Bates
Digital Systems

Trends in CMOS Applications:

Faster. Smaller. Cheaper. Better?

Stephen Bates

July 2007

Faster!

- A pervasive trend in our industry is for things to get faster.
  - Processor IPS.
  - Clock speeds.
  - Data rates.
- This drive comes from the consumer who wants to move more information in less time than ever before.
- We, as CMOS ETers are more than happy to oblige.

TIFF (U
are r

Faster! Case Study

- 10GBASE-T delivers low-cost, lower power 10GBPS over 100m of cheap cable.
- Driven by Web2.0 (photos+movies+social sites = huge server farms).
- Close to channel capacity => massive amounts of signal processing.
- $40M+ development costs. However final product can be considered a commodity.

What is 10GBASE-T

10GBASE-T

Bates Digital Systems

What is 10GBASE-T

10GBASE-T

- 10 Gigabit Per Second.

Bates Digital Systems

What is 10GBASE-T

10GBASE-T

- 10 Gigabit Per Second.
- Baseband Signaling.

Bates Digital Systems

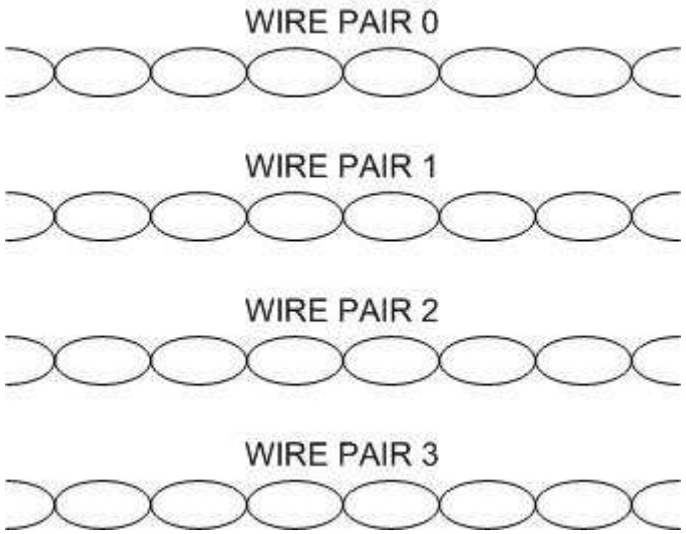
What is 10GBASE-T

10GBASE-T

- 10 Gigabit Per Second.
- Baseband Signaling.
- 100m of Unshielded Twisted Pair Cabling.

Bates Digital Systems

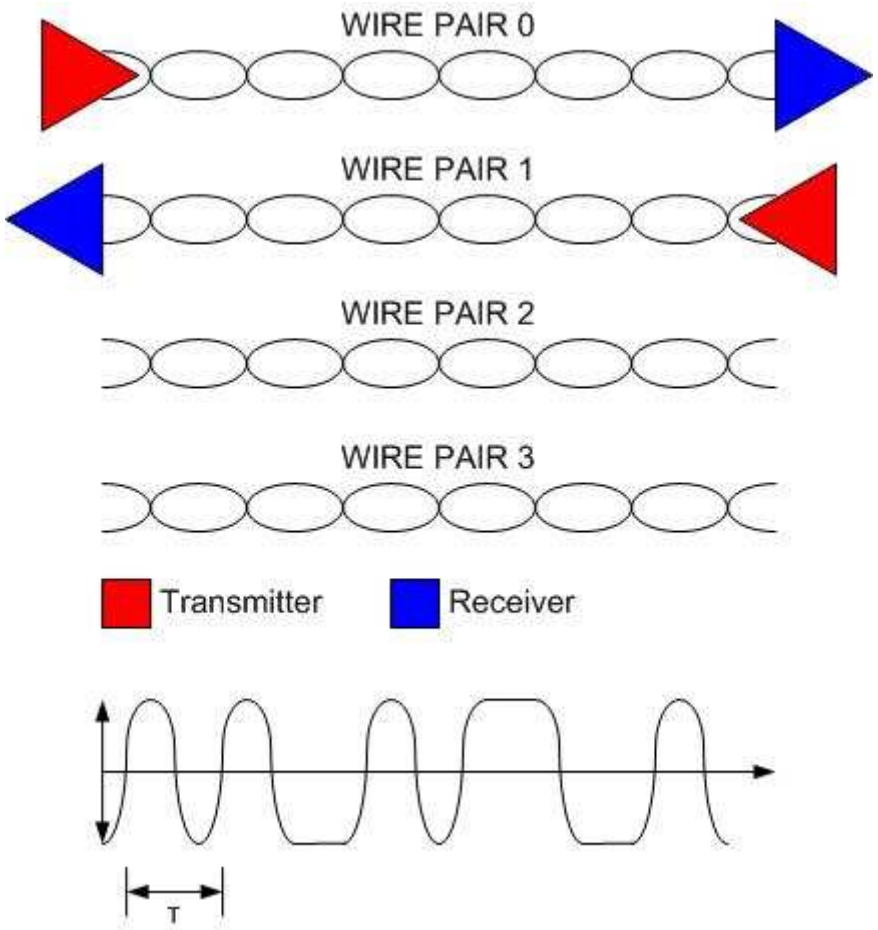
How did we get here?



Bds Bates Digital Systems

How did we get here?

