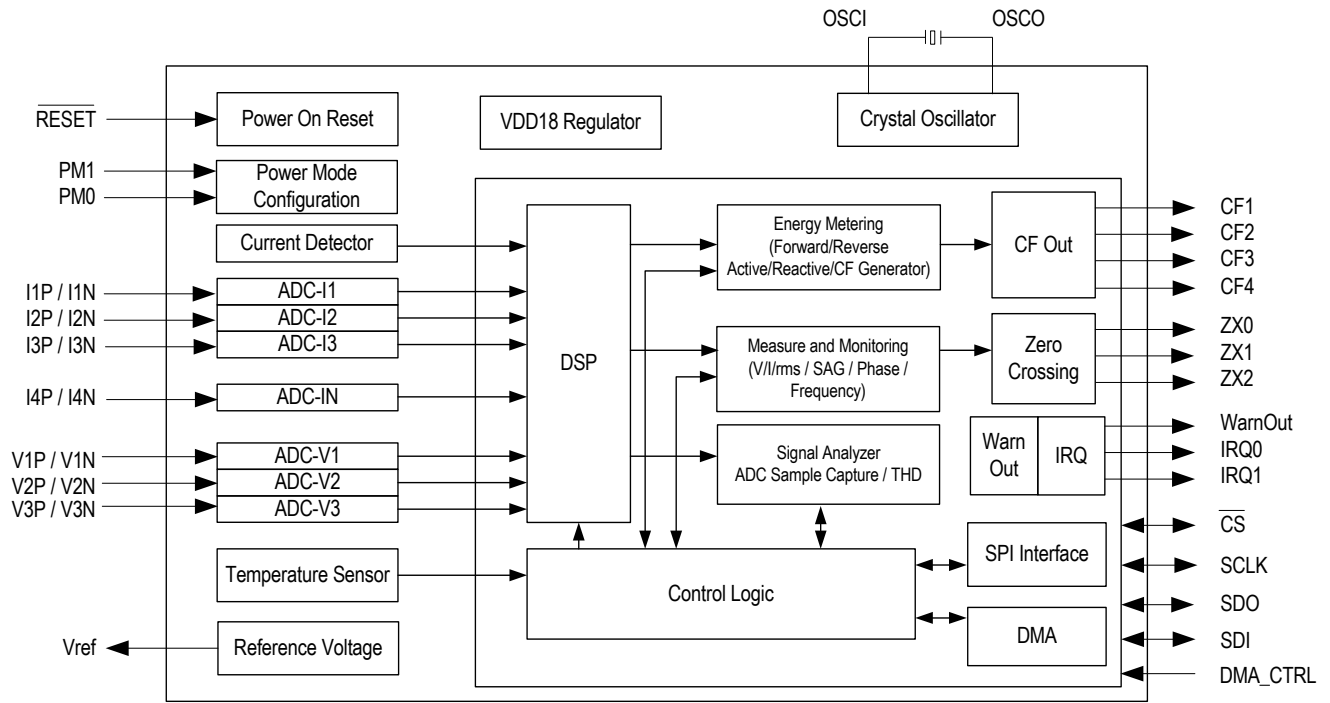


Figure-1 M90E36A Block Diagram

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1 PIN ASSIGNMENT

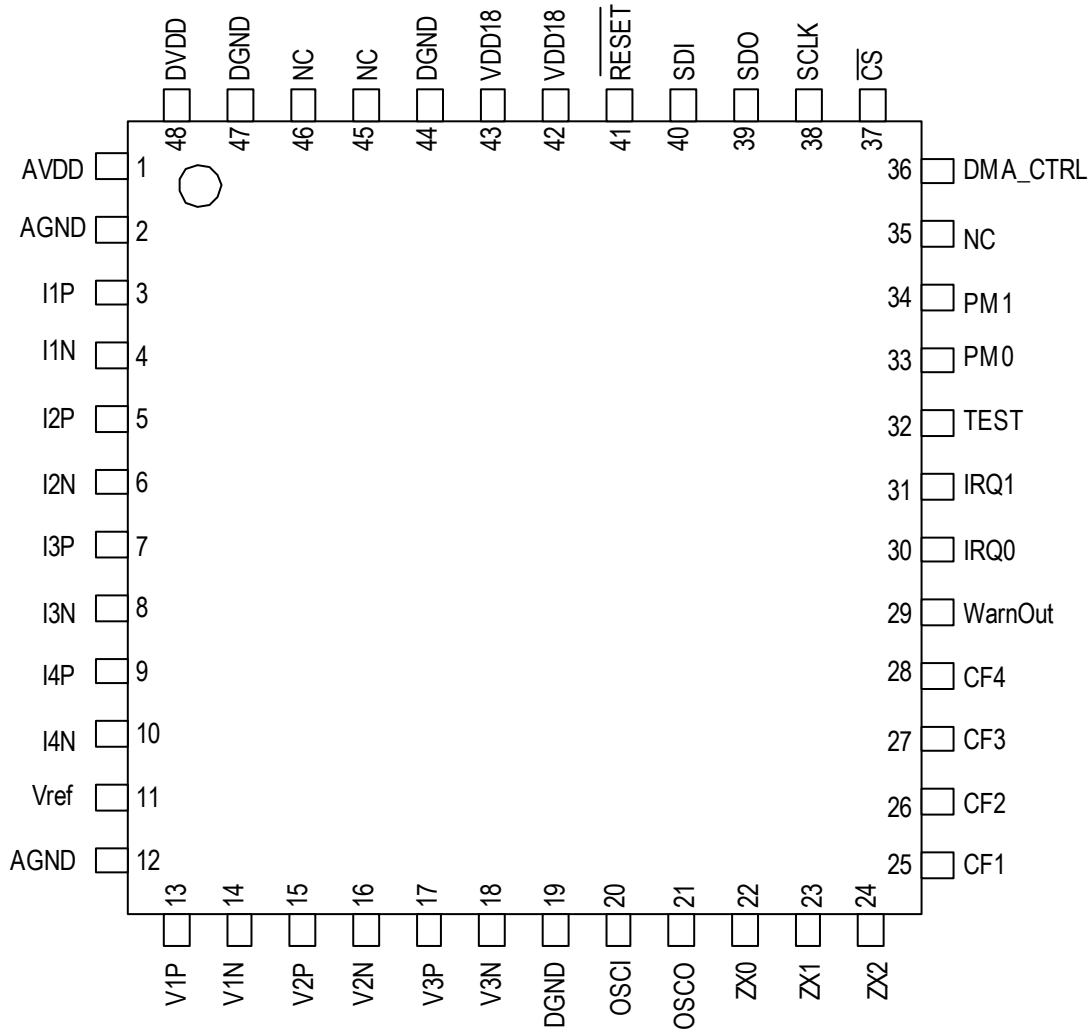


Figure-2 Pin Assignment (Top View)

