The World Leader in High Performance Signal Processing Solutions

ADI专家面对面：

深度了解16位8通道同步采样数据采集系统AD7606

Customer Application Center， Asia

ANALOG DEVICES

Agenda

- **Introduction to the AD7606 Data Acquisition System**
  - **Key features and functions**
  - **Design hints**
  - **Typical applications**
- **ADI PLM demo**
- **Case studies**
  - **Hardware related issues**
  - **Software related issues**

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Introduction to the AD7606 Data Acquisition System

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AD7606 win EDN China 2010 Innovation Award

模拟与混合信号	转换类	亚德诺半导体技术(上海)有限公司 (Analog Devices)	AD7606: 8通道DAS，内置16位、双极性、同步采样ADC

转换类 Converters

产品：AD7606：8通道DAS，内置16位、双极性、同步采样ADC

厂商：亚德诺半导体技术(上海)有限公司(Analog Devices)

评语：AD7606 系列集成最多有八通道的同步采样16位ADC，可实现90 dB 的 SNR（信噪比），可选的过采样模式进一步提高了 SNR 性能，减少了代码扩展，并增强了抗混叠能力。可提供下一代电力线监控系统设计所需的分辨率和性能，现有用户可以通过该产品对原有系统进行有效的升级，从而增强市场竞争力。

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AD7606 16 bit, 8 channel Data Acquisition System

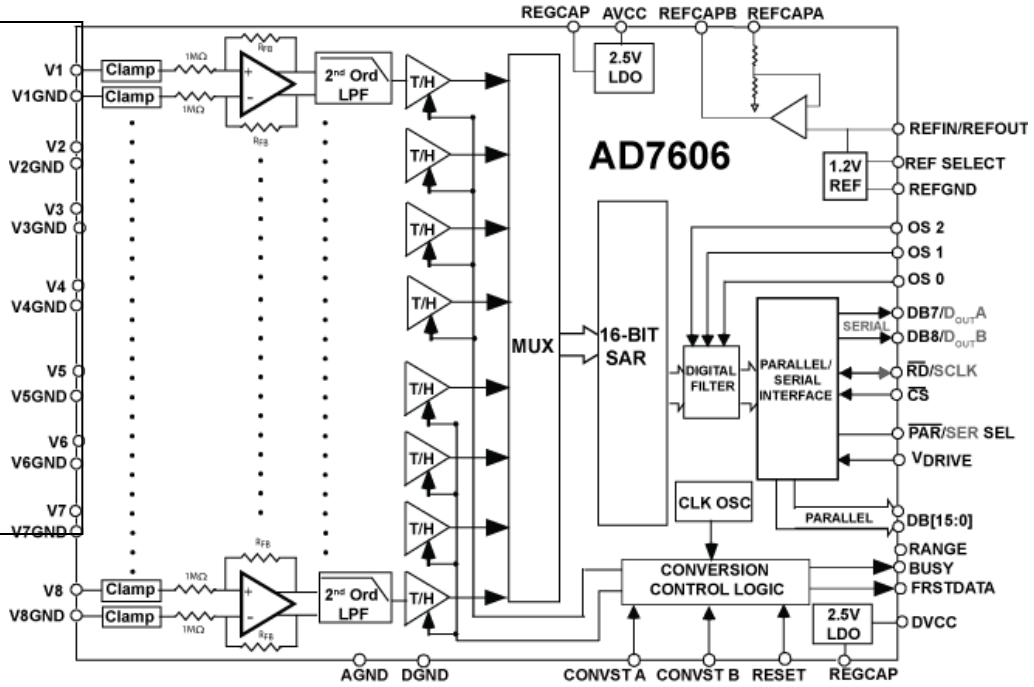
Released

Features

- 8 simultaneous sampling channels
- Single 5V supply operation
- +-10V +-5V bipolar input
- Analog input clamp protection
- 1Meg Resistor input impedance
- 2nd Order Analog Anti-Alias Filter
- Flexible Digital filter
- 2.5V reference and reference buffer
- Serial and Parallel interface.
- 64 lead LQFP Package

Performance

- 90dB SNR @ 200k
- 96dB SNR @ 12.5k (digital filter)
- 100mW Power
- INL +/- 2 LSB, 16 Bit NMC
- Input Clamps to +-16.5V
- NFS/PFS Code 8 LSB @ 25
- NFS/PFS Code 32 LSB max



AD7606-4/AD7606-6

- As per AD7606 except
  - 4,6 channel

AD7607

- As per AD7606 except
  - 14-Bit

AD7608/AD7609

- As per AD7606 except
  - 18-Bit S.E. / 18-Bit Diff
  - preliminary

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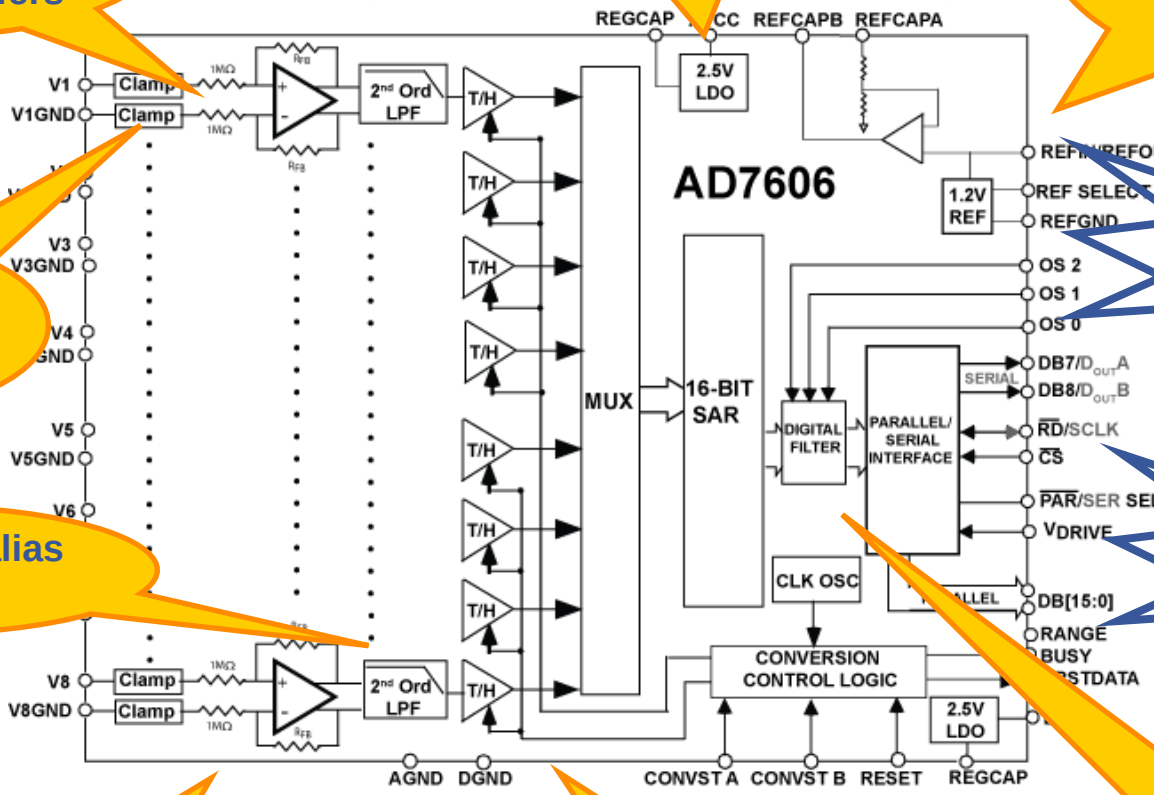
AD7606 DAS Benefits

1MΩ Analog Inputs saves on external buffers

Single 5V supply saves on negative supply rail

Fewer Decoupling Caps simplify PCB design, improve performance and reduce BOM



Input Clamp protection to ± 16.5V

SNR 96dB!

TUE ±12 LSB

Analog Anti-alias Filter

~same power as AD7656 - plus 2 more channels and integration!

64-ld LQFP Package

Digital Filter

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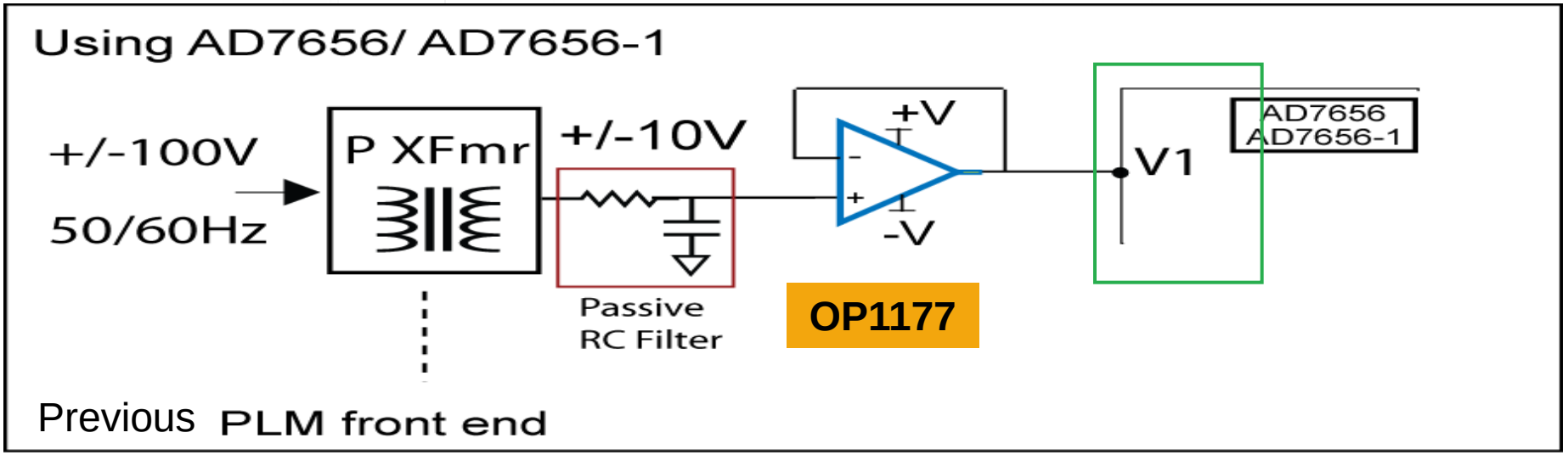
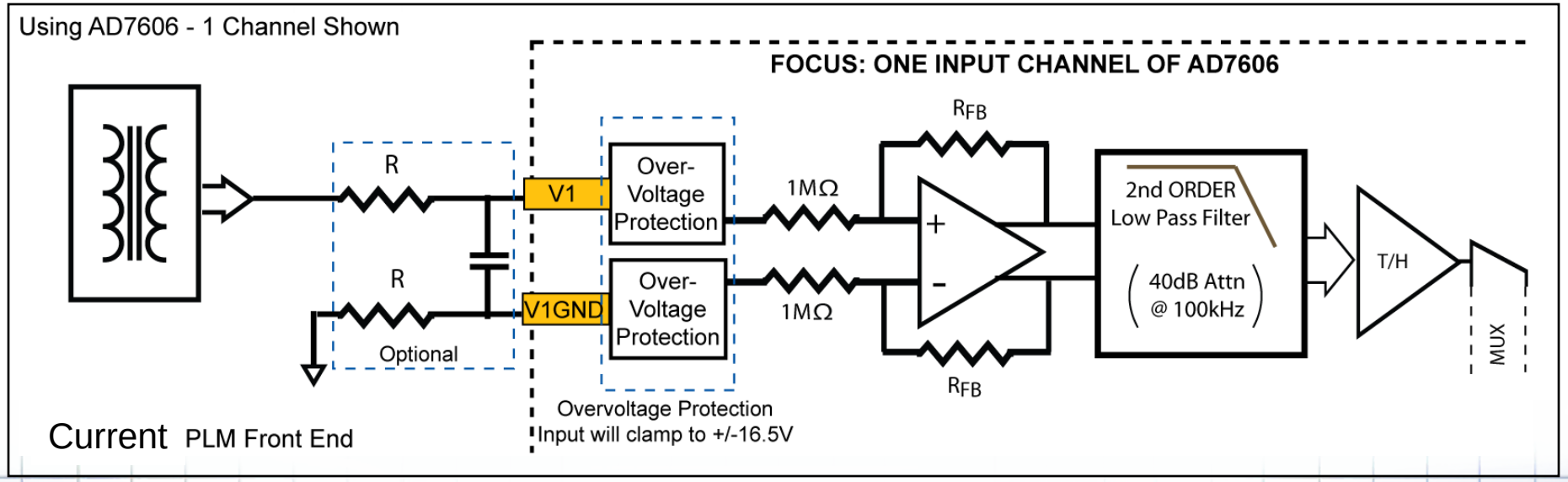
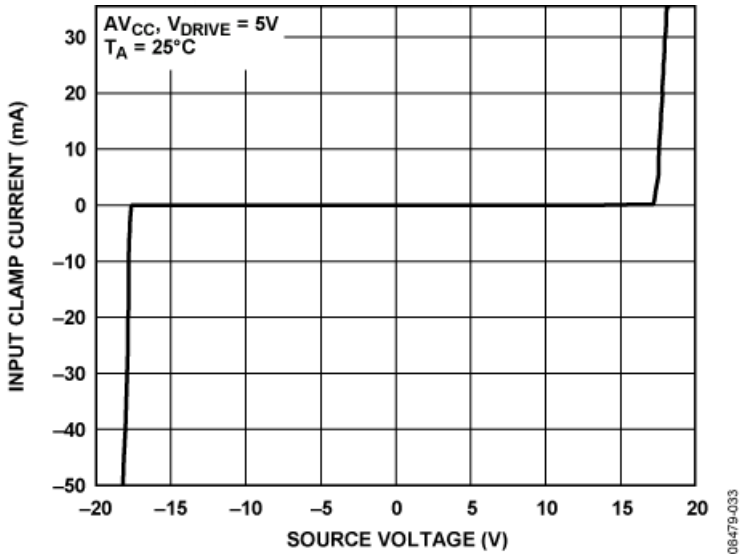
AD7606 Front End Integration





AD7606 Analog input Clamps

- **AD7606 clamps to ±16.5V in fault condition.**
- **Input current must be limited to +-10mA for fault voltages > +-16.5V.**
- **ESD performance on Analog Inputs 7kV HBM**

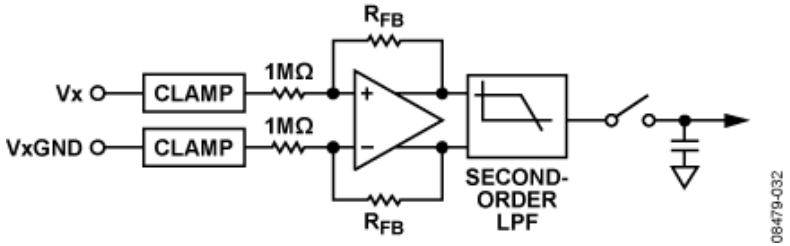


AD7606

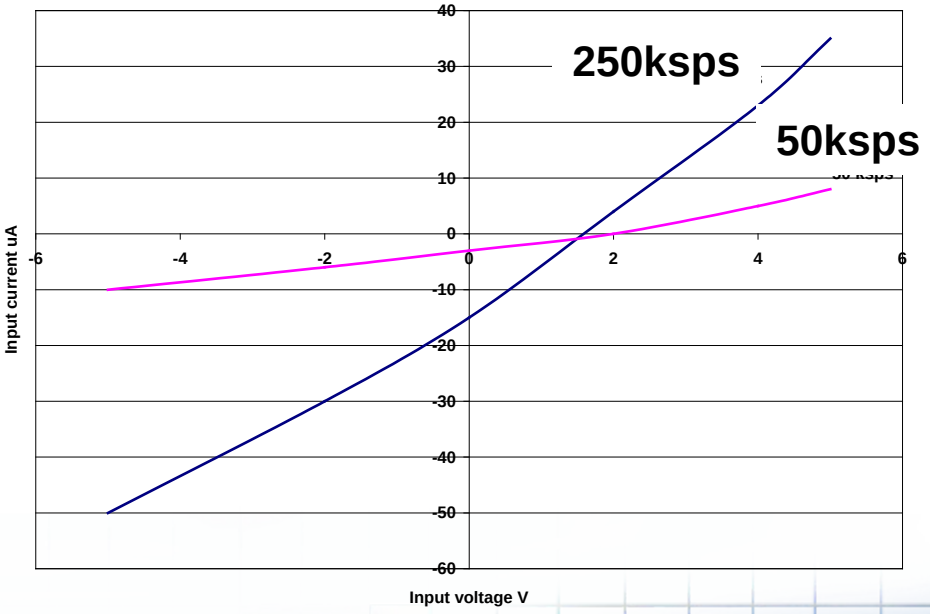
Analog input impedance

- AD7606 analog input impedance is fixed at 1 MOhm.
- The input current (uA) required to drive the AD7606 is fixed regardless of Fsample.
- Capacitive input - impedance is dependant on the Fsample
- As Fsample increases the current required to drive the analog inputs will increase.
- Example shown where ADC X input current is a function of Fsample.
- Regardless of Fsample the AD7606 does not need an input buffer.

AD7606



Input current vs Fsample



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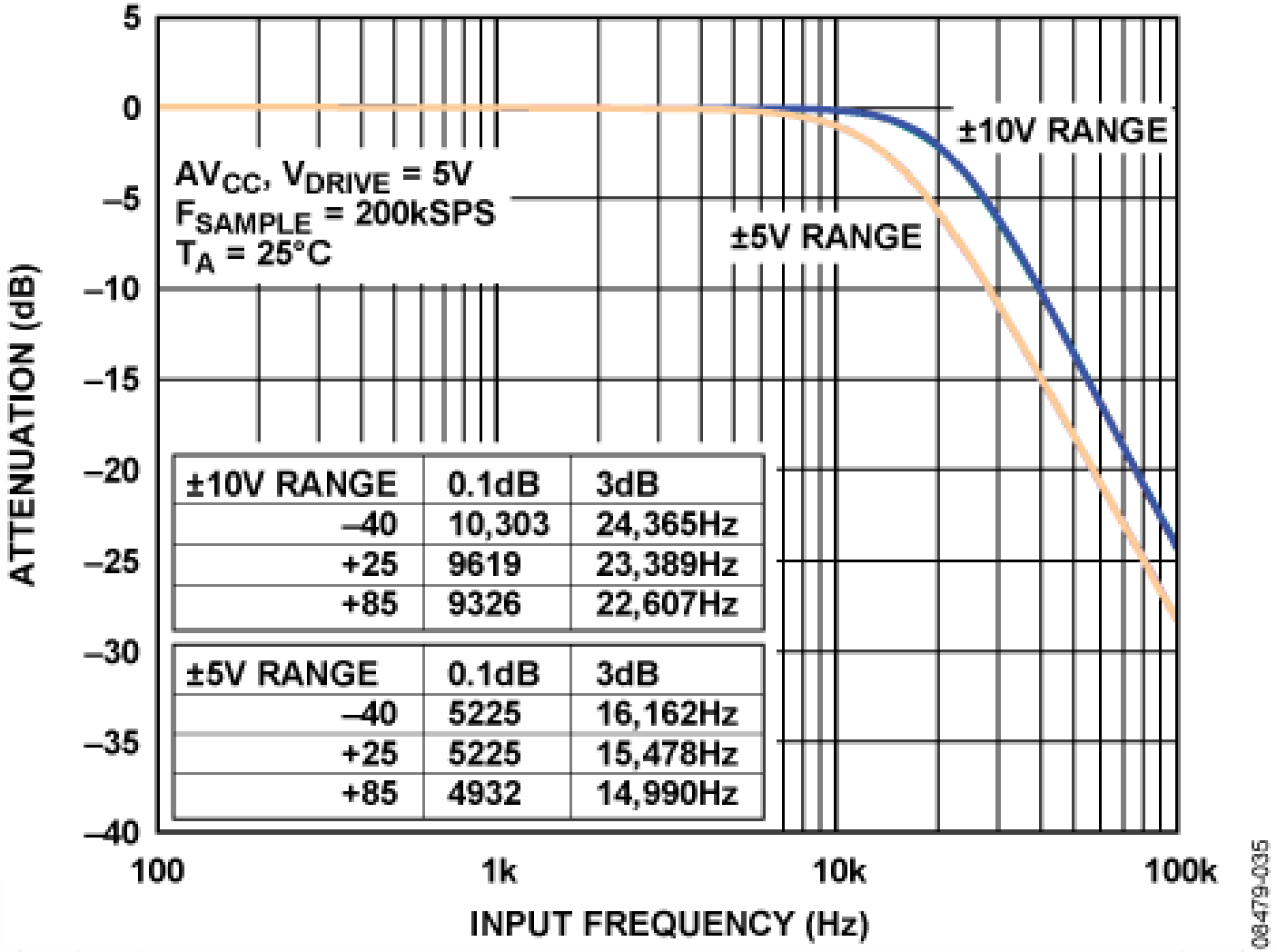
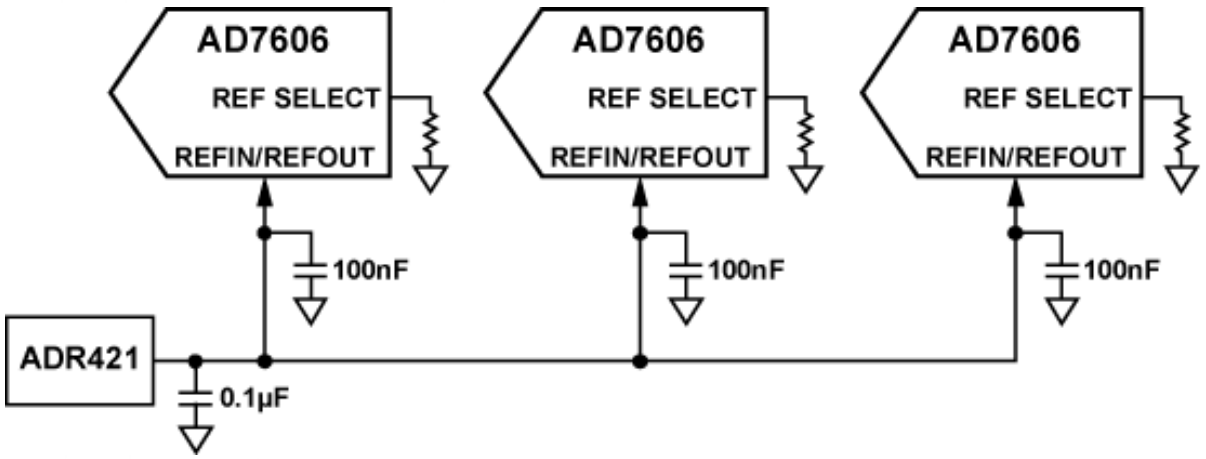
AD7606 Antialias Filter Frequency Response



