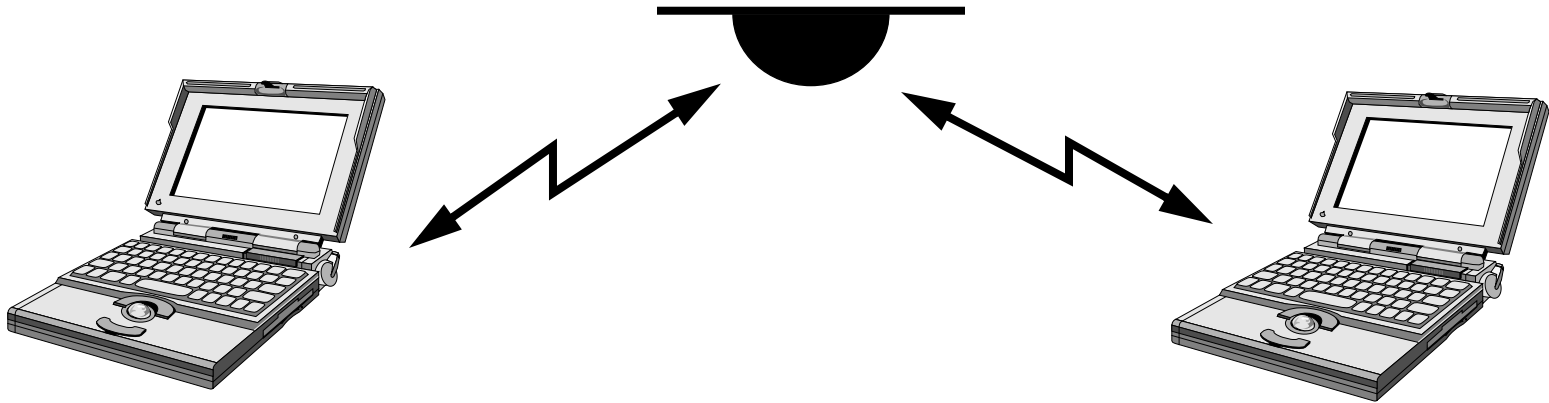


**A 75mW 128MHz DS-CDMA
Baseband Correlator for High-Speed
Wireless Applications**

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**University of California
Berkeley**

High-Speed CDMA Application



Wireless Local Area Network

- Data Rate: 1Mb/s - 10Mb/s

Requirements

- Spread Spectrum
- Multi-user Access
- Portable ➔ Low Power

Low-Power CDMA Demodulation

Problem

Digital CDMA Demodulation

- **High-Speed Correlation**
- **High Sampling Rate ADC**
- **High Power**

Solution

Analog Correlator Eliminates High-Power ADC

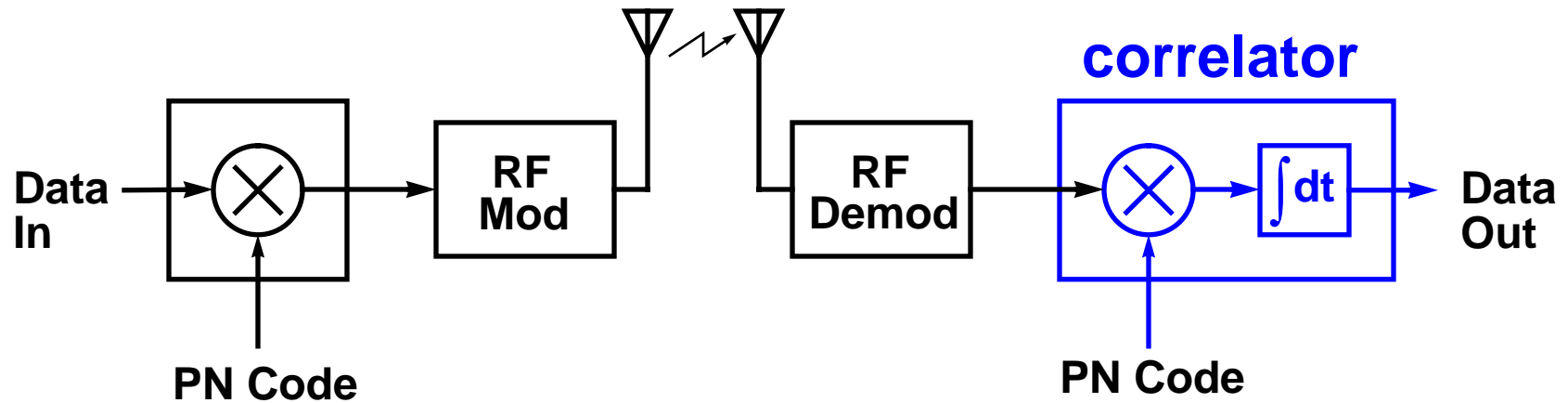
Outline

- *DS-CDMA Overview*
- **Correlation In The Analog Domain**
- **Experimental Prototype**
- **Conclusions**