10BASE-T (802.3i)

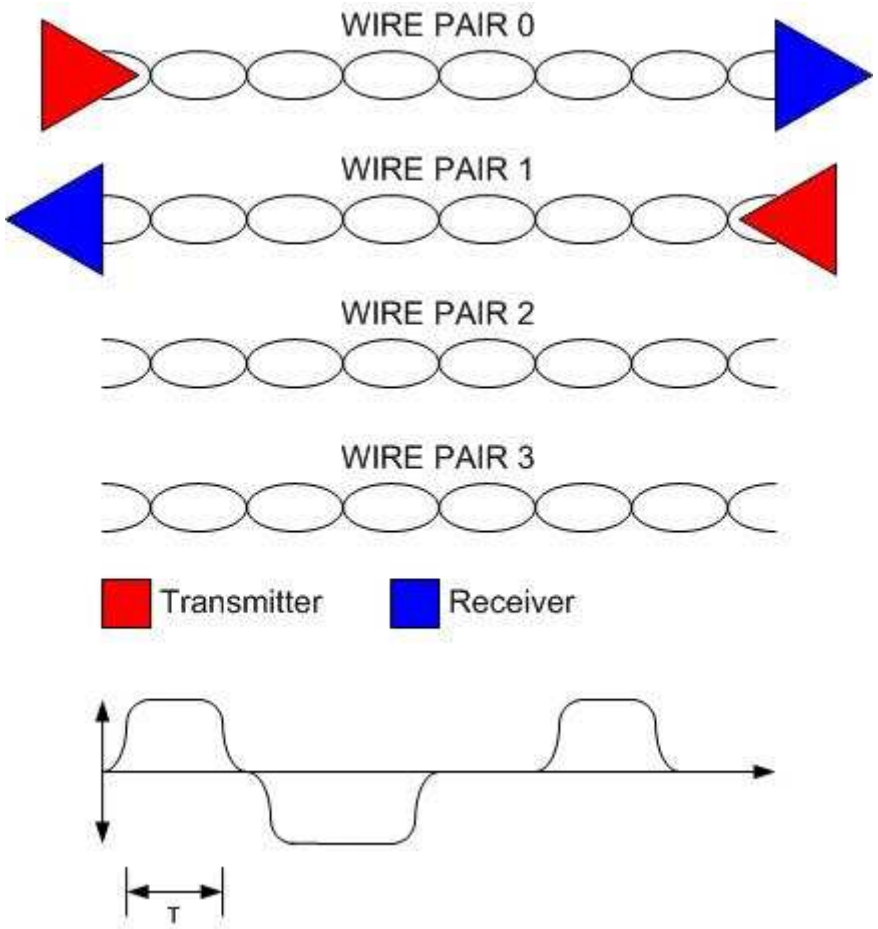


- Standard in 1991.
- 10Mb/s
- Half-Duplex.
- Two Pairs Used.
- 10MS/s Baud Rate.
- Manchester Encoded
- 1 bit per baud.
- Purely Analog Solutions.
- No real EMI

Bds Bates Digital Systems

How did we get here?

100BASE-T (802.3u)

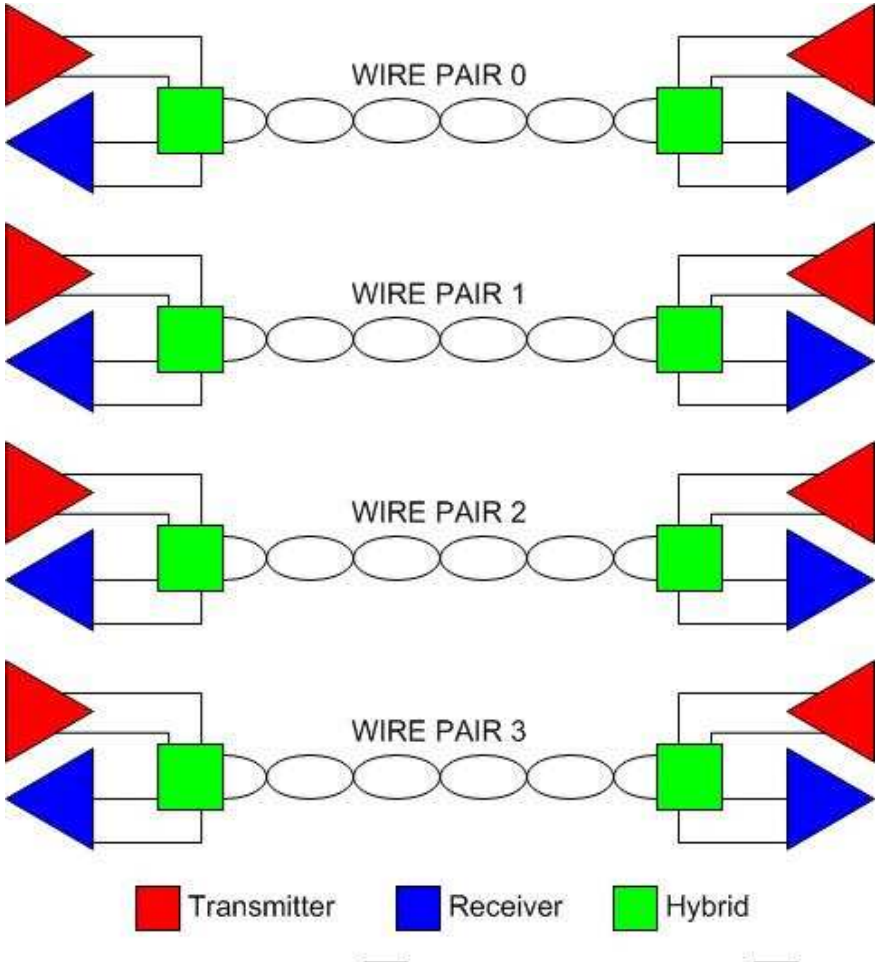


- Standard in 1995.
- 100Mb/s
- Half-Duplex.
- Two Pairs Used.
- 125MS/s Baud Rate.
- MLT-3 Encoded
- 0.8 bit per baud.
- Mixed Solutions.
- NEXT (minimal)