±10V RANGE	0.1dB	3dB
–40	10,303	24,365Hz
+25	9619	23,389Hz
+85	9326	22,607Hz

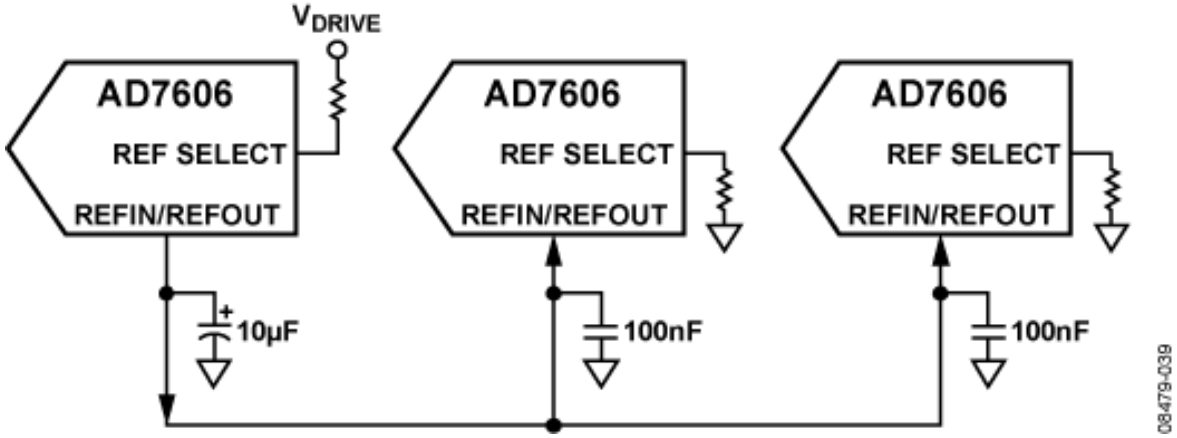
±5V RANGE	0.1dB	3dB
–40	5225	16,162Hz
+25	5225	15,478Hz
+85	4932	14,990Hz

AD7606 Using external reference



- **Where absolute gain PFS error is important an external reference should be used for multiple ADCs**
- **Ideal code = Vin/10V * 2^15**
- **Actual code = Vin/10V * 2^15* (REFIN/2.5V)**
- **Choose a tight tolerance reference with low drift when absolute gain error is important.**

AD7606 Using Internal reference



- **Where PFS error matching is important the internal ref on one AD7606 can be used as the ref for other AD7606 devices.**
- **If the same reference is used for multiple AD7606 devices ANY channel on ANY AD7606 device will always be within 32 codes of any other AD7606 channel (irrespective of temperature)**

AD7606 Digital Filter

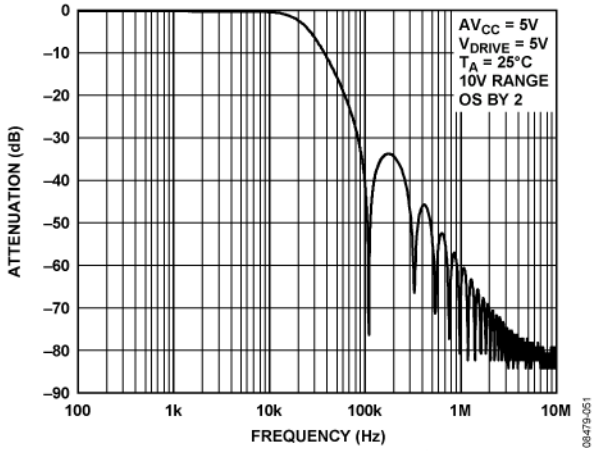
- **Easy to use -> Pin driven**
  - OS 2, OS 1, OS 0
- **Oversampling ratio**
  - 2x, 4x, 8x, 16, 32x, 64X
- **Digital Filter is a sinc filter**
  - simply accumulates, averages and decimates
- **Features of Digital Filter**
  - Improves SNR by 3dB for every doubling in oversampling ratio
  - decreases thruput by 2X by every doubling in oversampling ratio
  - Reduces analog input 3dB bandwidth by increasing oversampling ratio
- **AD7606 analog anti-alias filter, ADC and digital filter is the complete Data Acquisition System.**

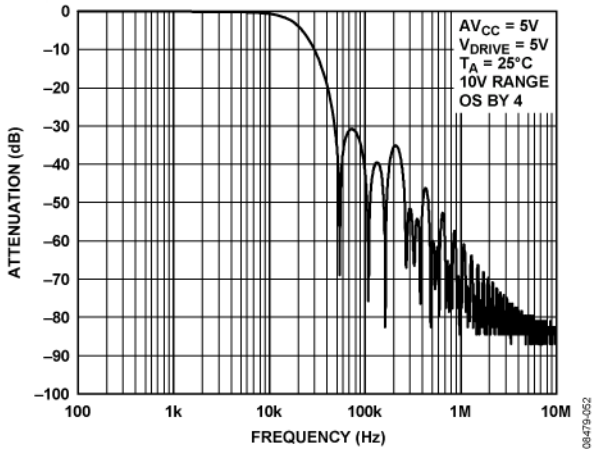
Digital Filter

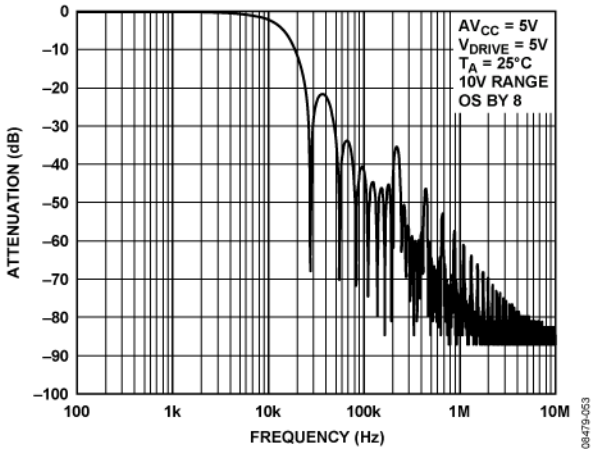
OS[2:0]	OS Ratio	SNR 5 V Range (dB)	SNR 10 V Range (dB)	3 dB BW 5 V Range (kHz)	3 dB BW 10 V Range (kHz)	Maximum Throughput CONVST Frequency (kHz)
000	No OS	89	90	15	22	200
001	2	91.2	92	15	22	100
010	4	92.6	93.6	13.7	18.5	50
011	8	94.2	95	10.3	11.9	25
100	16	95.5	96	6	6	12.5
101	32	96.4	96.7	3	3	6.25
110	64	96.9	97	1.5	1.5	3.125
111	Invalid					

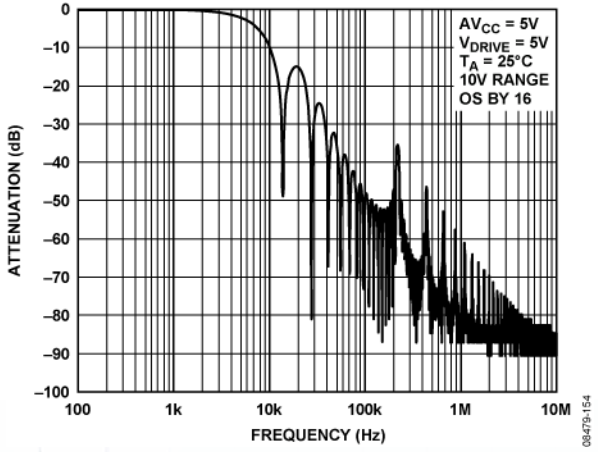
- **SNR improves as OS rate increased**
- **3dB Bandwidth reduces**
- **Maximum allowed CONVST sample rate reduces**

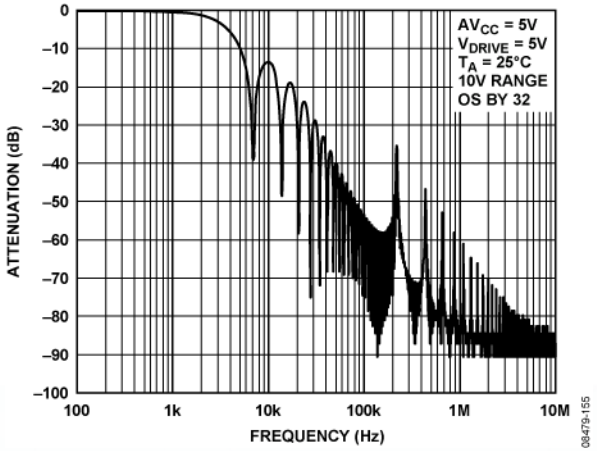
Digital Filter Responses by OS Rate

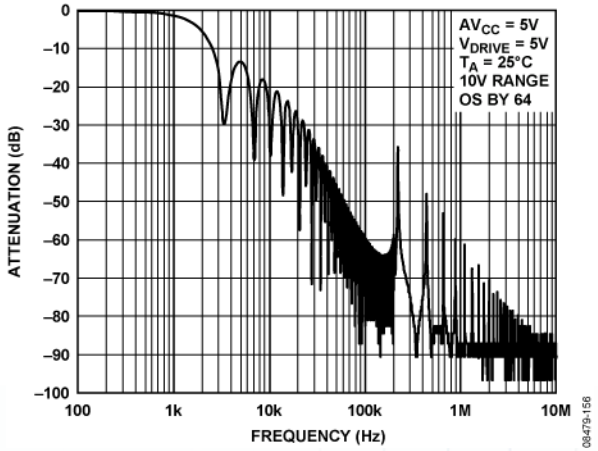












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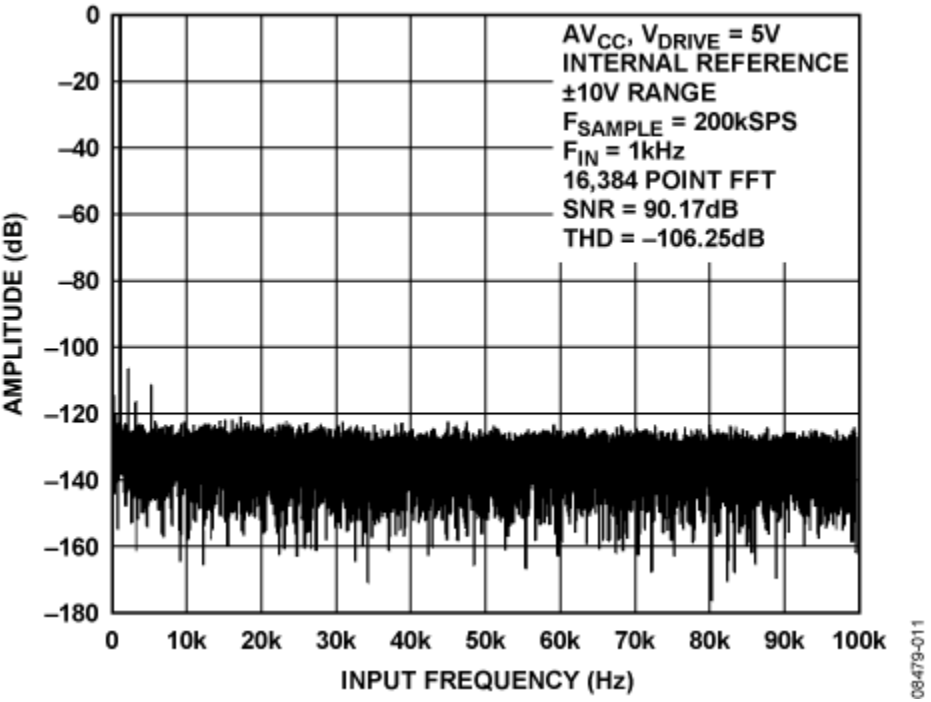
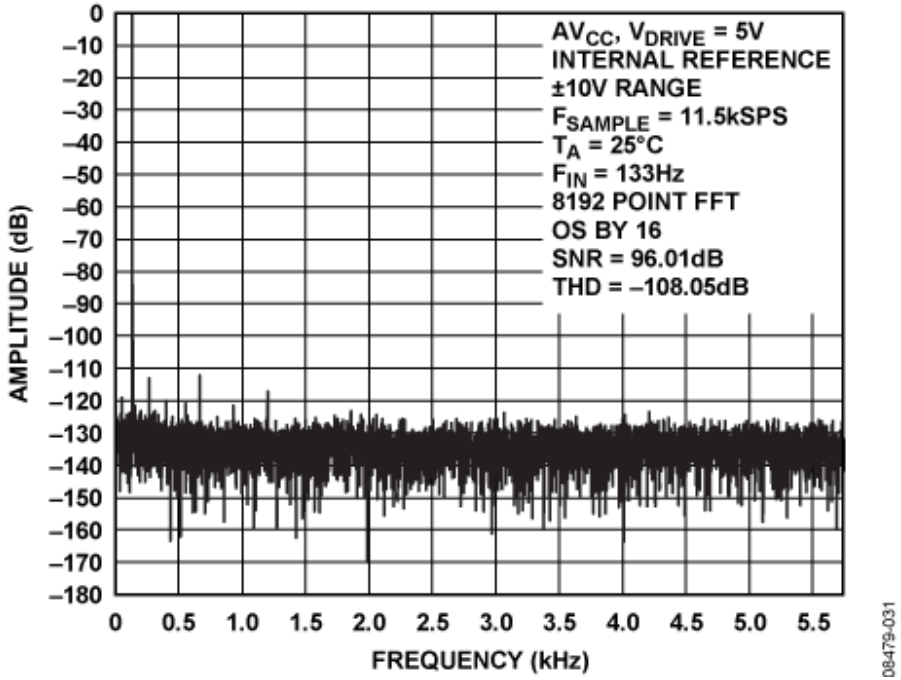
Benefit of Oversampling





No Oversampling

Oversampling x 16

Histogram of Codes (No OS to OS32)

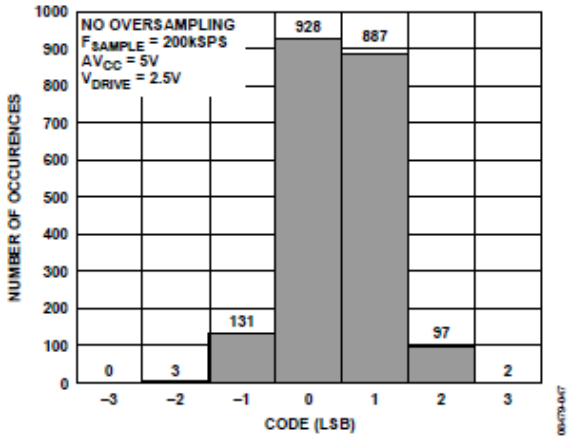


Figure 49. Histogram of Codes—No OS (Six Codes)

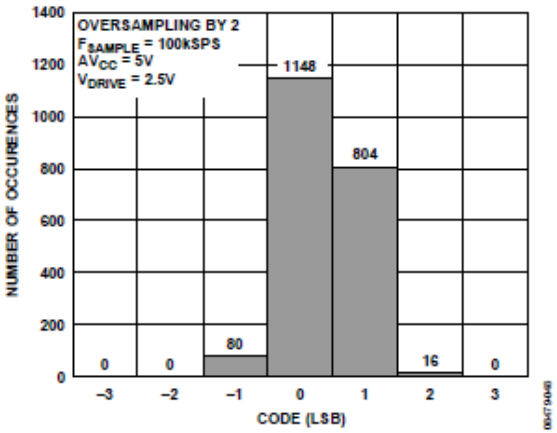


Figure 50. Histogram of Codes—OS × 2 (Four Codes)

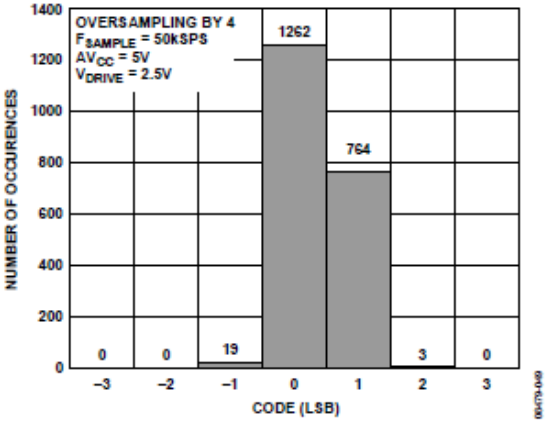


Figure 51. Histogram of Codes—OS × 4 (Four Codes)

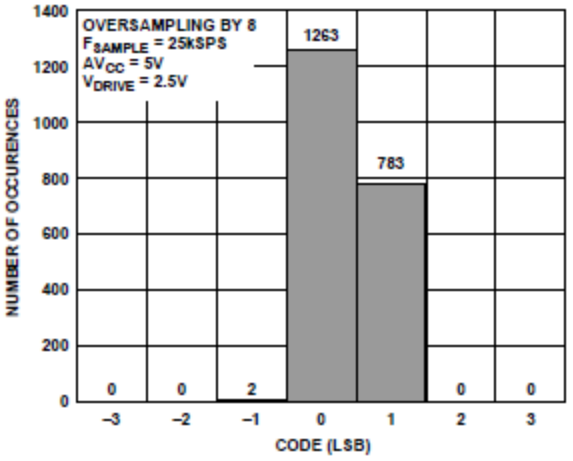


Figure 52. Histogram of Codes—OS × 8 (Three Codes)

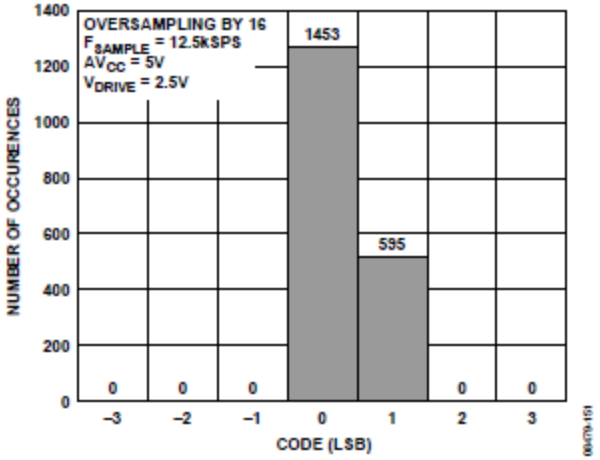


Figure 53. Histogram of Codes—OS × 16 (Two Codes)