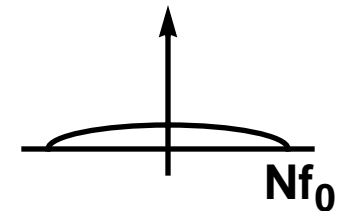
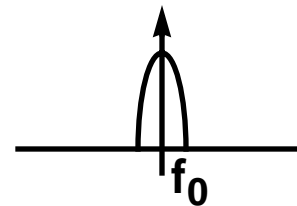
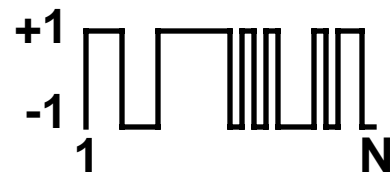
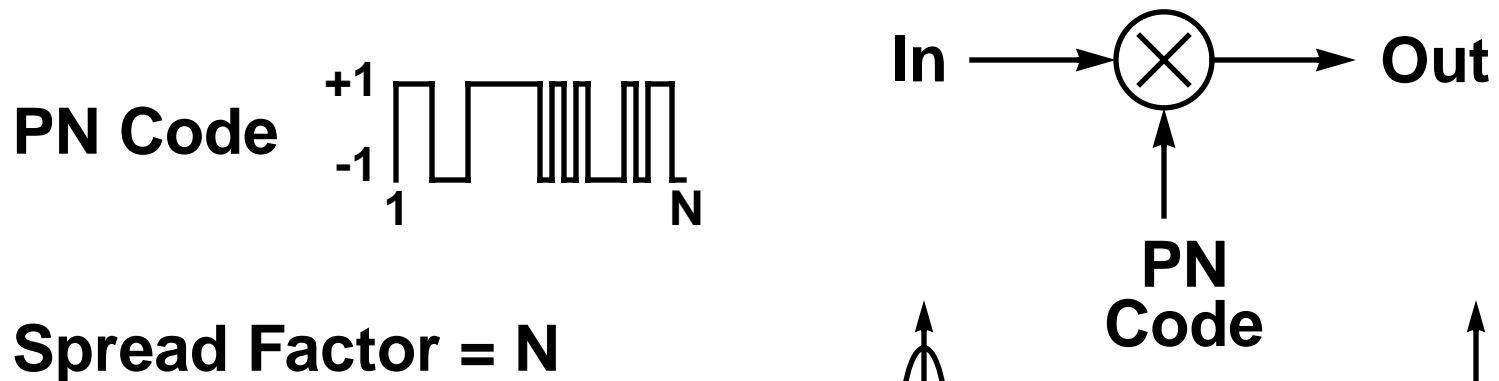
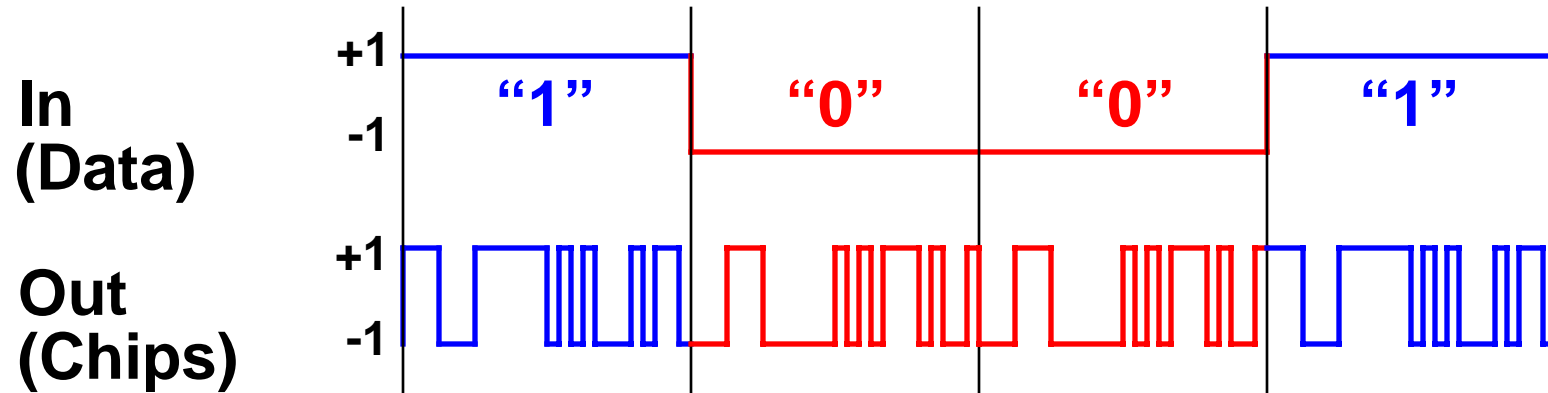
Wireless DS-SS System