Bates Digital Systems

How did we get here?

1000BASE-T

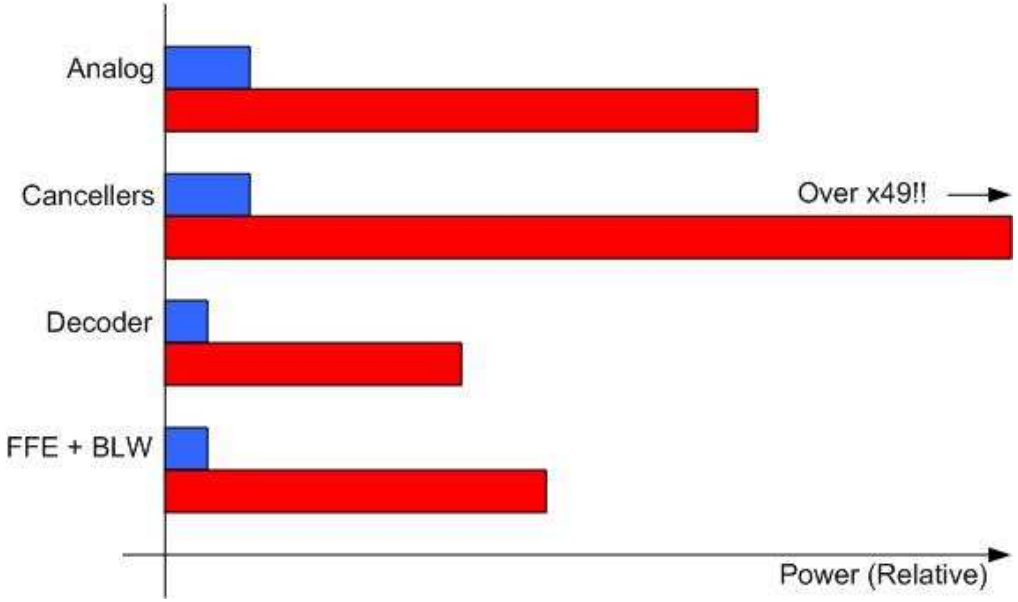


- Standard in 1999.
- 1000Mb/s
- Full-Duplex.
- Four Pairs Used.
- 125MS/s Baud Rate.
- PAM 5
- 8 bits per baud.
- DSP Intensive
- NEXT (lots) + FEXT

Bates Digital Systems

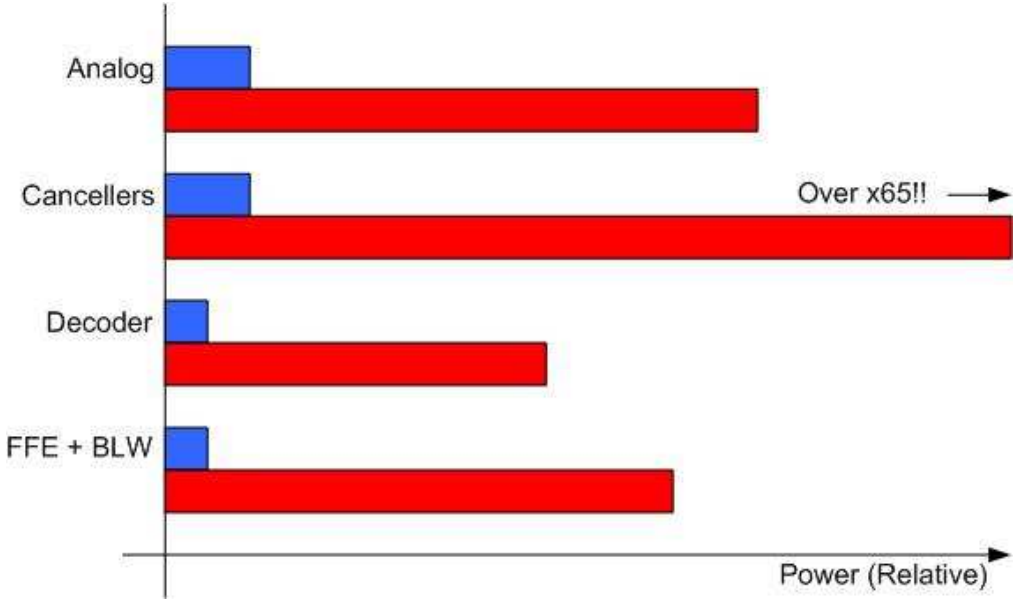
Power Estimation

- 125Ms/s->800MS/s.