2 PIN DESCRIPTION

Table-1 Pin Description

Name	Pin No.	I/O	Type	Description
$\overline{\text{Reset}}$	41	I	LVTTL	Reset: Reset Pin (active low) This pin should connect to ground through a 0.1 μF filter capacitor and a 10k Ω resistor to VDD. In application it can also directly connect to one output pin from microcontroller (MCU).
AVDD	1	I	Power	AVDD: Analog Power Supply This pin provides power supply to the analog part. This pin should connect to DVDD and be decoupled with a 0.1 μF capacitor.
DVDD	48	I	Power	DVDD: Digital Power Supply This pin provides power supply to the digital part. It should be decoupled with a 10 μF capacitor and a 0.1 μF capacitor.
VDD18	42, 43	P	Power	VDD18: Digital Power Supply (1.8 V) These two pins should be connected together and connected to ground through a 10 μF capacitor.
DGND	19, 44, 47	I	Power	DGND: Digital Ground
AGND	2, 12	I	Power	AGND: Analog Ground
I1P I1N	3 4	I	Analog	I1P: Positive Input for Phase A Current I1N: Negative Input for Phase A Current These pins are differential inputs for phase A current. Note: I1 to phase A and I3 to phase C mapping can be swapped by configuring the I1I3Swap bit (b13, MMode0).
I2P I2N	5 6	I	Analog	I2P: Positive Input for Phase B Current I2N: Negative Input for Phase B Current These pins are differential inputs for phase B current.
I3P I3N	7 8	I	Analog	I3P: Positive Input for Phase C Current I3N: Negative Input for Phase C Current These pins are differential inputs for phase C current. Note: I1 to phase A and I3 to phase C mapping can be swapped by configuring the I1I3Swap bit (b13, MMode0).
I4P I4N	9 10	I	Analog	I4P: Positive Input for N Line Current I4N: Negative Input for N Line Current These pins are differential inputs for N line current.
Vref	11	O	Analog	Vref: Output Pin for Reference Voltage This pin should be decoupled with a 10 μF capacitor, possibly a 0.1 μF ceramic capacitor and a 1nF ceramic capacitor.
V1P V1N	13 14	I	Analog	V1P: Positive Input for Phase A Voltage V1N: Negative Input for Phase A Voltage These pins are differential inputs for phase A voltage.
V2P V2N	15 16	I	Analog	V2P: Positive Input for Phase B Voltage V2N: Negative Input for Phase B Voltage These pins are differential inputs for phase B voltage.
V3P V3N	17 18	I	Analog	V3P: Positive Input for Phase C Voltage V3N: Negative Input for Phase C Voltage These pins are differential inputs for phase C voltage.
OSCI	20	I	OSC	OSCI: External Crystal Input
OSCO	21	O	OSC	OSCO: External Crystal Output A 16.384 MHz crystal is connected between OSCI and OSCO. There are two on-chip capacitor, therefore no need of external capacitors.
ZX0 ZX1 ZX2	22 23 24	O	LVTTL	ZX2/ZX1/ZX0:Zero-Crossing Output These pins are asserted when voltage or current crosses zero. Zero-crossing mode can be configured by the ZXConfig register (07H).

Table-1 Pin Description (Continued)

Name	Pin No.	I/O	Type	Description
CF1	25	O	LVTTL	CF1: (all-phase-sum total) Active Energy Pulse Output
CF2	26	O	LVTTL	CF2: (all-phase-sum total) Reactive/ Apparent Energy Pulse Output The output of this pin is determined by the CF2varh bit (b7, MMode0) and the CF2ESV bit (b8, MMode0).
CF3	27	O	LVTTL	CF3: (all-phase-sum total) Active Fundamental Energy Pulse Output
CF4	28	O	LVTTL	CF4: (all-phase-sum total) Active Harmonic Energy Pulse Output
WarnOut	29	O	LVTTL	WarnOut: Fatal Error Warning This pin is asserted high when there is metering related parameter check-sum error. Otherwise this pin stays low. Refer to 6.2.2 IRQ and WarnOut Signal Generation .
IRQ0	30	O	LVTTL	IRQ0: Interrupt Output 0 This pin is asserted when one or more events in the SysStatus0 register (01H) occur. It is deasserted when there is no bit set in the SysStatus0 register (01H). In Detection mode, the IRQ0 is used to indicate the output of current detector. The IRQ0 state is cleared when entering or exiting Detection mode.
IRQ1	31	O	LVTTL	IRQ1: Interrupt Output 1 This pin is asserted when one or more events in the SysStatus1 register (02H) occur. It is deasserted when there is no bit set in the SysStatus1 register (02H). In Detection mode, the IRQ1 is used to indicate the output of current detector. The IRQ1 state is cleared when entering or exiting Detection mode.
PM0 PM1	33 34	I	LVTTL	PM1/0: Power Mode Configuration These two pins define the power mode of M90E36A. Refer to Table-2 .
DMA_CTRL	36	I	LVTTL	DMA_CTRL: DMA Enable DMA is started when this pin is asserted. DMA is stopped when this pin is deasserted. Refer to 4 SPI / DMA Interface .
\overline{CS}	37	B	LVTTL	\overline{CS}: Chip Select (Active Low) In SPI mode, this pin must be driven from high to low for each read/ write operation, and maintain low for the entire operation. In DMA mode, this pin is asserted during data transmission. Refer to 4 SPI / DMA Interface .
SCLK	38	B	LVTTL	SCLK: Serial Clock This pin is used as the clock for the SPI/DMA interface. Refer to 4 SPI / DMA Interface .
SDO	39	B	LVTTL	SDO: Serial Data Output This pin is used as the data output for the SPI mode and input for the DMA mode. Refer to 4 SPI / DMA Interface .
SDI	40	B	LVTTL	SDI: Serial Data Input This pin is used as the data input for the SPI mode and output for the DMA mode. Refer to 4 SPI / DMA Interface .
TEST	32	I	LVTTL	This pin should be always connected to DGND in system application.
NC	35, 45, 46			NC: These pins should be left open.

3 FUNCTION DESCRIPTION

3.1 POWER SUPPLY

The M90E36A works with single power rail 3.3V. An on-chip voltage regulator regulates the 1.8V voltage for the digital logic.

The regulated 1.8V power is connected to the VDD18 pin. It needs to be bypassed by an external capacitor.

The M90E36A has multiple power modes, in Idle and Detection modes the 1.8V power regulator is not turned on and the digital logic is not powered. When the logic is not powered, all the configured register values are not kept (all context lost) except for Detection mode related registers (10H~13H) for Detection mode configuration.

User has to re-configure the registers in Partial Measurement mode or Normal mode when transiting from Idle or Detection mode. Refer to [3.7 Power Mode](#) for power mode details.

3.2 CLOCK

The M90E36A has an on-chip oscillator and can directly connect to an external crystal.

The OSCI pin can also be driven with a clock source.

The oscillator will be powered down in Idle and Detection power modes, as described in [3.7 Power Mode](#).

3.3 RESET

There are three reset sources for the M90E36A:

- $\overline{\text{RESET}}$ pin
- On-chip Power On Reset circuit
- Software Reset generated by the [Software Reset](#) register

3.3.1 $\overline{\text{RESET}}$ PIN

The $\overline{\text{RESET}}$ pin can be asserted to reset the M90E36A. The $\overline{\text{RESET}}$ pin has RC filter with typical time constant of 2 μ s in the I/O, as well as a 2 μ s (typical) de-glitch filter.