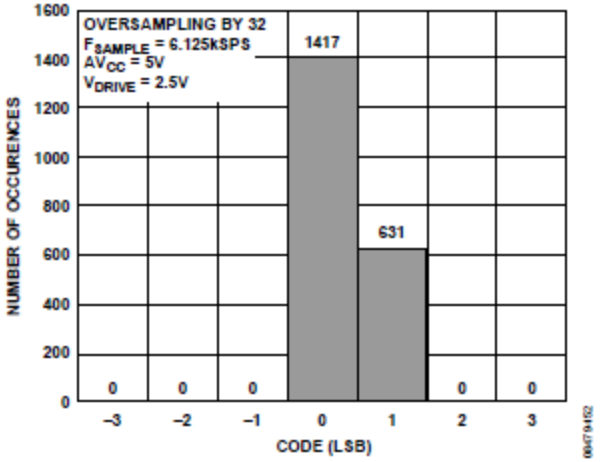
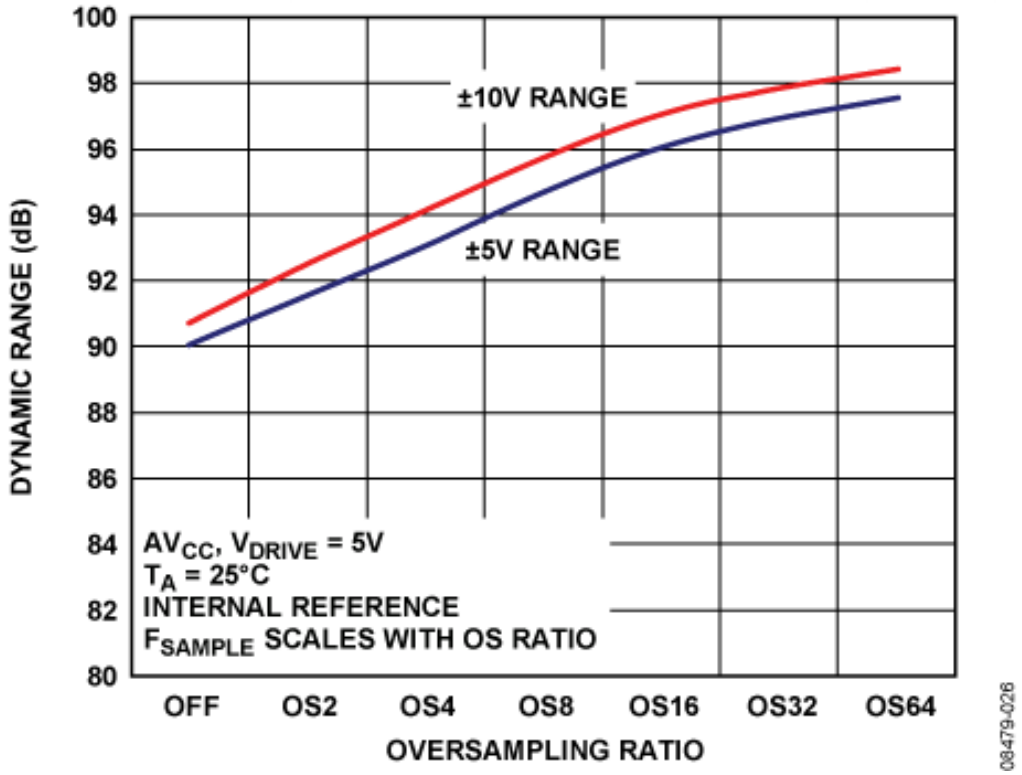


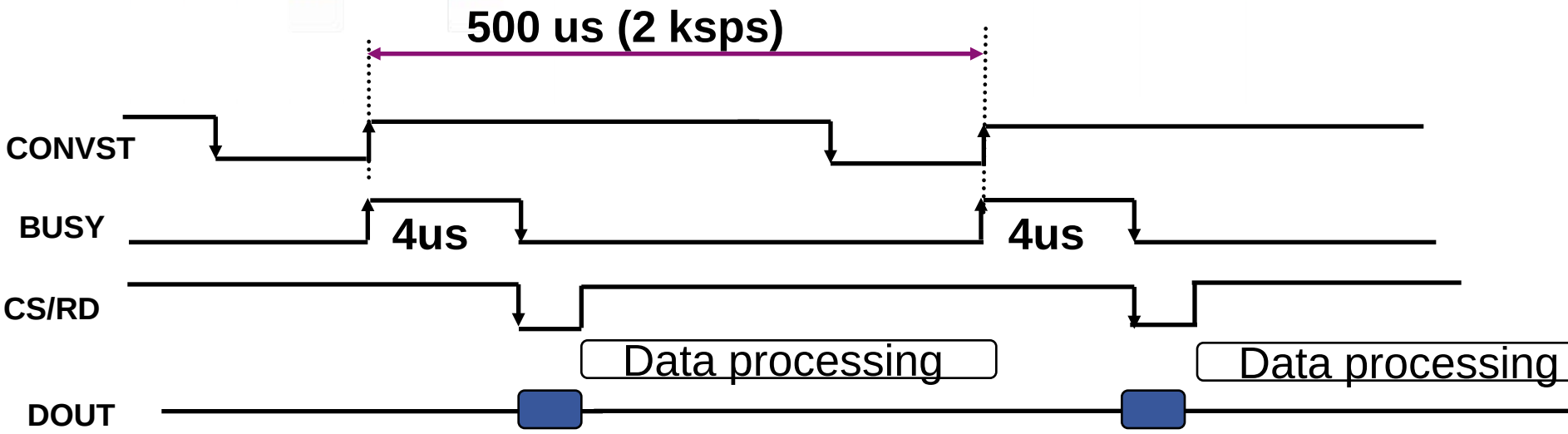
Figure 54. Histogram of Codes—OS × 32 (Two Codes)

ANALOG DEVICES

Oversampling Increases Dynamic Range

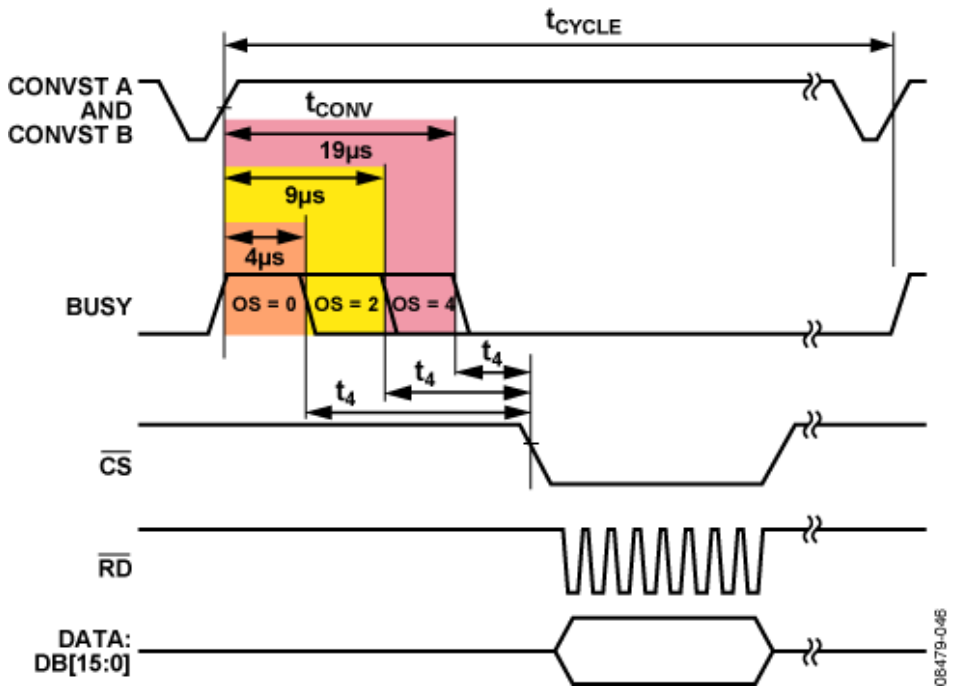


Current Interface Solution (AD7606-OS off)

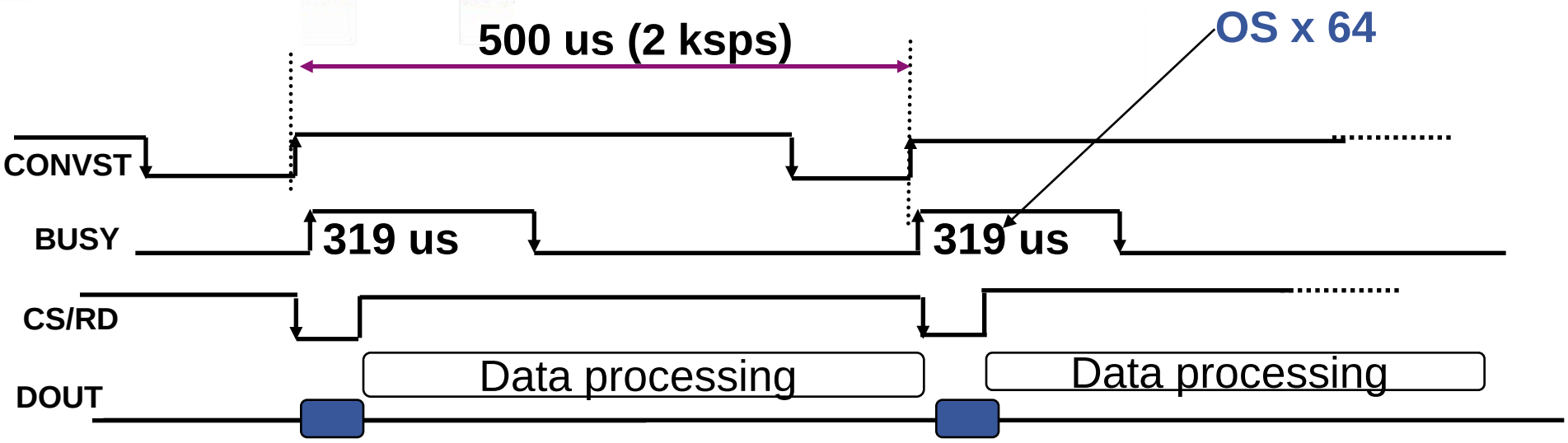


- All channels are read after the BUSY high time.
- Depending on the number of ADC devices on the boards, could be up to ~ 495 us processing time.
- But with the AD7606, a read is allowed during conversion and CONVST can idle high or low

Oversampling extends BUSY High Time



AD7606 over sampling solution



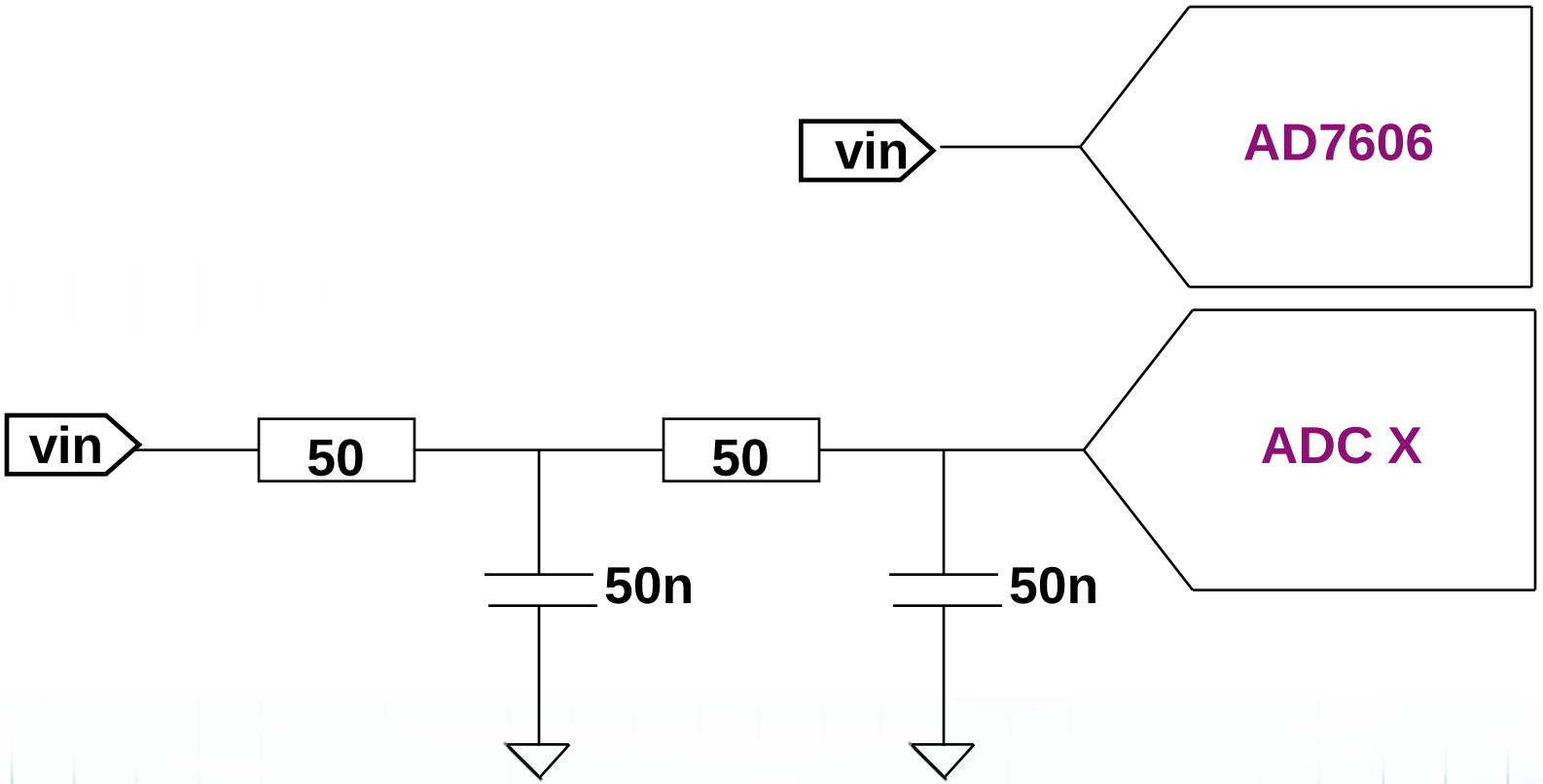
- CONVST rising edge could be used to trigger a read from the AD7606 during conversion.
- A read of all 8 AD7606 channels is ~ 240 ns.
- CONVST rising edge will start a new conversion.
- This method of using the AD7606 will have little effect on data processing time.
- It will yield benefits in noise performance and code spread.

Substation Automation Design Examples

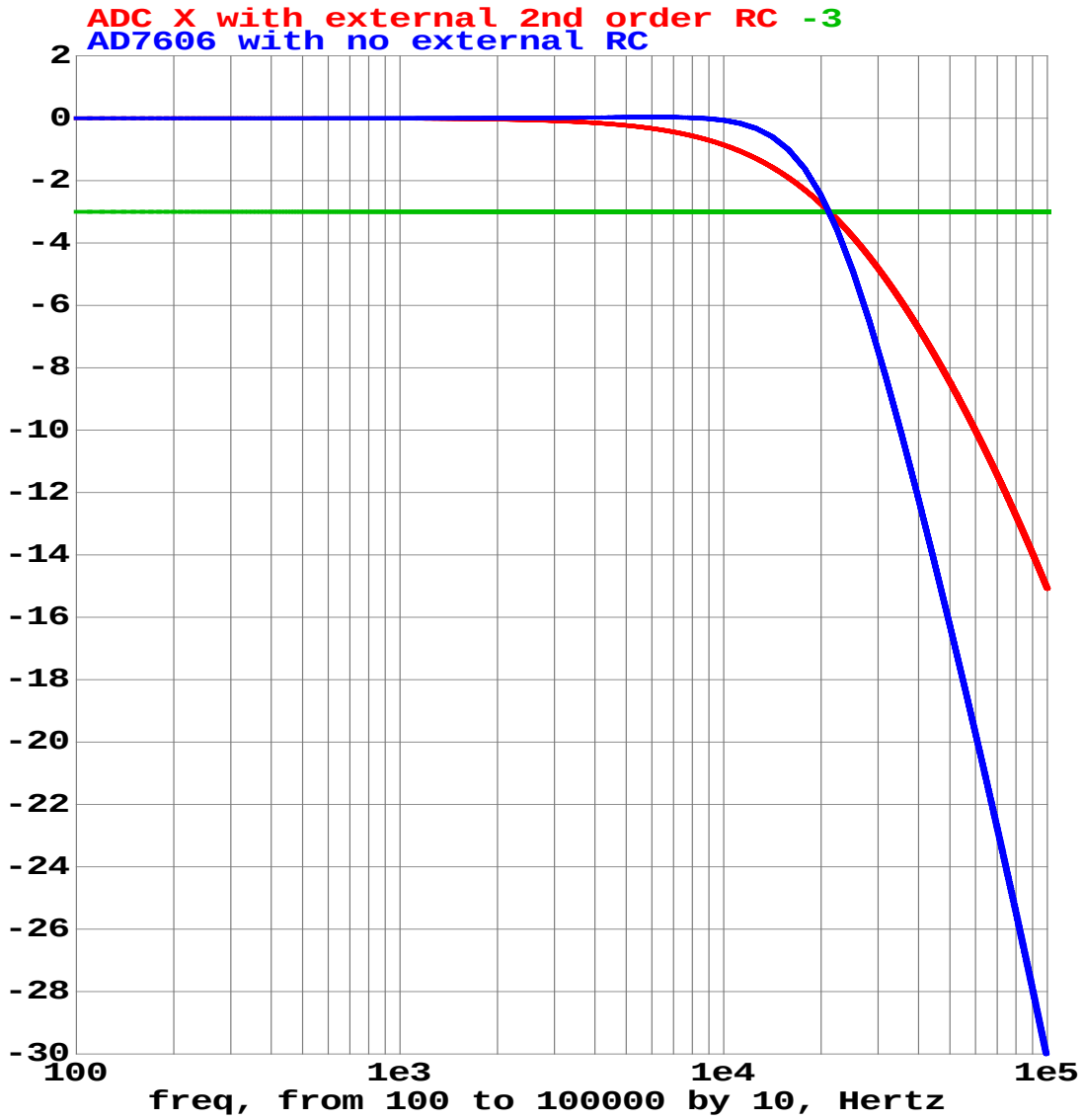
- **Purpose of examples**
  - Compare AD7606 versus traditional bipolar input ADC (ADC X)
  - How to best use AD7606 analog and digital filters.
- **AD7606**
  - 1Meg resistor input, impedance fixed with thruput.
  - Integrated 2nd order anti-alias active low pass filter
  - Integrated digital sinc low pass filter
- **ADC X (other bipolar ADCs e.g. AD7656)**
  - Capacitor input, impedance varies with throughput
  - No on chip analog anti-alias filter
  - No on chip Digital Filter

Example 1: Need a 22kHz -3dB bandwidth

- AD7606 -> using internal 2nd order active analog filter, digital filter disabled (no external circuitry required)
- ADC X -> with external 2nd order RC



Example 1: Need a 22kHz -3dB bandwidth



ADC X with 2nd order RC
3db Freq = 22kHz
0.1db freq = 3.4kHz
Attenuation @100kHz = -15dB

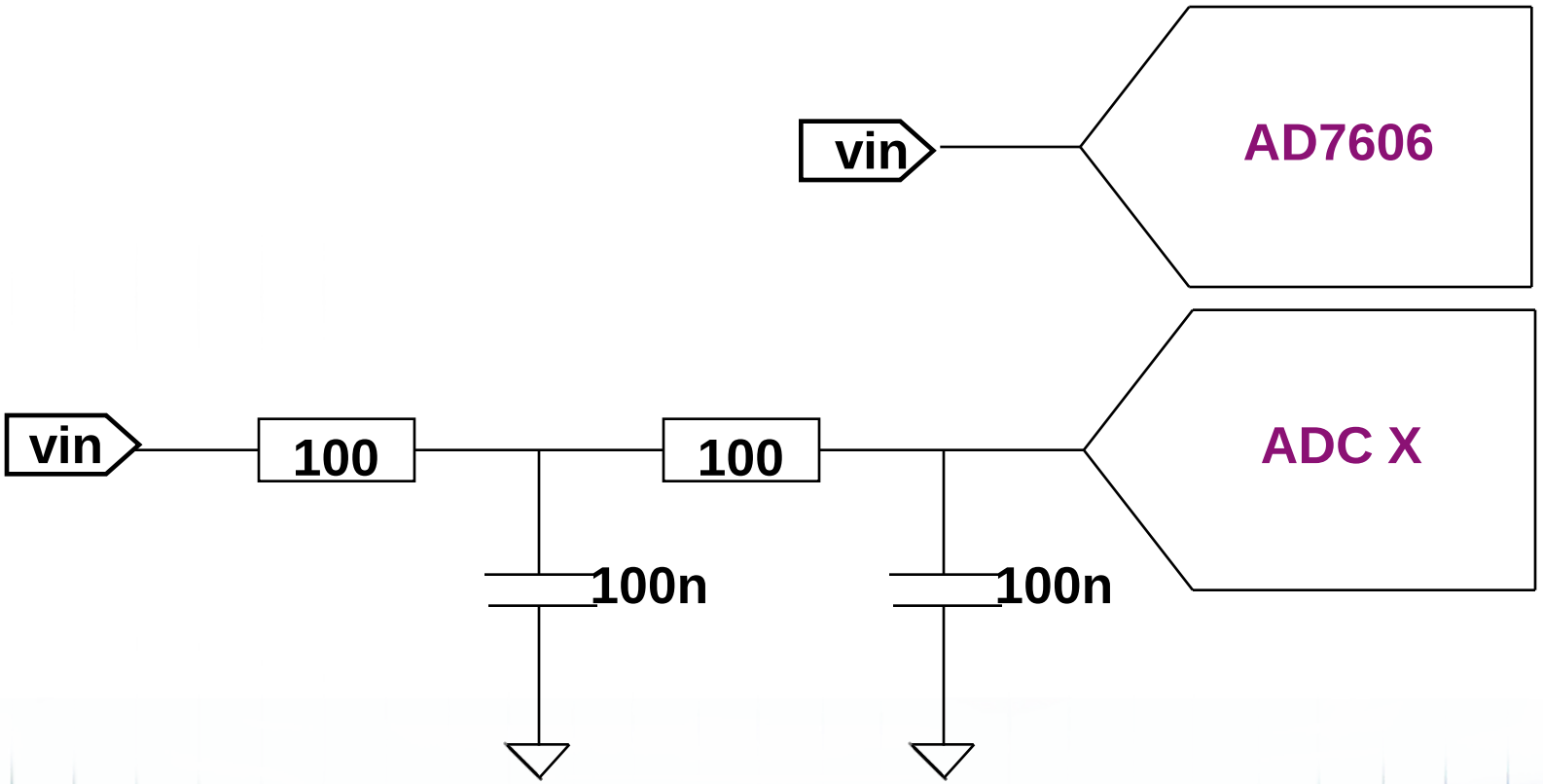
AD7606 with internal filters
3db Freq = 22kHz
0.1db freq = 10kHz
Attenuation @100kHz = -30dB

External R-C filter has attenuation in pass band.

