

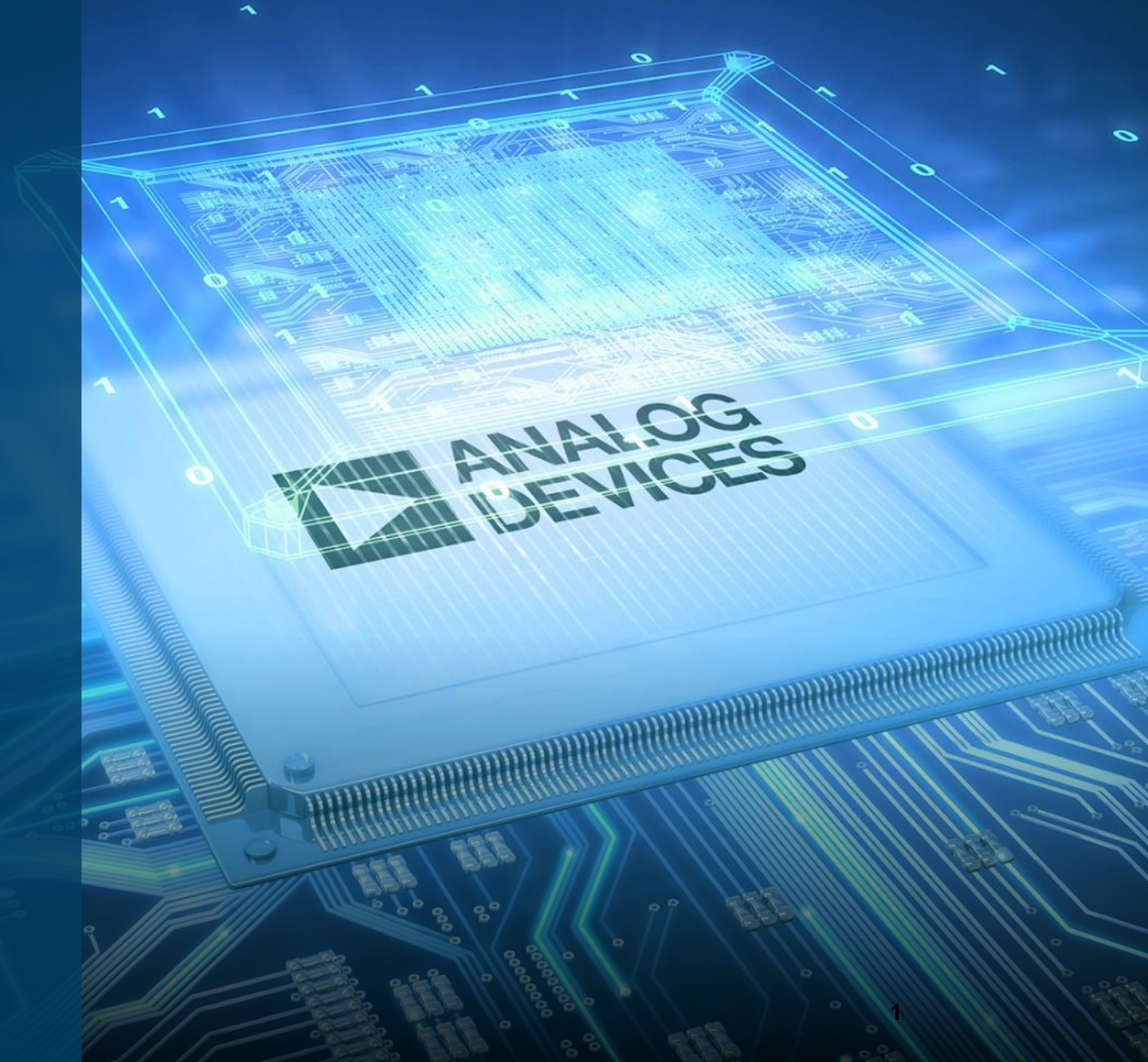


AHEAD OF WHAT'S POSSIBLE™

Analog Devices

- Energy Metering IC Overview
- Evaluation Board

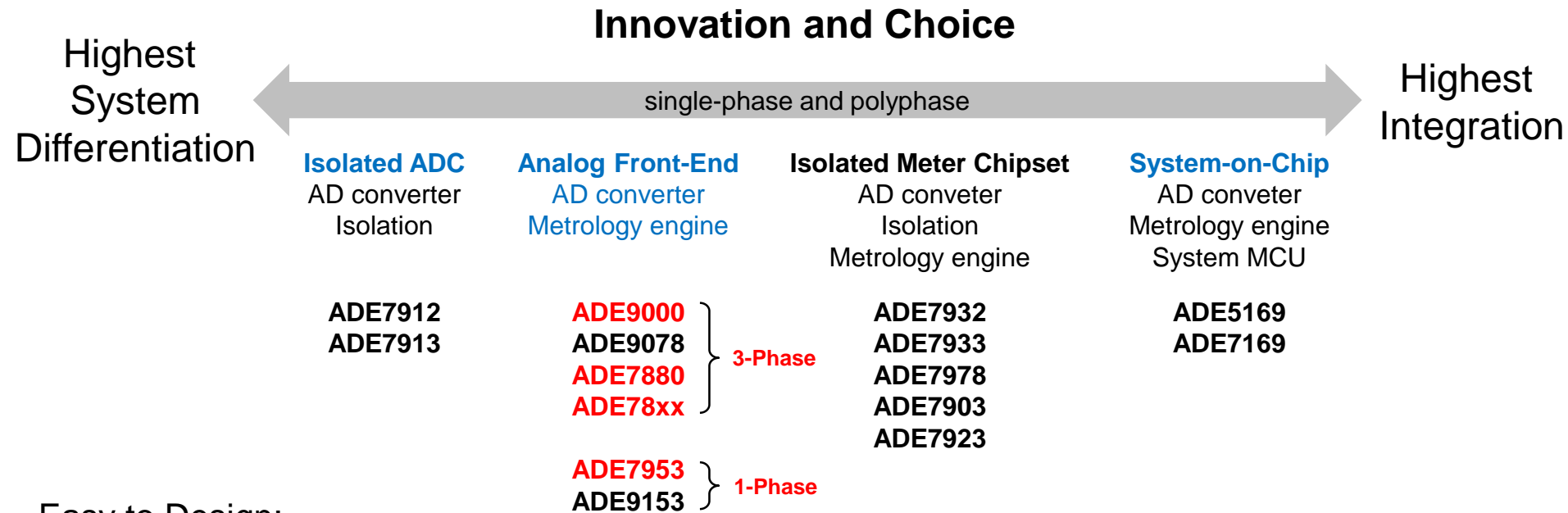
JUN 2021



ADI Energy meter Positioning

Energy market – Our Offers

ADI Offers a Range of IC Architectures for Energy Monitoring



Easy to Design:

- Reduces processing requirements, enabling the use of a lower cost MCU
- Integrated MCU core, and all necessary peripherals, with field proven metering front end
- Direct and flexible sensor interface without external gain amplifiers. Greater system control with minimized current consumption in battery mode



ADI Energy meter Positioning

Energy market – Our strenghts

Value of ADE products

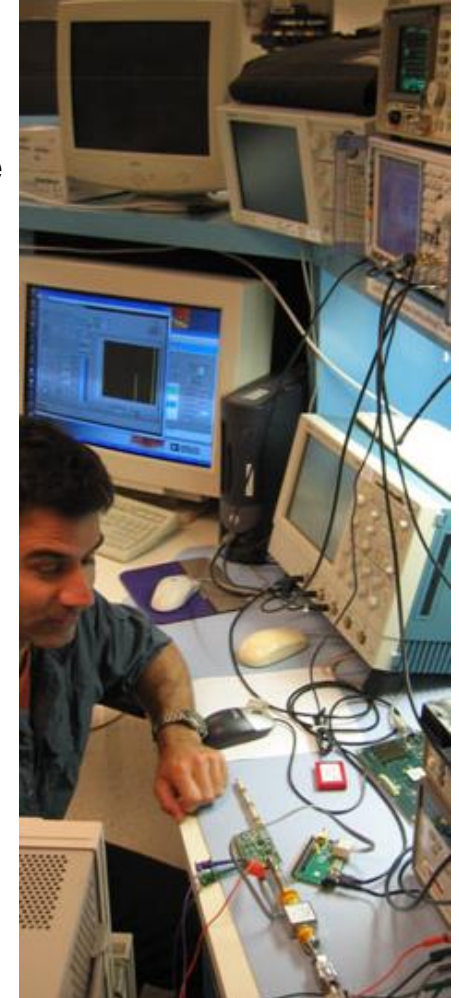
Proven Technology : high quality, **reliability** and performances

- Quality: **low ppm failure rate** that reflects the **stability** and **high quality** of the manufacturing process over time
 - System-level validation: Accuracy, Electrical fast transient (EFT), Electro-static discharge (ESD), Radiated emission
- Reliability: over **60 years** in the field
- Performances: Σ - Δ ADCs provide excellent performance with an error of less than 0.1% over an extended current dynamic range

ADI Helps Meter Customers Achieve Manufacturing Release and Maintain High-Volume Production for Years