Modulator

Demodulator

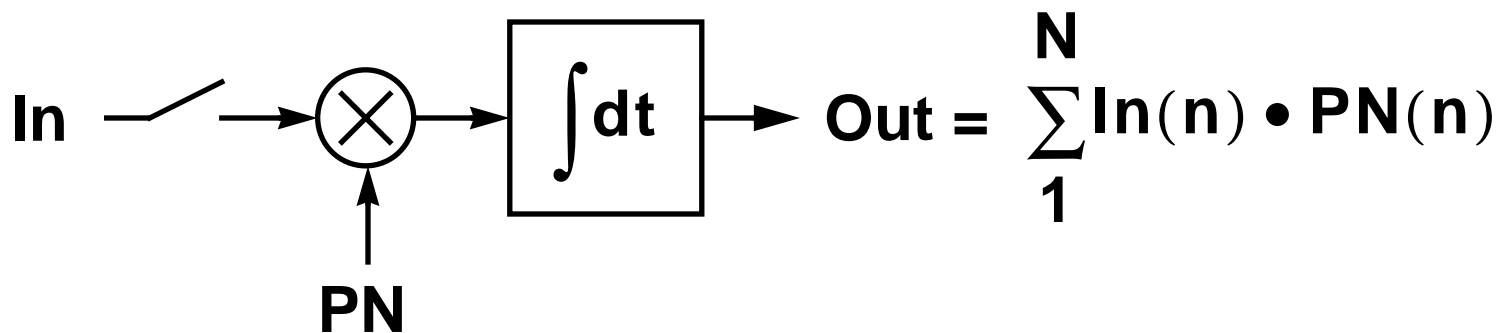
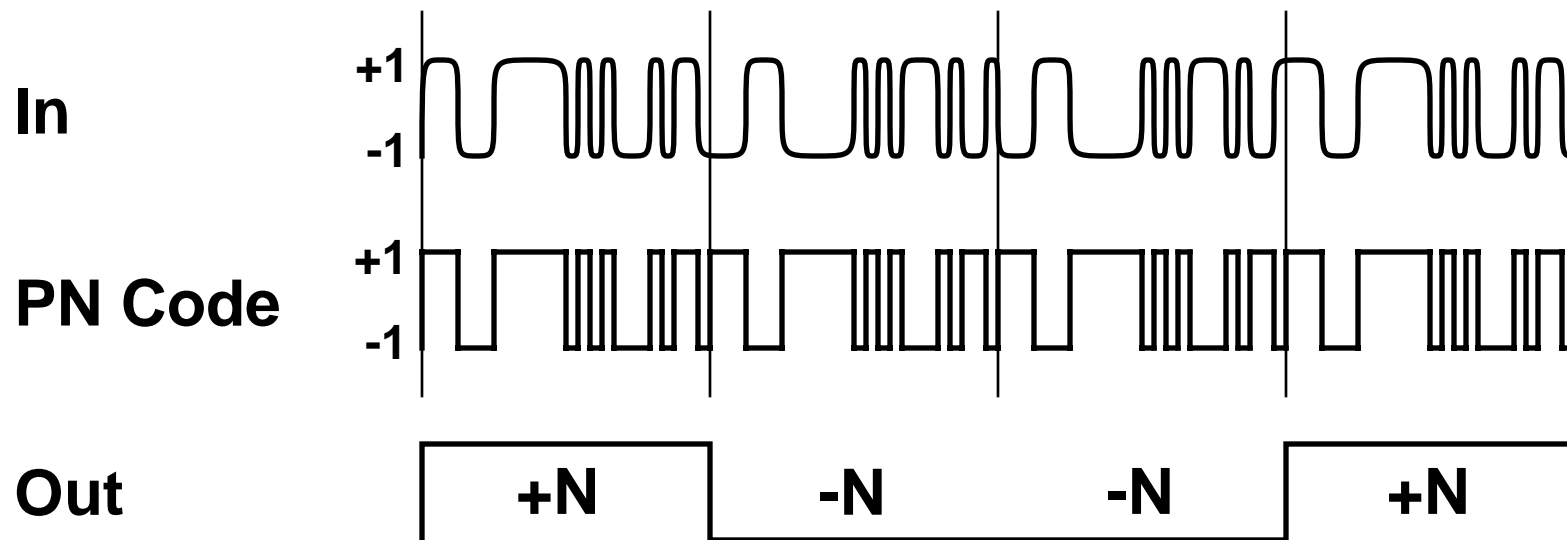


Direct Sequence Modulation



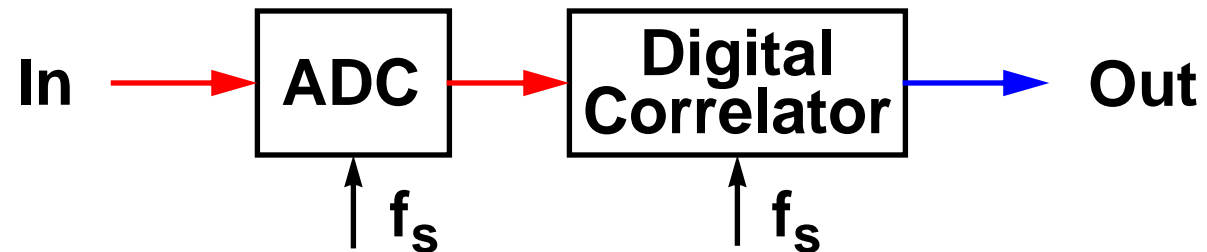
Spread Factor = N

Demodulation: Discrete Time Correlation

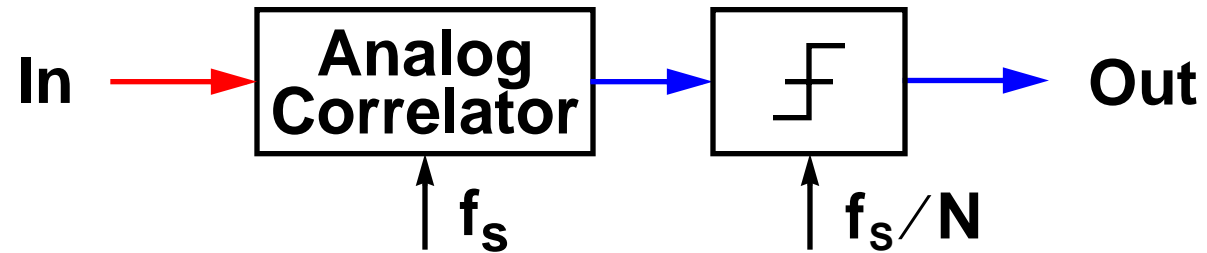


Digital Or Analog?

