GPS Timing

ACIGA

Research Presentation

by

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Agenda

- Why do we need precise timing?
- Introduction to GPS
- Data acquisition system synchronized to GPS timing

Why do we need precise timing?

- Precise frequency ⇨ precise timing
- Correlate and synchronise measurements anywhere in the world without direct connection ⇨ precise timing

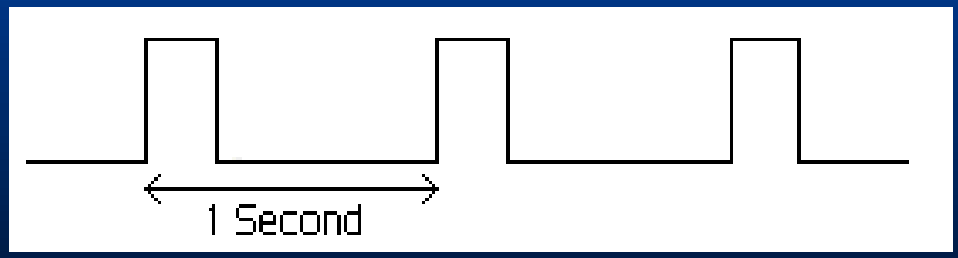
⇨ GPS time synchronisation can be used to precisely timestamp and trigger the data acquisition events

Introduction to GPS

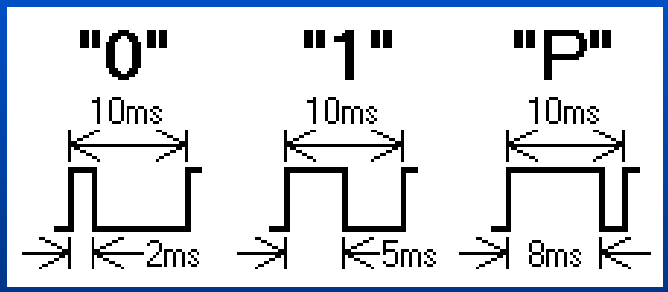
- Global Positioning System, GPS
  - 24 satellites
  - Revolving around the earth every 12 hours
  - The atomic clock onboard with an accuracy of $\Delta f/f < 10^{-14}$
  - Transmit their coordinates in space along with a time message on a 1.5 GHz carrier frequency.

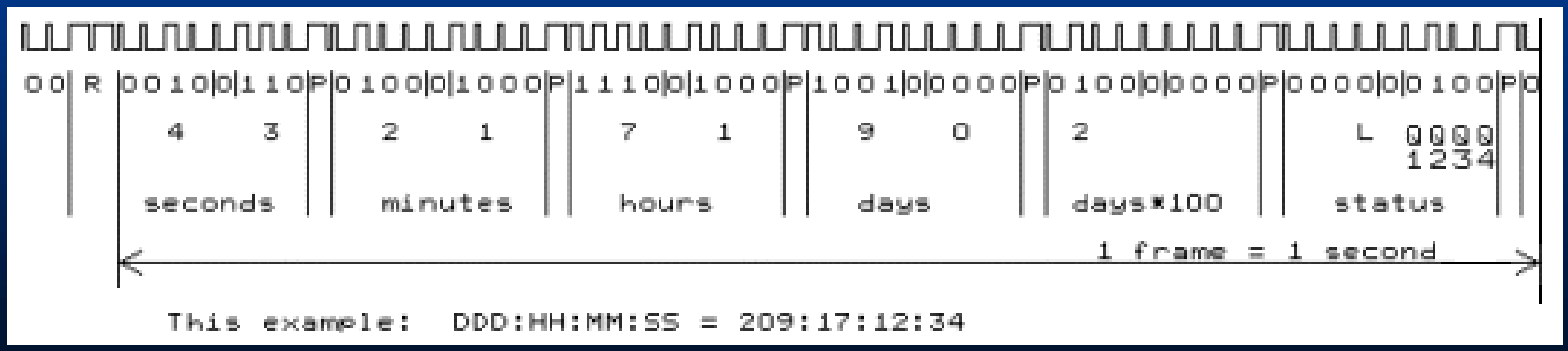
Two GPS timing signals

- Pulse Per Second - PPS
  - GPS receiver outputs a pulse once a second
  - The pulse width is generally 100 ms, but programmable
  - The rising edge define each second start