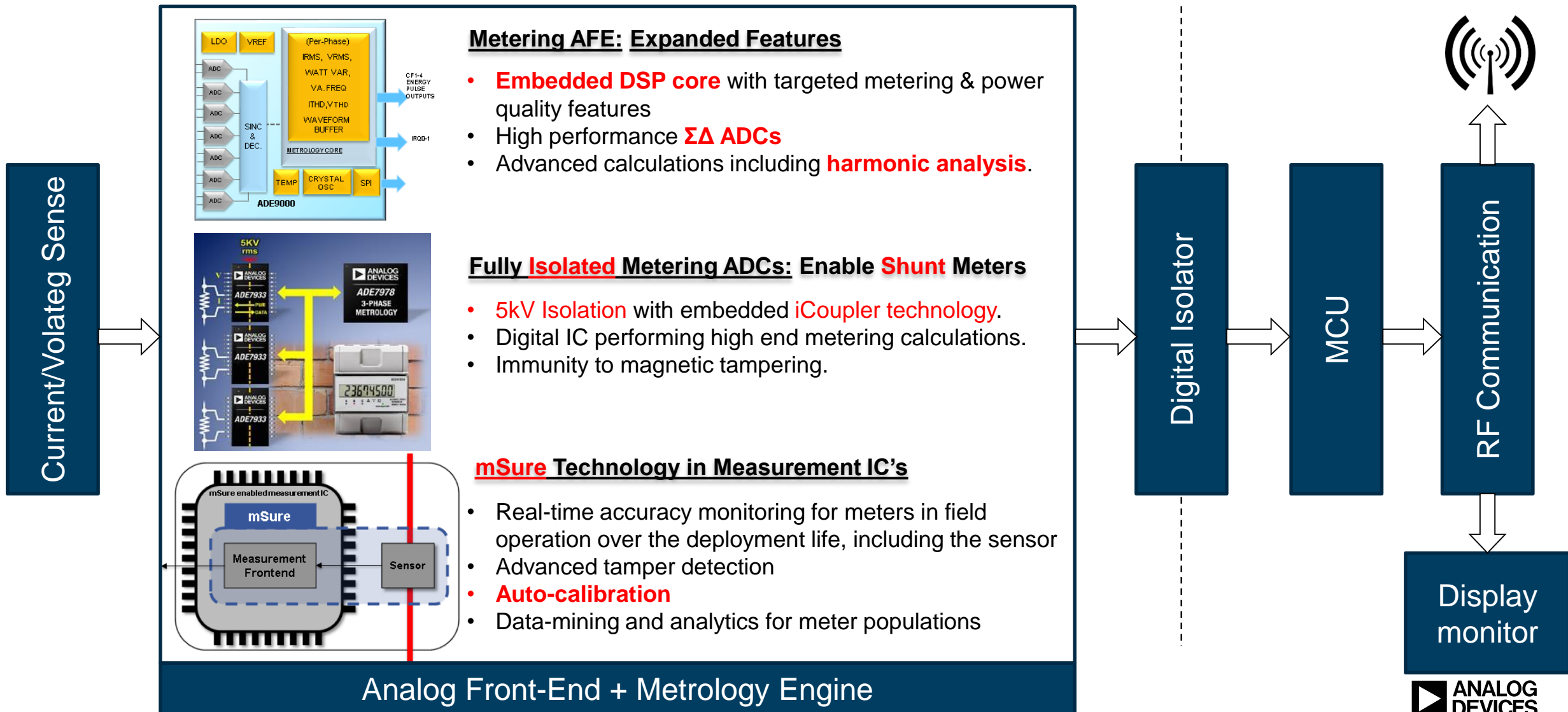
Dedicated team of application engineers provide:

- **Design consulting** and application **troubleshooting support**
- IC evaluation platforms
 - **Reference designs for utility metering customers**
 - **Arduino module for not utility customers**
- Industry-leading product collateral (datasheets, application notes, technical articles and best practices)



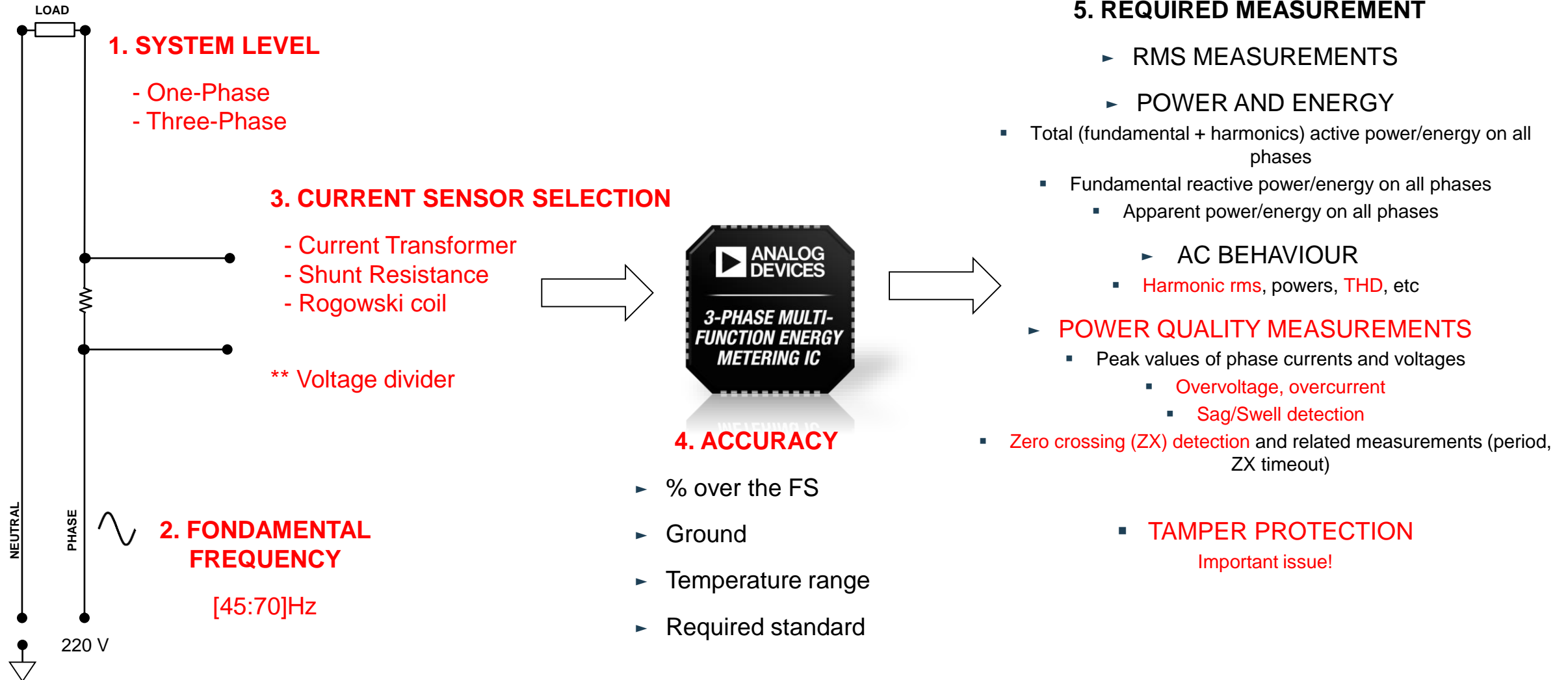
Understanding the Core technology

System Overview – Energy and Electric Meter (top view)



Understanding the Core technology

Critical specifications



Applications

Application target (1/3)

Utility Metering



Single Phase Metering: ADE7953

Diagnostics & Tamper Detection

3 Phase Metering: New ADE9078 AFE
and Isolated Shunt Current Sensing ADC

SWWG

*i*Coupler® Isolated
Communications and Power

Building infrastructures:

- Common measurements required:
 - High accuracy, Large dynamic
 - Watt, I_{RMS} , V_{RMS} , Power Factor
- Support:
 - Tamper detection
 - Calibration definition
 - Real-time accuracy monitoring
 - Compensation and auto-correction

Data Centre & Equipment Monitoring

Power Quality Solution in a chip
(**ADE9000** or many **ADE7953**)

Power is the highest cost for a datacenter :

- Required up to $380V_{AC}$
- It is recommended that the voltage THD be less than 5% and each individual harmonic up to the 40th be under 3%
- Ideal solution monitors power consumption, power factor and current and voltage THD

SWWG

Easy to use energy
metering

Application target (2/3)

Renewable Generation and Storage



High Density & High Voltage Power Conversion:
Mixed Signal Controller
iCoupler® Gate Drivers and Current Sensors



iCoupler® Isolation (Data, Power, Comms)

Precision Op-Amps / Refs

Energy metering: **ADE9000**, **ADE9078**

Improving renewable generation system integration:

- 99% performance efficiency increase
- 50% size and weight reduction

Advanced diagnostics and analytics for grid infrastructure and asset health

EV Charging Systems



Power Conversion Systems:
iCoupler® Gate Drivers
Mixed Signal Controller “Tesla”



iCoupler® Portfolio

Precision Op-Amps / Refs

Energy metering: **ADE9000**, **ADE9078**

Application target (3/3)

Machine Health



Diagnostic Levels / Prognostics for Failure detection:

- Local modelling machine
- Machine learning



ADE9000 for power quality monitor

ADXL for vibration and velocity detection

Consumer applications



Load monitoring

Monitoring energy consumption of individual or multiple loads like freezers in a supermarket, motors, etc