Any reset pulse that is shorter than 2 μ s can not reset the M90E36A.

3.3.2 POWER ON RESET (POR)

The POR circuit resets the M90E36A at power up.

POR circuit triggers reset when:

- DVDD power up, crossing the power-up threshold. Refer to [Figure-26](#).
- VDD18 regulator changing from disable to enable, i.e. from Idle or Detection mode to Partial Measurement mode or Normal mode. Refer to [Figure-25](#).

3.3.3 SOFTWARE RESET

Chip reset can be triggered by writing to the [SoftReset](#) register in Normal mode. The software reset is the same as the reset scope generated from the $\overline{\text{RESET}}$ pin or POR.

These three reset sources have the same reset scope.

All digital logics and registers, except for the Harmonic Ratio registers will be subject to reset. The Harmonic Ratio registers can not be reset.

- Interface logic: clock dividers
- Digital core/ logic: All registers except for the Harmonic Ratio registers and some other special registers, refer to [6.3.1 Detection Mode Registers](#).

3.4 METERING FUNCTION

The accumulated energy is converted to pulse frequency on the CF pins and stored in the corresponding energy registers. The M90E36A provides energy accumulation registers with 0.1 or 0.01 CF resolution. 0.01CF / 0.1CF setting is defined by the 001LSB bit (b9, [MMode0](#)).

3.4.1 THEORY OF ENERGY REGISTERS

The energy accumulation runs at 1 MHz clock rate, by accumulating the power value calculated by the DSP processor.

The power accumulation process is equivalent to digitally integrating the instantaneous power with a delta-time of about 1 μ s. The accumulated energy is used to calculate the CF pulses and the corresponding internal energy registers.

The accumulated energy is converted to frequency of the CF pulses. One CF usually corresponds to 1KWh / MC (MC is Meter Constant, e.g. 3200 imp/kWh), and is usually referenced as an energy unit in this datasheet. The internal energy resolution for accumulation and conversion is 0.01 CF.

The 0.01 CF pulse energy constant is referenced as 'PL_constant'.

Within 0.01 CF, forward and reverse energy are counteracted. When energy exceeds 0.01 pulse, the respective forward/reverse energy is increased.

Take the example of active energy, suppose:

T0: Forward energy register is 12.34 pulses and reverse energy register is 1.23 pulses.

From t0 to t1: 0.005 forward pulses appeared.

From t1 to t2: 0.004 reverse pulses appeared.

From t2 to t3: 0.005 reverse pulses appeared.

From t3 to t4: 0.007 reverse pulses appeared.

The following table illustrates the process of energy accumulation process:

	t0	t1	t2	t3	t4
Input energy	+ 0.005	-0.004	-0.005	-0.007	
Bidirectional energy accumulator	0.005	0.001	-0.004	-0.001	
Forward 0.01 CF	0	0	0	0	
Reverse 0.01CF	0	0	0	1	
Forward energy register	12.34	12.34	12.34	12.34	12.34
Reverse energy register	1.23	1.23	1.23	1.23	1.24

When forward/reverse energy reaches 0.1/0.01 pulse, the respective register is updated. When forward or reverse energy reaches 1 pulse, CFx pins output pulse and the REVP/REVQ bits (b7~0, [SysStatus1](#)) are updated. Refer to [Figure-3](#).

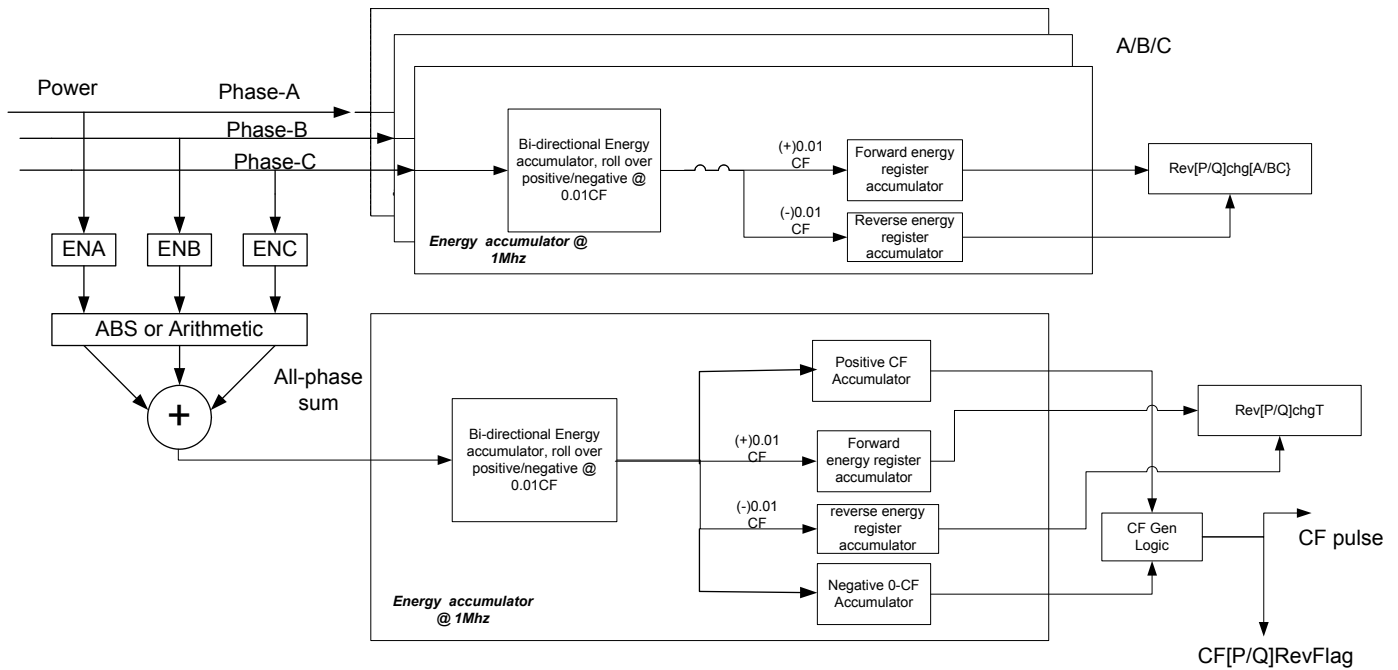


Figure-3 Energy Register Operation Diagram

For all-phase-sum total of active, reactive and (arithmetic sum) apparent energy, the associated power is obtained by summing the power of the three phases. The accumulation method of all-phase-sum energy is determined by the EnPC/EnPB/EnPA/ABSEnP/ABSEnQ bits (b0~b4, **MMode0**).

Note that the direction of all-phase-sum power and single-phase power might be different.

3.4.2 ENERGY REGISTERS

The M90E36A meters non-decomposed total active, reactive and apparent energy, as well as decomposed active fundamental and harmonic energy. The registers are listed as below.