- IRIG-B
  - IRIG, Inter-Regional Instrumentation Group
  - An encoded TTL signal carrying the absolute time.
  - IRIG repeats or re-synchronises every second





- IRIG-B
  - 10 ms period ⇒ One bit
  - 2 ms high ⇒ 0
  - 5 ms high ⇒ 1
  - 8 ms high ⇒ P-bit
  - The P- bit separates seconds from minutes, minutes from hours, and so on, within the 1-second frame.

Data Acquisition with GPS Timing

- Hardware
  - NI PCI-MIO-16XE-50 DAQ card
    - » 8 16-bit input channels (ADC)
    - » 2 16-bit output channels (DAC)
    - » 20kHz sampling rate maximum
    - » 2 24-bit counter/timer
    - » 20MHz internal time base
  - Garmin GPS receiver
    - » Output GPS time
    - » Output PPS signal

Limitations of the DAQ Card

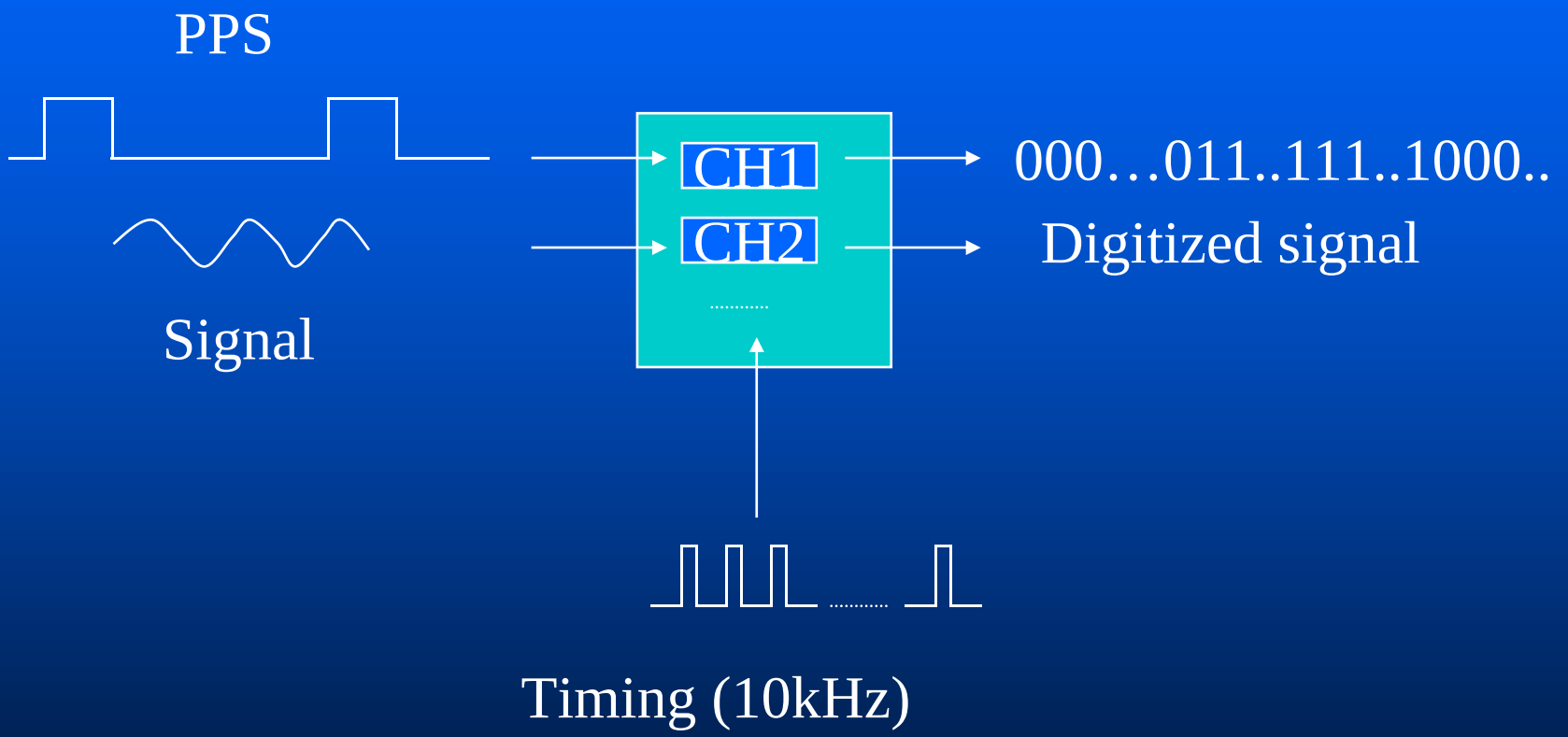
- Software timing: 1ms
- Internal hardware timing
  - Accuracy determined by base clock on the card
  - Base clock accuracy:
    - » 0.01% (specifications)
    - » ~10 us/sec (measured using GPS PPS)