- Many single phases
- Required Watt, RMS, and PF



ADE7816

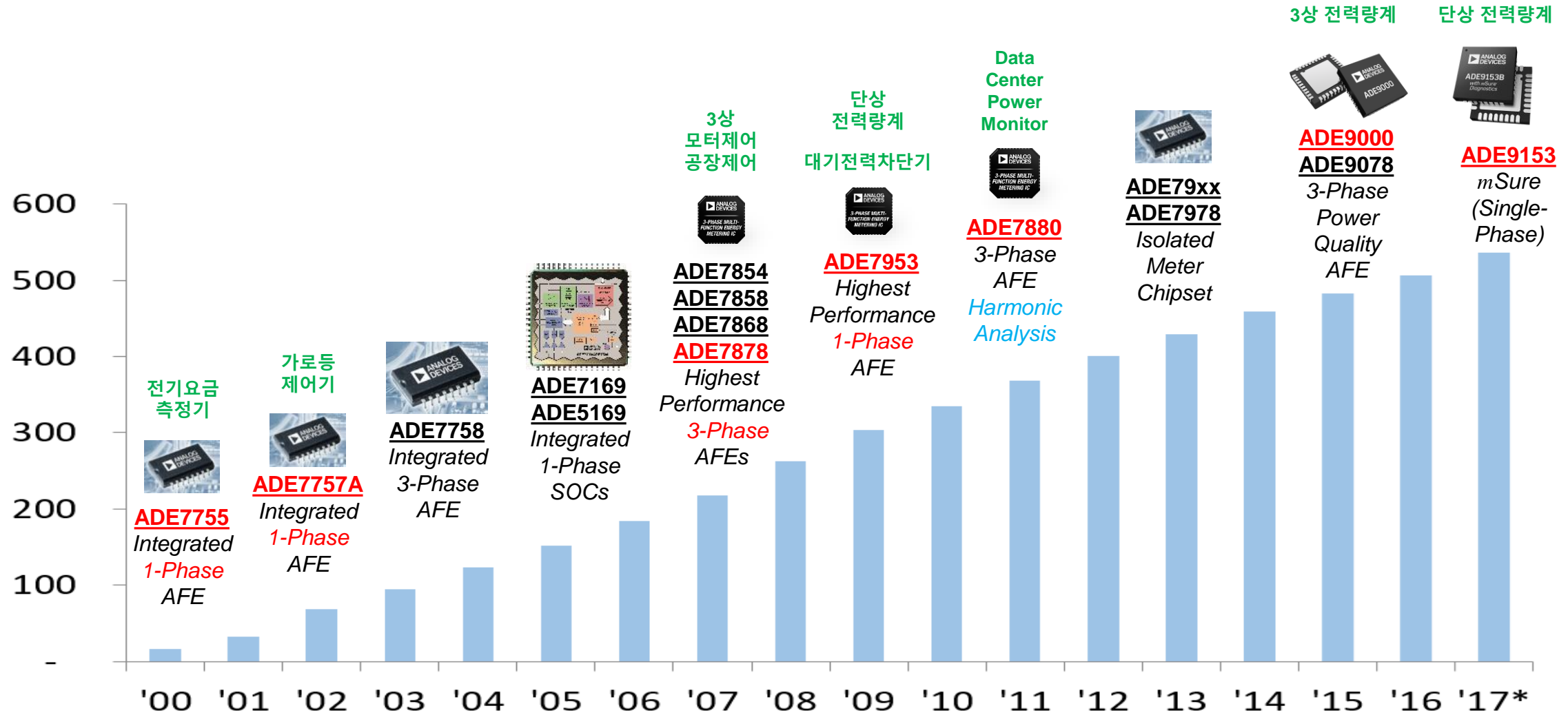
ADE7953

Our Products

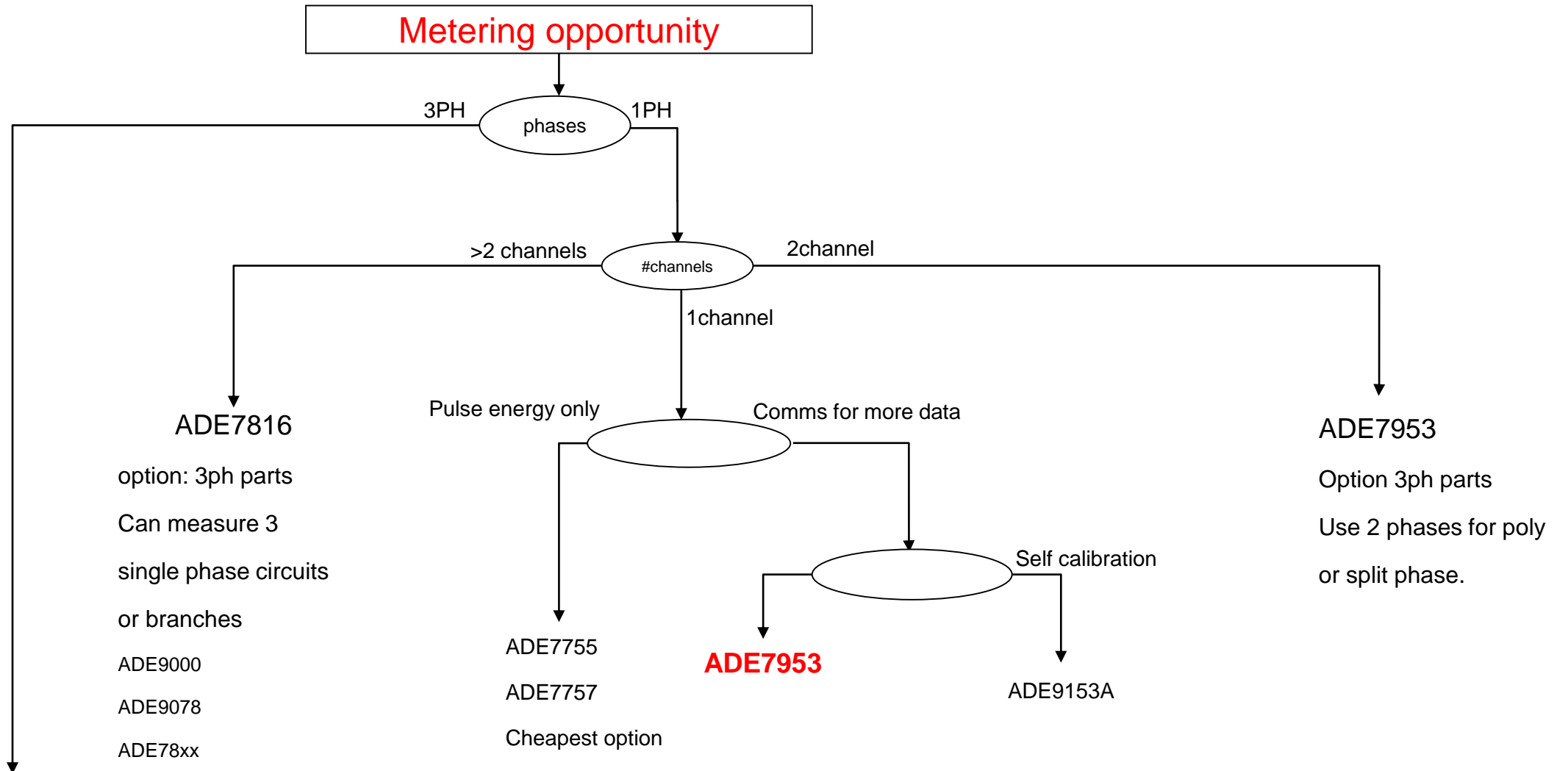
ADI Energy meter Product

Our History

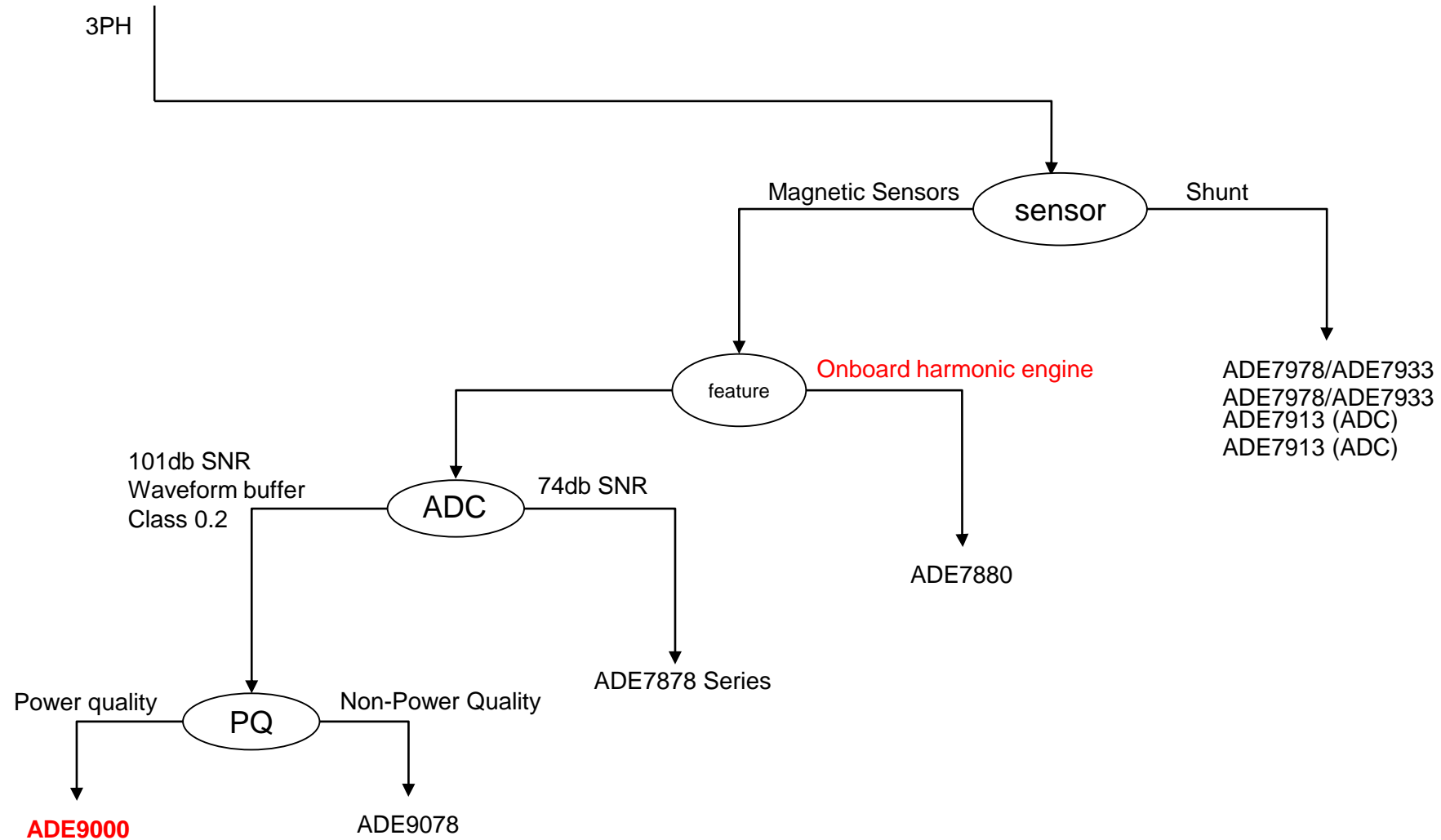
Cumulative Qty Metrology ICs Shipped (M)



