Diamond Hardware Synchronisation

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January 2011

Diamond Control System

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- Synchronisation through EPICS PV's
- Synchronisation with the encoder compare output of motor controllers.
- 4 Channel timer
- Synchronisation through the timing system
- Discrete wiring

Time Frame Generator 2

- 6U double slot VME card
- Requires Linux VME SBC for communication
  - Uses GDA for drivers and configuration software.
- Time resolution to 10ns.
- Times range from 10ns to 24hrs
- Repetitive frame patterns (1 to 2^{32})
  - either free running or synchronous to the synchrotron beam bunch structure or other external clock.
- Wide variety of I/O standards (TTL, LvTTL (terminated or unterminated), LVDS, CMOS)
  - including variable threshold +/-5V 50Ω terminated, and +/-24V high impedance inputs.
- Analogue triggers could be added, but aren't at the moment.

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Time Frame Generator 2

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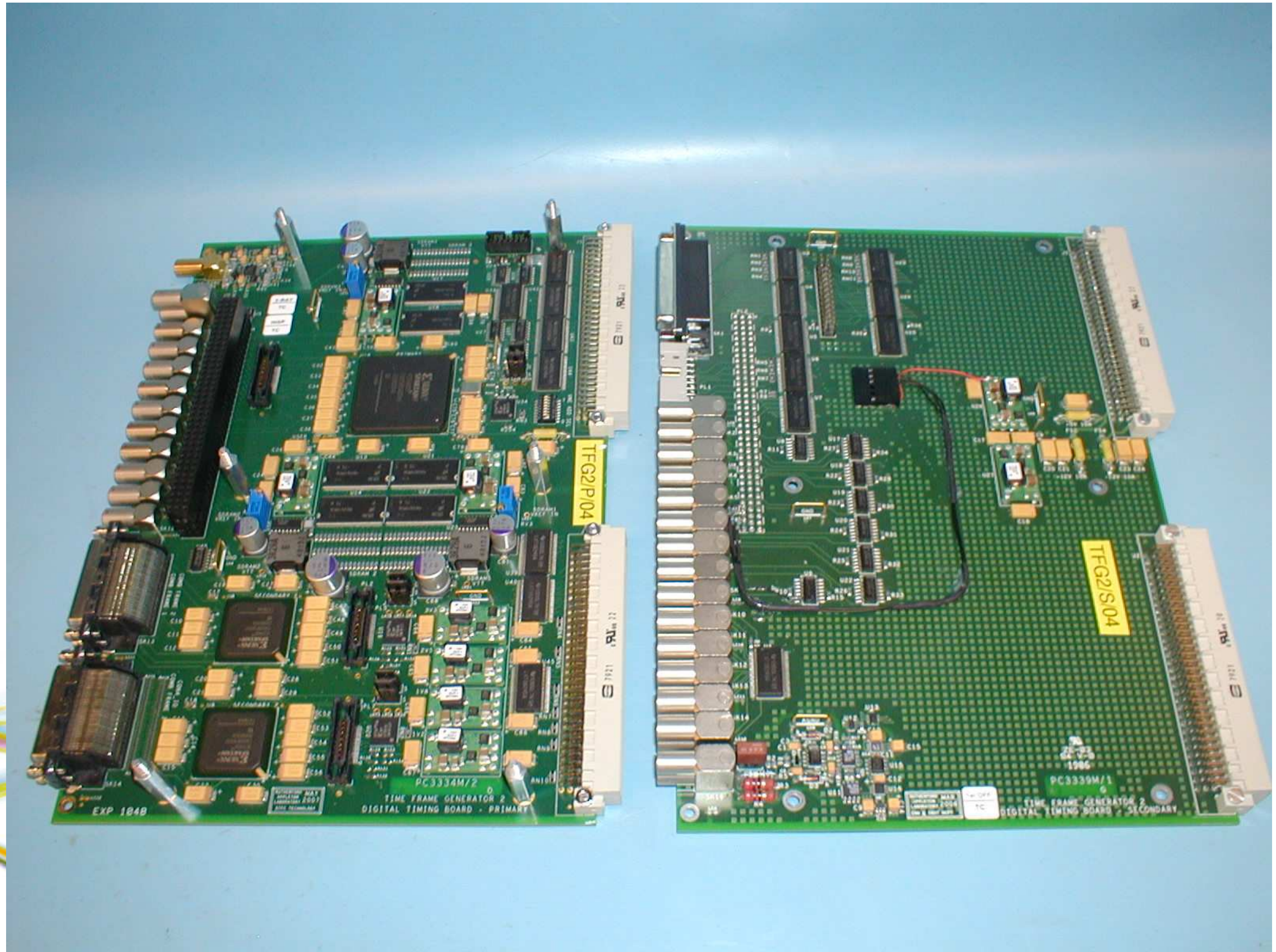
Time Frame Generator 2