Bds Bates Digital Systems

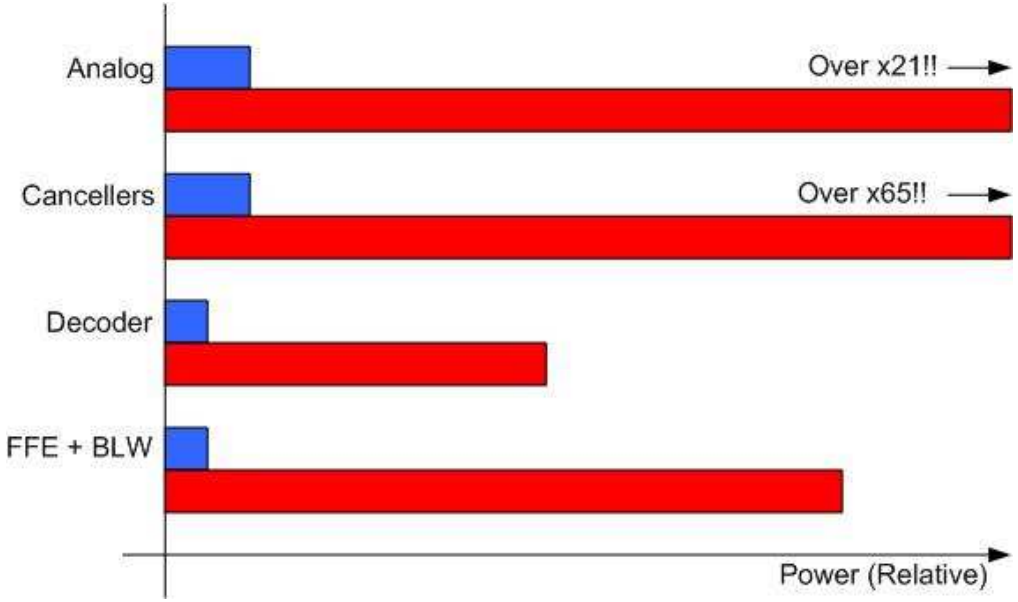
Power Estimation



- 125Ms/s->800MS/s.
- PAM-5->PAM16.

Bates Digital Systems

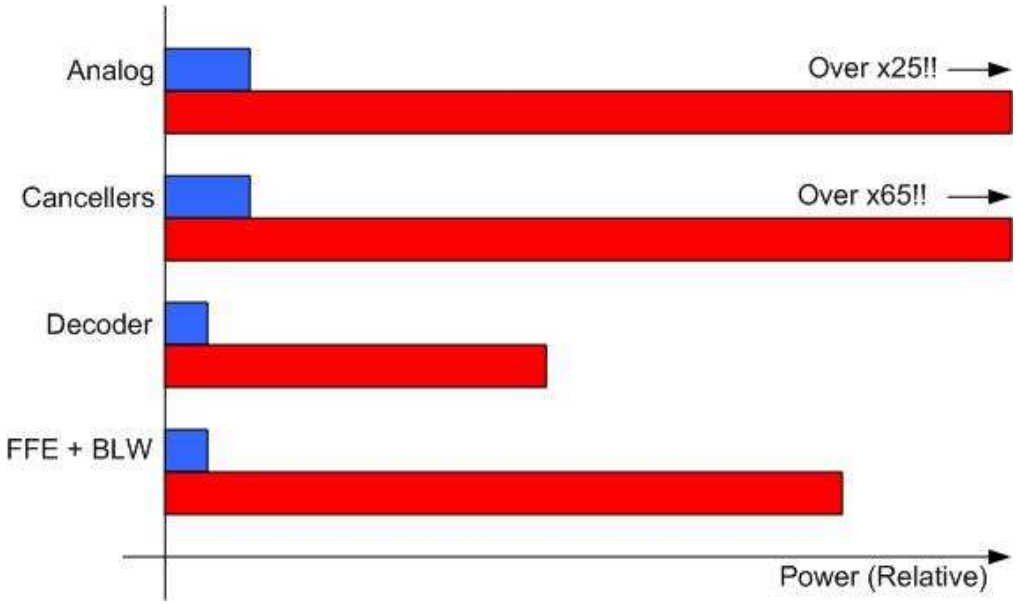
Power Estimation



- 125Ms/s->800MS/s.
- PAM-5->PAM-16.
- 7 ENOB->10 ENOB.