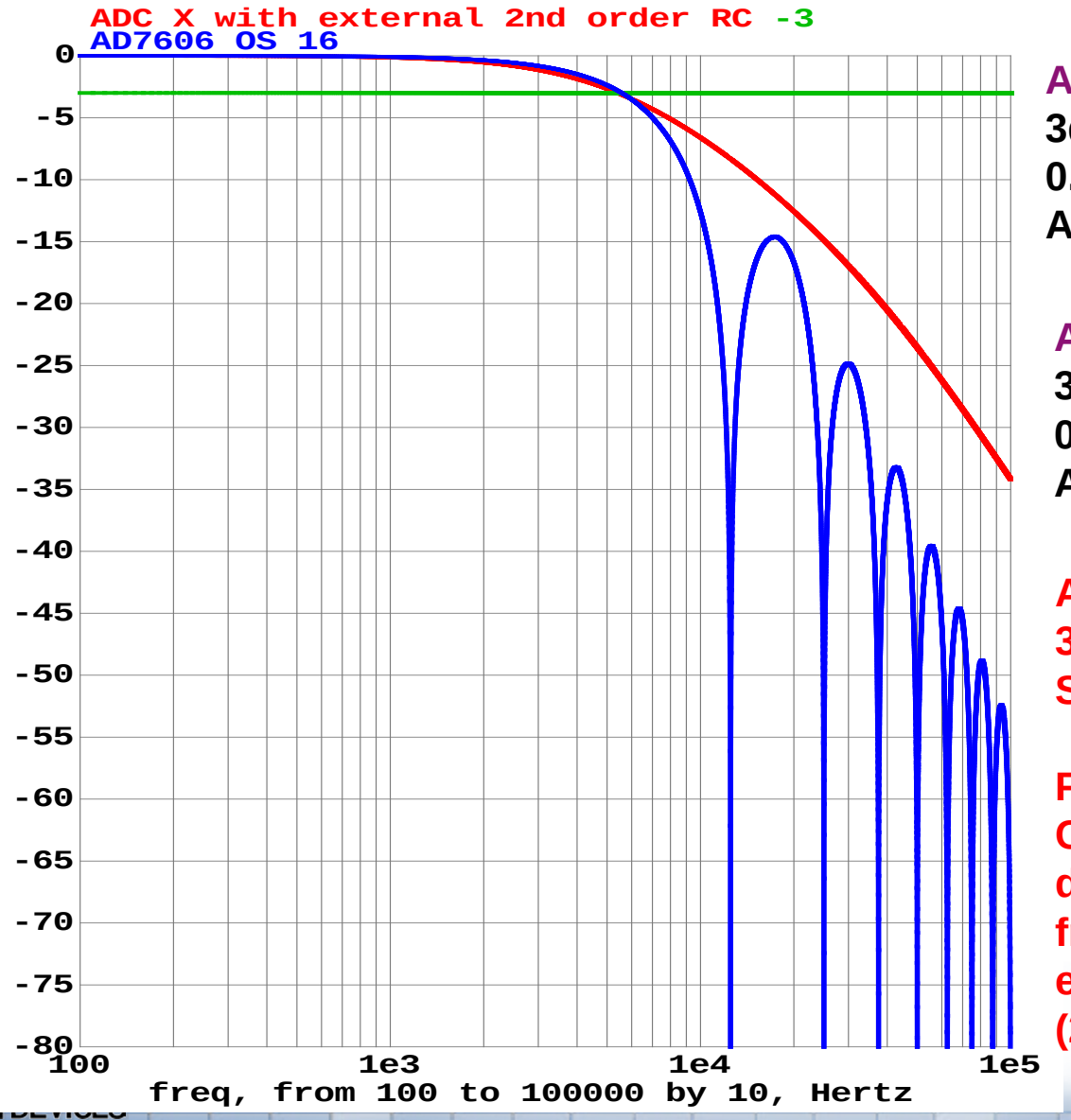
AD7606 internal filter is 2nd order active which is optimised for gain flatness in pass band and good roll off at higher frequencies.

Example 2: Need a 5.5kHz -3dB bandwidth

- AD7606 -> using internal 2nd order active analog filter and internal digital filter enabled (OS 16)
- ADC X -> with external 2nd order RC



Example 2: Need a 5.5kHz -3dB bandwidth



ADC X with 2nd order RC
3db Freq = ~5.5kHz
0.1db freq = 830hZ
Attenuation @100kHz = -35dB

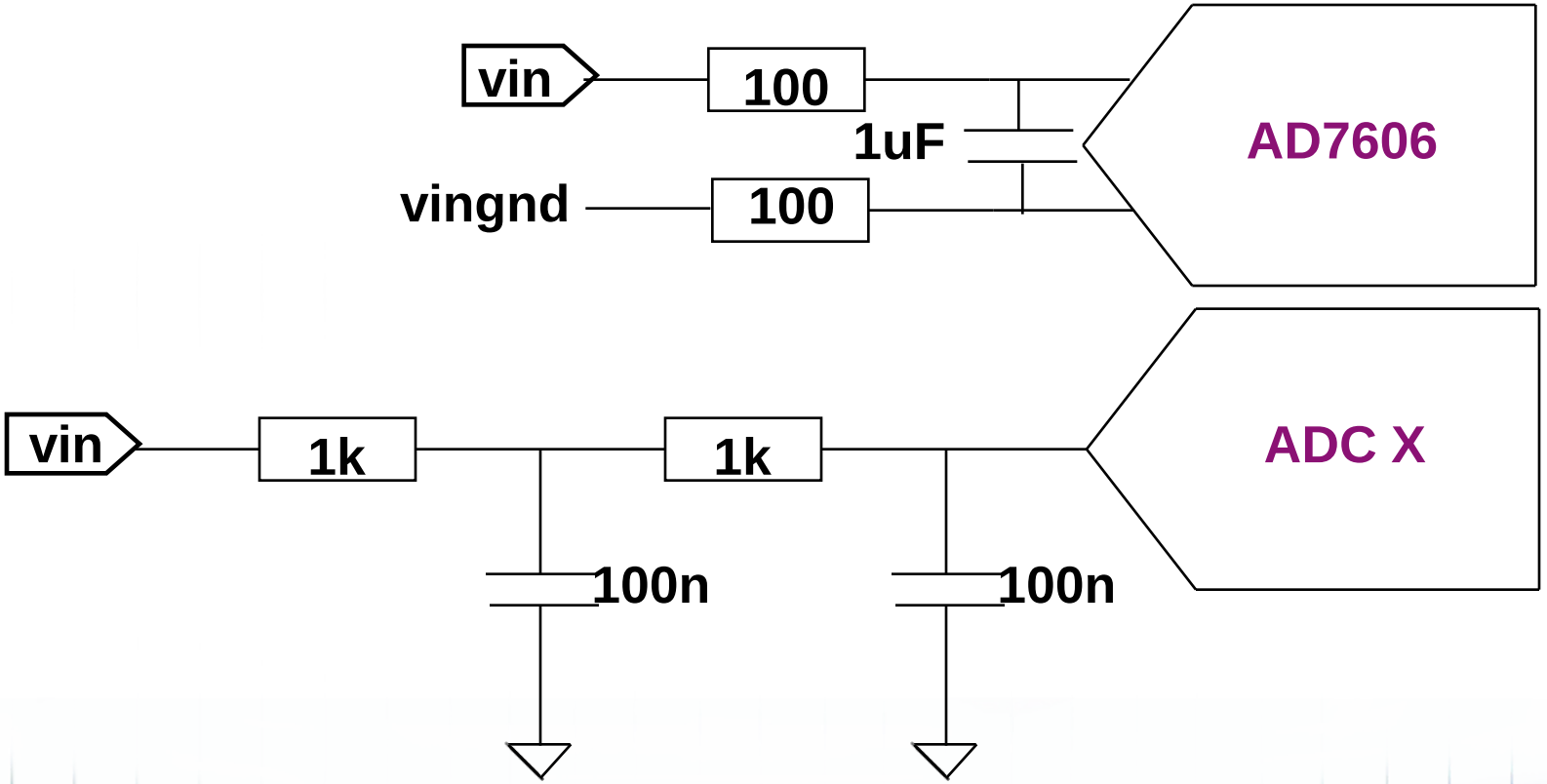
AD7606 with internal filters
3db Freq = ~5.5kHZ
0.1db freq = 1100hZ
Attenuation @100kHz = -55dB

AD7606 digital filter reduces 3dB frequency and improves SNR.

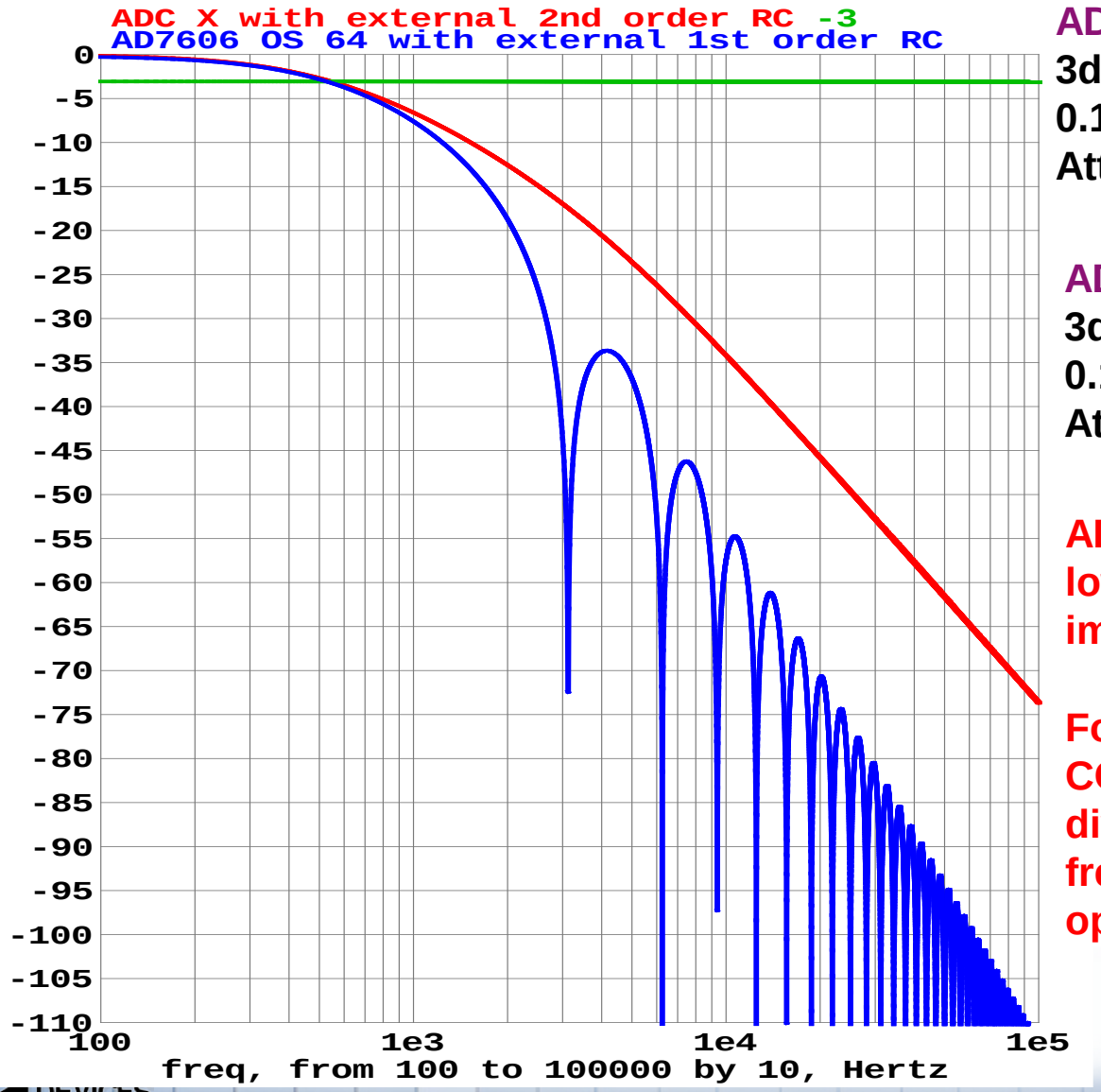
For more rejection align CONVST sample frequency on divisions of internal sampling frequency (200ksps). This example optimum is 12.5kHz (200k/16)

Example 3: Need a 550hZ -3dB bandwidth

- AD7606 -> using internal 2nd order active analog filter, internal digital filter enabled (OS 64) and external 1st order RC
- ADC X -> with external 2nd order RC



Example 3: Need a 550hZ -3db bandwidth



ADC X with 2nd order RC
3db Freq = 550hZ
0.1db freq = 80hZ
Attenuation @100kHz = -75dB

AD7606 with internal filters
3db Freq = 550hZ
0.1db freq = 80hZ
Attenuation @100kHz = -110dB

AD7606 digital filter reduces lowers 3dB frequency and improves SNR.

For more rejection align CONVST sample frequency on divisions of internal sampling frequency (200k). This example optimum is 3.125kHz (200k/64)

ADC X needs an opamp per analog input

- **AD7606 gives a better filter response**
  - More gain flatness in pass band for wide bandwidth applications
  - More anti-alias rejection at higher frequencies
- **How to improve filter response of ADC X**
  - Increase external filter to 3rd order.
    - More attenuation in pass band using 3rd order RC.
    - Need to be careful with ADC X, external R impacts acquisition time, charging input cap. Can also affect distortion.
    - Need to switch to active filter -> Which means using an op-amp
- **Sample at higher frequency**
  - ADC X analog impedance varies with throughput.
  - Sampling at 100ksps requires an op-amp on the analog input as impedance is lower
- **Op-amp**
  - Need dual supplies on the board for the op-amp.
  - Op-amp adds noise, power, offset and gain errors and drift to the system.
  - Increased BOM Cost (8 op-amps) and design challenge to obtain best performance

AD7606 vs Competition

- 1 Mohm input impedance and Integrated input amplifier
- Fixed analog input impedance regardless of Fsample.
- ±16.5V input over voltage protection
- Integrated AA Filter and Digital Filter
  - AD7606 AA and Digital filter eliminates the need for complex external filtering circuitry
- Wide Dynamic range with Digital Filter
  - Up to 98 dB dynamic range
- Superior INL, THD and power specifications
- AD7606 is 33% smaller board solution and 83% cheaper decoupling solution compared to competitor 8 channel solution.
- Pin compatibility from 14 to 18 bits.

Family of DAS Solutions

Resolution	Single-Ended Inputs	True Differential Inputs	Number of Simultaneous Sampling Channels
18 Bits	AD7608	AD7609	8
16 Bits	AD7606		8
	AD7606-6		6
	AD7606-4		4
14 Bits	AD7607		8

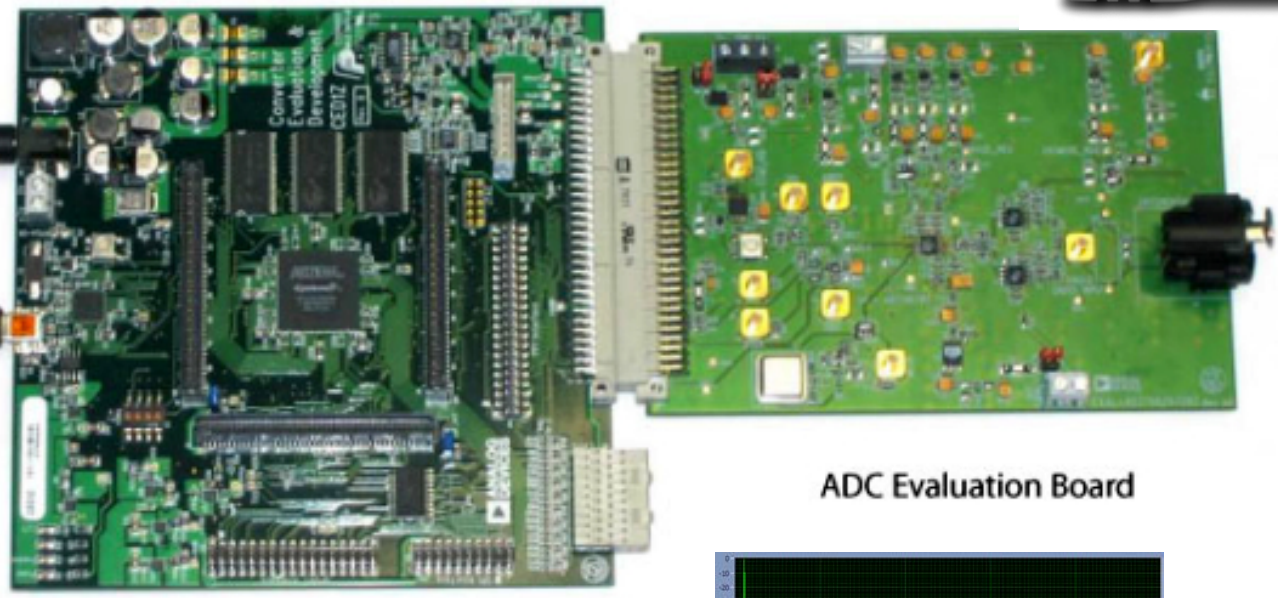
Test AD7606 with Evaluation Board

Function Generator

Converter Evaluation & Development Board

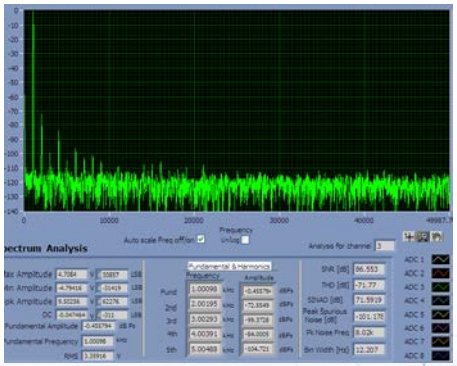
Power Supply: +7.5v DC @ 2A (Provided)

High-speed USB 2.0 cable (provided)



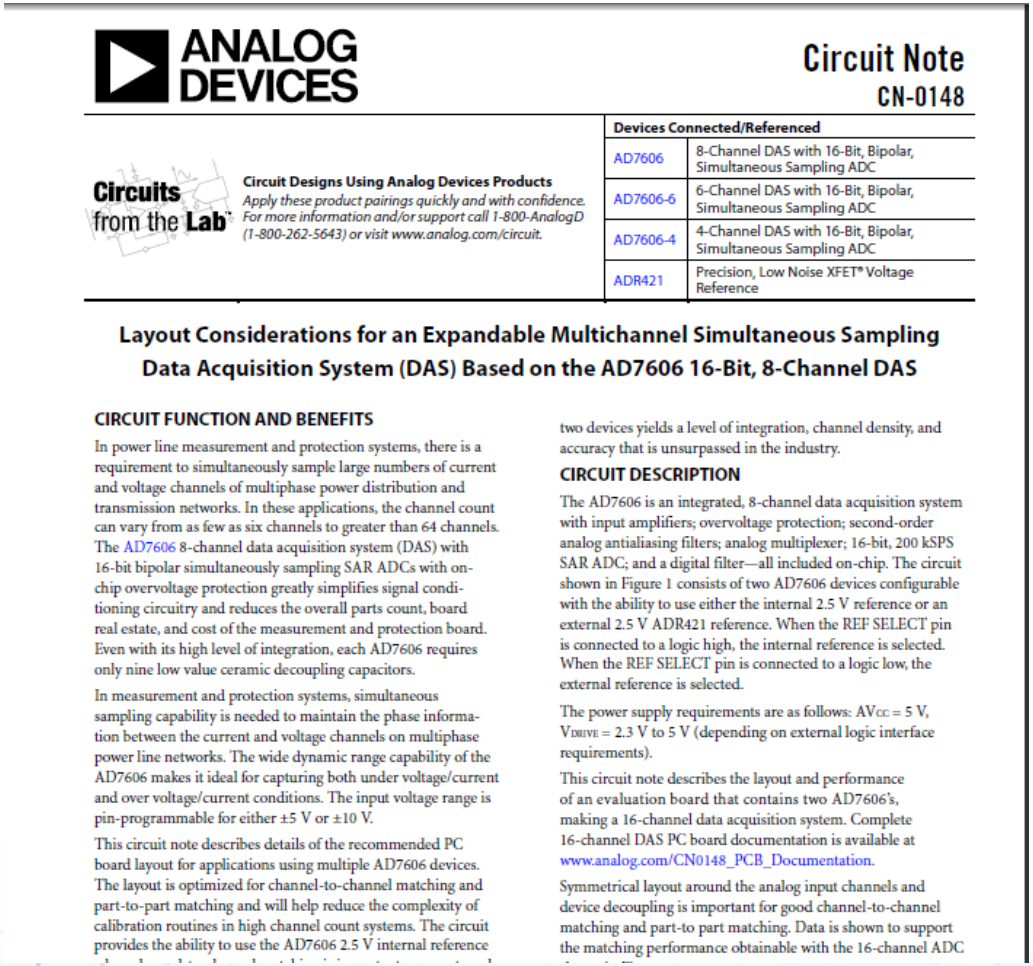
ADC Evaluation Board

PC Running Windows 2000 or XP with 1 free USB port



Layout Guidelines

CN0148 - Layout Considerations for an Expandable Multichannel Simultaneous Sampling Data Acquisition System (DAS) Based on the AD7606 16-Bit, 8-Channel DAS



ANALOG DEVICES

Circuit Note
CN-0148

Circuits from the Lab™

Circuit Designs Using Analog Devices Products
Apply these product pairings quickly and with confidence. For more information and/or support call 1-800-AnalogD (1-800-262-5643) or visit www.analog.com/circuit.