Digital Approach



Analog Approach

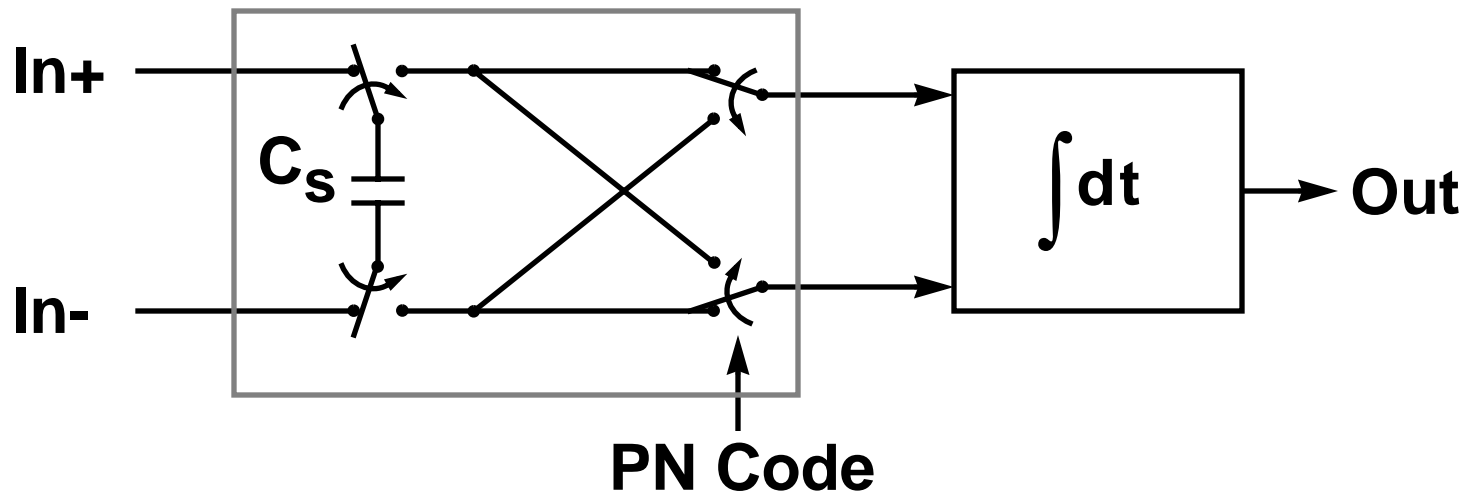
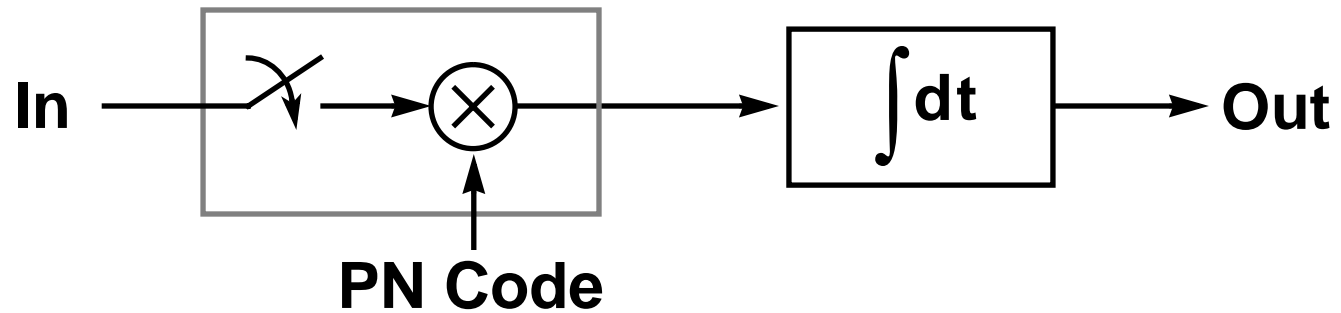


Analog Correlation Eliminates High-Speed ADC

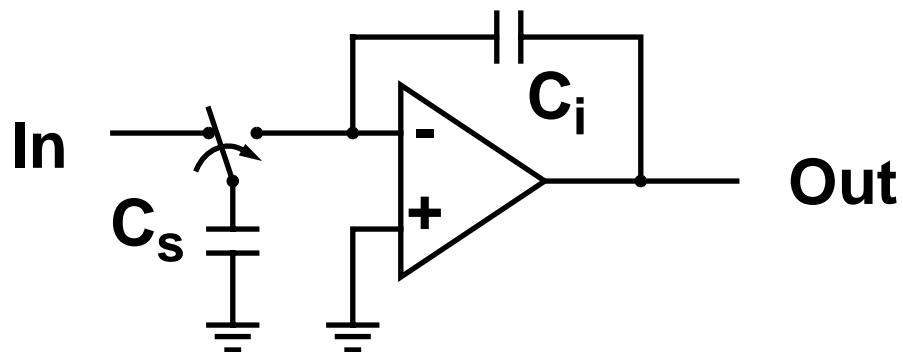
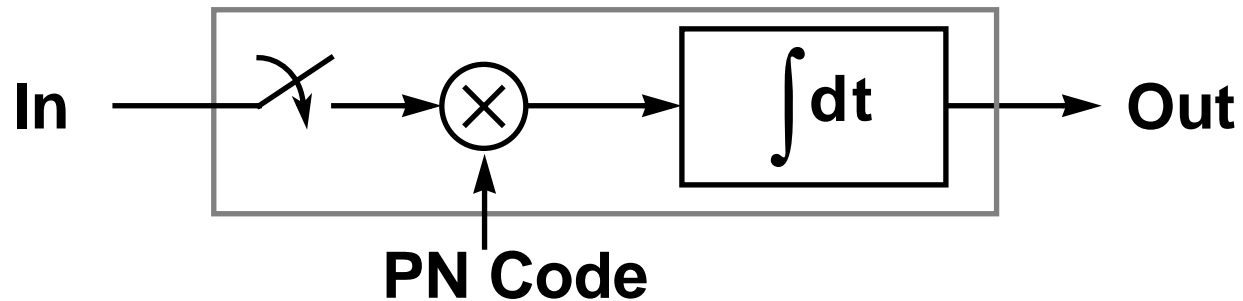
Outline

