Design and Test Challenges of High Performace Data Converters

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(Part I)

Applications of Data Converters

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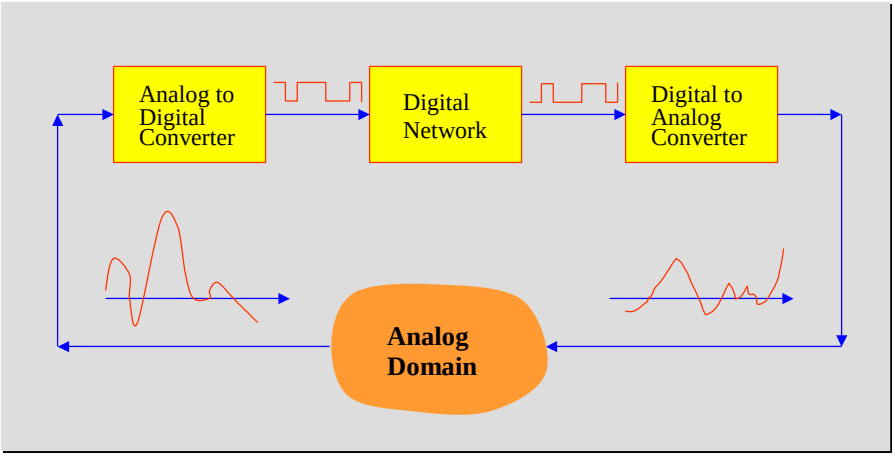
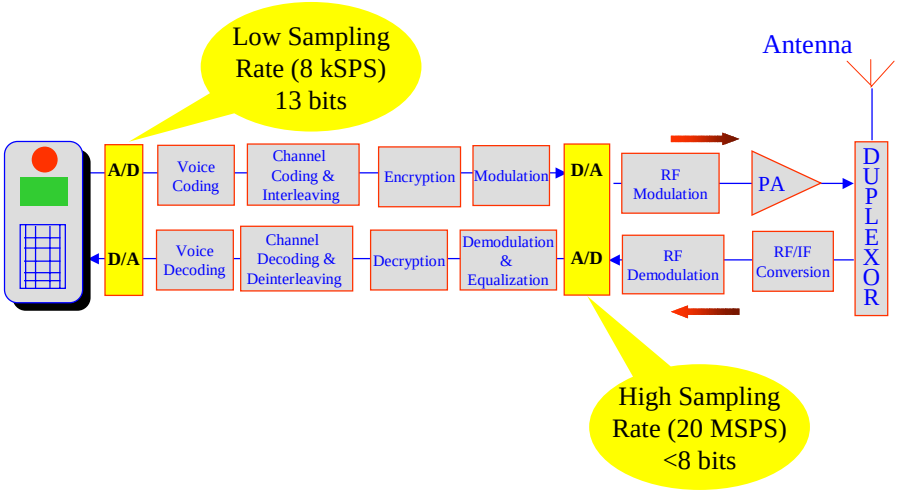
Why Data Converters?

Typical Application of Data Converters:



Wireless Communications

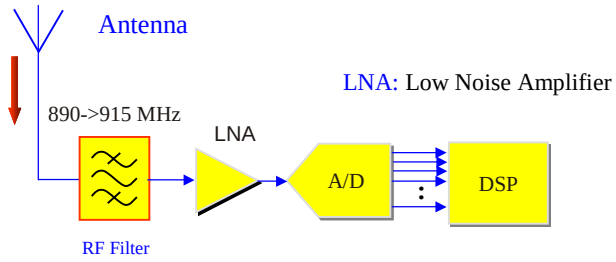
Cellular Phones:



Wireless Communications

Ideal GSM Basestation:

The intention is to bring the A/D converter as near as possible to the RF antenna of the system.

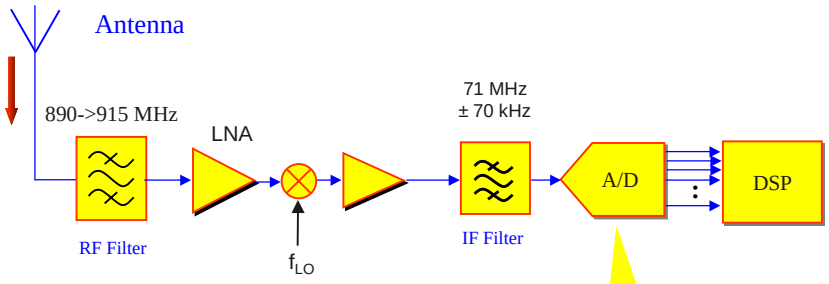


Challenge:

In GSM systems an analog input bandwidth of more than 900MHz would be required!