3.4.2.1 Total Energy Registers

Each phase and all-phase-sum has the following registers:

- Active forward/ reverse
- Reactive forward/ reverse
- Apparent energy

In addition, there is an apparent energy all-phase vector sum register.

Altogether there are 21 energy registers. Those registers are defined in [6.5.1 Regular Energy Registers](#).

3.4.2.2 Fundamental and Harmonic Energy Registers

The M90E36A counts decomposed active fundamental and harmonic energy. Reactive energy is not decomposed to fundamental and harmonic.

The fundamental/harmonic energy is accumulated in the same way as active energy accumulation method described above.

Registers:

- Fundamental / harmonic
- all-phase-sum / phase A / phase B / phase C
- Forward / reverse

Altogether there are 16 energy registers. Refer to [3.4.2.2 Fundamental and Harmonic Energy Registers](#).

3.4.3 ENERGY PULSE OUTPUT

CF1 is fixed to be total active energy output (all-phase-sum). Both forward and reverse energy registers can generate the CF pulse (change of forward/ reverse direction can generate an interrupt if enabled).

CF2 is reactive energy output (all-phase-sum) by default. It can also be configured to be arithmetic sum apparent energy output (all-phase-sum) or vector sum apparent energy output (all-phase-sum).

CF3 is fixed to be active fundamental energy output (all-phase-sum).

CF4 is fixed to be active harmonic energy output (all-phase-sum).

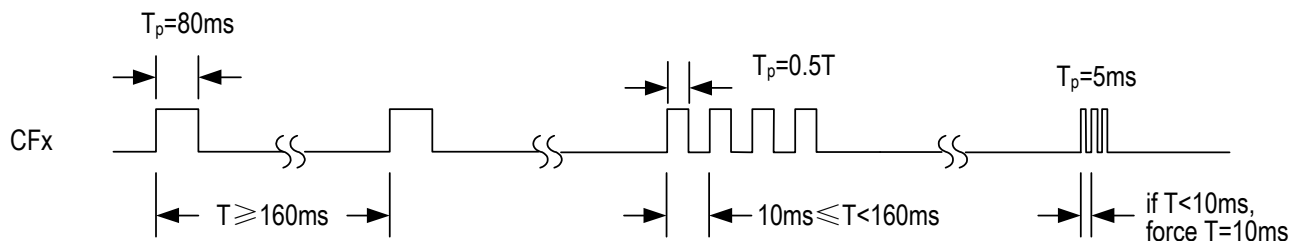


Figure-4 CFx Pulse Output Regulation

For CFx pulse width regulation, refer to [Figure-4](#).

Case 1 $T \geq 160\text{ms}$, $T_p = 80\text{ms}$

Case 2 $10\text{ms} \leq T < 160\text{ms}$, $T_p = T/2$

Case 3 If Calculated $T < 10\text{ms}$, force $T = 10\text{ms}$, $T_p = 5\text{ms}$

3.4.4 STARTUP AND NO-LOAD POWER

There are startup power threshold registers (e.g. PStartTh(35H)). Refer to [6.4 Configuration and Calibration Registers](#). The power threshold registers are defined for all-phase-sum active, reactive and apparent power. The M90E36A starts metering when the corresponding all-phase-sum power is greater than the startup threshold. When the power value is lower than the startup threshold, energy is not accumulated and it is assumed as in no-load status. Refer to [Figure-5](#).

There are also no-load Current Threshold registers for Active, Reactive and Apparent energy metering participation for each of the 3 phases. If $|P|+|Q|$ is lower than the corresponding power threshold, that particular phase will not be accumulated. Refer to the PStartTh register and other threshold registers.

There are also no-load status bits (the TPnoload/TQnoload bits (b14~15, EnStatus0)) defined to reflect the no-load status. The M90E36A does not output any pulse in no-load status. The power-on state is of no-load status.

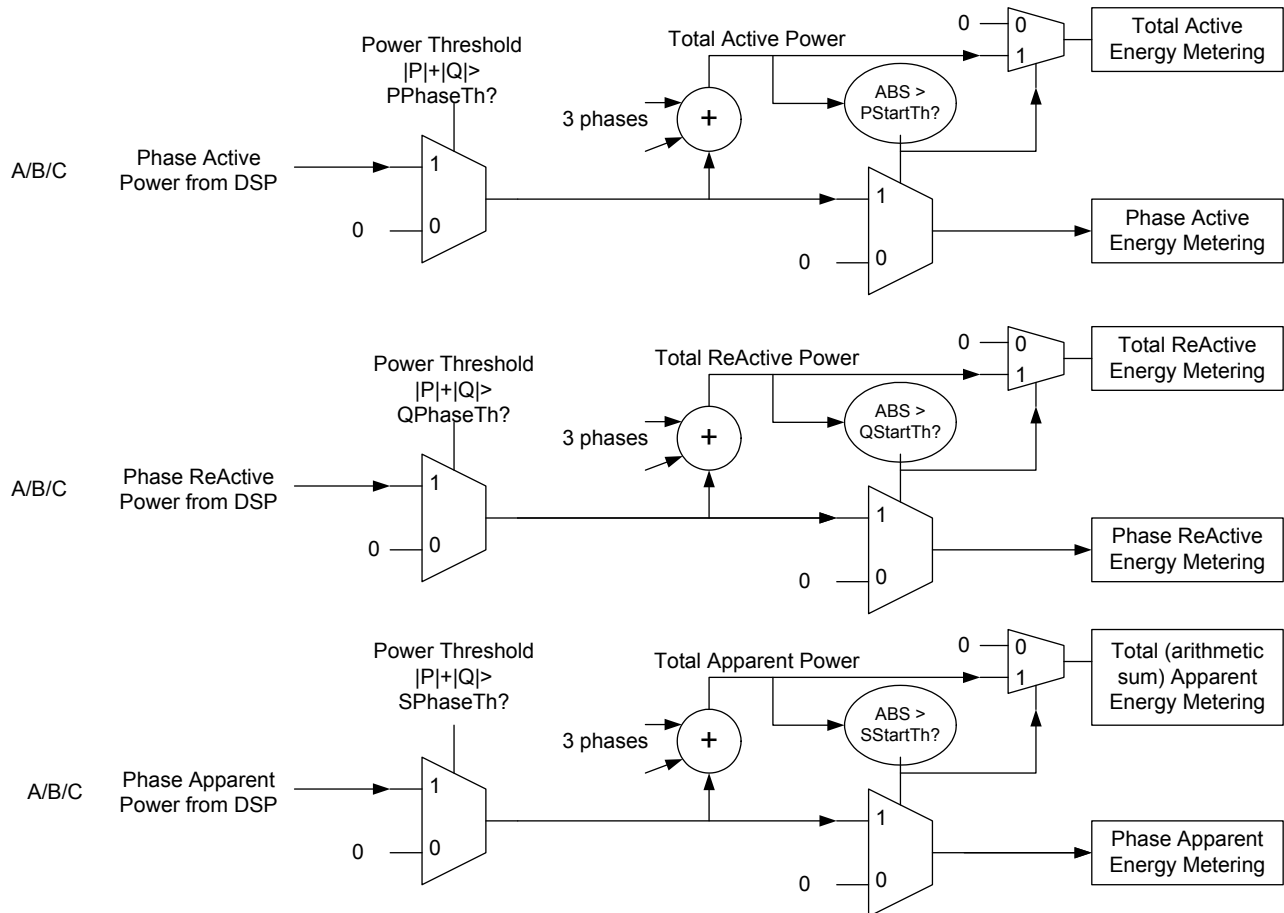


Figure-5 Metering Startup Handling

3.5 MEASUREMENT FUNCTION

Measured parameters can be divided to 7 types as follows:

- Active/ Reactive/ Apparent Power
- Fundamental/ Harmonic Power
- RMS for Voltage and Current
- Power Factor
- Phase Angle
- Frequency
- Temperature

Measured parameters are average values that are averaged among 16 phase-voltage cycles (about 320ms at 50Hz) except for the temperature. The measured parameter update frequency is approximately 3Hz. Refer to [Table-15](#).