Bates Digital Systems

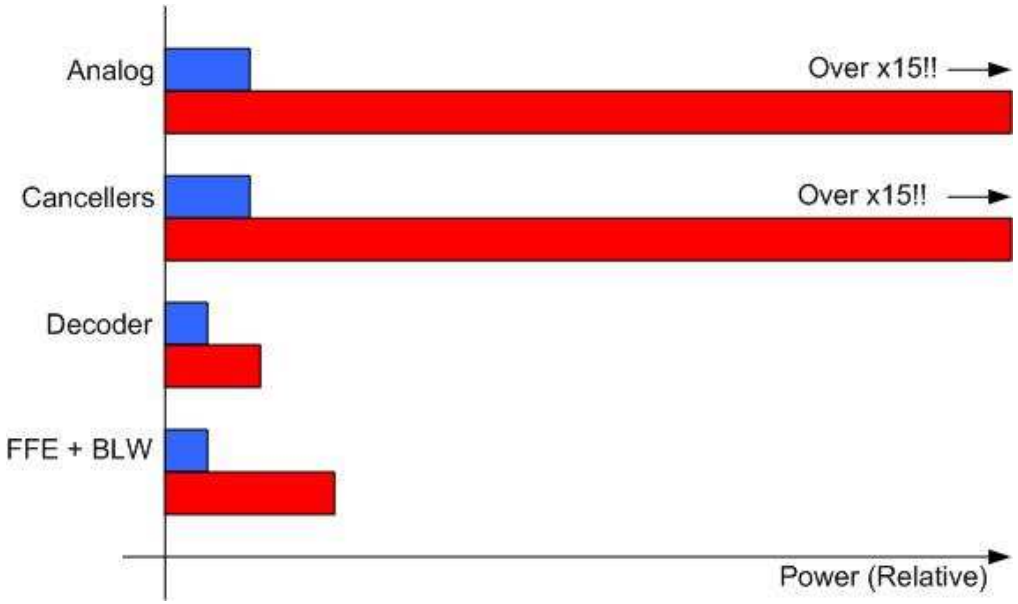
Power Estimation



- 125Ms/s->800MS/s.
- PAM-5->PAM-16.
- 7 ENOB->10 ENOB.
- Improved Linearity.

Bds Bates Digital Systems

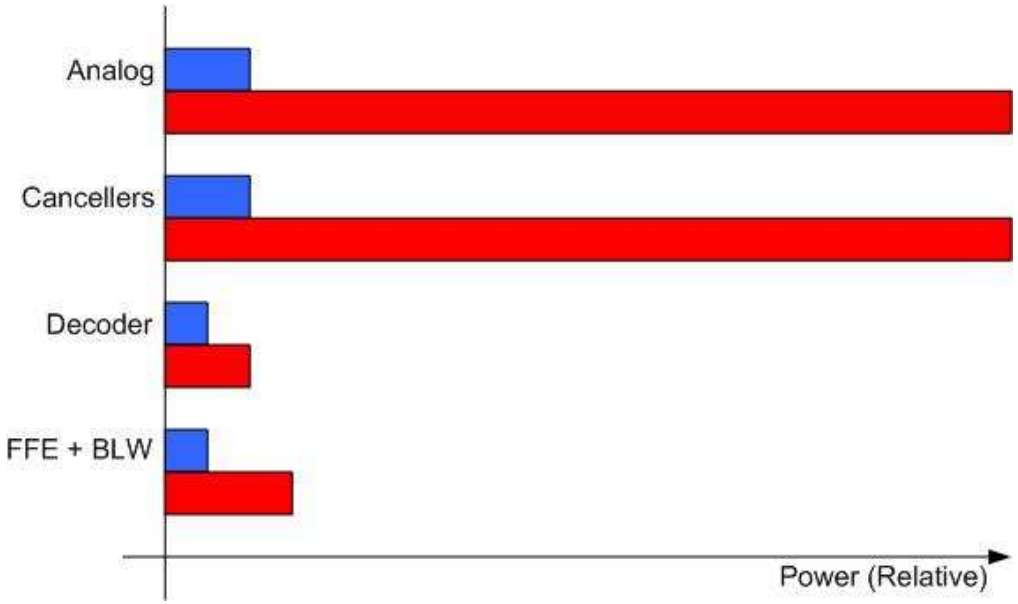
Power Estimation



- 125Ms/s->800MS/s.
- PAM-5->PAM-16.
- 7 ENOB->10 ENOB.
- Improved Linearity.
- Process Scaling (65nm)

Bds Bates Digital Systems

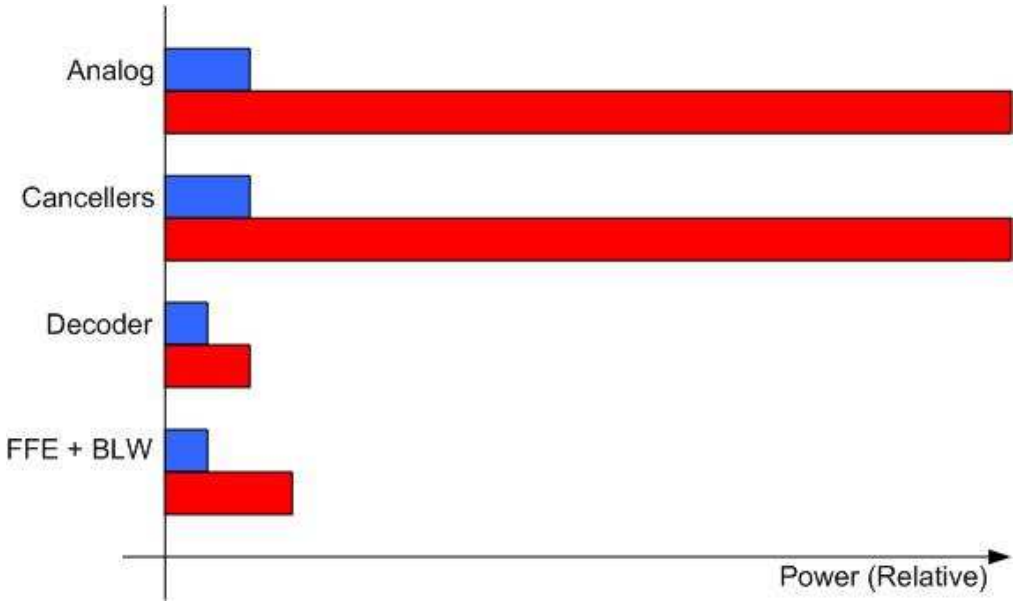
Power Estimation



- 125Ms/s->833MS/s.
- PAM-5->PAM-10.
- 7 ENOB->10 ENOB.
- Improved Linearity.
- Process Scaling (65nm).
- Advances in Design (optimistic).