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- ***Correlation In The Analog Domain***
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Analog Sample & Modulate

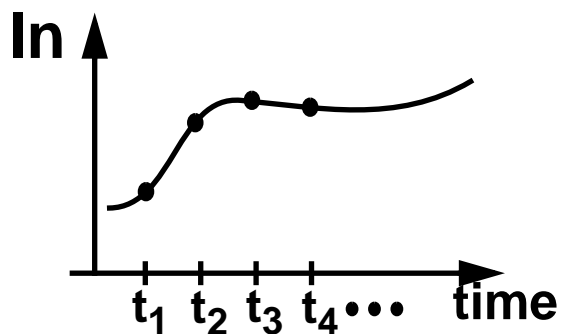
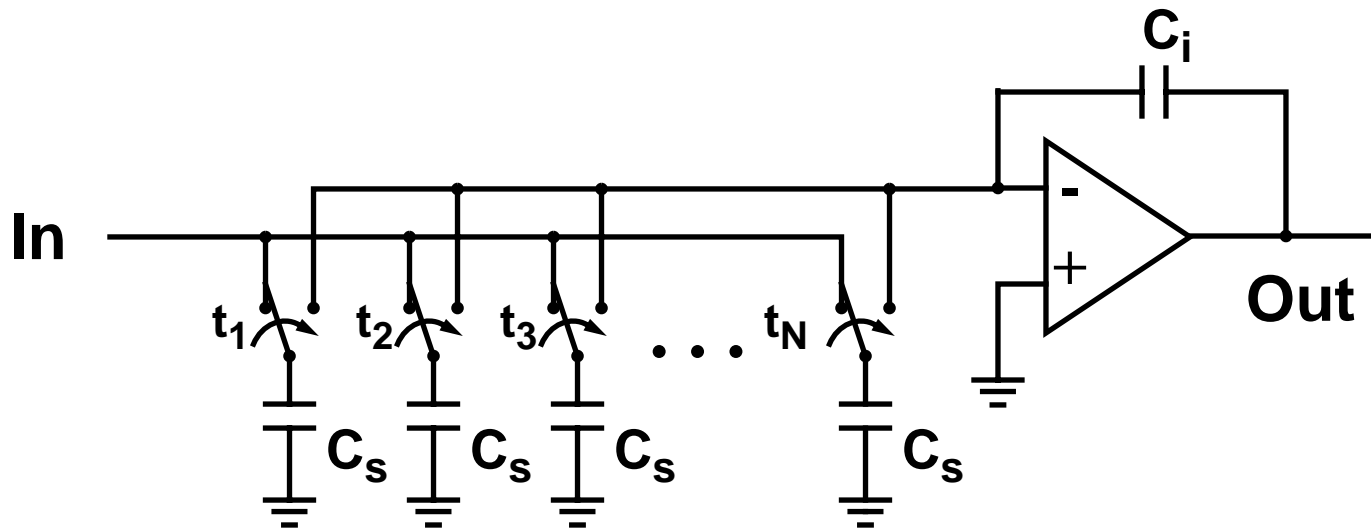


Active *Chip* Rate Correlation



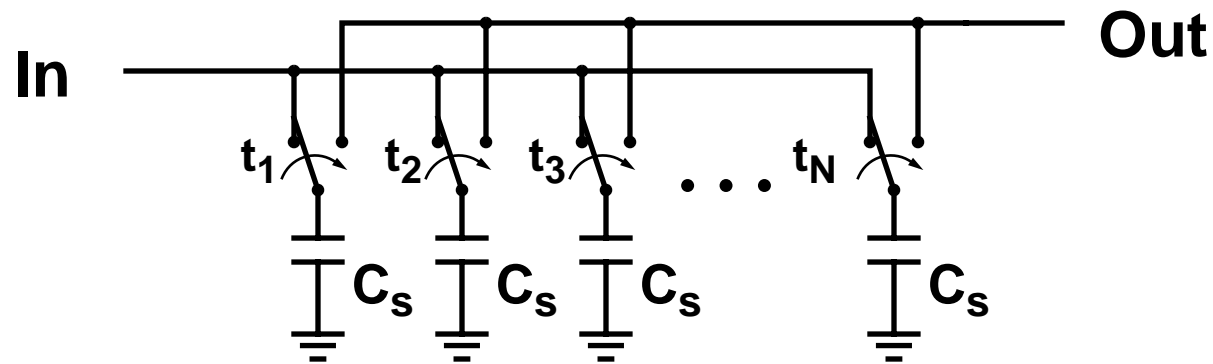
- Output At Chip Rate
- High Static Power