Part Selection (1/2)



Part Selection (2/2)



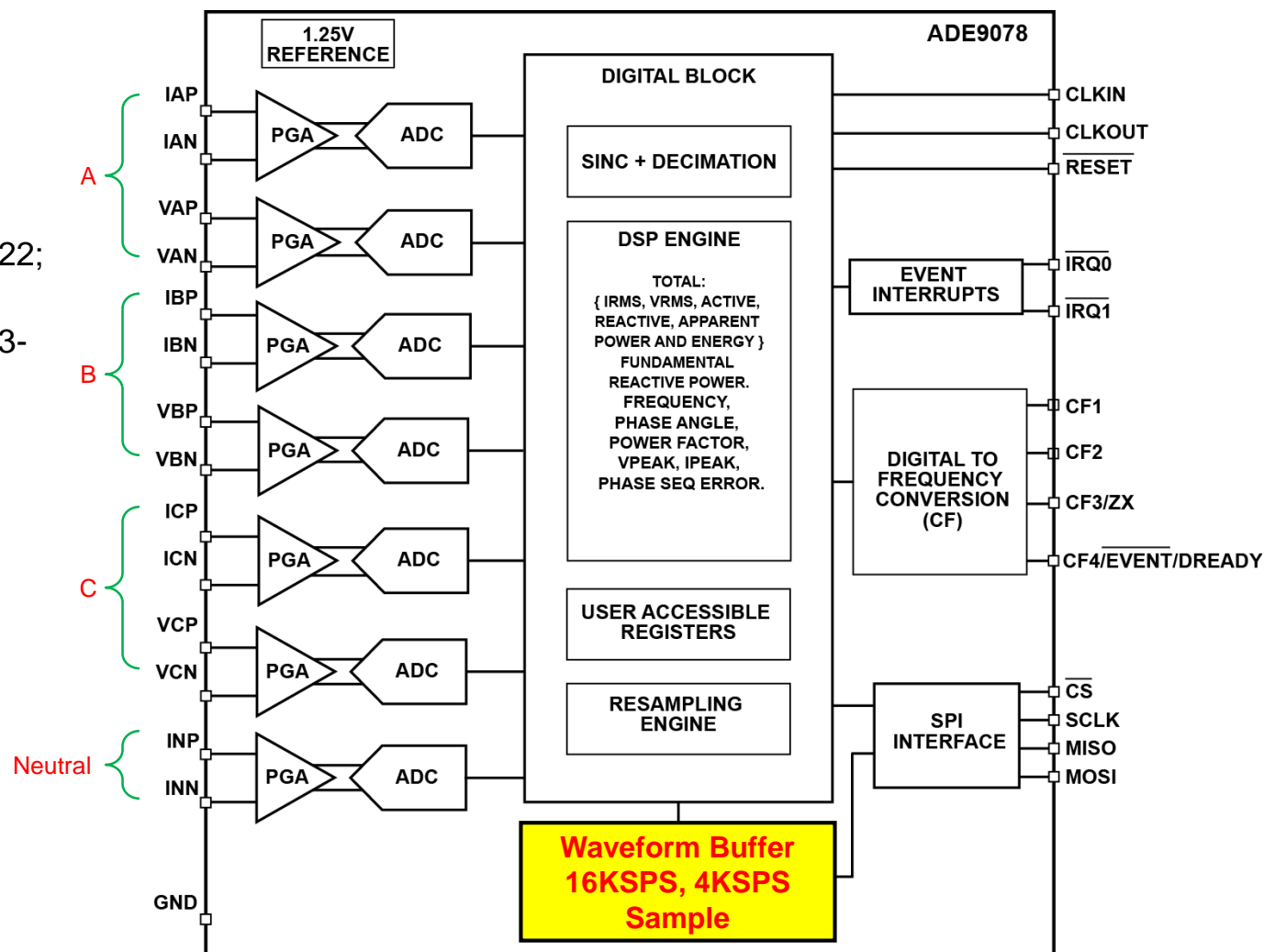
POWER QUALITY ANALYSIS

ADE9078

High Performance, Polyphase Energy Metering Analog Front End

Features and Specifications

- ▶ Advanced metrology feature set
 - Total W, var, VA, Watt-hr, VAR-hr, and VA-hr, IRMS, VRMS
 - Fundamental VAR and VAR-hr
 - Supports active energy standards: IEC 62053-21, IEC 62053-22; EN50470-3; OIML R46; ANSI C12.20
 - Supports reactive energy standards: IEC 62053-23, IEC 62053-24
 - **64 points/cycle waveform buffer for external analysis**
- ▶ High performance analog (101 dB SNR)
 - Watt: 0.1% error at 5000:1; 0.2% error at 10000:1
 - Max channel drift (ADC and internal reference and PGA): ± 25 ppm/ $^{\circ}$ C
- ▶ Flexible sensor interface
 - Multipoint CT phase/gain compensation
 - Digital integrators for Rogowski coils
- ▶ 10 MHz high speed SPI
- ▶ Low power: 10 mA
- ▶ Temperature range: -40° C to $+85^{\circ}$ C



ADE7878A metrology features: W, W-hr, IRMS, VRMS, VA, VA-hr, total VAR, total VAR-hr, fundamental VAR, fundamental VAR-hr, phase angles (V, I)

ADE9000

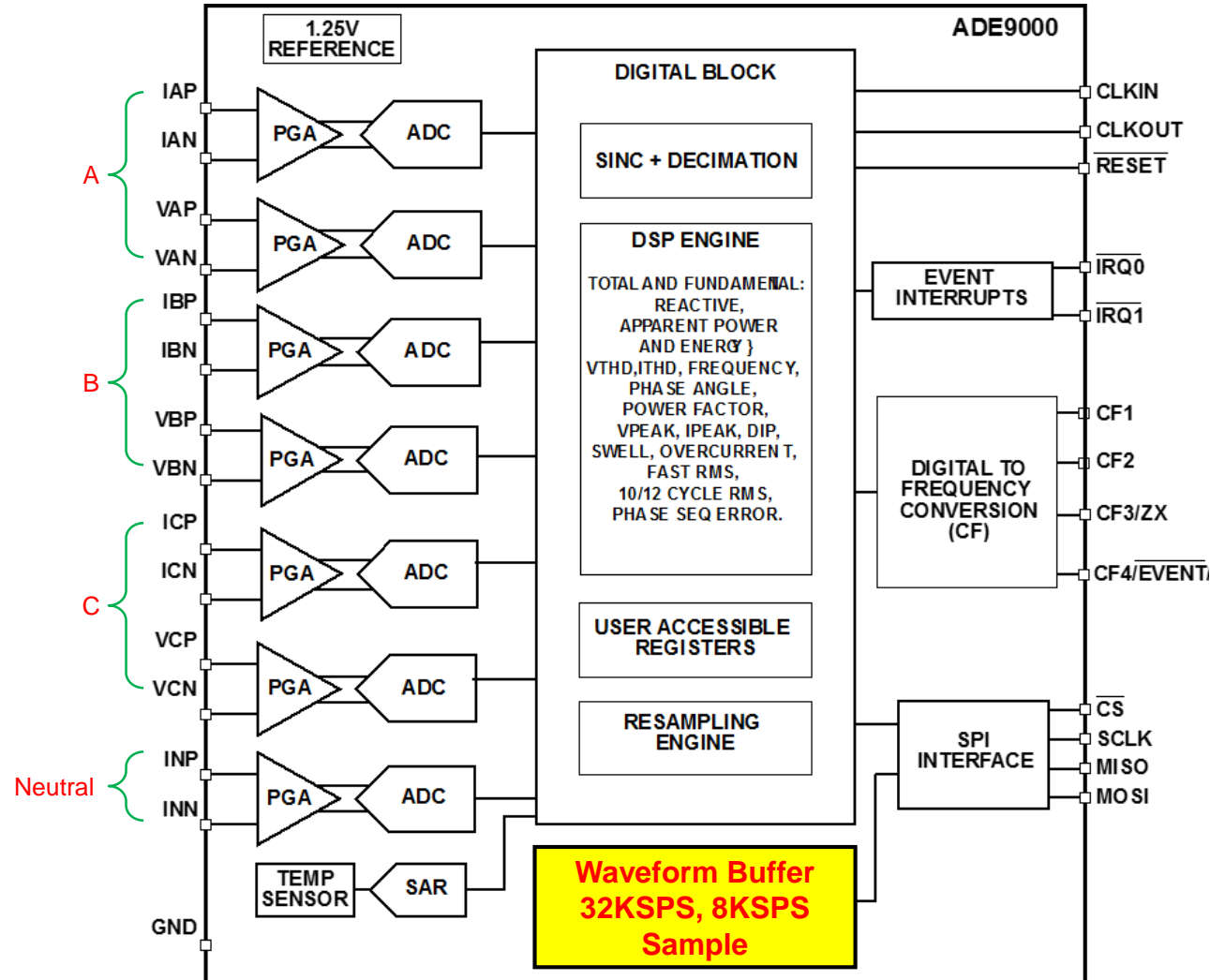
High Performance Polyphase Energy Metering Analog Front End