Bates Digital Systems

Power Estimation



- 125Ms/s->833MS/s.
- PAM-5->PAM-10.
- 7 ENOB->10 ENOB.
- Improved Linearity.
- Process Scaling (65nm).
- Advances in Design (optimistic).

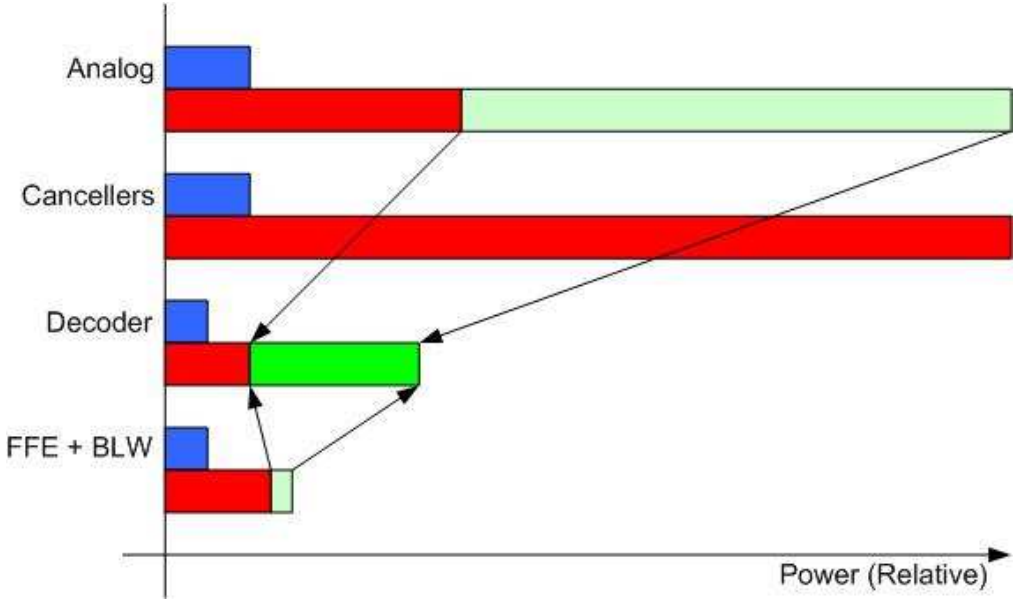
Digital: 600mW -> 7W

Analog: 300mW -> 3W

=> 10 Watts

Bates Digital Systems

Power Estimation



Digital: 600mW -> 7.5W

Analog: 300mW -> 1W

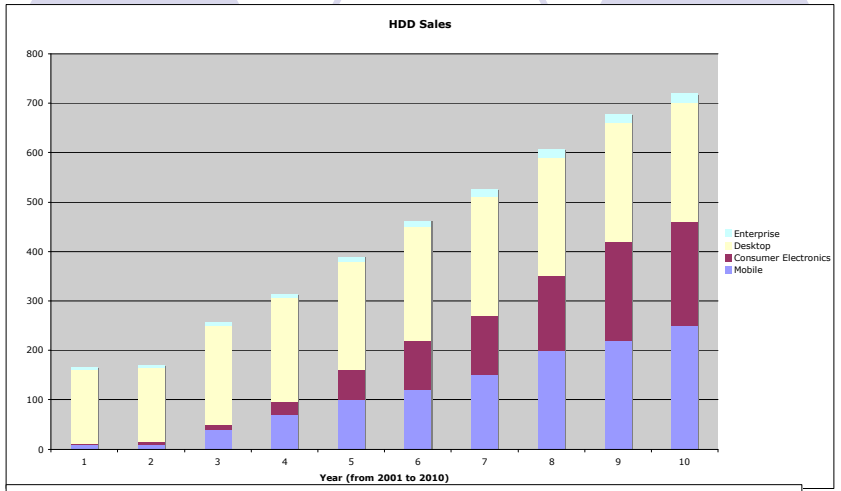
=> 8.5 Watts

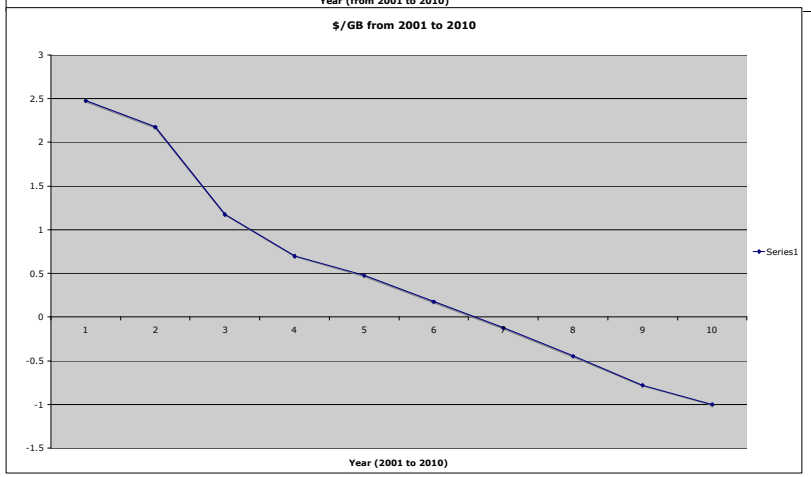
- Use a stronger code.
- More complex encoder and decoder.
- Less ENOB Required in ADC.
- Save on FFE data-path too.
- This is done using THP and LDPC Codes.