Devices Connected/Referenced	
AD7606	8-Channel DAS with 16-Bit, Bipolar, Simultaneous Sampling ADC
AD7606-6	6-Channel DAS with 16-Bit, Bipolar, Simultaneous Sampling ADC
AD7606-4	4-Channel DAS with 16-Bit, Bipolar, Simultaneous Sampling ADC
ADR421	Precision, Low Noise XFET® Voltage Reference

Layout Considerations for an Expandable Multichannel Simultaneous Sampling Data Acquisition System (DAS) Based on the AD7606 16-Bit, 8-Channel DAS

CIRCUIT FUNCTION AND BENEFITS

In power line measurement and protection systems, there is a requirement to simultaneously sample large numbers of current and voltage channels of multiphase power distribution and transmission networks. In these applications, the channel count can vary from as few as six channels to greater than 64 channels. The AD7606 8-channel data acquisition system (DAS) with 16-bit bipolar simultaneously sampling SAR ADCs with on-chip overvoltage protection greatly simplifies signal conditioning circuitry and reduces the overall parts count, board real estate, and cost of the measurement and protection board. Even with its high level of integration, each AD7606 requires only nine low value ceramic decoupling capacitors.

In measurement and protection systems, simultaneous sampling capability is needed to maintain the phase information between the current and voltage channels on multiphase power line networks. The wide dynamic range capability of the AD7606 makes it ideal for capturing both under voltage/current and over voltage/current conditions. The input voltage range is pin-programmable for either ±5 V or ±10 V.

This circuit note describes details of the recommended PC board layout for applications using multiple AD7606 devices. The layout is optimized for channel-to-channel matching and part-to-part matching and will help reduce the complexity of calibration routines in high channel count systems. The circuit provides the ability to use the AD7606 2.5 V internal reference

two devices yields a level of integration, channel density, and accuracy that is unsurpassed in the industry.

CIRCUIT DESCRIPTION

The AD7606 is an integrated, 8-channel data acquisition system with input amplifiers; overvoltage protection; second-order analog antialiasing filters; analog multiplexer; 16-bit, 200 kSPS SAR ADC; and a digital filter—all included on-chip. The circuit shown in Figure 1 consists of two AD7606 devices configurable with the ability to use either the internal 2.5 V reference or an external 2.5 V ADR421 reference. When the REF SELECT pin is connected to a logic high, the internal reference is selected. When the REF SELECT pin is connected to a logic low, the external reference is selected.

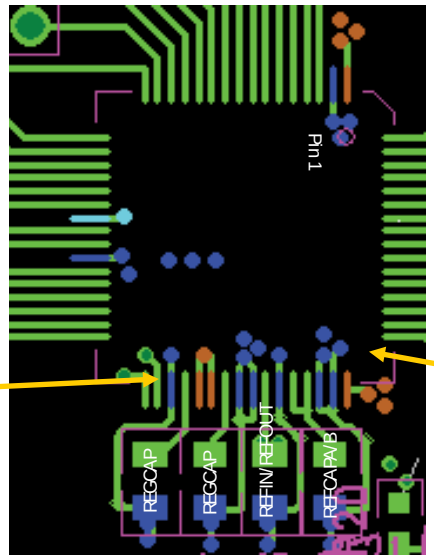
The power supply requirements are as follows: AV_{CC} = 5 V, V_{DRIVE} = 2.3 V to 5 V (depending on external logic interface requirements).

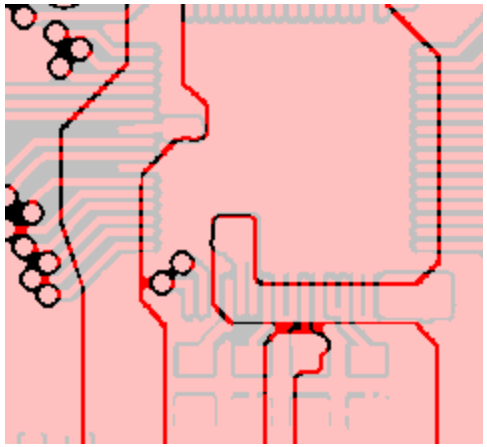
This circuit note describes the layout and performance of an evaluation board that contains two AD7606's, making a 16-channel data acquisition system. Complete 16-channel DAS PC board documentation is available at www.analog.com/CN0148_PCB_Documentation.

Symmetrical layout around the analog input channels and device decoupling is important for good channel-to-channel matching and part-to part matching. Data is shown to support the matching performance obtainable with the 16-channel ADC

Decoupling for the AD7606

- **REFIN/REFOUT, REFCAPA, REFCAPB and REGCAP pins are critical caps for the AD7606 performance.**
- **Ideally these caps should be placed on the same side of the board as the AD7606 device.**





Parallel Bus

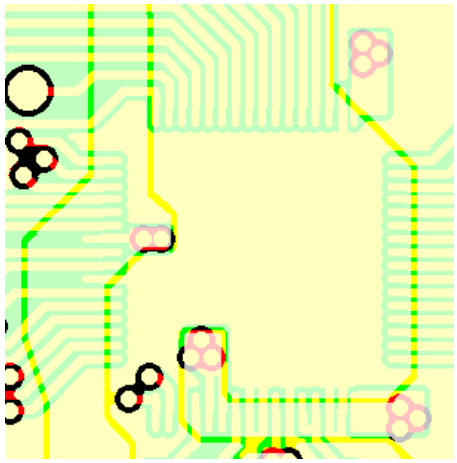
Low impedance path to GND - Pins grounded to the north and south of pin

Analog Inputs

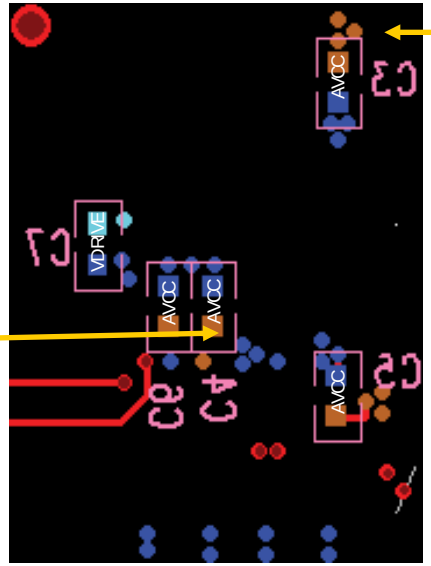
Multiple vias to connect to GND plane

Bottom layer decoupling for the AD7606

- Use the bottom layer for power supply decoupling caps.
- AVCC and VDRIVE decoupling located on bottom layer.



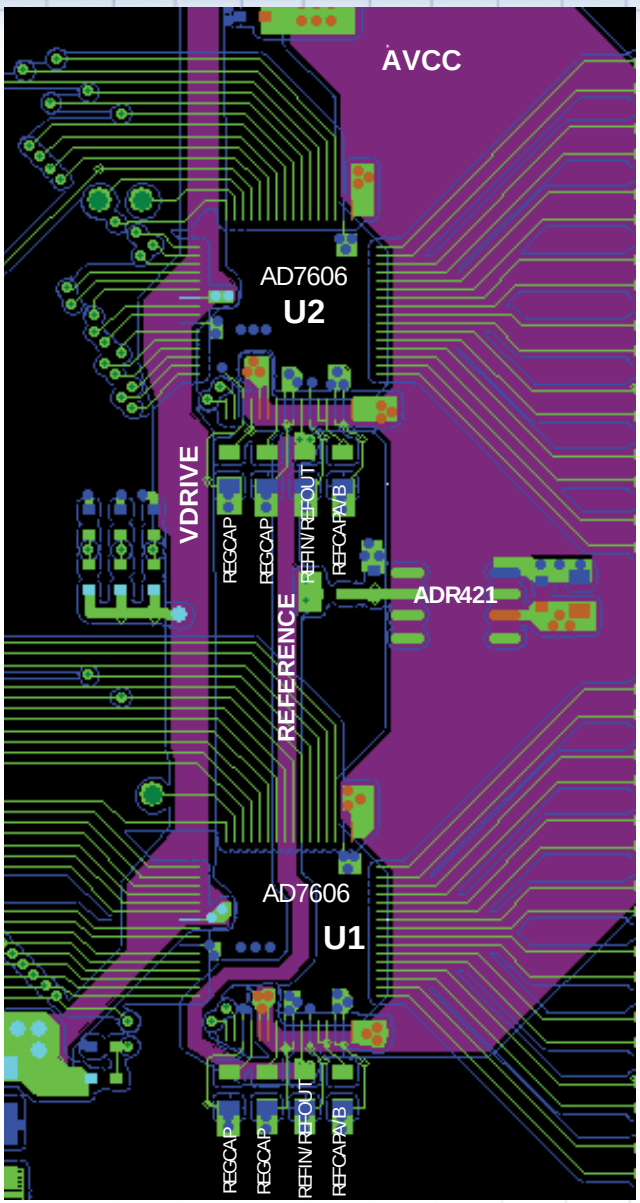
Can share decoupling cap if placed close to pins (37,38)



Multiple vias used to connect to the supply track/plane

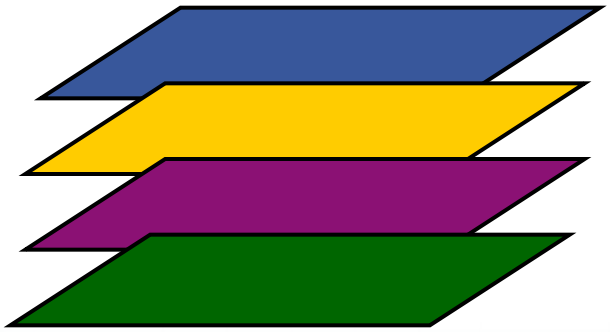
Power Supply routing

- Use large traces for the supply tracks.
- Ideally use a power plane.
- Layer 3 is dedicated to supply and reference routing and also ground.
- AVCC supply runs to the right of the device.
- VDRIVE track runs to the left of the device.
- Reference ADR421 is located between U1 and U2.
- The reference voltage track runs north to U1 and south to U2



Grounding for the AD7606

- **Use large area ground planes for low impedance return paths.**
- **Dedicate at least 40 % of connector pins for ground.**
- **In a 4 layer board, at least one layer should be dedicated for the ground plane.**
- **In a greater than 4 layer board multiple layers should be dedicated for ground planes and these should be evenly distributed throughout the layer stack.**



Layer 1: components, signal routing and grounding

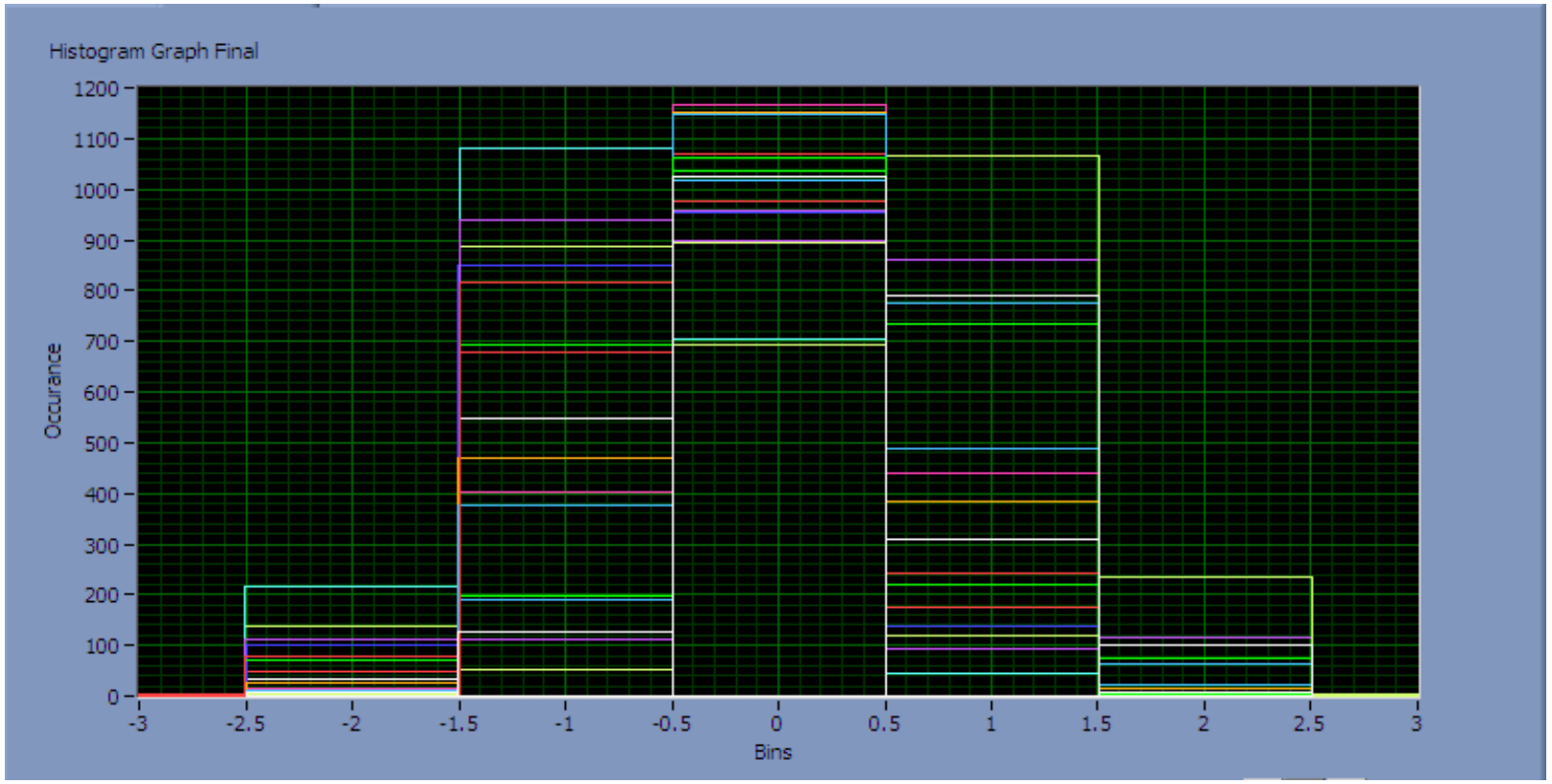
Layer 2: ground plane

Layer 3: power/ground plane and ref routing

Layer 4: signal routing and soldering

16 Channel Histogram

Optimised Channel to Channel Matching



Smart Grid Applications and Trends

Transmission & Distribution:

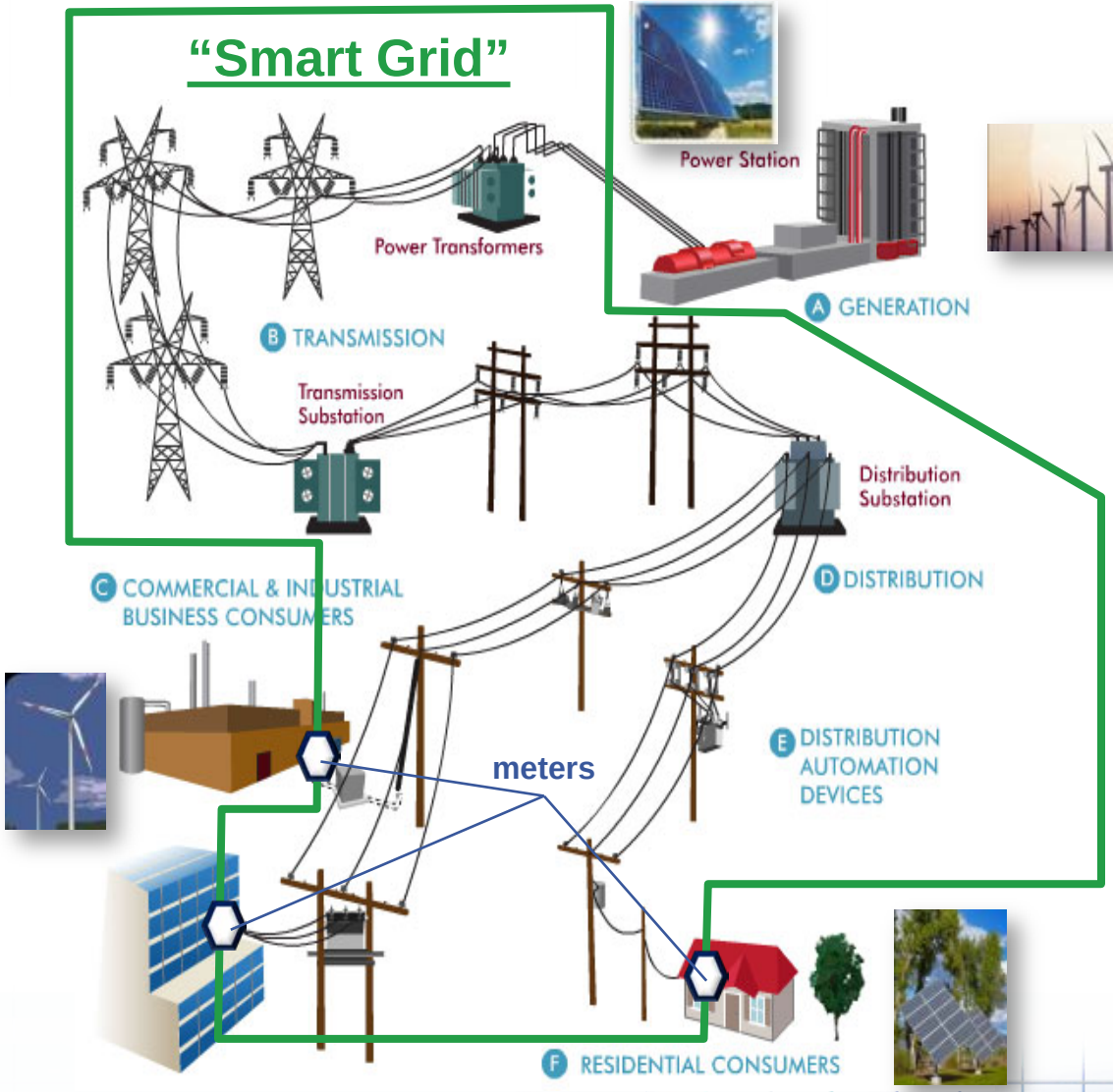
- Increasing grid measurement & control
- New vs. upgraded infrastructure
- Advanced sensing technologies