3.5.1 ACTIVE/ REACTIVE/ APPARENT POWER

Active/ Reactive/ Apparent Power measurement registers can be divided as below:

- active, reactive, apparent power
- all-phase-sum / phase A / phase B / phase C
- apparent power all-phase vector sum

Altogether there are 13 power registers. Refer to [6.6.1 Power and Power Factor Registers](#) and the SVmeanT register (98H).

Per-phase apparent power is defined as the product of measured Vrms and Irms of that phase.

All-phase-sum power is measured by arithmetically summing the per-phase measured power. The summing of phases can be configured by the [MMode0](#) register.

The 'apparent power all-phase vector sum' is done according to IEEE std 1459.

3.5.2 FUNDAMENTAL / HARMONIC ACTIVE POWER

Fundamental / harmonic active power measurement registers can be divided as below:

- fundamental and harmonic power
- all-phase-sum / phase A / phase B / phase C

Altogether there are 8 power registers. Refer to [6.6.2 Fundamental/ Harmonic Power and Voltage/ Current RMS Registers](#).

3.5.3 MEAN POWER FACTOR (PF)

Power Factor is defined for those cases: all-phase-sum / phase A / phase B / phase C.

Altogether there are 4 power factor registers. Refer to [6.6.1 Power and Power Factor Registers](#).

For all-phase:

$$PF_{all} = \frac{All_phase_sum\ active_power}{All_phase_sum\ apparent_power}$$

The all-phase-sum apparent power selection is defined by the CF2ESV bit (b6, [MMode0](#)).

For each of the phase::

$$PF_{phase} = \frac{active_power}{apparent_power}$$

3.5.4 VOLTAGE / CURRENT RMS

Voltage/current RMS registers can be divided as follows:

Per-phase: Phase A / Phase B / Phase C

Voltage / Current

Altogether there are 6 RMS registers.

Neutral Line Current RMS:

Neutral line current can be measured by A/D, or calculated by instantaneous value $i_N = i_A + i_B + i_C$.

Altogether there are 2 N line current RMS registers.

Refer to [6.6.2 Fundamental/ Harmonic Power and Voltage/ Current RMS Registers](#).

3.5.5 PHASE ANGLE

Phase Angle measurement registers can be divided as below:

- phase A / phase B / phase C
- voltage / current

Altogether there are 6 phase angle registers. Refer to [6.6.3 THD+N, Frequency, Angle and Temperature Registers](#).

Note: Calculation of phase angle is based on zero-crossing interval and frequency. There might be big error when voltage/ current at low value.

3.5.6 FREQUENCY

Frequency is measured using phase A voltage by default. When phase A has voltage sag, phase C is used, and phase B is used when both phase A and C have voltage sag.

Refer to [6.6.3 THD+N, Frequency, Angle and Temperature Registers](#).

3.5.7 TEMPERATURE

Chip Junction-Temperature is measured roughly every 100 ms by on-chip temperature sensor.

Refer to [6.6.3 THD+N, Frequency, Angle and Temperature Registers](#).

3.5.8 THD+N FOR VOLTAGE AND CURRENT

Voltage THD+N is defined as:

$$\frac{\sqrt{(V_{\text{rms_total}}^2 - V_{\text{rms_fundamental}}^2)}}{V_{\text{rms_fundamental}}}$$

Current THD+N's definition is similar to that of voltage.

Registers:

- voltage and current
- phase A / phase B / phase C

Altogether there are 6 THD+N registers. Refer to [6.6.3 THD+N, Frequency, Angle and Temperature Registers](#).

The THD+N measurement is mainly used to monitor the percentage of harmonics in the system. Accuracy is not guaranteed when THD+N is lower than 10%.

3.6 FOURIER ANALYSIS FUNCTION

The M90E36A offers a hardware DFT Engine for 2nd to 32nd order harmonic component, both V and I of each phase with the same time period.

The registers can be divided as follows:

- voltage and current for each phase
- phase A / phase B / phase C
- 32 frequency components (fundamental value, and harmonic ratios)
- Total Harmonic Distortion (THD)

The harmonic analysis is implemented with a DFT engine. The DFT period is 0.5 second, which gives a resolution frequency bin of 2Hz. The input samples are multiplied with a Hanning window before feeding to the DFT processor. The DFT processor computes the fundamental and harmonic components based on the measured line frequency and sampling rate, which is 8KHz.