Features and Specifications

- ▶ Advanced metrology and power quality feature set
 - **Support for all ADE9078 measurements**
 - Enable implementation of EN 61000-4-30 **Class S**
 - $V_{rms}^{1/2}$, $I_{rms}^{1/2}$ r.m.s voltage refreshed each half cycle
 - 10/12 cycle rms
 - **Dip, swell monitors**
 - **Waveform buffer holds 128 points/cycle for external analysis**
- ▶ High performance analog (101 dB SNR)
 - Watt: 0.1% error at 5000:1; 0.2% error at 10000:1
 - Class 1, Class 0.5, and Class 0.2 energy meters
 - Voltage reference: ± 25 ppm/ $^{\circ}$ C maximum drift
- ▶ Flexible sensor interface
 - Multipoint CT phase/gain compensation
 - Rogowski coil support
- ▶ 20 MHz high speed SPI
- ▶ Industrial standard IEC 61000-4-30 Class S
- ▶ Low power: 15 mA
- ▶ Temperature range: -40° C to $+85^{\circ}$ C



ADE9000
ADE9078
Power
Quality
AFE



Potential Applications

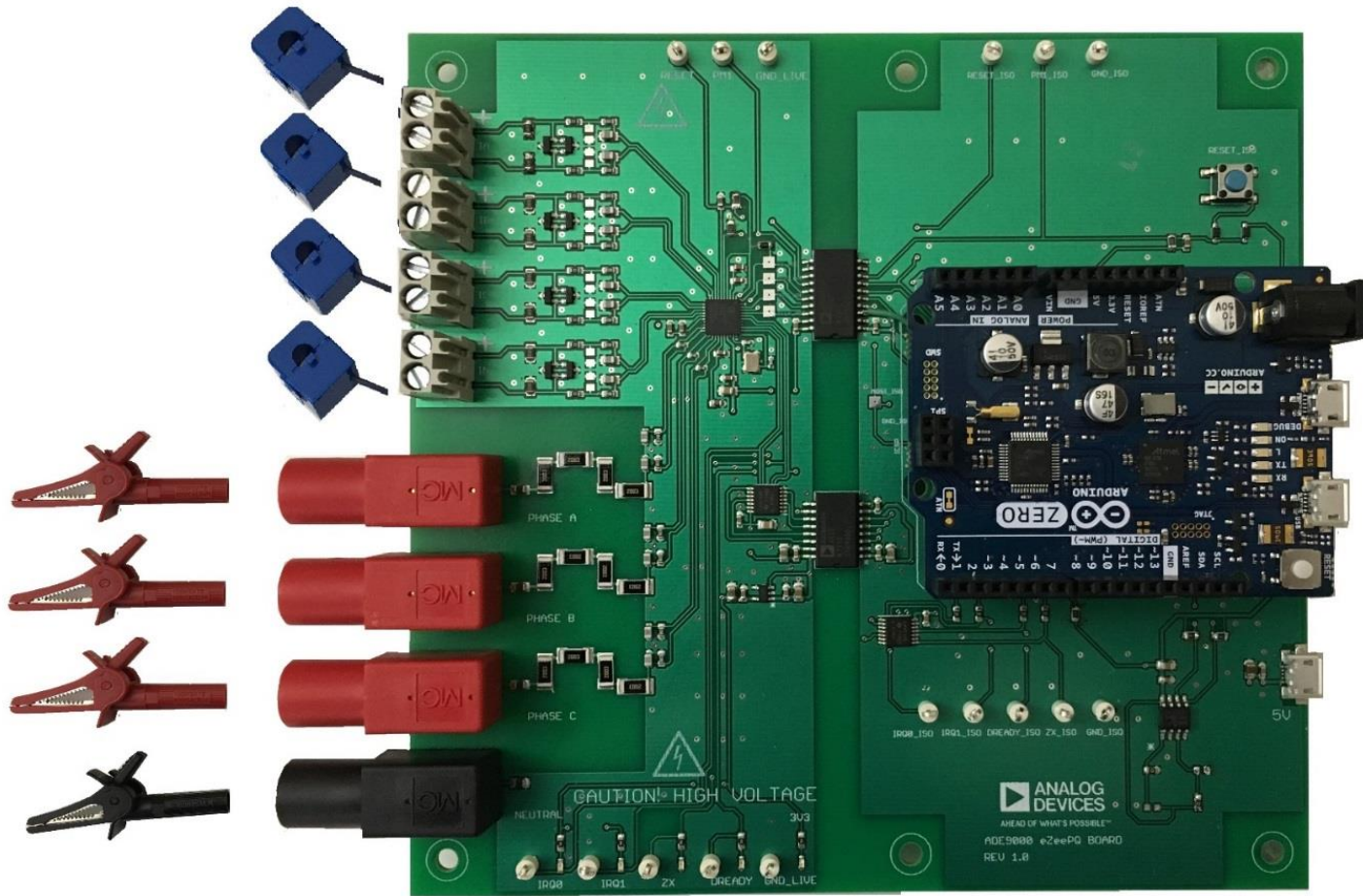
Smart Grid, Smart Buildings, Data Centers, Machine-health, Industrial IoT

Comparison Table

Product Features	ADE9000 Power quality	ADE9078 Utility Metering	ADE7880
Measurement Parameters	ADE7880 parameters** , Total VAR, Total VAR-hr Fundamental VA, Fundamental VA-hr, 1/2 cycle RMS , 10/12 cycle RMS, 3.2kHz BW	ADE7880 parameters** , Total VAR, Total VAR-hr Fundamental VA, Fundamental VA-hr, 1.6kHz BW	ADE7880 parameters** Harmonic Engine
Waveform analysis	On-chip buffer stores wave samples. 32ksps, 8ksps(133points) or 128 points per cycle	On-chip buffer stores wave samples. 16ksps, 4ksps or 64 points per cycle	SPI master outputs ADC samples
Watt accuracy	0.2% error at 10000:1	0.2% error at 10000:1	0.2% error at 5000:1
SNR	101dB 7 ADC channels	101dB 7 ADC channels	72dB 7 ADC channels
Max System Temp. Drift	±25 ppm / °C	±25 ppm / °C	±50 ppm / °C
Power consumption (Typ)	15mA	10.5mA	25mA
Temperature Range	-40C to +85C	-40C to +85C	-40C to +105C
Package Type	40-lead LFCSP	40-lead LFCSP	40-lead LFCSP

ADE9000

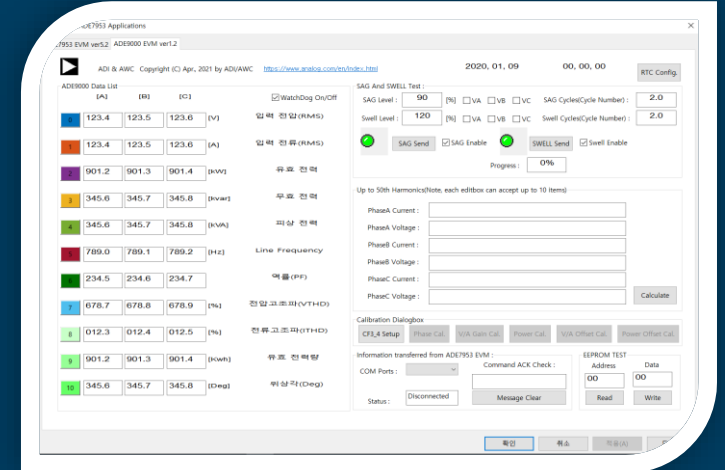
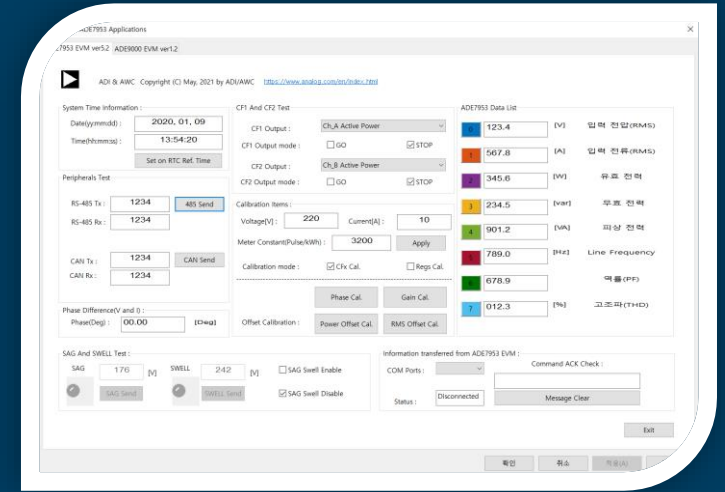
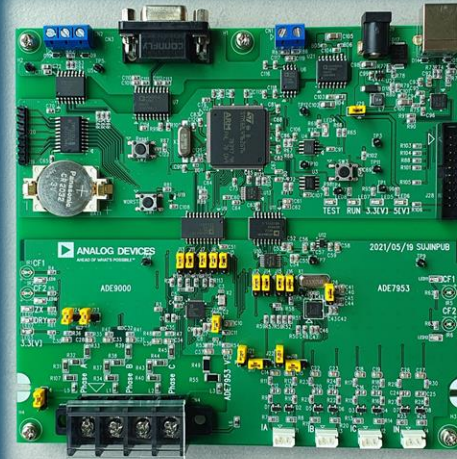
first IC with this new approach