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EPICS PV Synchronisation

- **Primary use is ID synchronisation**
  - ID's move slowly and 10's of msec is ample.
  - Typical system moves at ~1 micron/sec with an accuracy of ~1 micron.
- **Drive the monochromater at the desired speed and either:**
  - Trigger the ID with a one-off constant velocity move at the same time.
  - Drive the ID with an EPICS monitor placed on the monochrometer energy.
- **Technique independently developed and used at both DLS and SLS.**

Encoder compare outputs

- Of course, synchronisation between axes on a motor controller is done by the controller....
- Delta Tau has an EQU output triggered by encoder decode gate array when the encoder matches a pre-set value – or value + n*offset.
- Used for MX shutter synchronisation and detector triggers.
- Pros:
  - Uses existing hardware
  - Low latencies
- Cons:
  - Not direction sensitive
  - No hysteresis, so multiple triggers possible.
  - Not hardware gated (needs to be added separately).,
- Newport XPS has similar capability.
  - Also has time based output
- Considering using the Soleil SPIETBOX for more demanding requirements.

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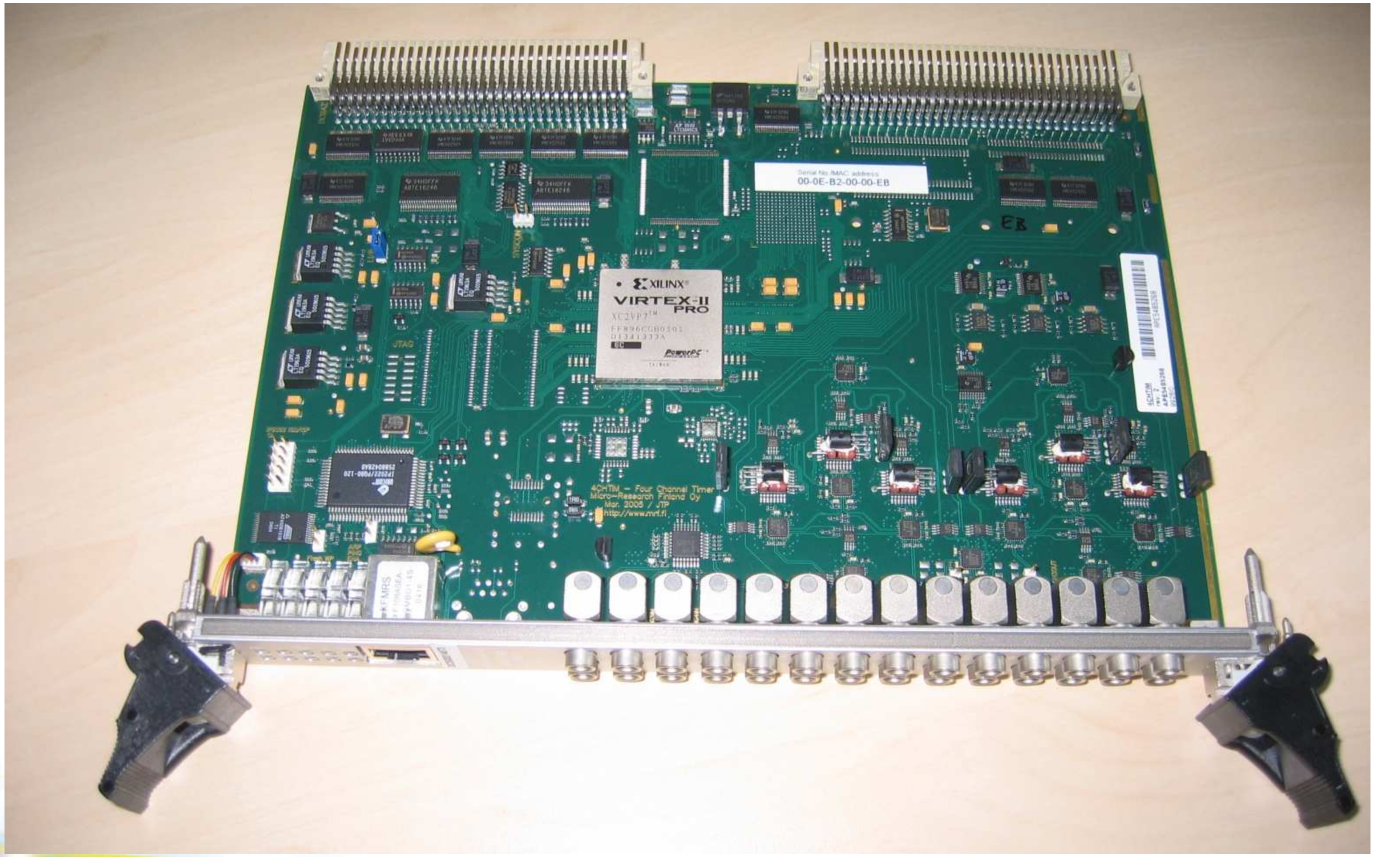
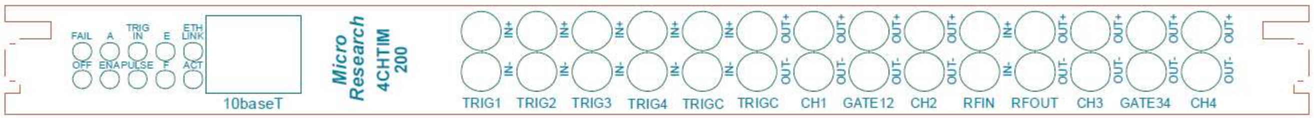
4 Channel timer