Smart Meter:

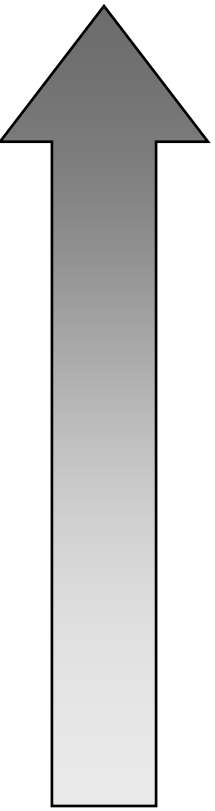
- Communications – RF or PLC
- Flexibility vs. cost
- High regional variation

Solar/Wind Energy:

- Central inverters vs. micro inverters (solar)
- Government subsidy dependence
- Energy storage



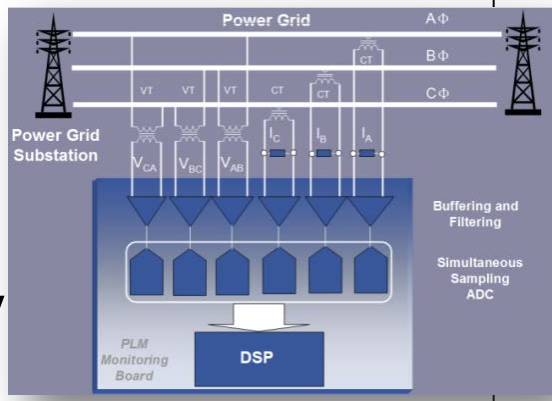
Power Line Monitoring Market – Voltage Segments



Category	Voltage level	Classification	Front-end Needs	Processor Needs
High End Voltages	>110 kV	Power Bus Monitoring, Power generation stations	Simultaneous Sampling Dynamic Range	Fast response Minimal latency Floating point DSP Multiprocessing
Mid-End Voltages	<110 kV, >3.5kV	Power Bus Monitoring	Functionally the same as high-end, Reduced performance compared to high-end	Fast response Minimal latency Floating point & Fixed Point math Multiprocessing in some cases
Low End Voltages	<3.5 kV	Power Line Monitoring / Protection	Multiplexed 14/16 bit-ADC	Typically Fixed Point DSP Connectivity

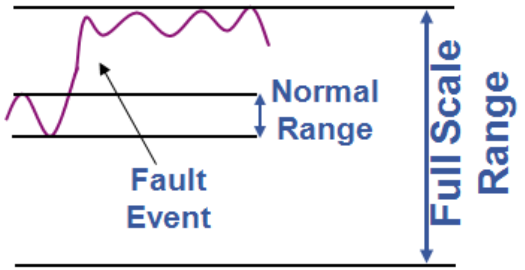
Substation Automation

- **Power grid – becoming more complex**
  - **Developing economies, upgrading, SMART grid**
- **Higher kV transmission**
- **Customers require increased monitoring and protection**
  - **Continuity of supply**
  - **Power Quality**
  - **Fault Detection e.g. Lightening strikes**

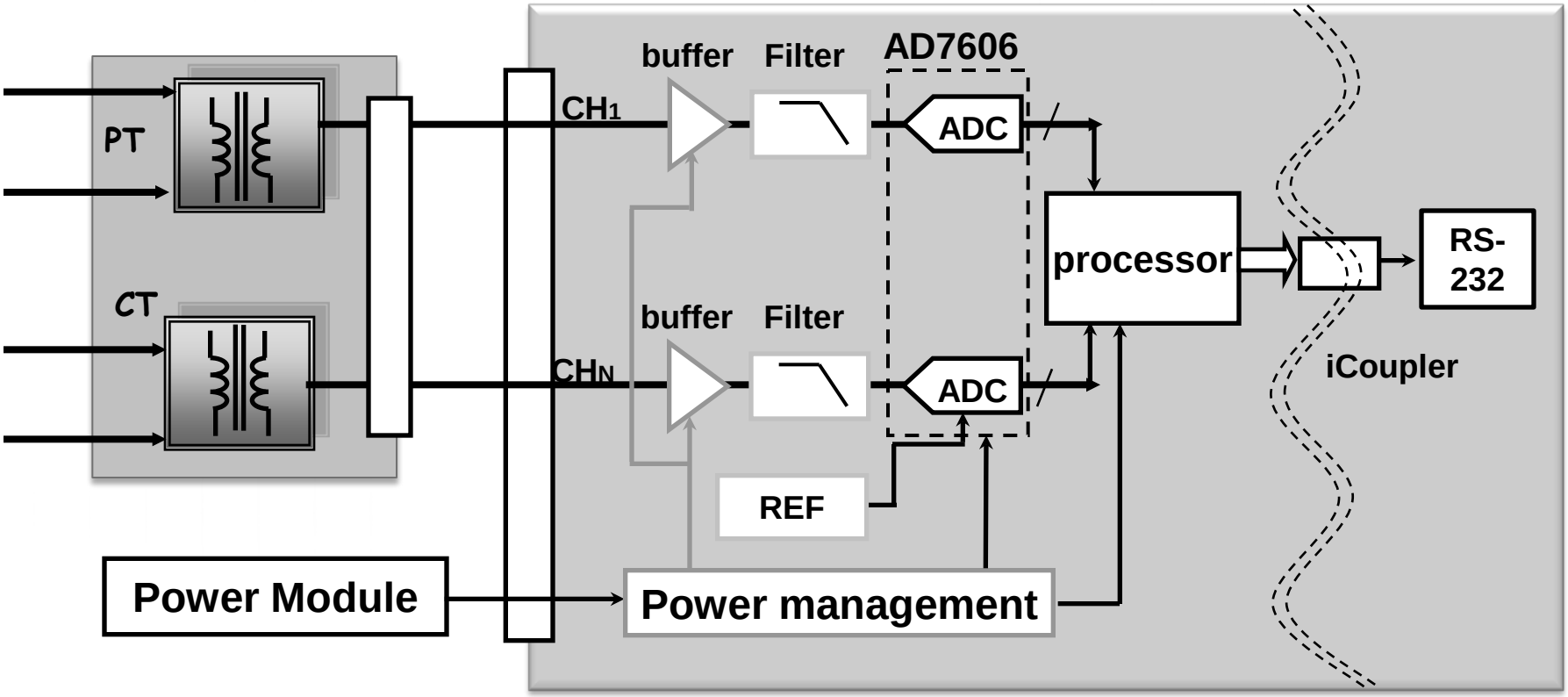


“Relay Protection & Measurement” - 35kV to 500 kV

- Preserve phase information – time stamp data
- Sample I & V to capture over/under I & V conditions.
- 16 bit resolution requirement to provide wide dynamic over/under Current and Voltage conditions
- Bipolar ADC capability

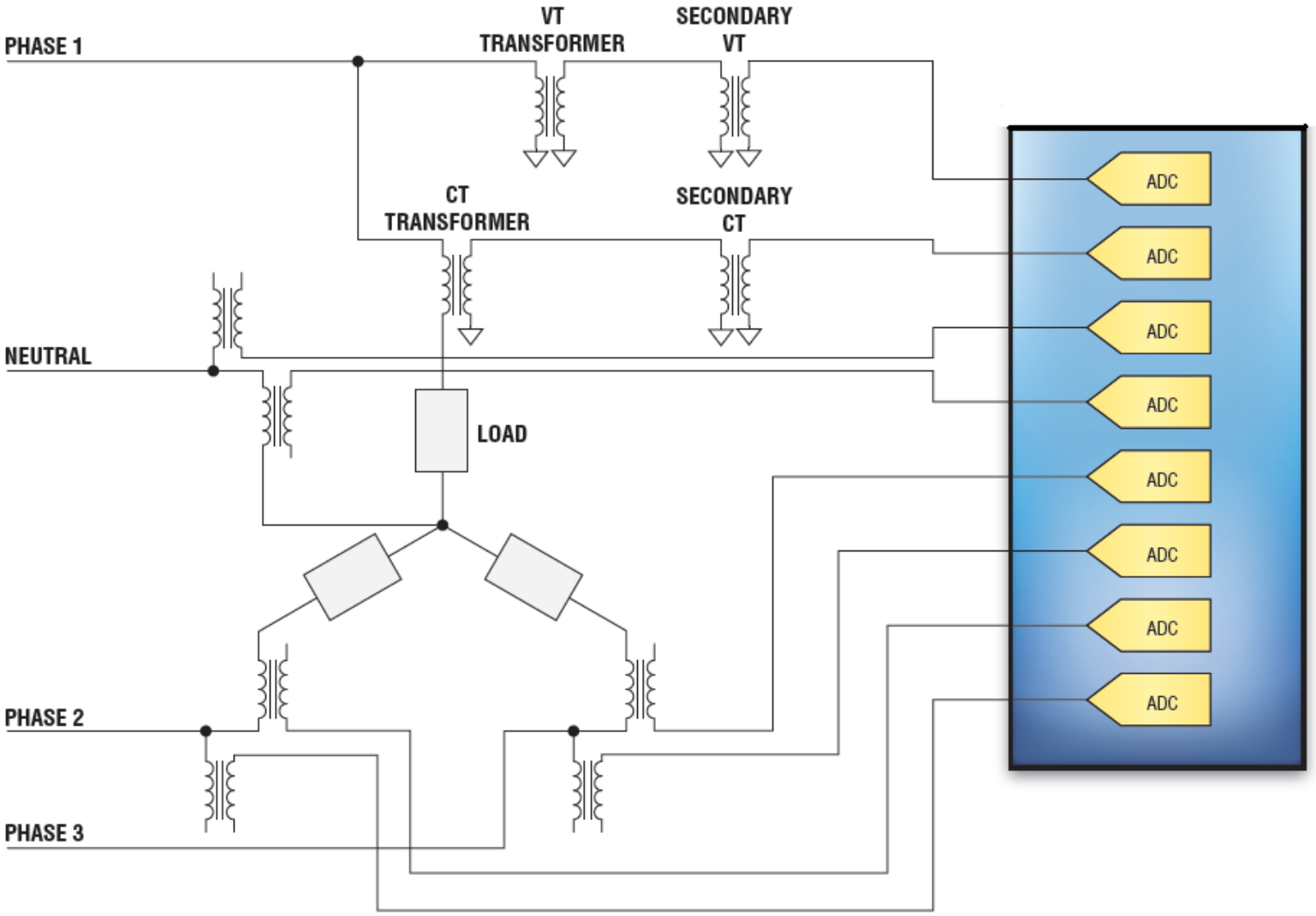


Protection and measurement SA Application

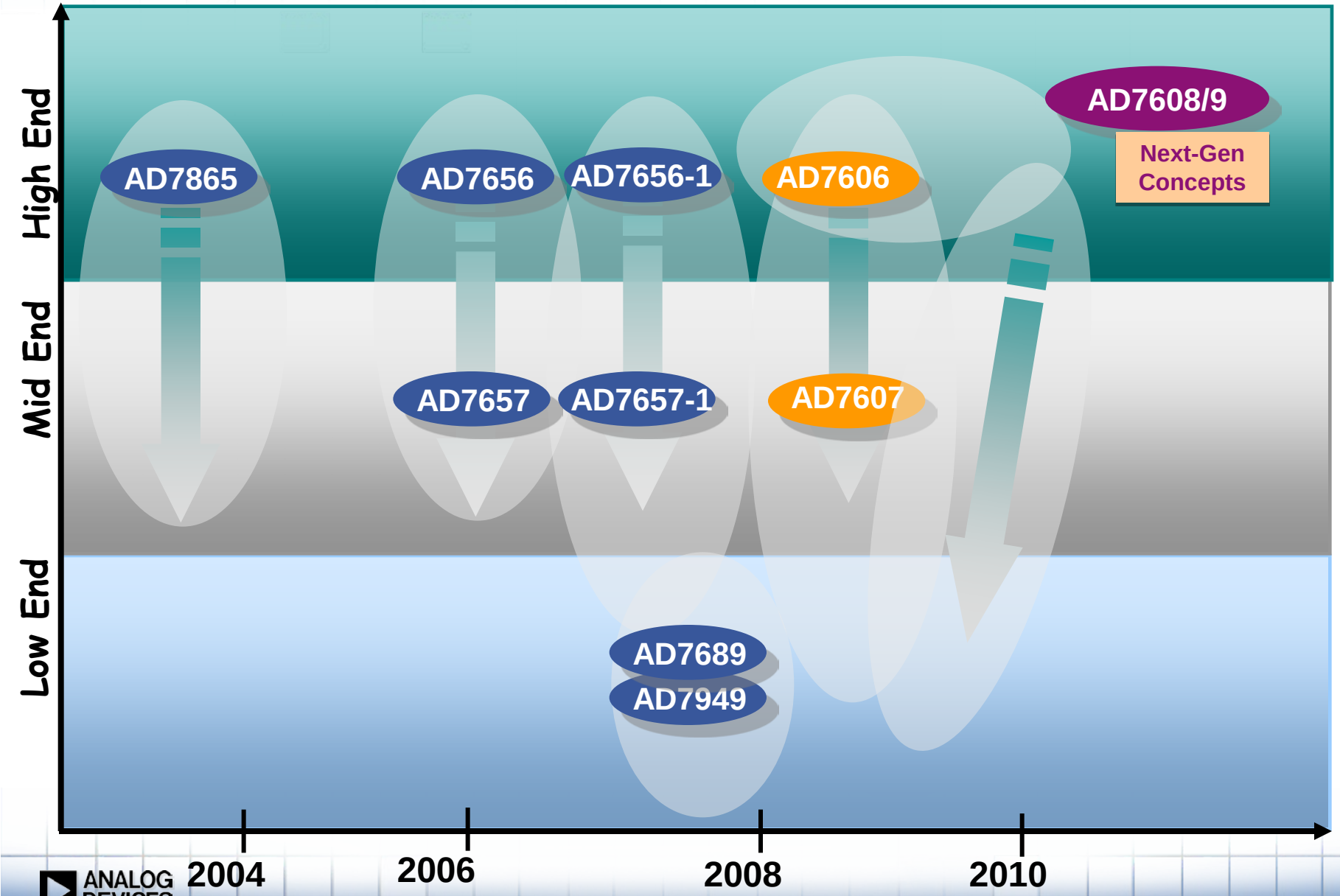


Monitor 3 x I, 3 x V, and I & V in Neutral.

8 channel sample with voltage and current monitoring of neutral line



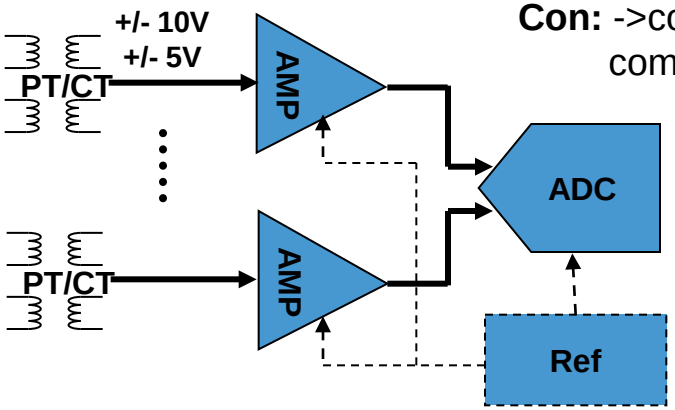
ADI's ADC in power line application



Analog Front Ending Circuit

Topology 1

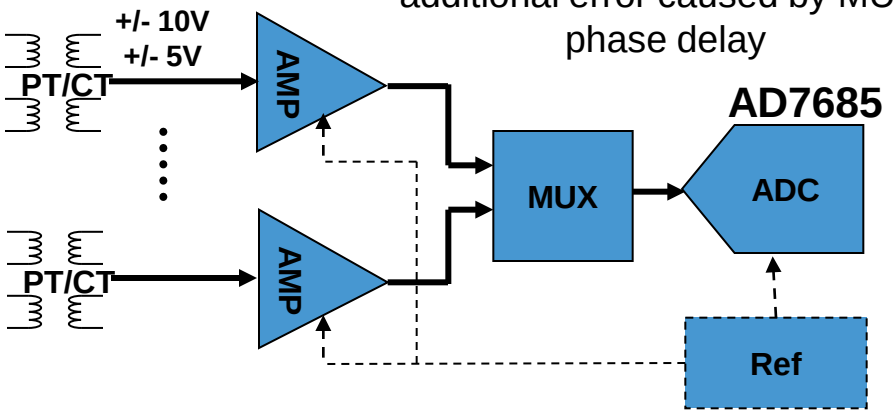
Pro: most popular, simultaneous sampling
Con: ->cost high, more components



AD7656
AD7865

Topology 2

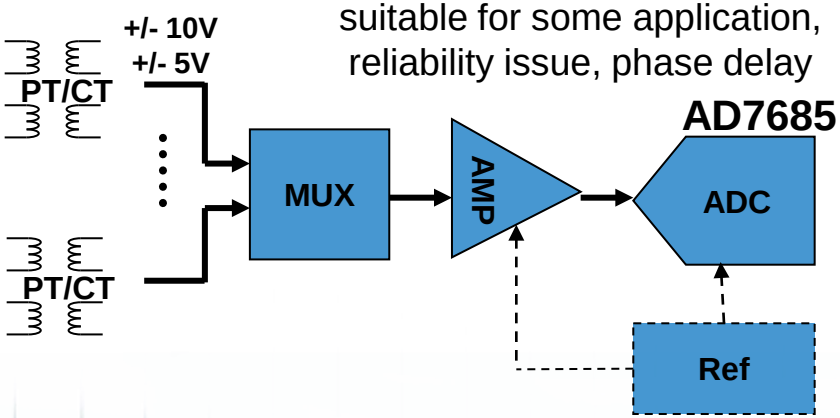
Pro: relative cheap
Con: not simultaneous -> not suitable for some application, additional error caused by MUX, phase delay



AD7685

Topology 3

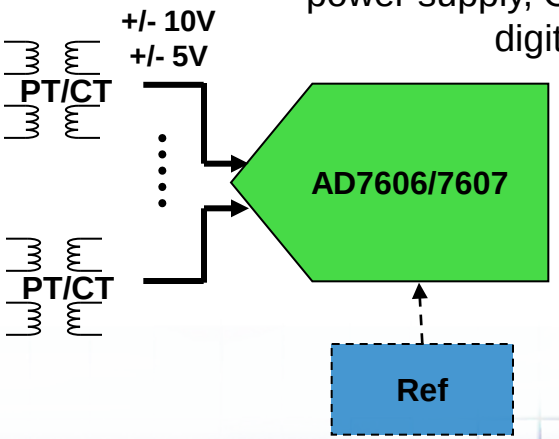
Pro: cheap, less components
Con: not simultaneous -> not suitable for some application, reliability issue, phase delay



AD7685

Topology 4

Pro: single chip – least components
Simultaneous sampling, single +5V power supply, OVP feature, optional digital filter…

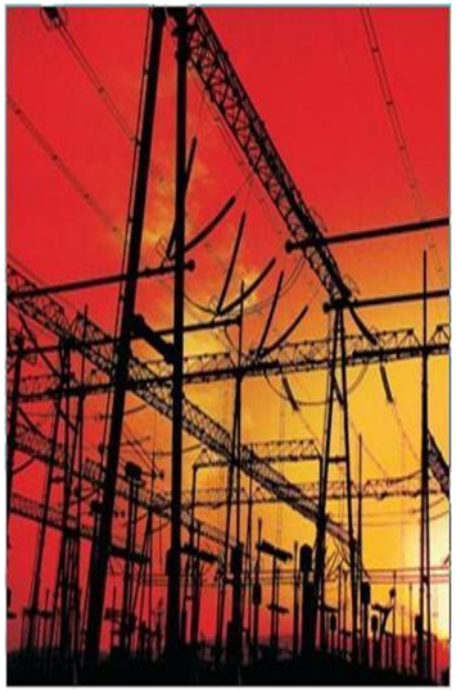


Industry next standard solution

Typical application in power line

Fault protection

- Over current protection
- Under/Over voltage protection
- Frequency deviation detection and protection
- Unbalance/phase sequence error protection
- Earth-fault detection and protection
- …