Wireless Communications

Realistic GSM Basestation:



LNA: Low Noise Amplifier

Wired Digital Communications

Modems:

Transmit and receive information through twisted pair wires.

1- High-speed voice band modems (56 kbps Modem)

2- Integrated Services Digital Network (ISDN) modems

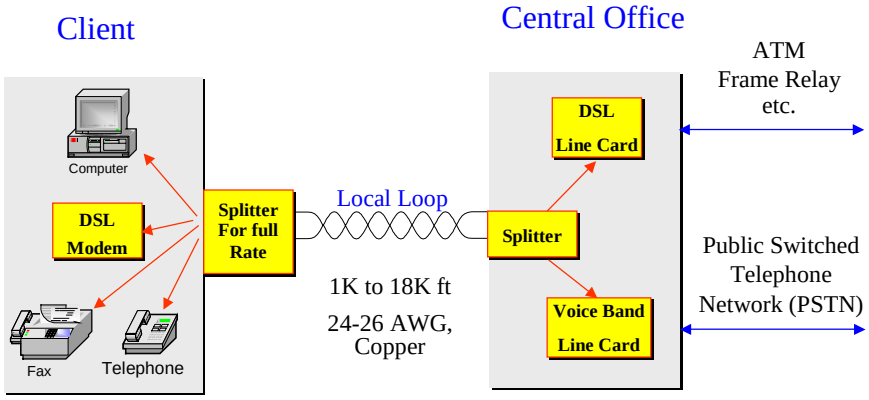
3- Digital Subscriber Line (DSL) modems

4- Cable Modems

5- Wireless modems

Wired Digital Communications

Digital Subscriber Line (DSL) Modems:



Wired Digital Communications

xDSL Modems:

xDSL

- **ADSL: Asymmetric DSL (1.5 Mbps)**
- **SDSL: Symmetric DSL (1 Mbps)**
- **RDSL: Rate-adaptive DSL (1.5 Mbps)**
- **IDSL: ISDN DSL (128 Kbps)**
- **CDSL: Consumer DSL (1 Mbps)**
- **HDSL: High-speed DSL (1.54 Mbps)**
- **VDSL: Very high-speed DSL (51 Mbps)**

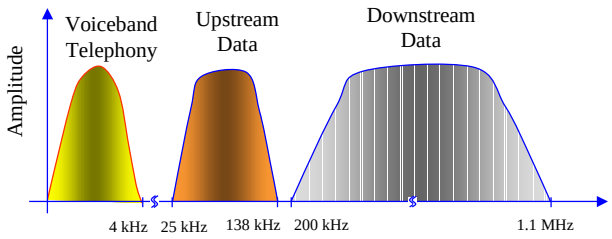
Wired Digital Communications

Types of ADSL:

1- Carrierless Amplitude-Phase (CAP)

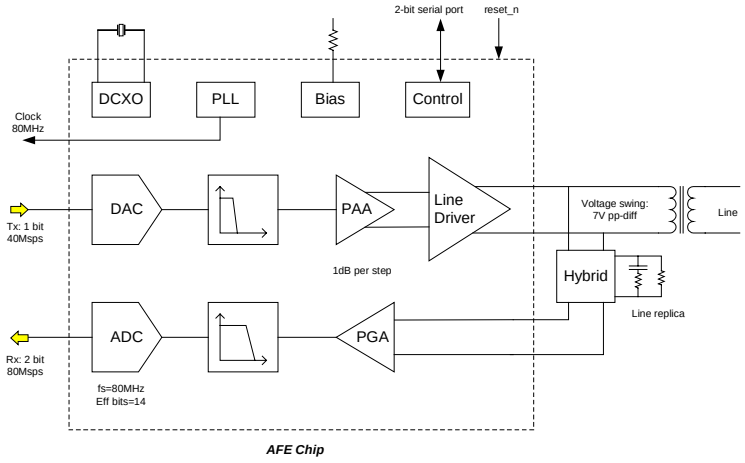
2- Discrete Moltitone (DMT)

Both use Quadrature Amplitude Modulation (QAM) and 2- 15 bits per tone.