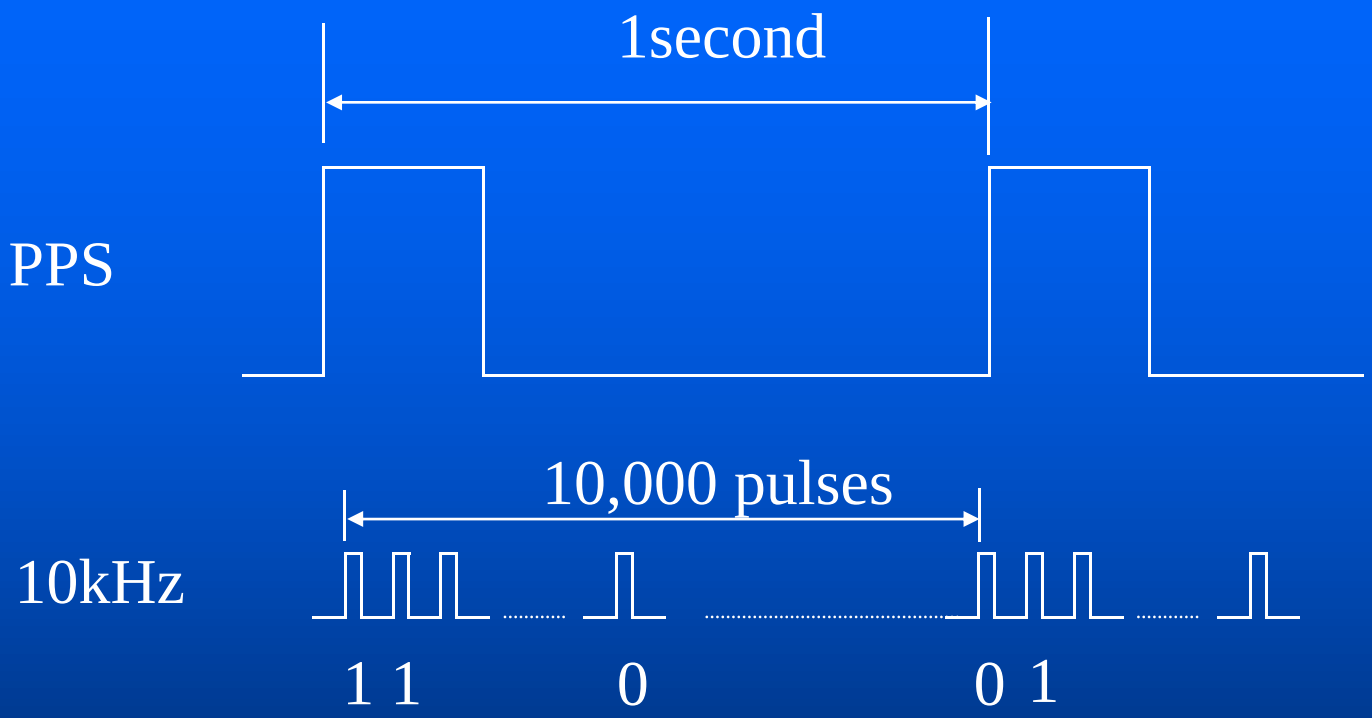
⇨ Error accumulation could be a problem

Possible Solutions

- External precision clock synchronized to GPS provides time base for DAQ timing
- Synchronize internal clock to GPS