Power quality monitoring

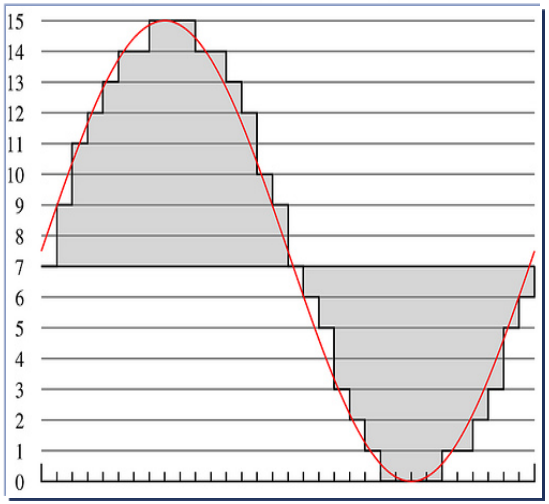
- Current/Voltage RMS value measurement
- Frequency measurement
- Harmonic content measurement
- Active/Reactive power measurement
- Power factor measurement
- Fault record
- Substation device status online diagnose
- …

Main Challenges & System Considerations

- **Robustness and reliability**
- **Wide signal dynamic range and high system accuracy**
- **Multi-channels measurement**
- **Variant system communication and synchronization interface**
- **Challenge from IEC61850**
- **Cost sensitive in some low/middle voltage application**

Select the ADC for power line application

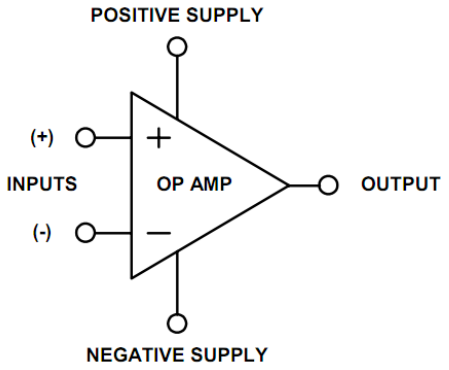
- **High resolution (>=14 bits ADC)**
- **High accuracy**
  - Good DC performance
    - INL, DNL typical value below 1 LSB
    - Small gain and offset error
  - Good AC performance
    - Low distortion (THD < -80dB)
    - High SNR and SINAD



- **Multi-Channel with min. channel to channel difference and high channel to channel isolation**
- **High sample rate**
- **High input signal range (+/-10V; +/-5V; +/-2.5V)...**
- **High PSRR...**

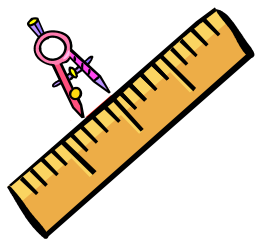
Select OPAMP for power line application

- High open loop gain (>100db)
- Low Vos (<500uV) and low Vos temperature drift
- Low Input bias current (Ib < 2nA, Ios < 1nA)
- Low noise (<20nV/√Hz and 1/f Vp-p< 1uV)
- Big power supply span (>=24V)
- High CMR, PSR (>100db)
- Input voltage rang, no output phase reversal
- Unity gain stable

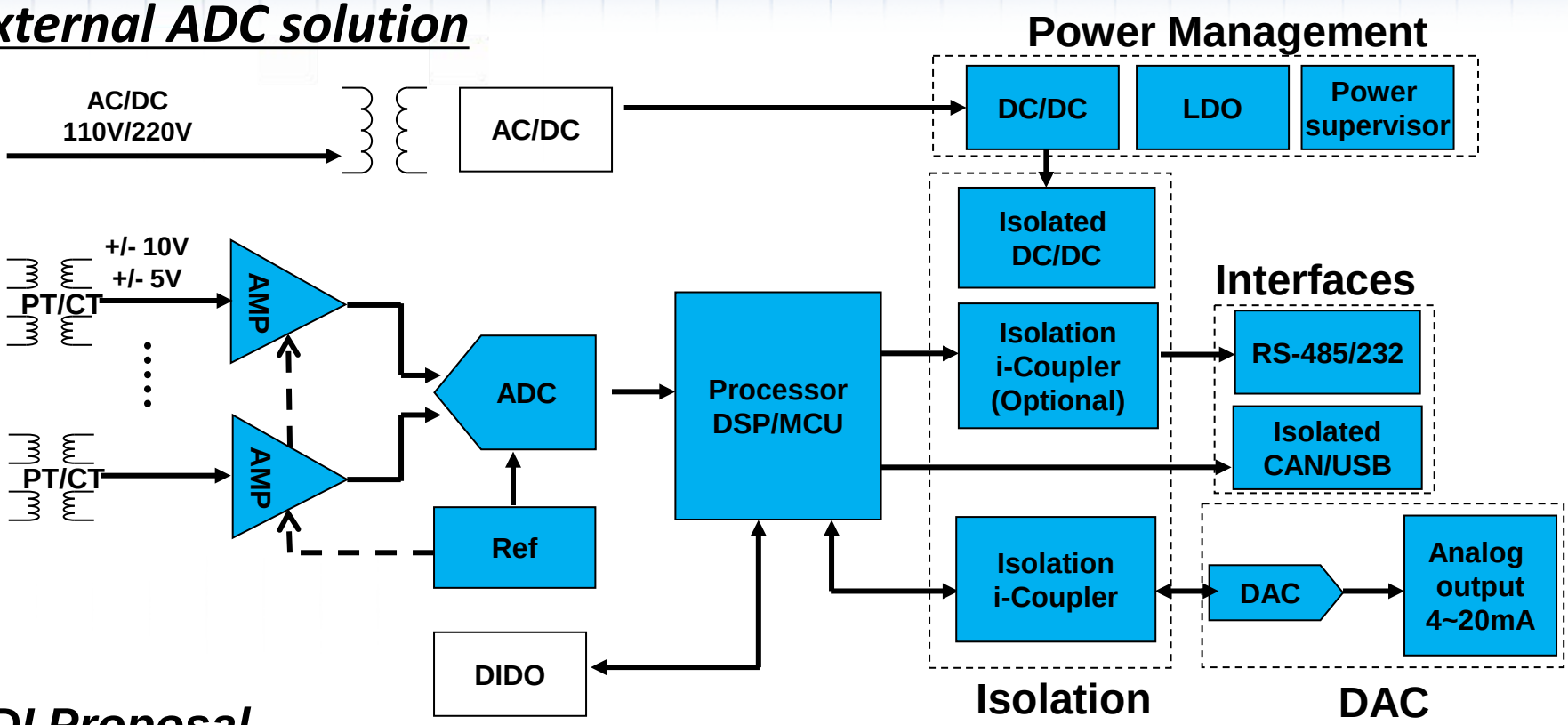


Select the voltage reference for power line application

- High initial accuracy (0.1%)
- Good temperature coefficient (below 3ppm)
- Small time drift
- Low noise
- Drive capacity (5mA, 10mA...) for multi-components
- Load/Line sensitivity
- Low output impedance
- High PSRR



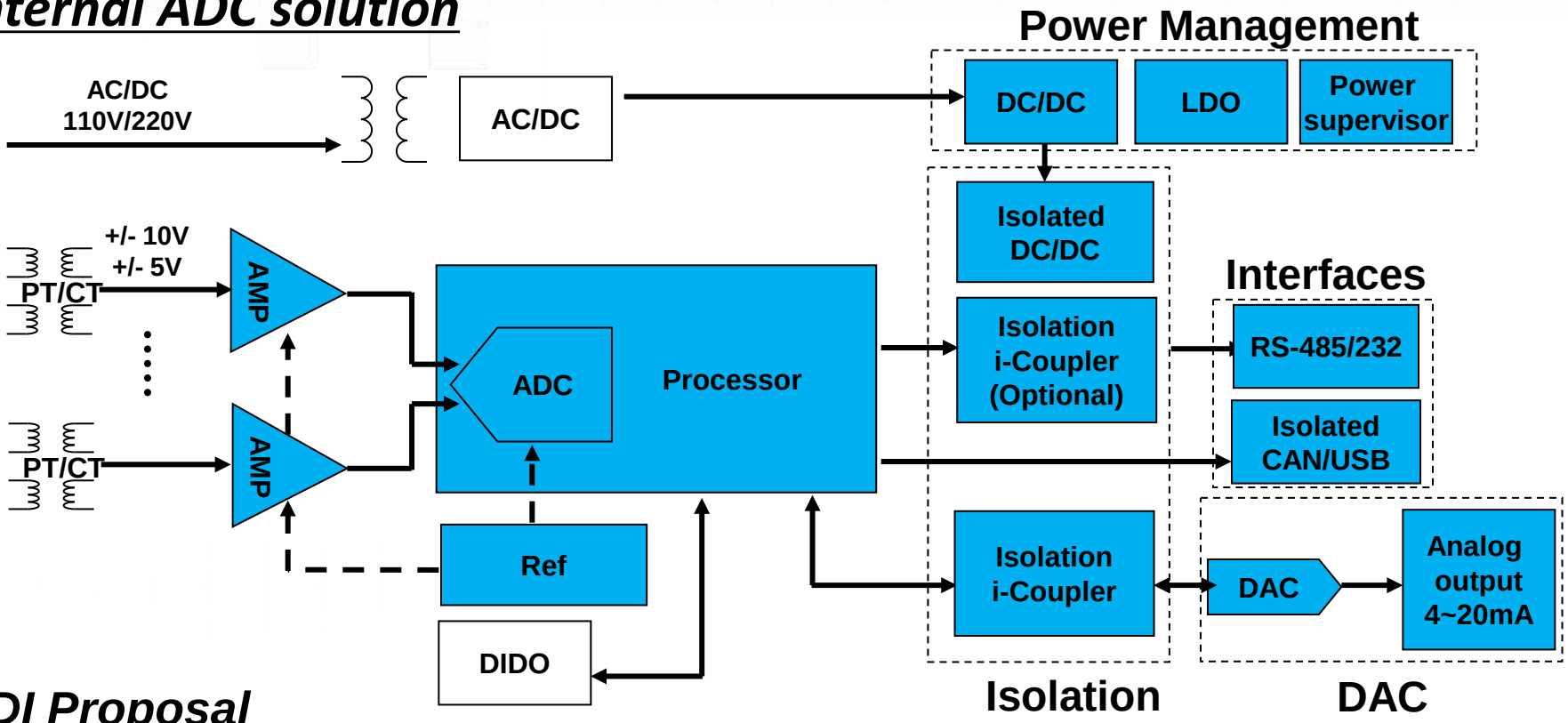
External ADC solution



ADI Proposal

Amplifier	ADC	Reference	Processor	Isolation	Interface	Power Management	DAC
Bipolar OP2177/4177 AD8672/8674, ADA4077-2, Single Supply AD8602/8604 AD8606/8608	Simultaneous AD7606/7607, AD7657-1/7658-1 Non-Simultaneous AD7327/7323 AD7689/7682 AD7490, AD7927 Metering AFE ADE7878	Voltage reference ADR42x ADR43x ADR34xx	Fix point DSP ADSP-BF512 ADSP-BF516 ADSP-BF518 Float point DSP ADSP-21489	Power Isolation ADuM5000 ADuM54xx Signal Isolation ADuM141x	RS485 ADM487E ADM2587E RS232 ADM3251E Isolated CAN ADM3053	LDO ADP125 DC/DC ADP1612,ADP2301 Multi-output (PMU) ADP5034 Power supervisor ADM6710	+/-5/10V & 4~20mA output AD5422

Internal ADC solution



ADI Proposal

Amplifier	Reference	Processor	Isolation	Interface	Power Management	DAC
Single Supply AD8602/8604 AD8606/8608 AD8618 AD8666	Voltage reference ADR34xx	Fix point DSP ADSP-BF506F ARM ADuC702x	Power Isolation ADuM5000 ADuM54xx Signal Isolation ADuM141x	RS485 ADM487E ADM2587E RS232 ADM3251E Isolated CAN ADM3053	LDO ADP125 DC/DC ADP1612,ADP2301 Multi-output (PMU) ADP5034 Power supervisor ADM6710	+/-5/10V & 4~20mA output AD5422

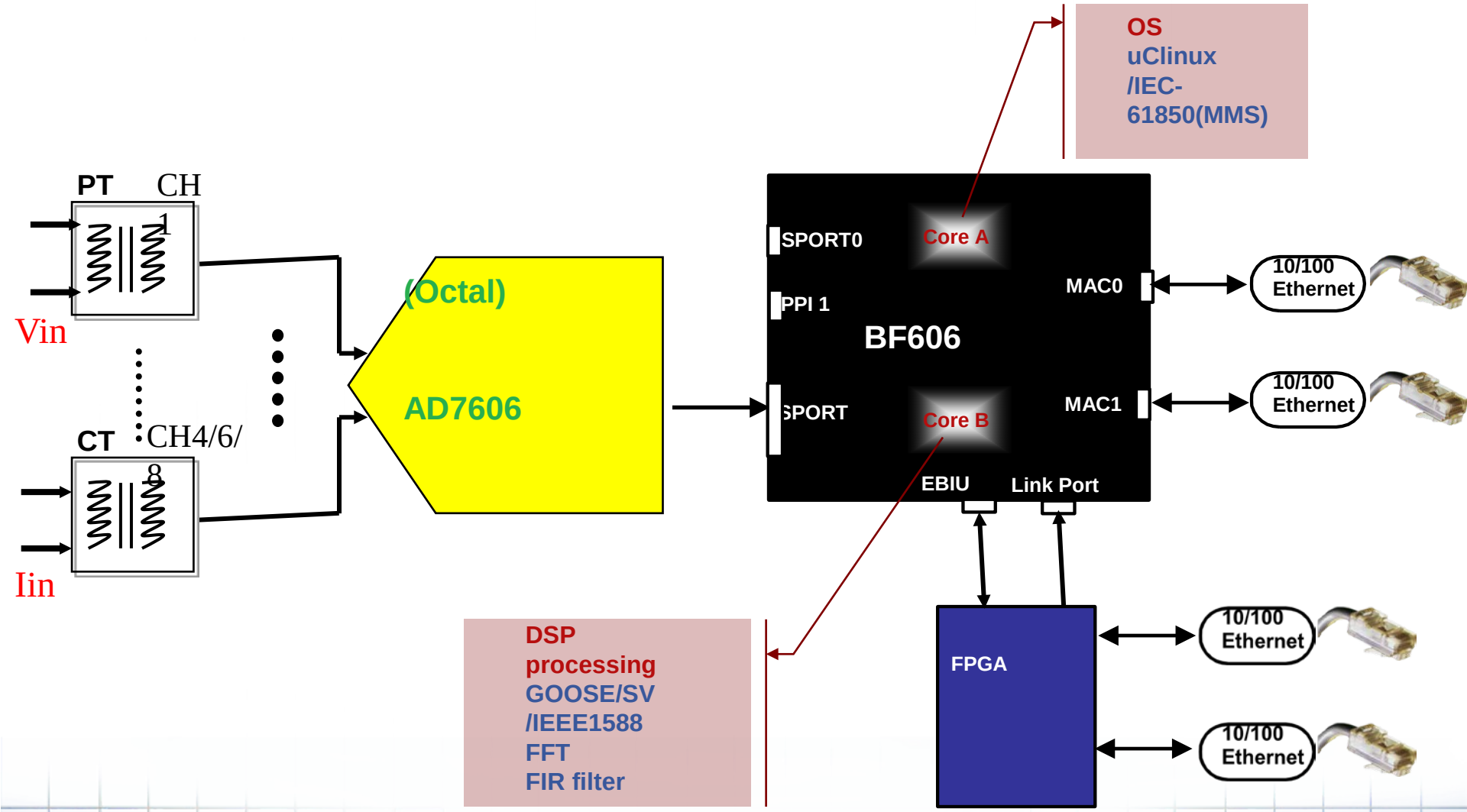
The World Leader in High Performance Signal Processing Solutions

Power Line Monitoring (PLM) Reference Design

on BF606

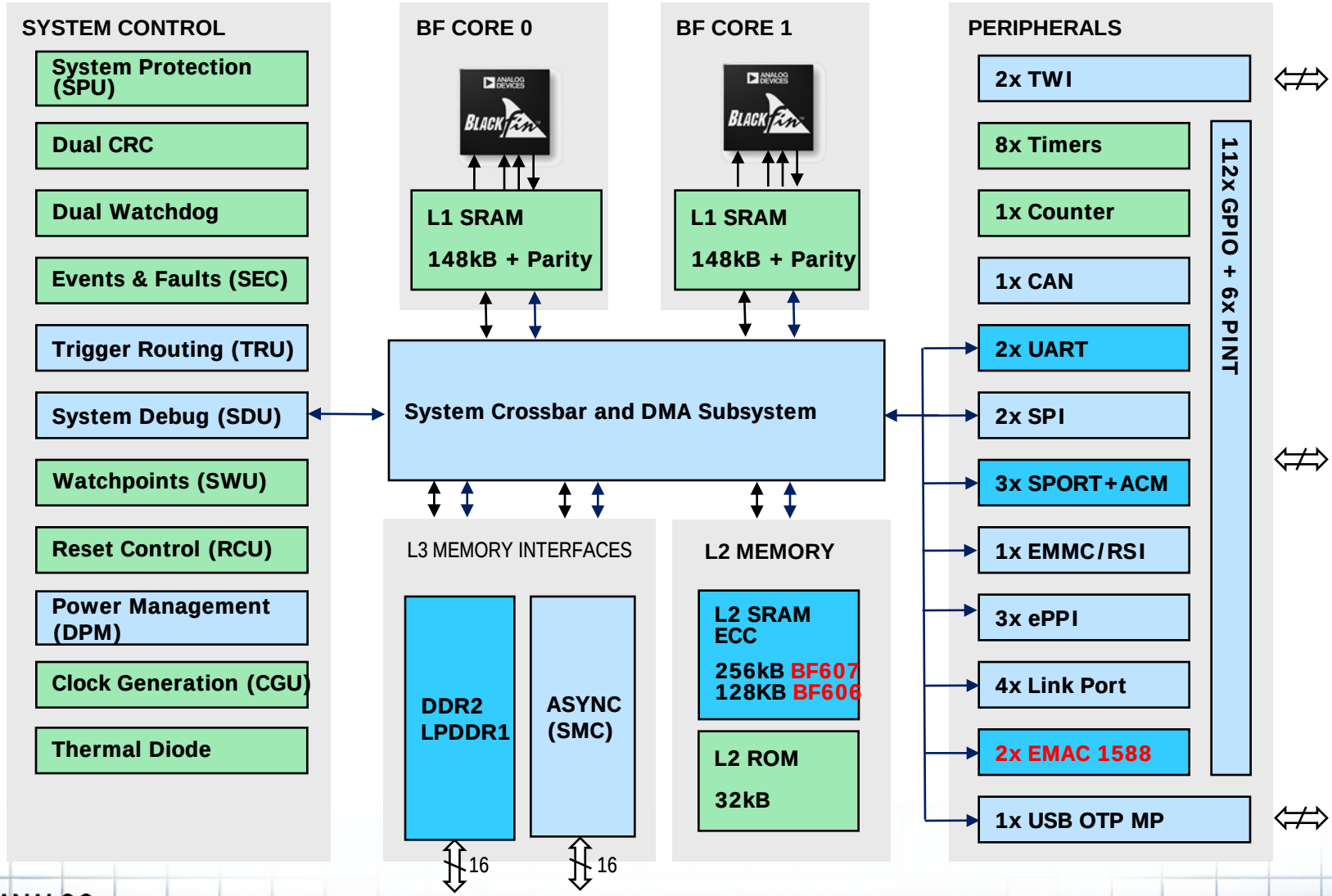
ANALOG DEVICES

PLM Reference Design (key signal chain)