Active *Data* Rate Correlation



- Output At Data Rate
- Low Static Power

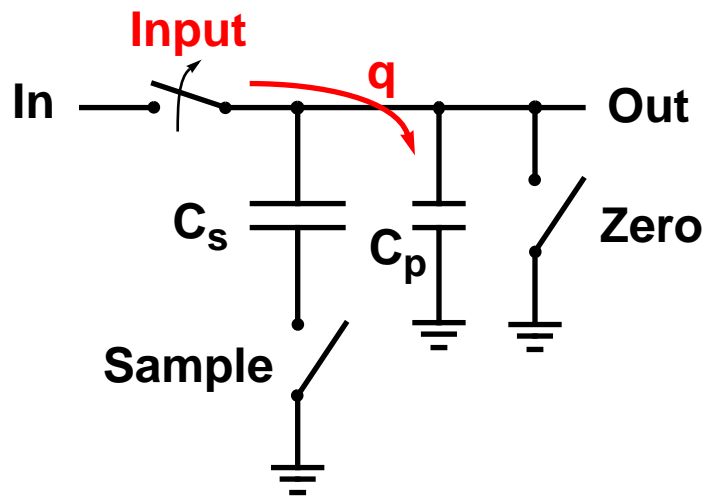
Passive Data Rate Correlation



- Output At Data Rate
- No Static Power

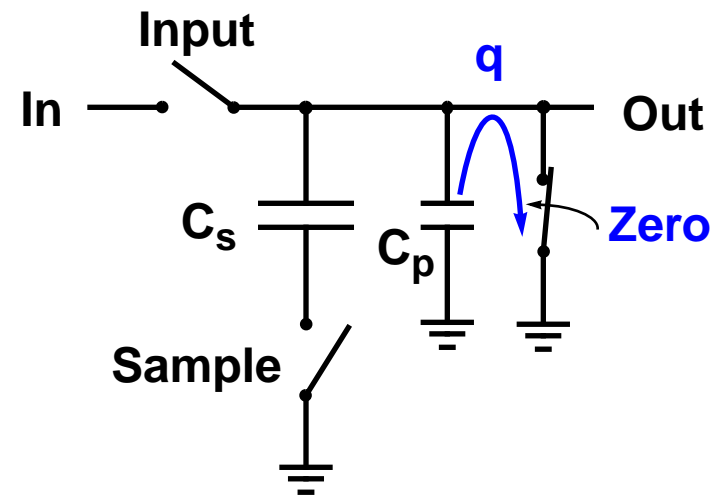
Eliminate Signal-Dependent Charge

Disconnect From Input



Charge Injected On C_p

Discharge To Ground



Charge Error Is Removed

Outline

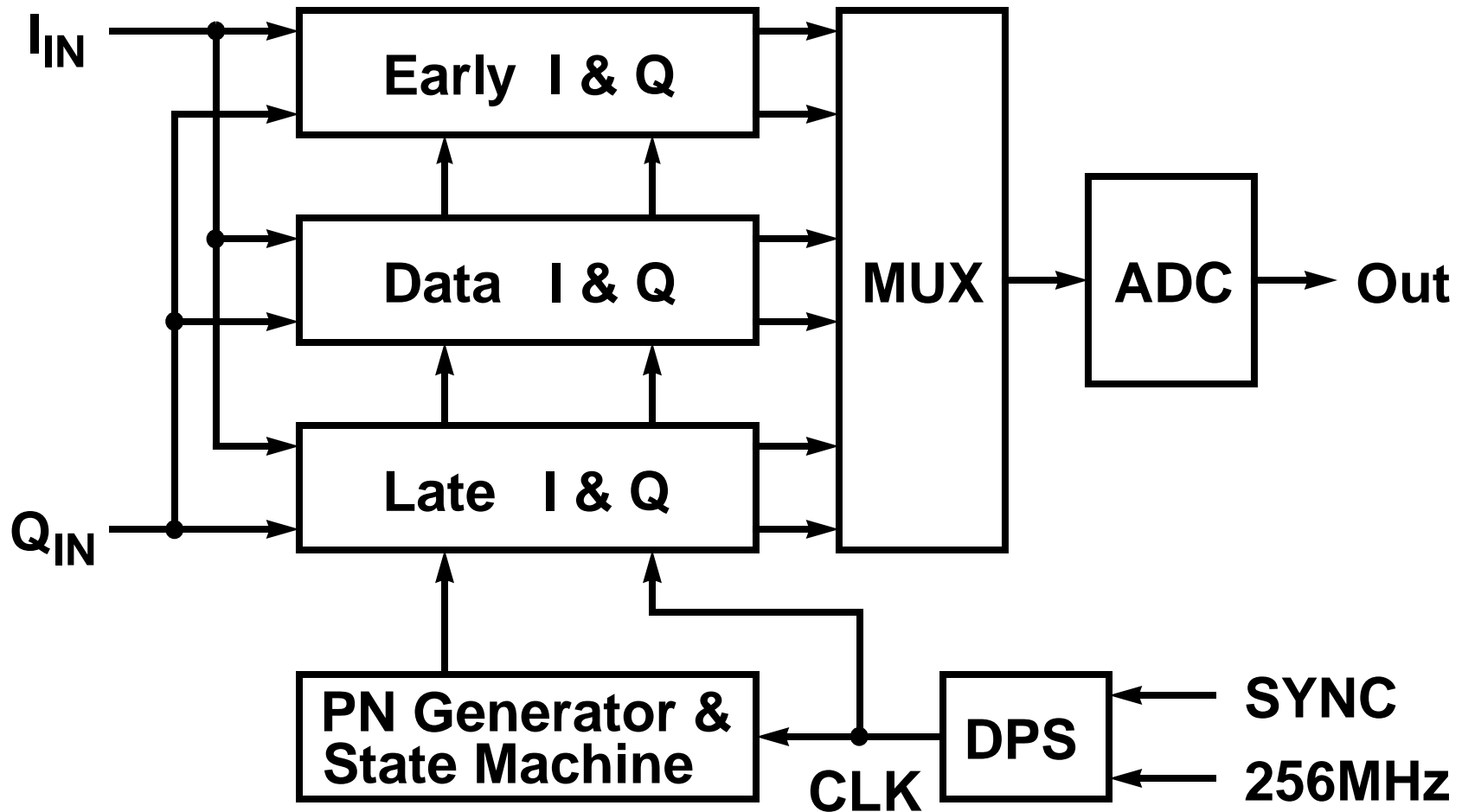
- **DS-CDMA Overview**
- **Correlation In The Analog Domain**
- ***Experimental Prototype***
- **Conclusions**