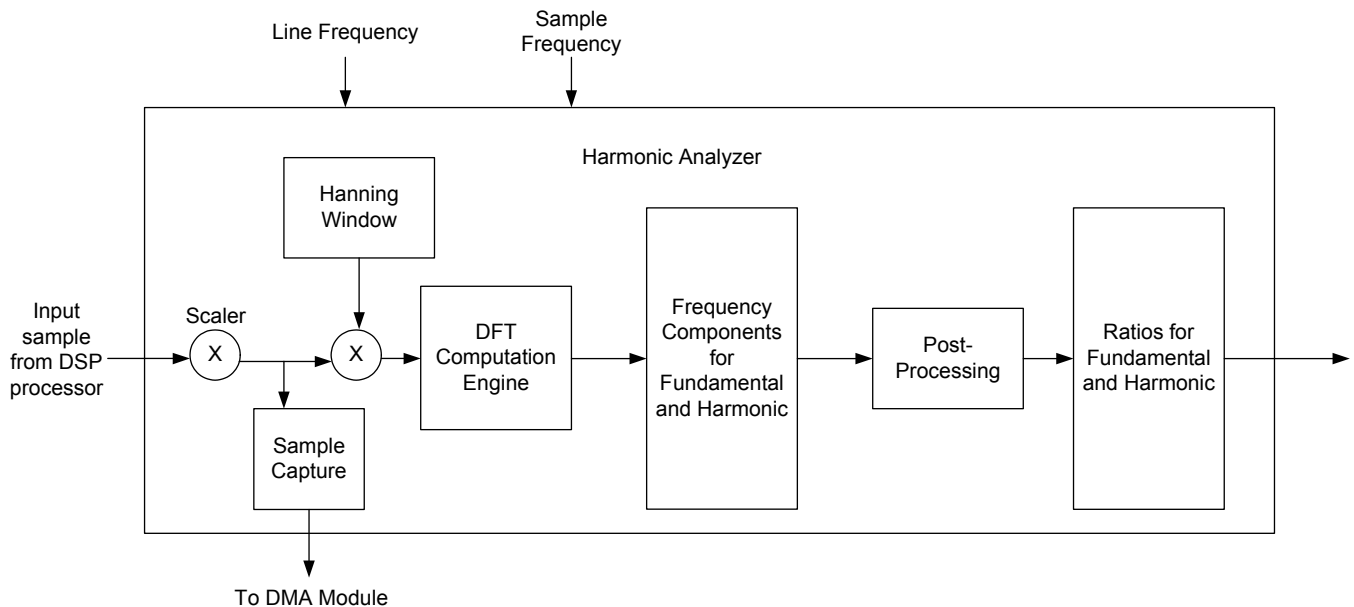


Figure-6 Analysis Function

3.7 POWER MODE

The M90E36A has four power modes. The power mode is solely defined by the PM1 and PM0 pins.

Table-2 Power Mode Mapping

PM1:PM0 Value	Power Mode
11	Normal (N mode)
10	Partial Measurement (M mode)
01	Detection (D mode)
00	Idle (I mode)

3.7.1 NORMAL MODE (N MODE)

In Normal mode, all function blocks are active except for current detector block. Refer to [Figure-7](#).

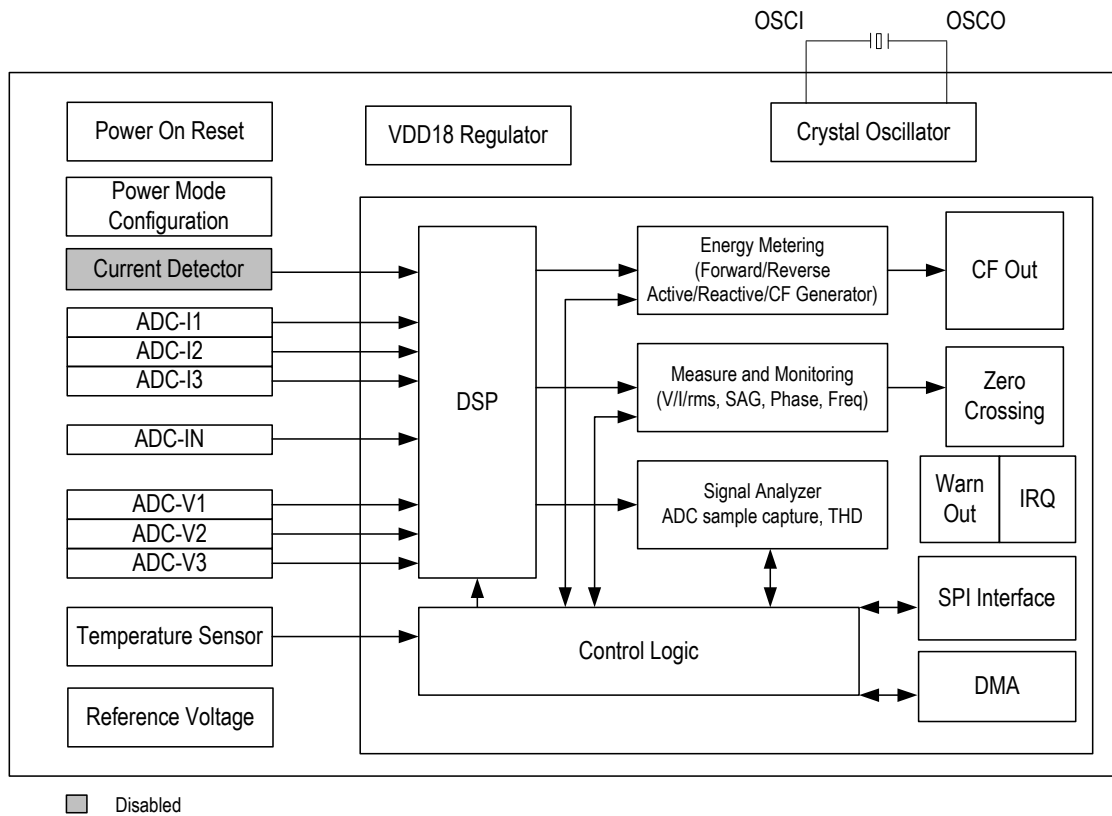


Figure-7 Block Diagram in Normal Mode

3.7.2 IDLE MODE (I MODE)

In Idle mode, all functions are shut off.

The analog blocks' power supply is powered but circuits are set into power-down mode, i.e, power supply applied but all current paths are shut off. There is very low current since only very low device leakage could exist in this mode.

The digital I/Os' supply is powered.

In I/O and analog interface, the input signals from digital core (which is not powered) will be set to known state as described in [Table-3](#). The PM1 and PM0 pins which are controlled by external MCU are active and can configure the M90E36A to other modes.

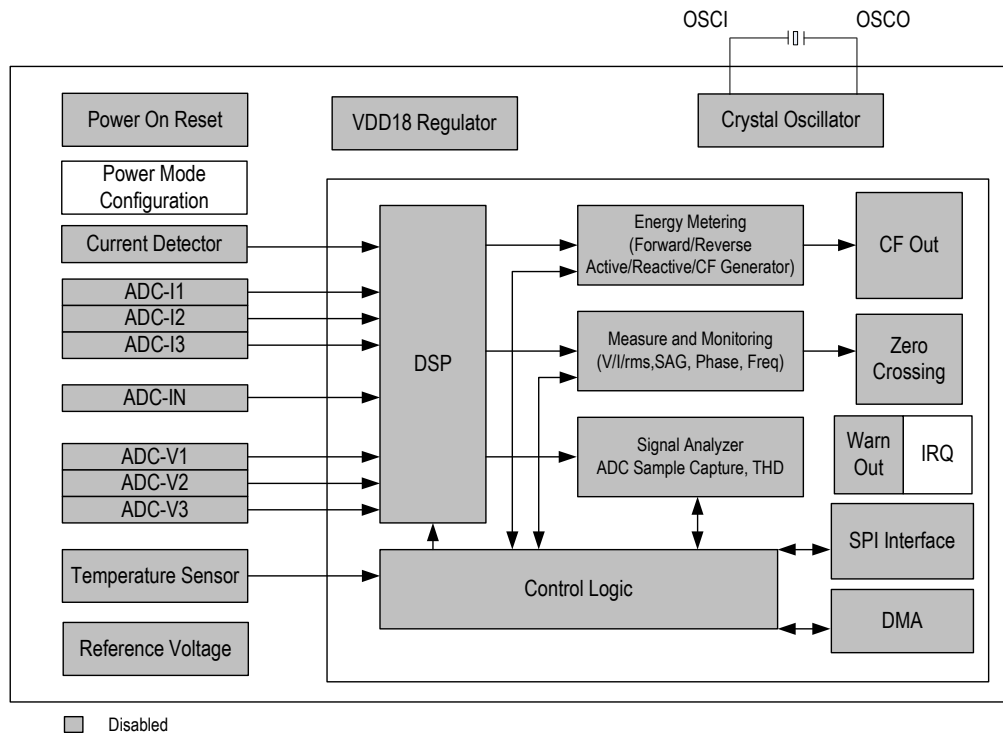


Figure-8 Block Diagram in Idle Mode

Please note that since the digital I/O is not shut off, the I/O circuit is active in the Idle mode. The application shall make sure that valid logic levels are applied to the I/O.