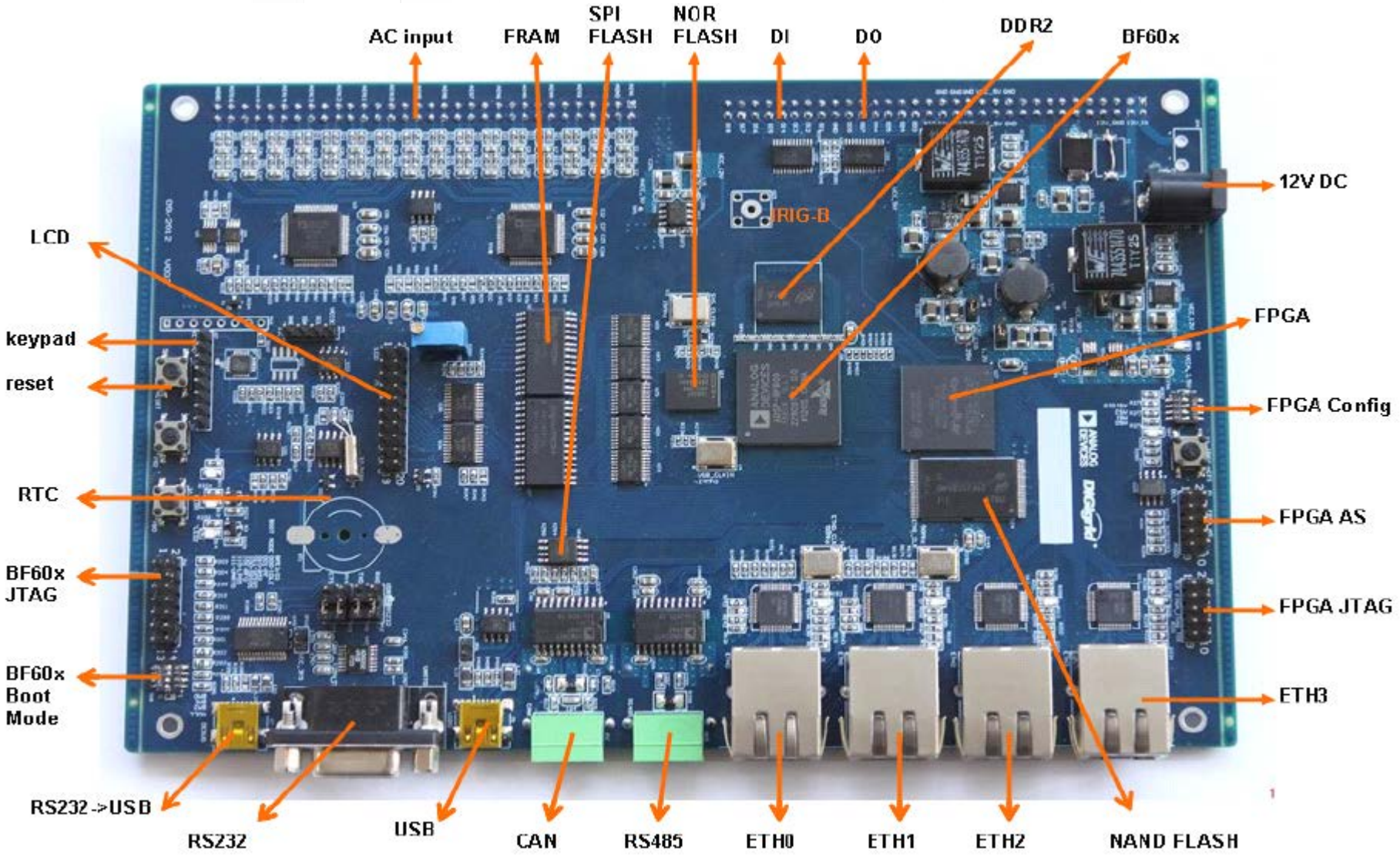
ADSP-BF607/6 Block Diagram

Part of Safety Concept

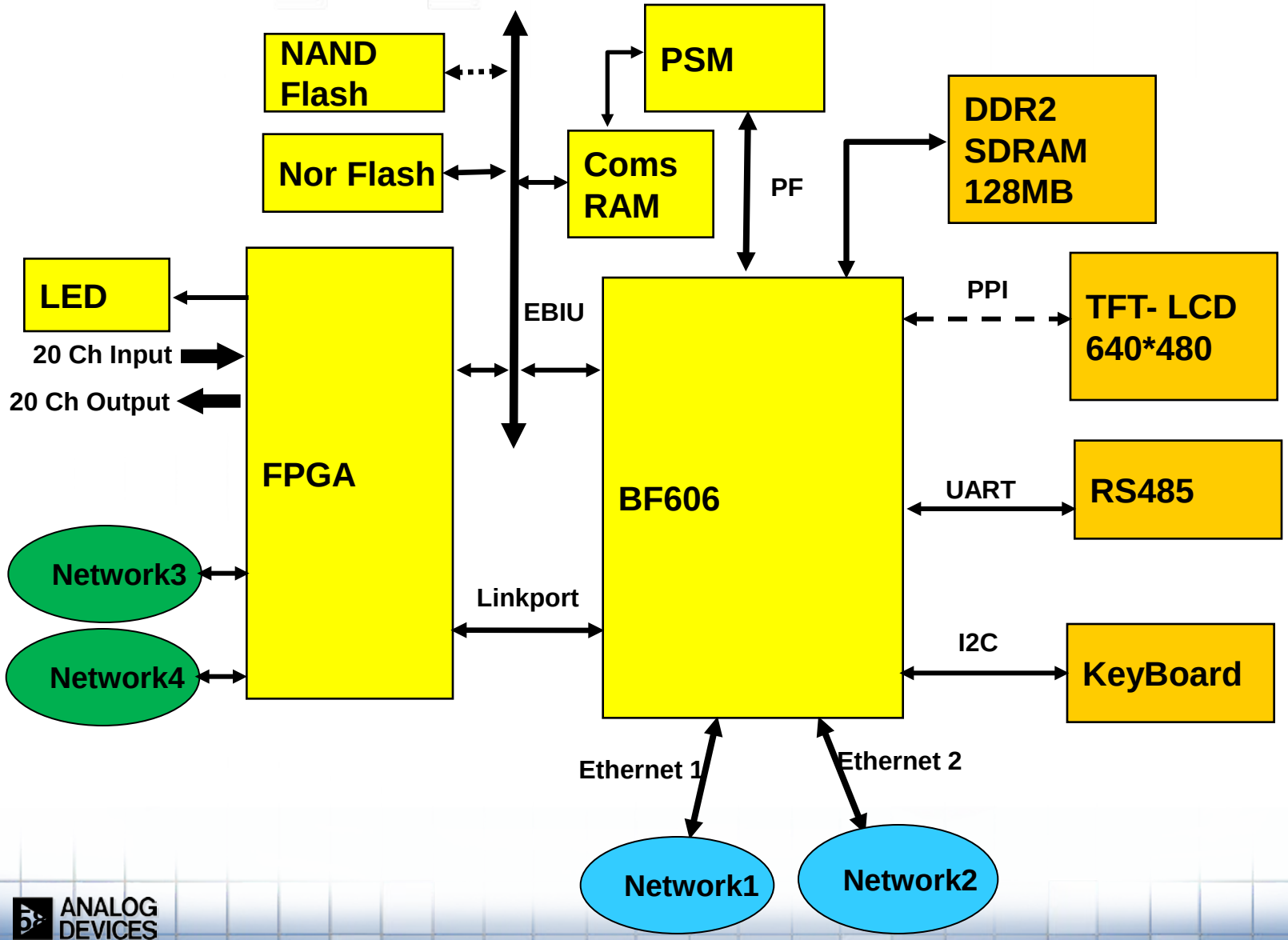


A picture of PLM demo (BF606)

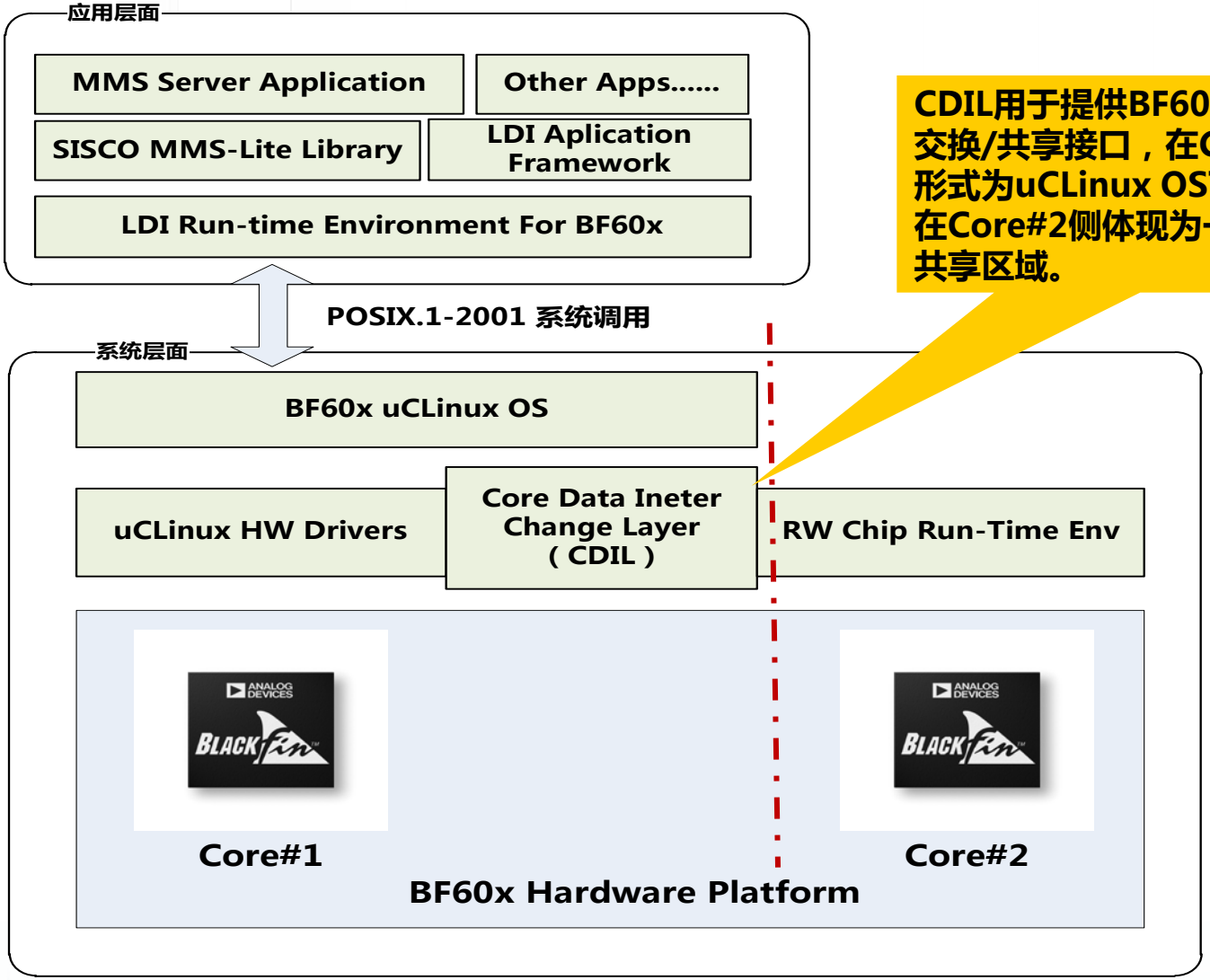
Picture of DSP/ADC board



PLM Reference Design (CPU parts)



Software structure on BF606



CDIL用于提供BF60x双核间的数据交换/共享接口，在Core#1侧可能的形式为uCLinux OS下的内核驱动，在Core#2侧体现为一段寄存器/内存共享区域。

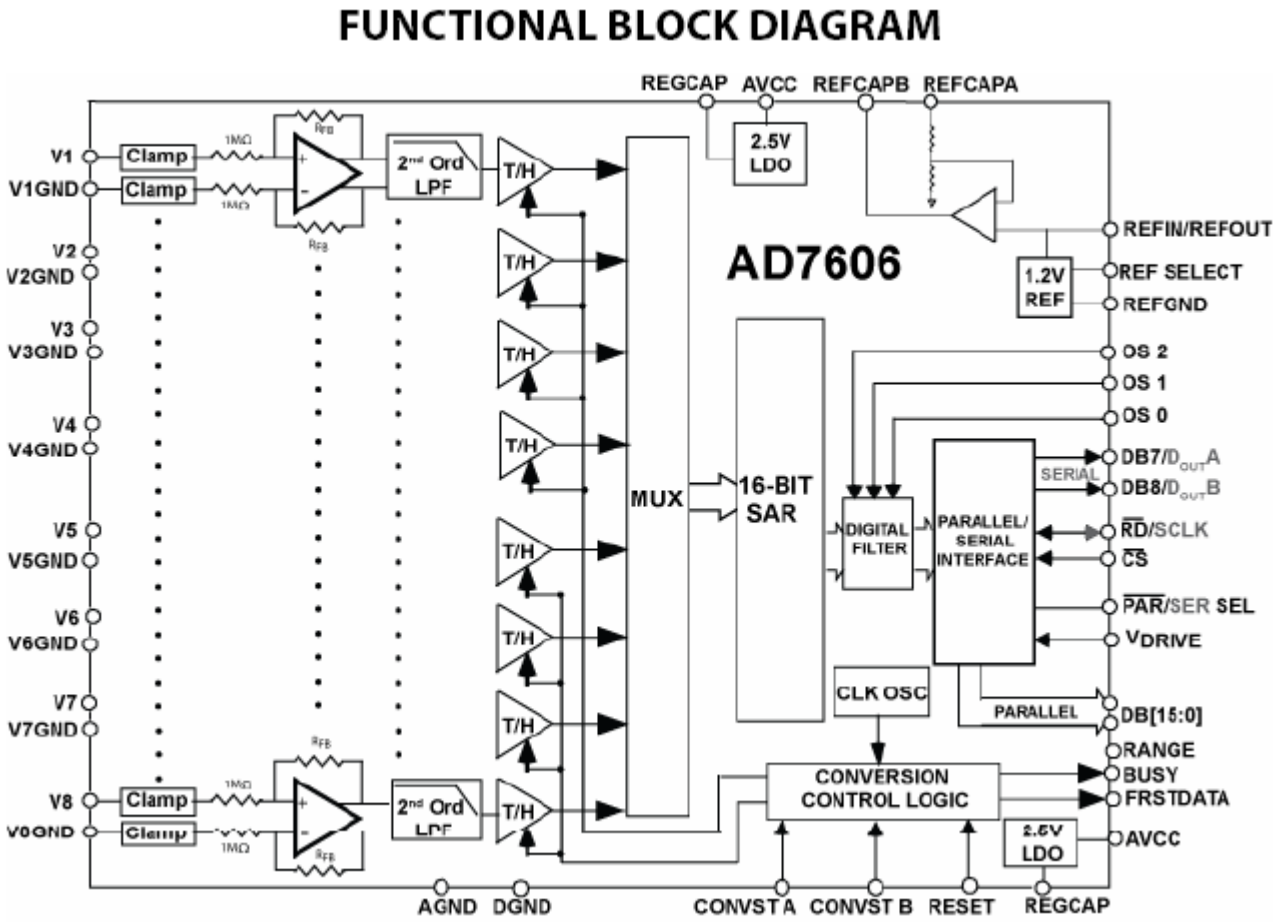
Software code on BF606

- 硬件测试程序
  - 串行口通讯测试程序
  - CAN口通讯测试程序
  - 键盘操作及LCD液晶显示测试程序
  - 网络口通讯测试程序
  - LED控制测试程序
  - 硬件WatchDog测试程序
- 应用软件
  - 简单的保护设备HMI软件（保护定值配置、通讯参数配置及当前运行量显示浏览）
  - IEC61850 MMS服务端实现
  - GOOSE Publish实现
  - 标准的Modbus Master/Slave实现
  - 设备远程诊断维护服务（可选）

BF60x Dual-Core Portfolio Summary (prelim)

Device	Market	MHz	L1 SRAM (kbytes)	L2 SRAM (kbytes)	Video Subsystem	Key Common Features	Package	Max Temp. (ambient)
BF607	Industrial & GP	500	148K/core	256K (ECC)	-	External Memory: 16-bit DDR2-500 3x ePPI (Camera/LCD/Parallel) USB2.0OTG HS multi-pt, CAN2.0, 2x Ethernet (w/1588), RSI/EMMC, 6x ½SPORT, 2x SPI, 2x UART, 2x PWM, 4x Link Port	19x19mm 0.8p CSP-BGA	85°C 70°C
BF606	Industrial & GP	400	148K/core	128K (ECC)	-			85°C 70°C

AD7606 Functional Block Diagram



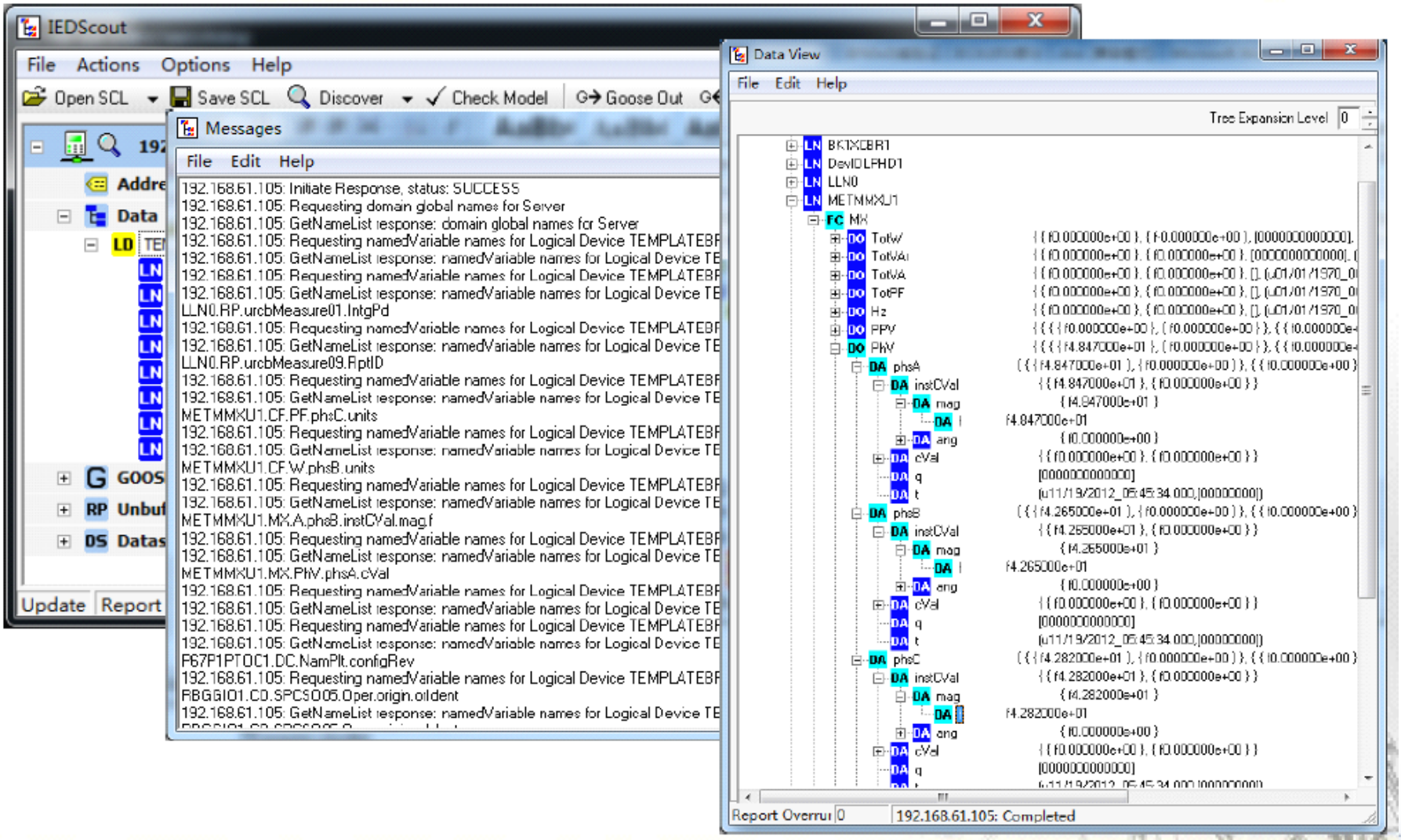
Key features on new PLM design

- **Dual-core processor (400/500MHz per core);**
  - **The Blackfin core-A -- OS (uClinux);**
  - **The Blackfin core-B – GOOSE/SV/DSP processing;**
- **Supporting 2 Ethernets port on-chip;**
  - **Two independence MAC address;**
- **Supporting IEC61850 protocol;**
- **One-Chip solution (OS and DSP in single BF606);**
- **Supporting up to 16-Chs Simultaneous Sampling ADCs (16-bit/16Chs ADC – AD7606);**
- **Supporting IEEE-1588v2 (optional);**
- **Supporting TFT-LCD (optional);**

Software tools for PLM solution

- ADI公司CCES 1.0.1 开发环境;
- Ubuntu 10.04环境 （Linux编译环境）;
- Buildroot定制软件包
  - 交叉编译 bfin-toolchain
  - Uboot
  - uCLinux kernel 3.3.0 + uImage/rootfs
- MMS Lite 软件包;

MMS协议的验证 – IEDScout MMS



Real-Time GOOSE 的测试方案

DO脉冲输出

捕获比对正确变化的GOOSE包，给出时间分析

What can we provide in PLM Ref.design?

- **SCH of PLM Ref. design;**
- **PCB of PLM Ref. design;**
- **Drivers on BF60x;**
- **Stack on BF60x (TCP/IP, GUI, FAT32…);**
- **Materials in Chinese（中文资料）;**

ADI亚洲技术支持中心

- **ADI 客户支持中心热线电话：4006-100-006 （24小时回复）**
- **模拟与其他线性产品技术支持：china.support@analog.com**
- **嵌入式处理器DSP技术支持：processor.china@analog.com**
- **ADI中文网站: http://www.analog.com/zh/index.html**
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- **ADI技术论坛: http://bbs.ednchina.com/ADI/**
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Thanks!

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