Wired Digital Communications

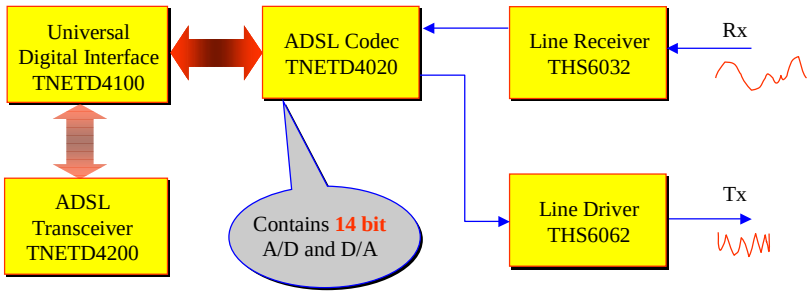
ADSL Analog Front-End (AFE):



Wired Digital Communications

ADSL Chipset:

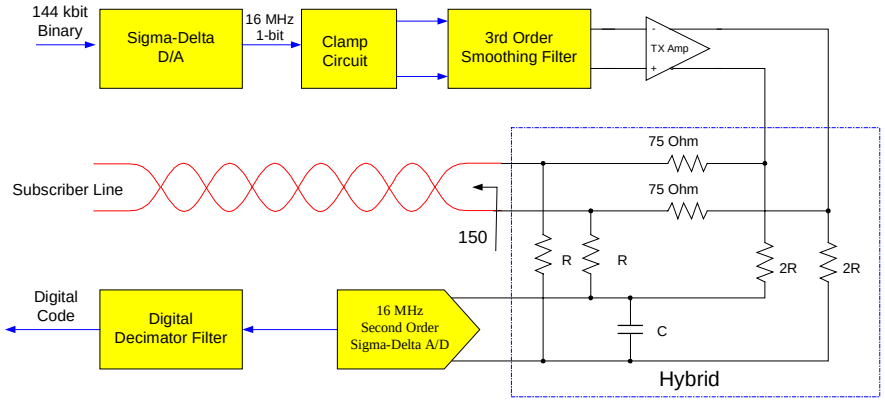
Texas Instruments (TI) solution:



- Transceiver performs the ADSL DMT modulation/demodulation, all initialization and training sequence of the ADSL specifications.

Wired Digital Communications

ISDN Modems:

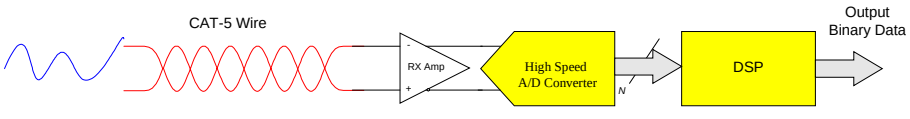


ISDN U-Interface (144 kbps)

Wired Digital Communications

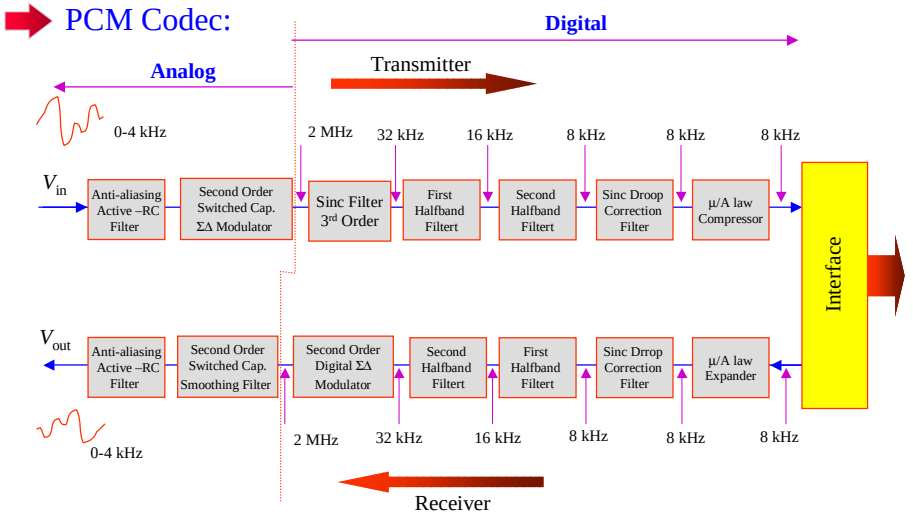
Gigabit Ethernet:

It requires four 8-bit A/D converters at the receiver end. The A/D converters should operate at 125 Mega sample per second (MSPS). Although the resolution is not high, the power consumption is the main challenge in the design procedure. The dynamic range of the A/D converters must be high enough to overcome the noise, interference, and attenuation through the cable.