[Table-3](#) lists digital I/O and power pins' states in Idle mode. It lists the requirements for inputs and the output level for output. For bi-directional pins, the direction is defined.

Table-3 Digital I/O and Power Pin States in Idle Mode

Name	I/O type	Type	Pin State in Idle Mode
Reset	I	LVTTL	Input level shall be VDD33.
\overline{CS}	B	LVTTL	I/O set in input mode. Input level shall be VDD33 or VSS.
SCLK	B	LVTTL	I/O set in input mode. Input level shall be VDD33 or VSS.
SDO	B	LVTTL	I/O set in input mode. Input level shall be VDD33 or VSS.
SDI	B	LVTTL	I/O set in input mode. Input level shall be VDD33 or VSS.
PM1 PM0	I	LVTTL	As defined in Table-2
OSCI OSCO	I O	OSC	Oscillator powered down. OSCO stays at fixed (low) level.
ZX0 ZX1 ZX2	O	LVTTL	0
CF1 CF2 CF3 CF4	O	LVTTL	0
WarnOut	O	LVTTL	0
IRQ0 IRQ1	O	LVTTL	0
DMA_CTRL	I	LVTTL	I/O set in input mode. Input level shall be VDD33 or VSS.
VDD18	I	Power	Regulated 1.8V: high impedance
DVDD	I	Power	Digital Power Supply: powered by system
AVDD	I	Power	Analog Power Supply: powered by system
Test	I	Input	Always tie to ground in system application

3.7.3 DETECTION MODE (D MODE)

In Detection mode, the current detector is active. The current detector compares whether any phase current exceeds the configured threshold using low-power comparators.

When the current of one phase or multiple phases exceeds the configured threshold, the M90E36A asserts the IRQ0 pin to high and hold it until power mode change. The IRQ0 state is cleared when entering or exiting Detection mode.

When the current of all three current channels exceed the configured threshold, the M90E36A asserts the IRQ1 pin to high and hold it until power mode change. The IRQ1 state is cleared when entering or exiting Detection mode.

The threshold registers need to be programmed in Normal mode before entering Detection mode.

The digital I/O state is the same as that in Idle state (except for IRQ0/IRQ1 and PM1/PM0).

The M90E36A has two comparators for detecting each phase's positive and negative current. Each comparator's threshold can be set individually. The two comparators are both active by default, which called 'double-side detection'. User also can enable one comparator only to save power consumption, which called 'single-side detection'.

Double-side detection has faster response and can detect 'half-wave' current. But it consumes nearly twice as much power as single-side detection.

Comparators can be power-down by configuring the [DetectCtrl](#) register.

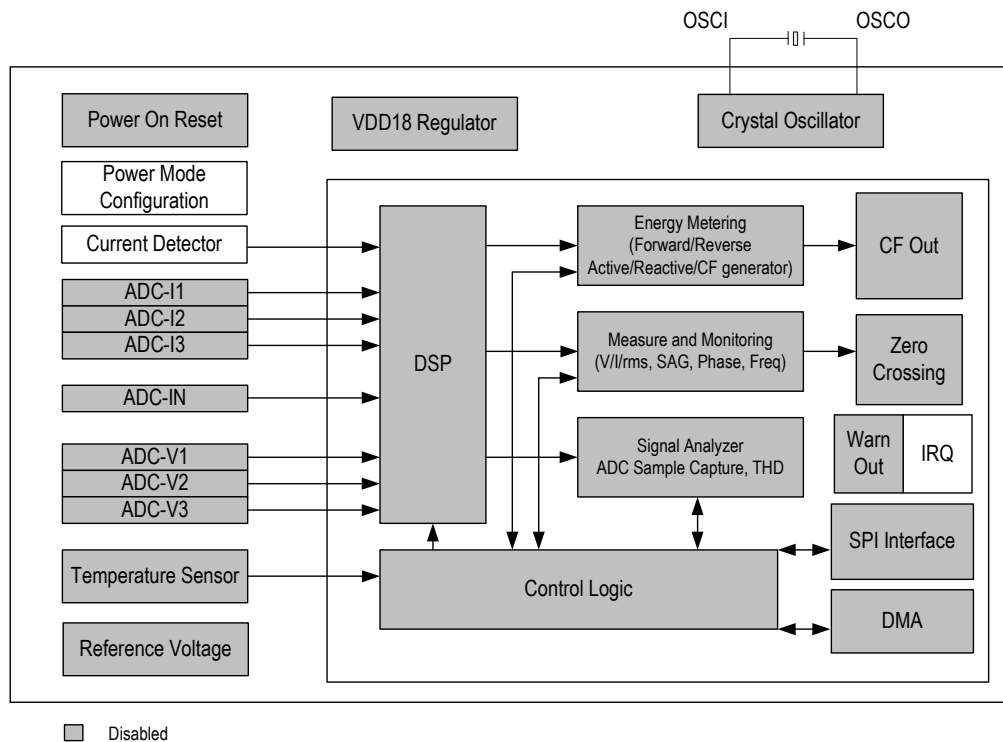


Figure-9 Block Diagram in Detection Mode

3.7.4 PARTIAL MEASUREMENT MODE (M MODE)

In this mode, Voltage ADCs, Neutral Line ADC and digital circuits are inactive.

The M90E36A measures the current RMS of one line cycle.

When the measurement is done, the M90E36A asserts the IRQ0 pin high until the Partial Measurement mode exits.

In this mode, the user needs to program the related registers (including PGA gain, channel gain, offset, etc.) to make the current RMS measurement accurate. Refer to [5.2 Partial Measurement mode Calibration](#). Please note that not all registers in this mode is accessible. Only the Partial Measurement related registers (14H~1DH) and some special registers (00H, 01H, 03H, 07H, 0EH, 0FH) can be accessed.