The Idea of GPS Synchronization

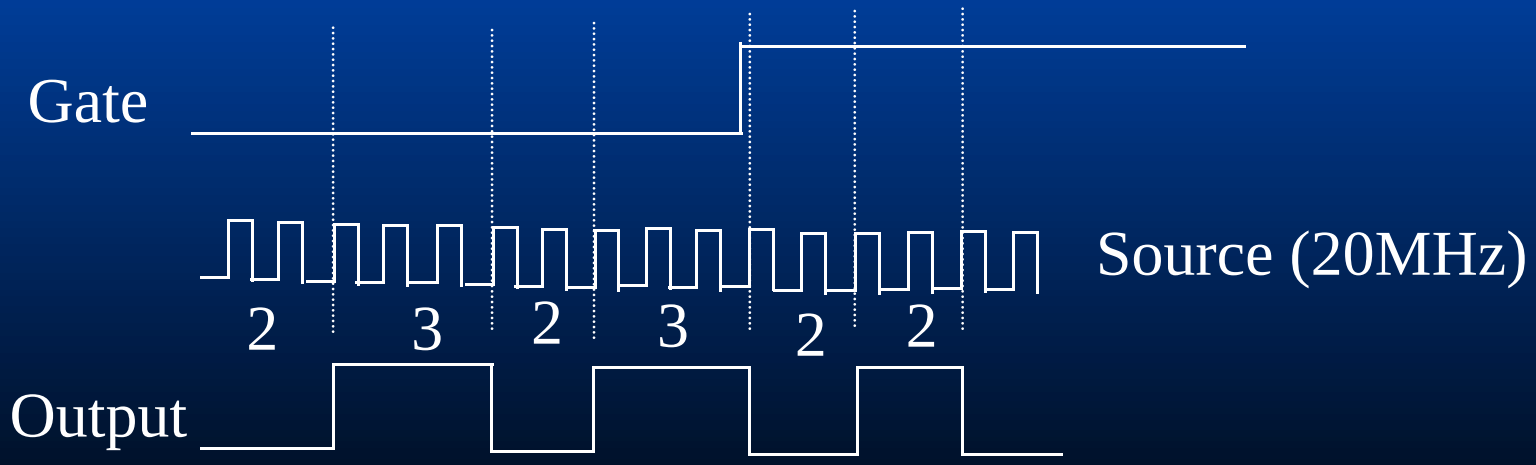


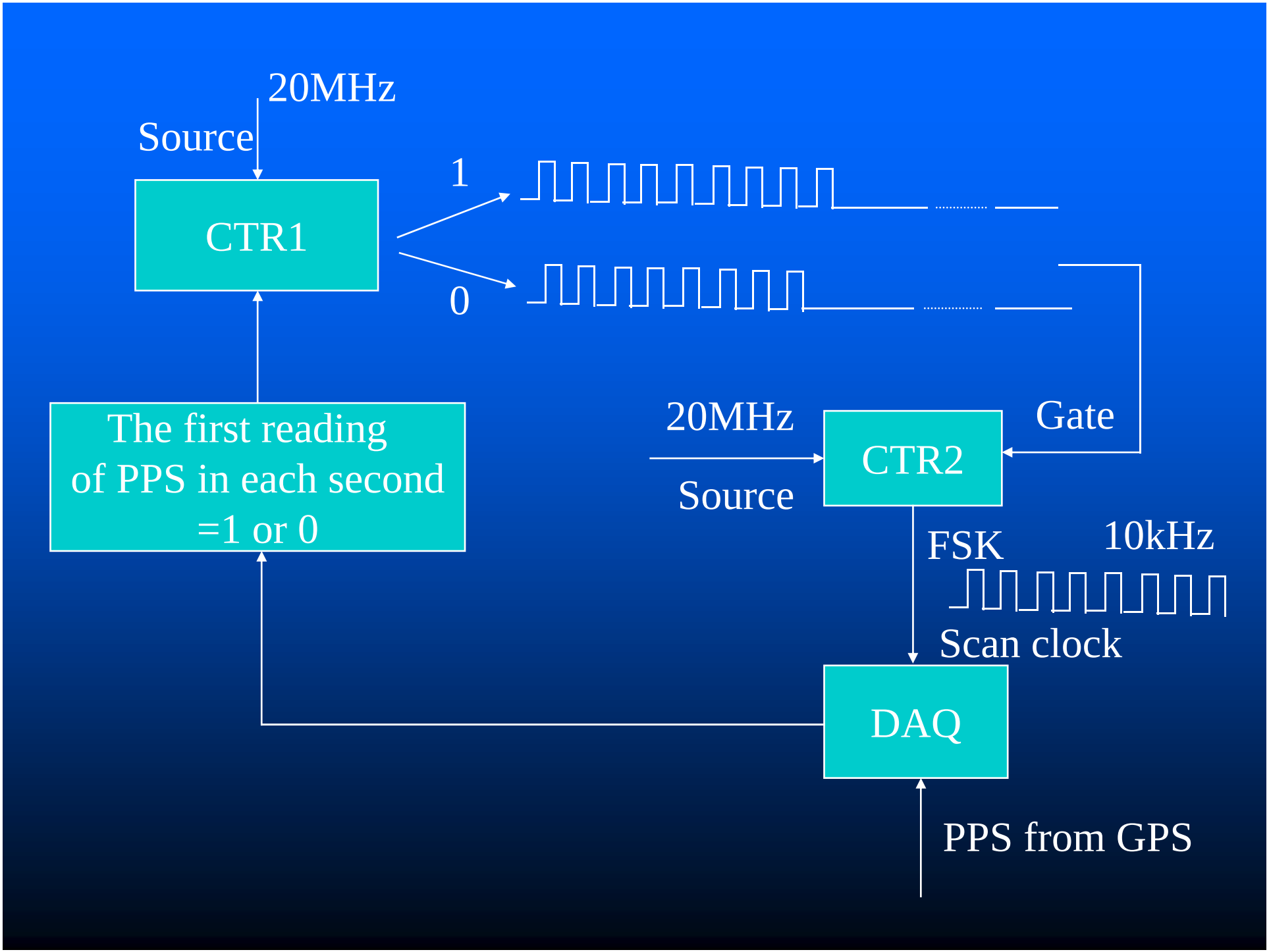

1second
PPS
10,000 pulses
10kHz
1 1
0
0 1

Realization

- Frequency Shift Keying (FSK)
  - Level controlled pulse train generation

•Gate is the signal present at the counter gate input.
•Source is the signal present at the counter source input.
•Output is the signal present at the counter output.




20MHz
Source
CTR1
1
0
The first reading
of PPS in each second
=1 or 0
20MHz
Source
CTR2
Gate
FSK
10kHz
Scan clock
DAQ
PPS from GPS

Conclusion

- Synchronising DAQ internal time base to GPS timing is practical
- The system is cost effective
- The accuracy depends on the stability of the internal time base
- More test to ensure the accuracy