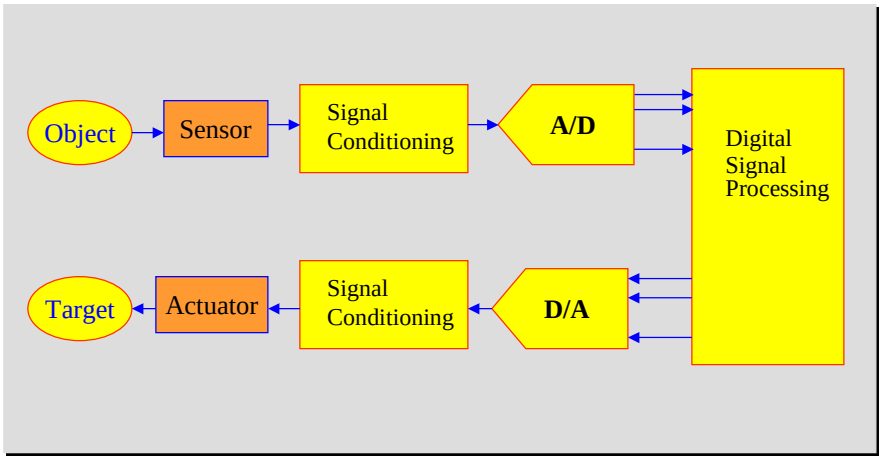


Voiceband Digital Communications

PCM Codec:



Smart Sensors

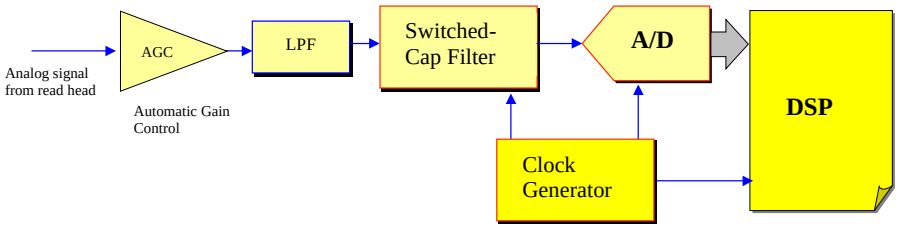


Smart Sensor is a sensor with data acquisition and data processing

Data Storage

Hard Disk:

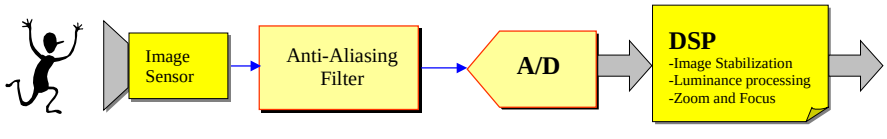
The data stored on a compact disk (CD) and computer hard disk are binary signals. However, the signal generated by the read head is analog and corrupted with noise and distortion. As a result, the disk drive read channels requires lots of filtering and post processing.



Digital Imaging

Camera Recorder:

Today's imaging systems make use of extensive digital post processing. Images can be captured by charge-coupled devices (CCDs) or by advanced CMOS image sensors. Image voltage or current signal is digitized by an A/D converter.

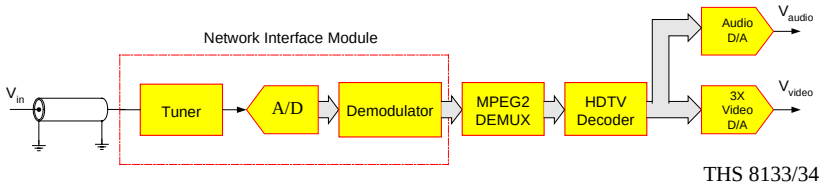


Video Systems

High-Definition Television (HDTV) Set-top Box:

A digital set top box is used to deliver interactive video services to a TV set via cable, satellite, or network. The video signal (270MBPS) is compressed into 2-15 MBPS (MPEG2) bit stream and modulated to form the RF signal.

The sampling speed of DAC must be 74.25 MHz, and with a resolution of 8 to 10 bits.



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Test of Integrated Circuits

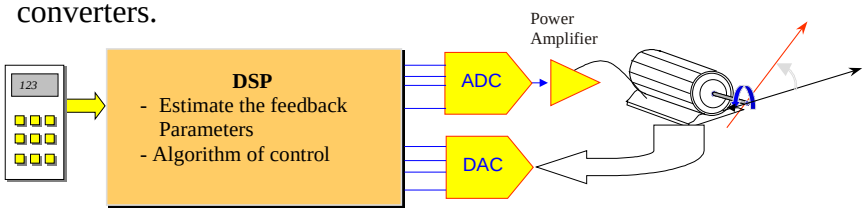
Arbitrary Waveform Generator (AWG) :

The test of analog and mixed signal circuits usually requires precision test signals. Therefore, an Arbitrary Waveform Generator (AWG) is needed. The main idea is to use DSP to create a coded binary signal which contains the information of test signal. The desired signal can be obtained by filtering the bit stream of the coded signal.