Bates Digital Systems

Smaller!

- A pervasive trend in our industry is for things to get smaller.
  - Process sizes.
  - Chip sizes.
  - Power consumptions.
  - **Storage area**.
- This drive comes from the consumer who wants to store more information in less space than ever before.
- We, as CMOS ETers are more than happy to oblige.





In Hard Disk Drive market volumes are rising but price per GB is dropping exponentially!

Bates Digital Systems

Sponsored in part by

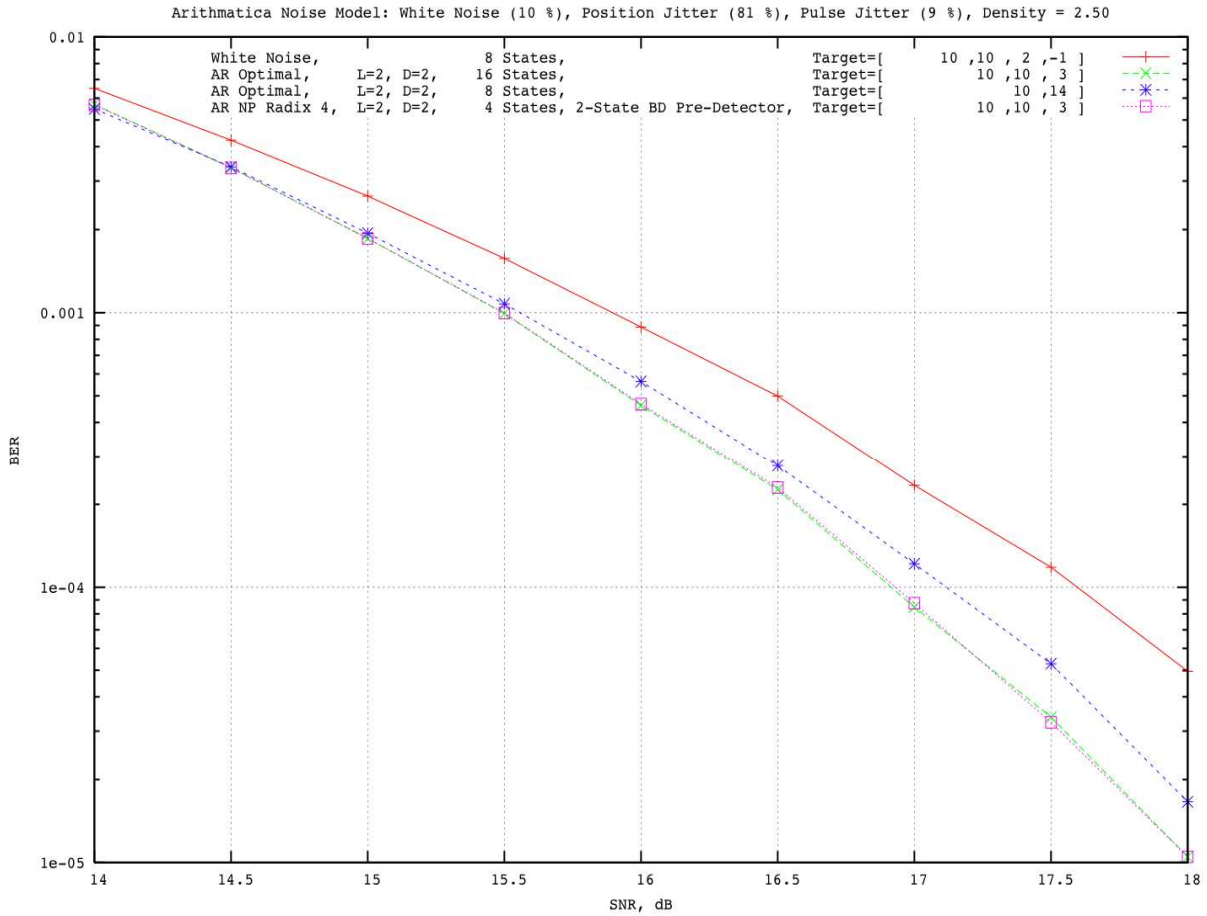
QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Smaller! Case Study

- Storage area in HDD hit a bottleneck 3-4 years ago.
- Solution: Flip magnetic “bits” on end a store them perpendicularly (PMR).
- Problem: More interference between bits, more noise, more precision in read head required.
- Solution: More complex DSP and error correction.