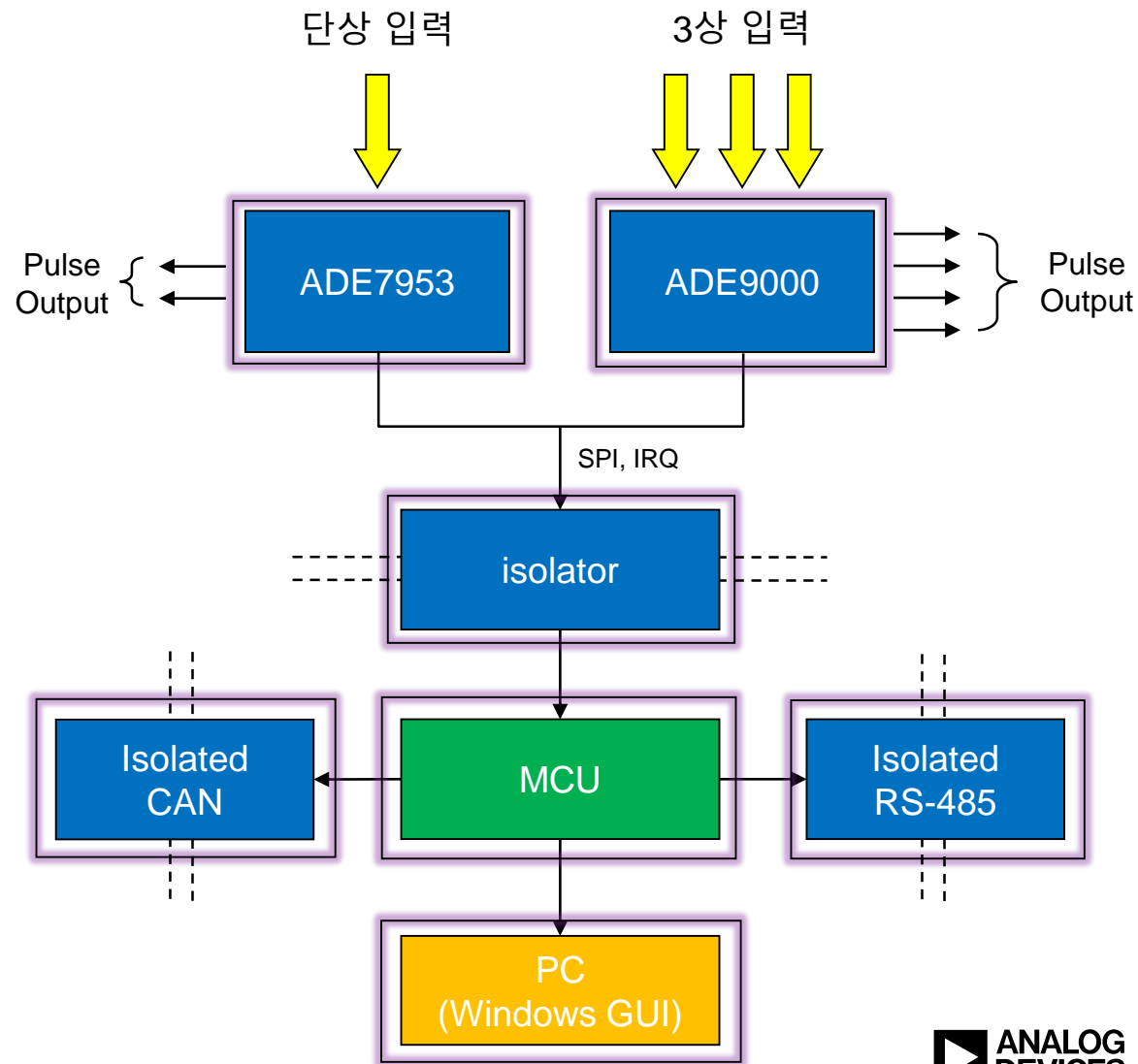
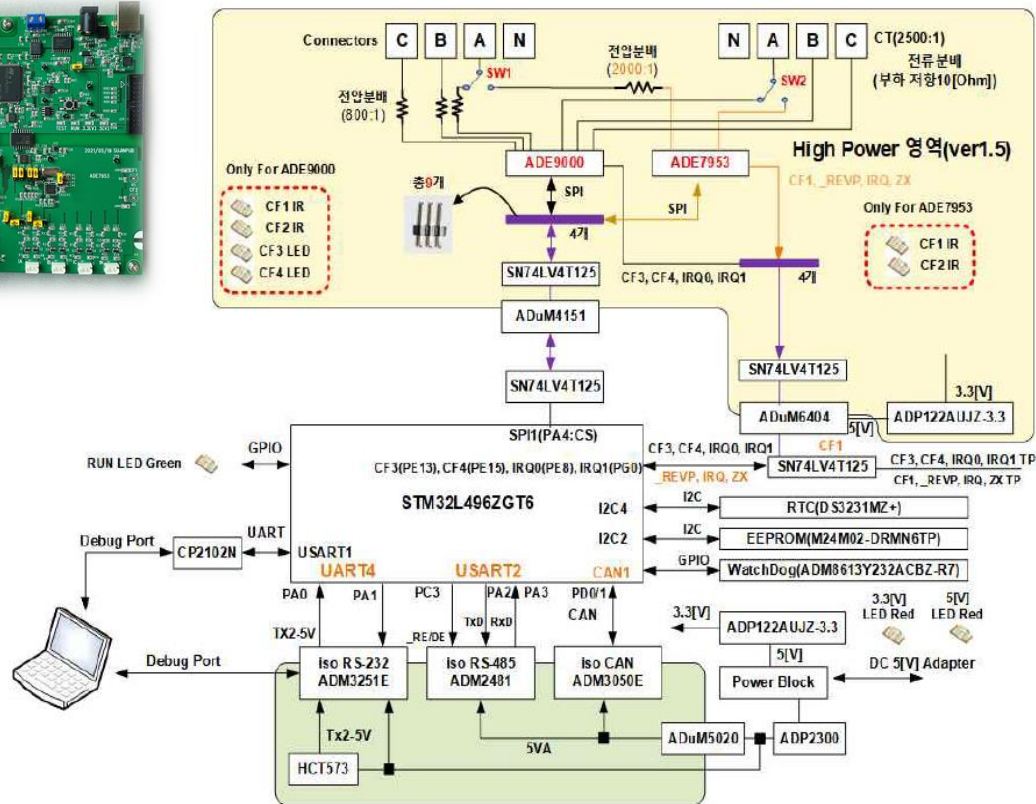
- ▶ **ADE9000** – new 3Ph Energy and Power Quality Monitoring IC
- ▶ Isolation Barrier
- ▶ Data sheet, TRM on web
- ▶ Eval board available:
 - Utility meter ref design
 - **Arduino module** (a low cost power quality monitor)