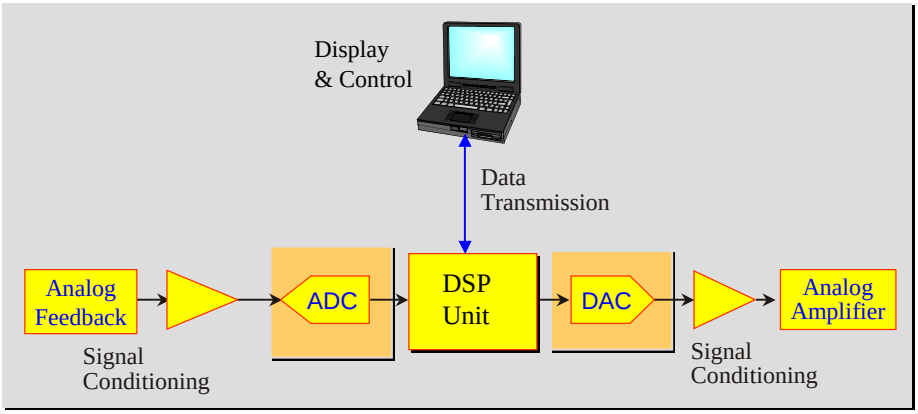
Motor Control

Cost-Effective Drivers :

AC induction motors are widely used because of its low cost, high reliability and high efficiency. Flexibility of DSP makes it possible to accomplish complex nonlinear control [8]. Feedback parameters like current, voltage, and position can be sensed and converted to digital signals by the use of A/D converters. After processing the analog command signals can be obtained by D/A converters.



Digital Control



- Position Control
- Speed Control

Data Converters for Telecom

Application	Year	Supply	Technology	Bits	fs OSR	Type	Area mm^2	Power mW
Speech	1980	±5V	5 µ NMOS	8	8 kHz	Suc. Appro A/D		50
	1985	±5V	2.4 µ CMOS	12	1 MHz 256x	2^{nd} Order ∑Δ A/D ∑Δ D/A	3.5 2	20
	1990	+5V	1.2 µ CMOS	13	2 MHz 512x	2^{nd} Order ∑Δ A/D ∑Δ D/A	2 1	6 4
	1995	+5V	0.7 µ CMOS	14	2 MHz 512x	2^{nd} Order ∑Δ A/D ∑Δ D/A	1.5 2	5 3
ISDN	1987	+5V	2 µ CMOS	10	16 MHz 128x	2^{nd} Order ∑Δ A/D ∑Δ D/A	2	15
	1996	+3V	0.5 µ CMOS	10	16 MHz 128x	4^{th} order ∑D A/D 6^{th} order ∑D D/A	2 1.5	35 10
GSM	1990	+5V	1.2 µ CMOS	8	270 kHz 1x	Suc. Appr. A/D Binary Weig D/A	1	10
	1993	+5V	0.7 µ CMOS	8	270 kHz 1x	Suc. Appr. A/D Binary Weig D/A	1	10
	1995	+3V	0.5 µ CMOS	13 8	6.5 MHz 24x	4^{th} order ∑D A/D Bin.-Weig. D/A	1.5 0.4	14 3
ADSL	1993	+5V	0.7 µ CMOS	12	53 MHz 24x	4^{th} order ∑D A/D 6^{th} order ∑D D/A	9 7	850 700
	1997	+3V	0.5 µ CMOS	12	8.8 MHz 4x	Pipelined A/D Switched-I D/A	5 2	120 30
VDSL	1998	+3V	0.35 µ CMOS	12	40 MHz 1x	Pipelined A/D Switched-I D/A	5 2	250 60

Conclusions

Target Applications:

- Wireless Communications
- xDSL
- Gigabit Ethernet
- Video Systems

References and Further Reading

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[6] G. W. Roberts and A. K. Lu, *Analog Signal Generation for Built-In-Self-Test of Mixed-Signal Integrated Circuits*, Kluwer Academic Publishers, 1995.

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[7] Texas Instruments, *Providing the Right Solution for VDSL*, Version 1.05, July 1999.

[8] Texas Instruments, *DSP Solutions for Motor Control Using the TMS320f240 DSP Controller*, SPRA345, 1999.