Prototype Specifications

Wireless Indoor LAN

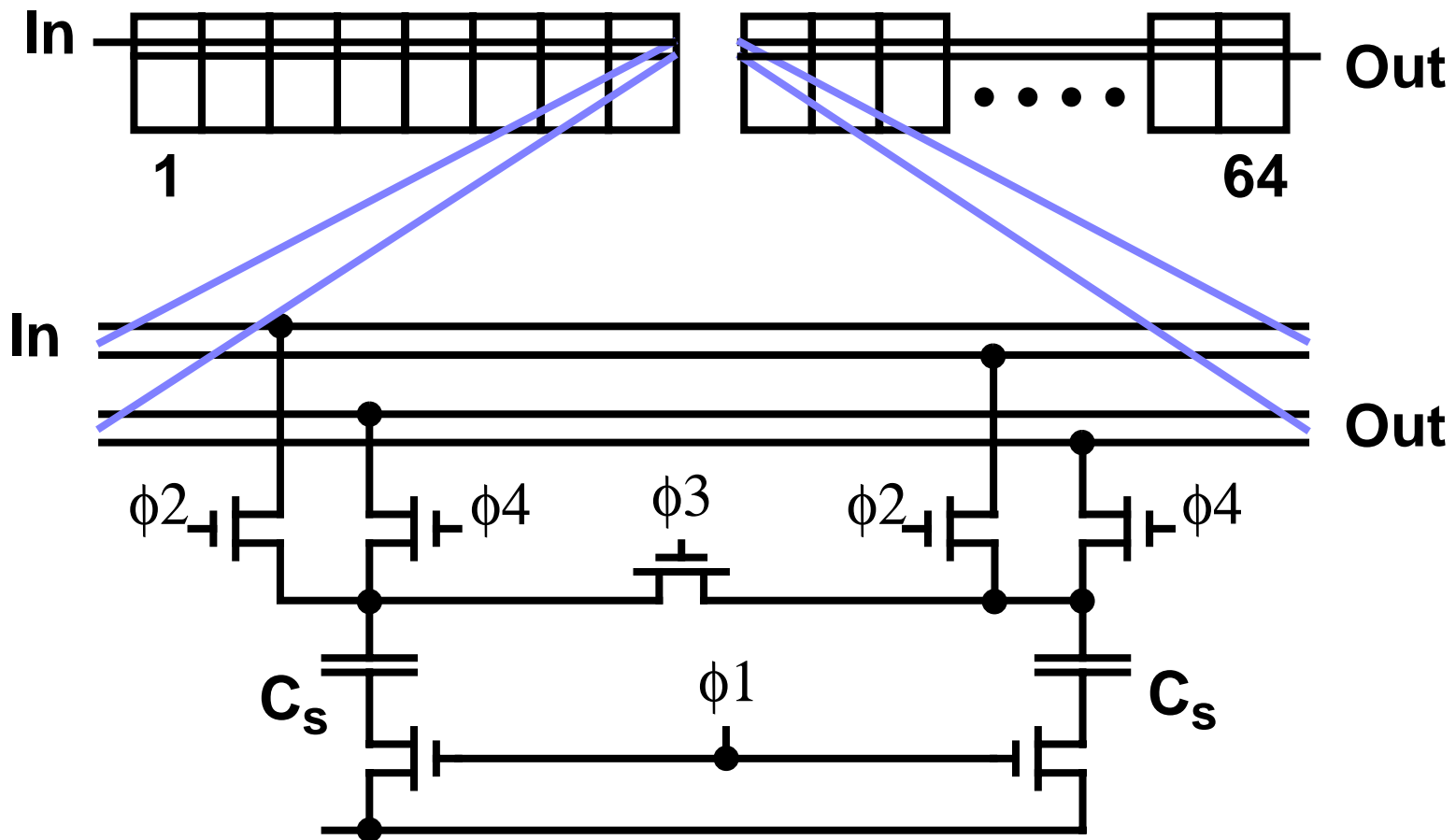
- **Data Rate:** 2Mb/s
- **Modulation:** DS-CDMA QPSK
- **Spread Factor:** 64 (50+ users)
- **Chip Rate:** 64Mc/s
- **Sampling Rate:** 128MS/s