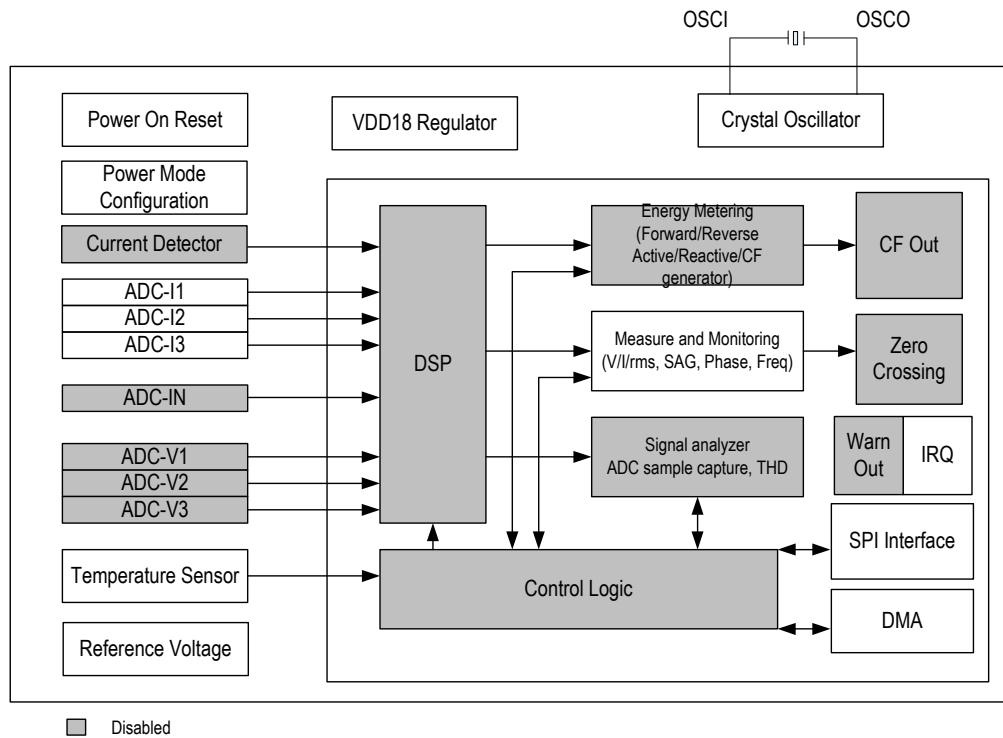


Figure-10 Block Diagram in Partial Measurement Mode

3.7.5 TRANSITION OF POWER MODES

The above power modes are controlled by the PM0 and PM1 pins. In application, the PM0 and PM1 pins are connected to external MCU. The PM0 and PM1 pins have internal RC- filters.

Generally, the M90E36A stays in Idle mode most of the time while outage. It enters Detection mode at a certain interval (for example 5s) as controlled by the MCU. It informs the MCU if the current exceeds the configured threshold. The MCU then commands the M90E36A to enter Partial Measurement mode at a certain interval (e.g. 60s) to read related current. After current reading, the M90E36A gets back to the Idle mode.

The measured current may be used to count energy according to some metering model (like current RMS multiplying the rated voltage to compute the power).

Any power mode transition goes through the Idle mode, as shown in [Figure-11](#).

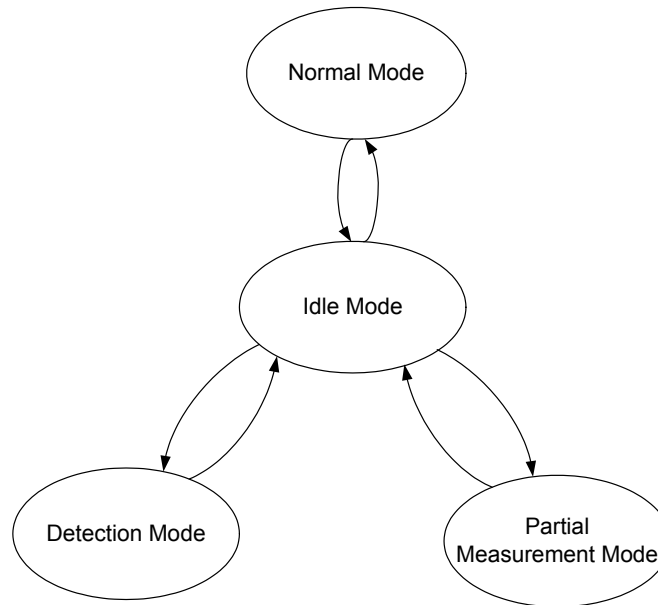


Figure-11 Power Mode Transition

3.8 EVENT DETECTION

3.8.1 ZERO-CROSSING DETECTION

Zero-crossing detector detects the zero-crossing point of the fundamental component of voltage and current for each of the 3 phases.

Zero-crossing signal can be independently configured and output. Refer to the definition of the [ZXConfig](#) register.

3.8.2 SAG DETECTION

Usually in the application the Sag threshold is set to be 78% of the reference voltage. The M90E36A generates Sag event when there are less than three 8KHz samples (absolute value) greater than the sag threshold during two continuous 11ms time-window.

For the computation of Sag threshold register value, refer to application note 46104.

The Sag event is captured by the SagWarn bit (b3, [SysStatus0](#)). If the corresponding IRQ enable bit the SagWnEn bit (b3, [FuncEn0](#)) is set, IRQ can be generated. Refer to [Figure-28](#).

3.8.3 PHASE LOSS DETECTION

The phase loss detection detects if there is one or more phases' voltage is less than the phase-loss threshold voltage.

The processing and handling is similar to sag detection, only the threshold is different. The threshold computation flow is also similar. The typical threshold setting could be 10% Un or less.

If any phase line is detected as in phase-loss mode, that phase's zero-crossing detection function (both voltage and current) is disabled.

3.8.4 NEUTRAL LINE OVERCURRENT DETECTION

3.8.4.1 Sampled N-Line

The neutral line measured RMS is checked with the threshold defined in the [INWarnTh1](#) register. If the N Line current is greater than the threshold, the INOV1 bit (b15, [SysStatus1](#)) is set. IRQ1 is generated if the corresponding Enable bit (the INOV1En bit (b15, [FuncEn1](#))) is set.

3.8.4.2 Computed N-Line

The neutral line computed current (calculated) RMS is checked with the threshold defined in the [INWarnTh0](#) register. If the N Line current is greater than the threshold, the INOV0 bit (b14, [SysStatus1](#)) bit is set. IRQ1 is generated if the corresponding Enable bit the INOV0En bit (b14, [FuncEn1](#)) is set.

3.8.5 PHASE SEQUENCE ERROR DETECTION

The phase sequence is detected in two cases: 3P4W and 3P3W, which is defined by the 3P3W bit (b8, [MMode0](#)).

3P4W case:

Correct sequence: Voltage/current zero-crossing sequence: phase-A, phase-B and phase-C.

3P3W case:

Correct sequence: Voltage/current zero-crossing between phase-A and phase-C is greater than 180 degree.

If the above mentioned criteria are violated, it is assumed as a phase sequence error.

3.9 DC AND CURRENT RMS ESTIMATION

The M90E36A has a module named 'PMS' which can estimate current channel RMS or current channel arithmetic average (DC component). The measurement type is defined in the [PMConfig](#) register. It can be used to estimate current RMS in Partial Measurement mode. Since the PMS block only consume very small power, it can be also used to estimate current RMS in Normal mode. The PMS module is turned on in both Partial Measurement mode and Normal mode.

The result is in different format and different scale for the RMS and average respectively. The RMS result is unsigned; while current average is signed.

Refer to [6.3.2 Partial Measurement mode Registers](#) for associated register definition.