Evaluation Board Support

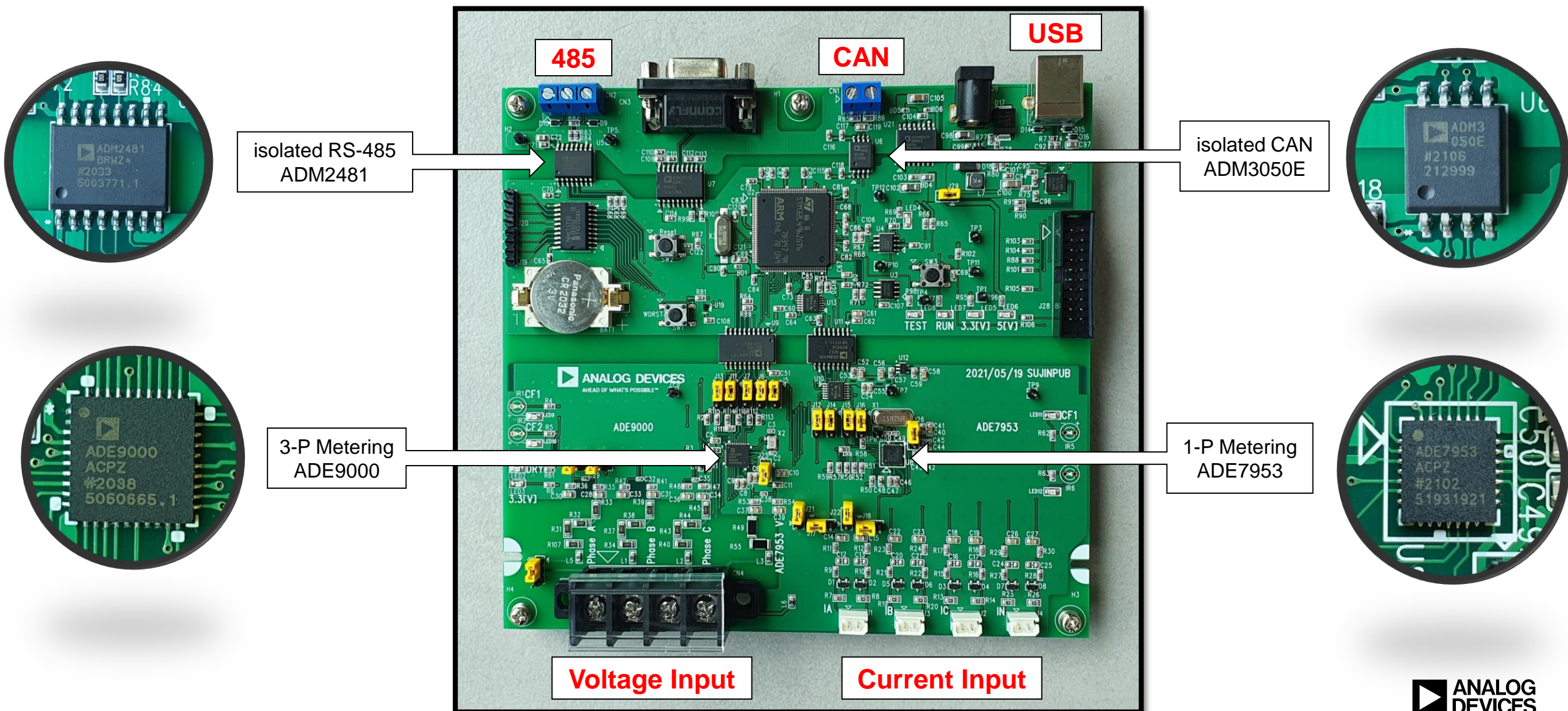
- ADE7953 (Single Phase)
- ADE9000 (Poly Phase)
- Windows GUI



Evaluation Board (1+3 : ADE7953 + ADE9000) → Integration Board



Evaluation Board (1+3 : ADE7953 + ADE9000) → Integration Board



Windows GUI – ADE7953

The screenshot displays the ADE7953 Windows GUI with several sections highlighted by red boxes and labels:

- Pulse Output:** Located at the top center, it includes controls for CF1 and CF2 tests. CF1 Output is set to 'Ch_A Active Power' with 'STOP' mode selected. CF2 Output is also set to 'Ch_B Active Power' with 'STOP' mode selected.
- Measurement:** Located on the right side, it shows the 'ADE7953 Data List' with 8 rows of data. The data is as follows:

Index	Value	Unit	Label
0	123.4	[V]	입력 전압(RMS)
1	567.8	[A]	입력 전류(RMS)
2	345.6	[W]	유효 전력
3	234.5	[var]	무효 전력
4	901.2	[VA]	피상 전력
5	789.0	[Hz]	Line Frequency
6	678.9		역률(PF)
7	012.3	[%]	고조파(THD)
- RS-485 / CAN:** Located on the left side, it includes fields for RS-485 Tx/Rx and CAN Tx/Rx, all set to '1234'. Buttons for '485 Send' and 'CAN Send' are present.
- Calibration:** Located in the center, it includes 'Calibration Items' with Voltage[V] set to 220, Current[A] set to 10, and Meter Constant(Pulse/kWh) set to 3200. The 'Apply' button is visible. Below this, there are buttons for 'Phase Cal.', 'Gain Cal.', 'Power Offset Cal.', and 'RMS Offset Cal.'.
- SAG / SWELL:** Located at the bottom left, it includes 'SAG And SWELL Test' with SAG set to 176 [V] and SWELL set to 242 [V]. There are buttons for 'SAG Send' and 'SWELL Send', and checkboxes for 'SAG Swell Enable' (unchecked) and 'SAG Swell Disable' (checked).

Other visible sections include 'System Time Information' (Date: 2020, 01, 09; Time: 13:54:20), 'Peripherals Test', and 'Information transferred from ADE7953 EVM' (COM Ports, Command ACK Check, Status: Disconnected, Message Clear).

Windows GUI – ADE9000

ADE9000 & ADE7953 Applications

ADE7953 EVM ver5.2 ADE9000 EVM ver1.2

Measurement **SAG / SWELL / Waeform Capture**

ADI & AWC Copyright (C) Apr., 2021 by ADI/AWC <https://www.analog.com/en/index.html> 2020, 01, 09 00, 00, 00 RTC Config.

ADE9000 Data List

	[A]	[B]	[C]	
0	123.4	123.5	123.6	[V] 입력 전압(RMS) <input checked="" type="checkbox"/> WatchDog On/Off
1	123.4	123.5	123.6	[A] 입력 전류(RMS)
2	901.2	901.3	901.4	[kW] 유효 전력
3	345.6	345.7	345.8	[kvar] 무효 전력
4	345.6	345.7	345.8	[kVA] 피상 전력
5	789.0	789.1	789.2	[Hz] Line Frequency
6	234.5	234.6	234.7	역률(PF)
7	678.7	678.8	678.9	[%] 전압고조파(VTHD)
8	012.3	012.4	012.5	[%] 전류고조파(ITHD)
9	901.2	901.3	901.4	[Kwh] 유효 전력량
10	345.6	345.7	345.8	[Deg] 위상각(Deg)

SAG And SWELL Test :

SAG Level : [%] VA VB VC SAG Cycles(Cycle Number) :

Swell Level : [%] VA VB VC Swell Cycles(Cycle Number) :

SAG Send SAG Enable SWELL Send SWELL Enable

Harmonic

Up to 50th Harmonics(Note, each editbox can accept up to 10 items)

PhaseA Current :

PhaseA Voltage :

PhaseB Current :

PhaseB Voltage :

PhaseC Current :

PhaseC Voltage :

Calibration

Calibration Dialogbox

Information transferred from ADE7953 EVM :

COM Ports : Command ACK Check :

Status :

EEPROM TEST

Address Data

SAG Event and Waveform Capture Function

[en/index.html](#) 2020, 01, 09 00, 00, 00 RTC Config.

SAG / SWELL / Waveform Capture

SAG And SWELL Test :

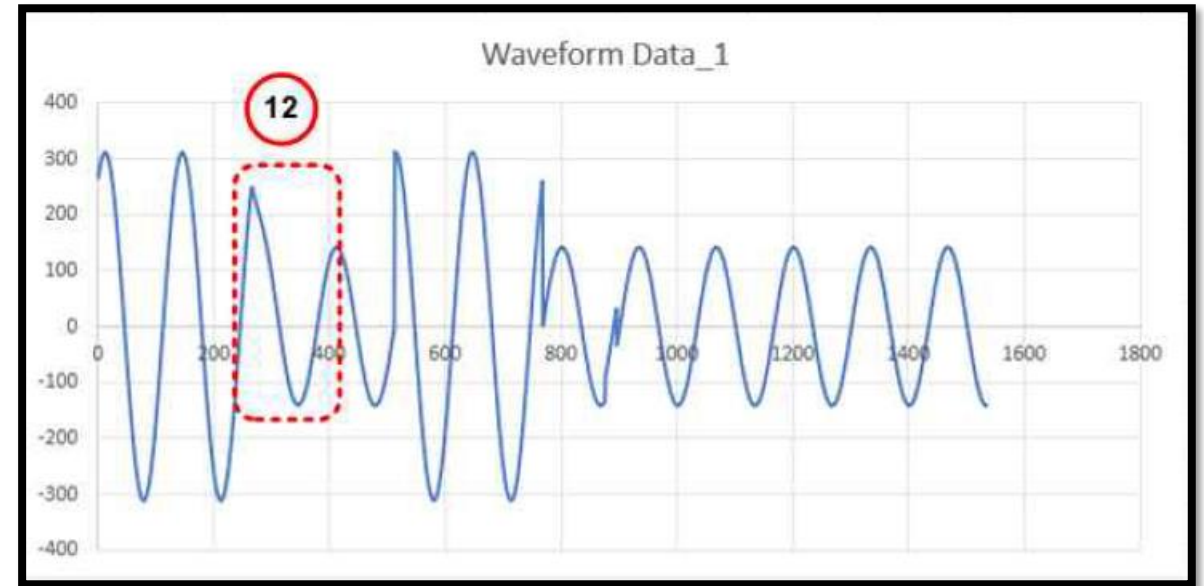
SAG Level : [%] VA VB VC SAG Cycles(Cycle Number) :

Swell Level : [%] VA VB VC Swell Cycles(Cycle Number) :

SAG Send SAG Enable SWELL Send Swell Enable

Progress :

Up to 50th Harmonics(Note, each editbox can accept up to 10 items)



SAG 발생 전
파형 모습

SAG 발생 후
파형 모습

Harmonic Analysis

The screenshot displays the software interface for harmonic analysis. On the left, there is a table of input parameters. On the right, there are settings for SAG and SWELL tests, and a section for entering harmonic orders. A 'Calculate' button is visible. Below the main interface, a text file named '20201218130737_1622211446HarmonicData.txt' is open, showing the output of the calculation. Red dashed boxes and numbered callouts (1-4) highlight key steps in the process.