Prototype Block Diagram



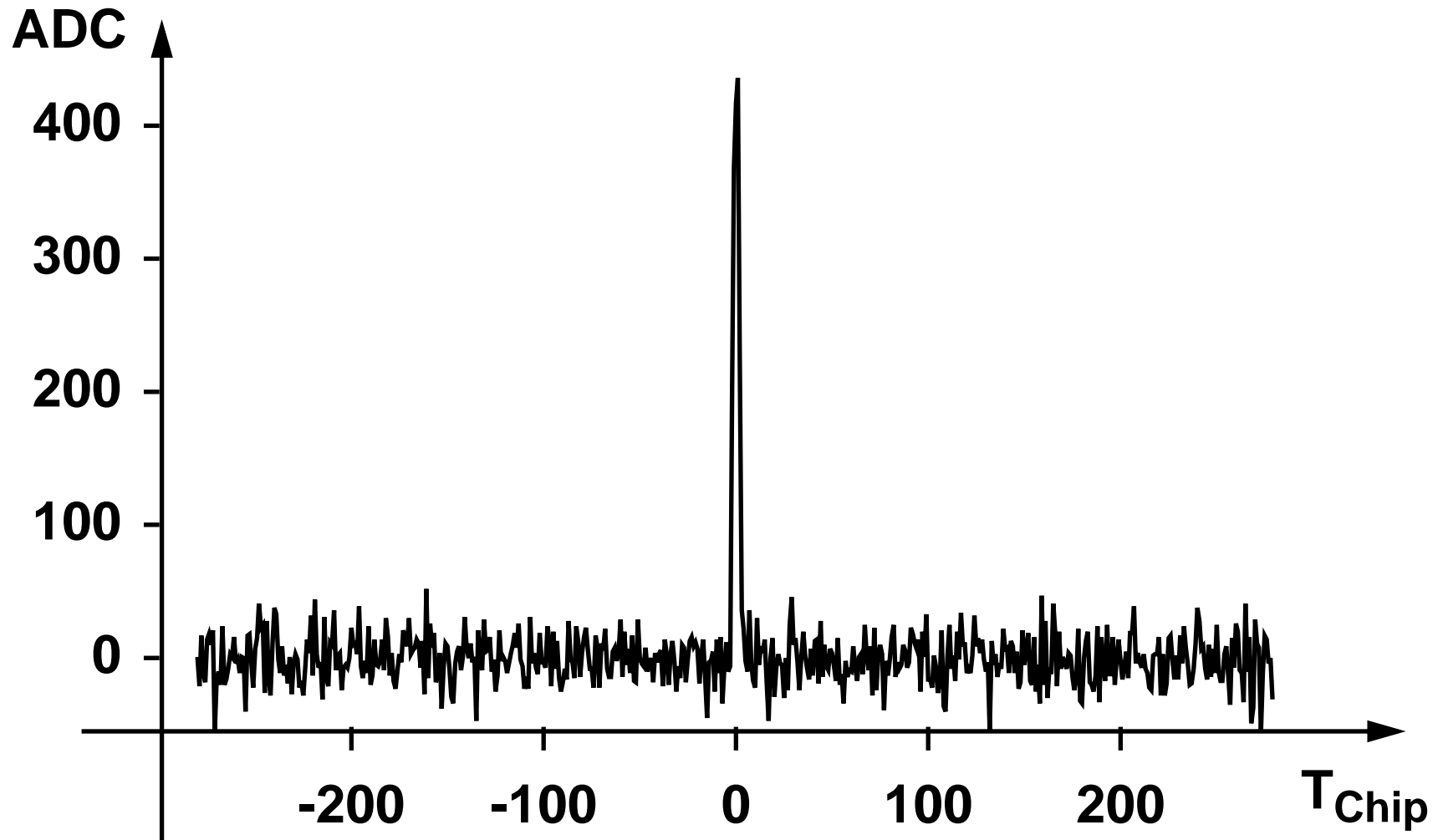
Single Correlator Cell

64-cell Correlator



Die Photo (place holder)

Measured Correlator Output



Input Dynamic Range

Why Is It Important?

- Accommodate Signal Strength Variations
- Proper Correlation In Presence Of Large Interfering Signals

Definition

- DR = $\frac{\text{Largest Valid Input Signal}}{\text{Minimum Detectable Signal}}$

Measured Data

- Largest Valid Signal: 1.500V
- Minimum Signal: 0.003V
- DR = 54dB

Performance Specifications

Correlator

- **Dynamic Range** 54dB
- **Sampling Rate** 128MS/s
- **Power Dissipation** 60mW (5V)
- **Size** 4.5mm X 5.6mm

ADC

- **Resolution** 10bits
- **Sampling Rate** 8MS/s
- **Power Dissipation** 15mW (3.3V)
- **Size** 4.5mm X 3.7mm

Technology

1.2um CMOS 2P2M

Conclusions

- **Low Power Analog Solution**
- **Passive Correlation Technique**
- **Signal-Dependent Charge Cancellation Method**
- **DS-CDMA Correlator Prototype**