Bates Digital Systems

Arithmatica Detector Performance

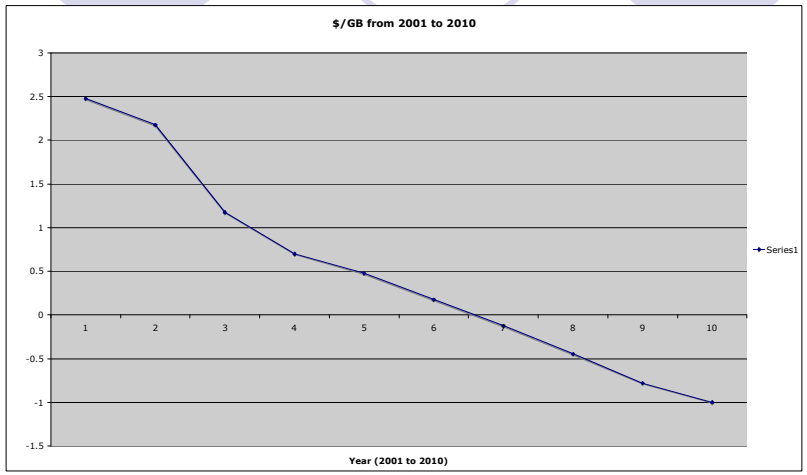


- BER of Arithmatica detector is identical to that of the optimal 16-state DDVD and is 0.4 dB better than WNVD.
- 0.4dB improvement allows you to increase storage density by 5% which leads to an increased storage value of $500,000,000 in 2010.

Bates Digital Systems

Cheaper!

- A pervasive trend in our industry is for things to get cheaper.
  - $/GB storage.
  - $/GMPS networking.
  - $/MIP computing.
- This drive comes from the consumer who *just* wants
  - Infinite network speed.
  - Infinite storage capacity.
  - Infinite computation resources.
  - Nominal cost.
- We, as CMOS ETers are more than happy to oblige.



Bates Digital Systems

Better?

- This desire by consumers for infinite speed, storage and computation power is a good thing.
- The fact they are not willing to pay for it is not.
- Someone has to get squeezed and that tends to be us, the CMOS ETers!
- This is not good…

Better? PE Ratios…

- Here are some Price/Earnings (PE) numbers.
- PE gives an indication of how of each dollar of market capitalization affects the bottom line. High is good for the company since you raise more money for each dollar of your earnings.
- Note profit is not at all like revenue! I can have $1Billion in revenue and make less profit than a university professor

Better? PE Ratios: Storage

- Google: Provides services to consumer. Sells advertising: **47.84**.
- Dell: Makes servers and PCs. Sells to Google. **21.59**.
- Seagate: Makes HDD. Sells to Dell. **38.54**.
- LSI Logic. Makes HDD chips. Sells to Seagate. **16.96**.
- Cadence. Makes EDA Tools. Sells to LSI. **37.19**.
- TSMC. Fabs chips. Sells to LSI. **28.83**.

Better? PE Ratios: Networking

- Google: Provides services to consumer. Sells advertising: **47.84**.
- Cisco: Makes networks for data centers. Sells to Google. **38.54**.
- LSI Logic. Makes network chips. Sells to Cisco. **16.96**.
- Cadence. Makes EDA Tools. Sells to LSI. **37.19**.
- TSMC. Fabs chips. Sells to LSI. **28.83**.

Better? Why these PEs?

- The consumers desire for cheap (free) storage, bandwidth and CPU is provided by companies like Google.
- This puts pricing pressure on their supplies (Cisco, Dell etc.).
- Which is turn puts pricing pressure on their suppliers etc.
- Until we get to the CMOS ETers. Here things change and our suppliers appear to be able to extract better PEs (margins?) than us.
- **No Fair!**

Better? Why these PEs?

- This is due to the fact that the products we provide are considered commodity. Even though the technology inside our chips is incredibly complex.
  - E.g. 1000BASE-T chips are currently sold for <$1/port.
- They are considered commodity because once the NRE is done, they are really just clever pieces of sand. No differentiation between competitors except price.
- Our margins are therefore incredible tight and can go negative very easily. Investors factor this in and hence the low PEs.
- Our suppliers tend to be enablers and also limited in number. They have better margins than us.

Conclusions

- Web 2.0 is helping our volumes. Consumers demand infinite storage, networking speeds and computation power.
- Web 2.0 is killing our margins. Network/Storage now seen as a commodity.
- Huge drive for technology that delivers on these:
  - Advanced coding.
  - Clever communications.
  - More DSP.
- Execute with perfection, move up the food chain or specialize in higher value areas of CMOS applications (e.g medical).

Bates Digital Systems

- One full time, one other at 50%.
- Seven sub-contractors. All with a mix of DSP, communications, digital design, ASIC, FPGA and software experience. Two experts (PhD+) in LDPC codes.
- 75% activity pure design services and consulting:
  - 10GBASE-T.
  - HDD Read Channels (DSP+LDPC).
  - RPR network optimization.
  - Receivers (TIMIG+LDPC) for satellite delivery of audio services.
- 25% IP development and R&D.
- 100% self-funded but considering options regarding capital investment.
- Based in Canmore and Calgary. Clients world-wide.

DBS2001: LDPC for STiMi

- IP Core for GY/T220 (STiMi) DVB standard developed by the Chinese Governmental department responsible for communications.
- OFDM based and 8 MBPS data rate. Similar RF/IF to DVB-H.
- Advanced error correction
  - LDPC with two rates.
  - Codeword size of about 4000.
- Our IP provides:
  - Compliant decoder.
  - Flow control.
  - Metrics for dynamic power optimization.
- Deliverables:
  - RTL for core.
  - Testbenches
  - FPGA development kit.

Bates Digital Systems

BDS: The daily commute…

Bates Digital Systems