[A]	[B]	[C]	[V]	입력 전압(RMS)
220.7	0.0	0.0	[V]	입력 전압(RMS)
10.0	0.0	0.0	[A]	입력 전류(RMS)
2.2	0.0	0.0	[kW]	유효 전력
0.0	0.0	0.0	[kvar]	무효 전력
2.2	0.0	0.0	[kVA]	피상 전력
58.3	60.0	60.0	[Hz]	Line Frequency
1.0	1.0	1.0	[%]	역률(PF)
1.9	0.0	0.0	[%]	전압고조파(VTHD)
1.9	0.0	0.0	[%]	전류고조파(ITHD)
0.0	0.0	0.0	[Kwh]	유효 전력량
370.5	0.0	0.0	[Deg]	위상각(Deg)

SAG And SWELL Test:
SAG Level: 90 (%) VA VB VC SAG Cycles(Cycle Number): 2.0
Swell Level: 120 (%) VA VB VC Swell Cycles(Cycle Number): 2.0
 SAG Send SAG Enable SWELL Send Swell Enable

Up to 50th Harmonics(Notes, each editbox can accept up to 10 items)
PhaseA Current:
PhaseA Voltage: 3;5;7;11
PhaseB Current:
PhaseB Voltage:
PhaseC Current:
PhaseC Voltage:

Calibration Dialogbox:
CF3_4 Setup Phase Cal V/A
Information transferred from ADE7953:
COM Ports: [COM39] 20201218130737_1622211446HarmonicData.txt 2020-12-18 13:07:37
ADE7953 Dig.exe

20201218130737_1622211446HarmonicData.txt
1 - Phase A Current :
2 - Phase A Voltage : 11(1.339327), 7(2.821868), 5(7.519176), 3(9.695736),
3 - Phase B Current :
4 - Phase B Voltage :
5 - Phase C Current :
6 - Phase C Voltage :

(1)
원하는 Harmonic
차수 입력

(2)
Calculate
Button Click

(4)
측정된 Harmonic
확인

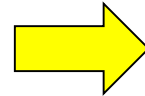
(3)
실시간
Txt 파일 생성

Gain Calibration

- Phase A, B, C : same input
- Input voltage : 220V
- Input current : 5A

Before Calibration

	[A]	[B]	[C]		<input checked="" type="checkbox"/> WatchDog On/Off
0	220.4	222.8	223.2	[V]	입력 전압(RMS)
1	5.0	5.0	5.0	[A]	입력 전류(RMS)
2	1.0	0.8	0.6	[kW]	유효 전력
3	0.6	0.8	1.0	[kvar]	무효 전력
4	1.1	1.1	1.1	[kVA]	피상 전력
5	60.0	60.0	60.0	[Hz]	Line Frequency



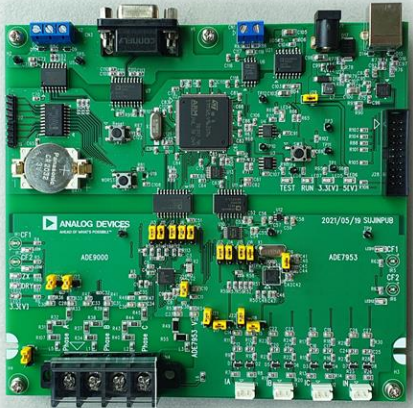
After Calibration

	[A]	[B]	[C]		<input checked="" type="checkbox"/> WatchDog On/Off
0	220.0	220.0	220.0	[V]	입력 전압(RMS)
1	5.0	5.0	5.0	[A]	입력 전류(RMS)
2	1.0	0.8	0.6	[kW]	유효 전력
3	0.5	0.8	1.0	[kvar]	무효 전력
4	1.1	1.1	1.1	[kVA]	피상 전력
5	60.0	60.0	60.0	[Hz]	Line Frequency

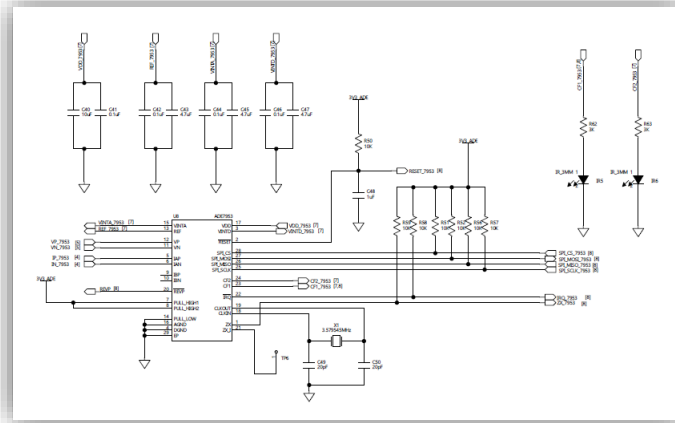
Calibration Tool (Excel Sheet)

Step 1: Input Conditions	
Select Channel Being Calibrated	Channel A
Enter Line Frequency(Hz)	60
Select Current Sensor	Current Transformer
Select Voltage Sensor	Resistor divider
Enter Nominal RMS Input Voltage(Vrms)	220
Enter Nominal RMS Input Current(Arms)	10
Enter Meter Constant(impulses/kWHR)	2000
Enter Energy Accumulation Time(sec)	1
Enter Voltage PGA_GAIN	1
Enter Current PGA_GAIN	1
Step 2: Setting up CF pulses	
Enter CT Turns ratio	2500
Enter Total CT Burden Resistor(Ohm)	10.2
Current Transfer Function(V/A)	0.00408
Enter Top Leg (R1) of Divider Resistor (KOhm)	800
Enter Bottom Leg (R2)of Divider Resistor (kOhm)	1
Voltage Transfer Function(V/V)	0.001248439
Expected CF at Nominal Conditions(Hz)	1.222222222
Program xTHR to Recommended Value(xTHR=0x00100000)	100000
Nominal Voltage percentage of full scale	38.84%
Nominal Current percentage of full scale	5.77%
CFxDEN Register(hex)	B4F
Voltage Conversion Constant(uVrms/Code)	10.74705975
Current Conversion Constant(uArms/Code)	3.288493474
Power Conversion Constant(mWatt/Code)	4.743474033
Energy Conversion Constant (uWxHr/xxTTHR_HI Code)	1.349254836
Step 3: Voltage and Current Gain Calibration	
Select Calibration technique	Calibrate using Register values
Enter Measured xIRMS register value(hex)	
Enter Measured xVRMS register value(hex)	

What We Supports ?



통합보드 무료대여

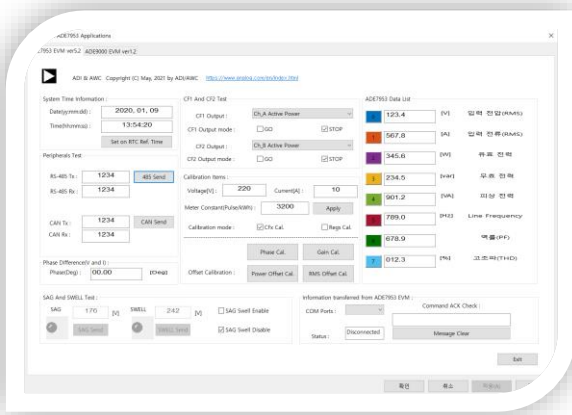


회로도 제공 및 검토지원

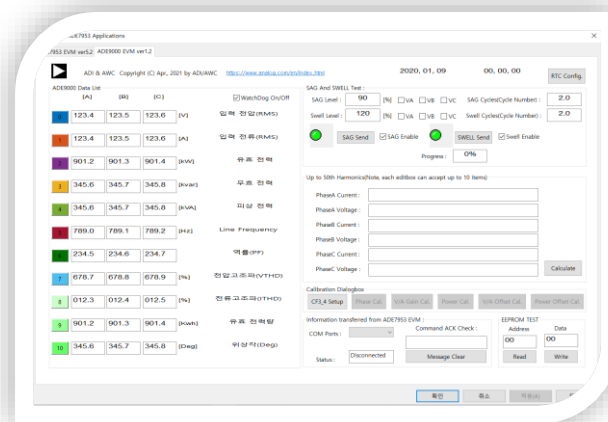
```

1831 // BIRMS_1(0x608)+ftmp3
1832 ftmp = AllPwr32Info[8]+ftmp3;
1833 AllPwr32InfoPC[8] = ftmp;
1834
1835 // CIRMS_1(0x609)+ftmp3
1836 ftmp = AllPwr32Info[9]+ftmp3;
1837 AllPwr32InfoPC[9] = ftmp;
1838
1839 // AVRMS_1(0x60A)+V_CNVCNST
1840 ftmp = AllPwr32Info[10]+ftmp2;
1841 AllPwr32InfoPC[10] = ftmp;
1842
1843 // BVRMS_1(0x60B)+V_CNVCNST
1844 ftmp = AllPwr32Info[11]+ftmp2;
1845 AllPwr32InfoPC[11] = ftmp;
1846
1847 // CVRMS_1(0x60C)+V_CNVCNST
1848 ftmp = AllPwr32Info[12]+ftmp2;
1849 AllPwr32InfoPC[12] = ftmp;
    
```

Software 지원



단상 GUI 제공



3상 GUI 제공

Full Support ? Yes
 Counseling ? Yes
 Let's Go with ADI.

Call Us.



AHEAD OF WHAT'S POSSIBLE™

Thank you for your attention

Thank You For Watching!

Analog Devices Homepage : www.analog.com

Ask Questions on EngineerZone

<https://ez.analog.com/>

아나로그월드 (제품 구매, 기술문의)

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Fax. 031-783-0598

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