- 6U VME board from Micro Research Finland
  - Four independent timer channels with programmable delay and pulse width.
- Channels may be triggered from front panel or a transition board (TTL or LVPECL).
- Common trigger inputs allow triggering several channels from a single trigger source.
- Enable signal for each channel
- The timer channels operate synchronously to an externally applied RF clock (typically 500 MHz).
  - The delay and pulse width for each channel may be adjusted from 0 to 2^{32}-1 clock cycles.
  - Delay of each channel may be fine tuned with approximately 10 ps resolution.
- Two gate outputs (Gate1-2 and Gate3-4) also available (derived from the delayed outputs.)

4 Channel timer





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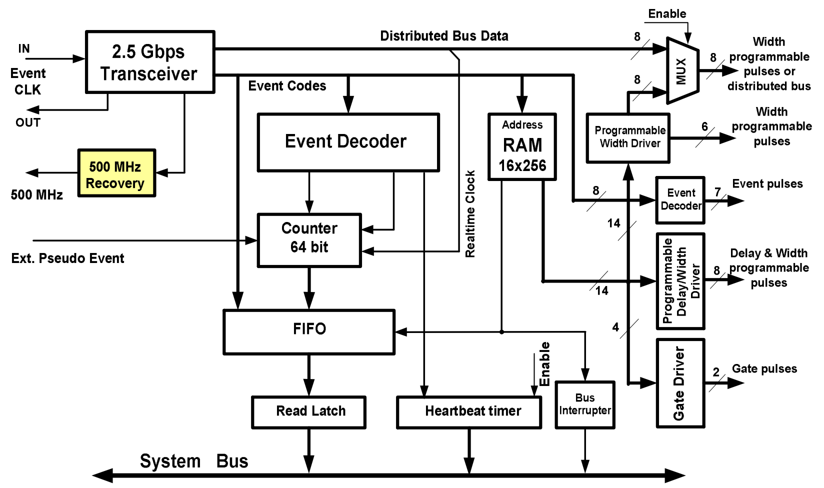
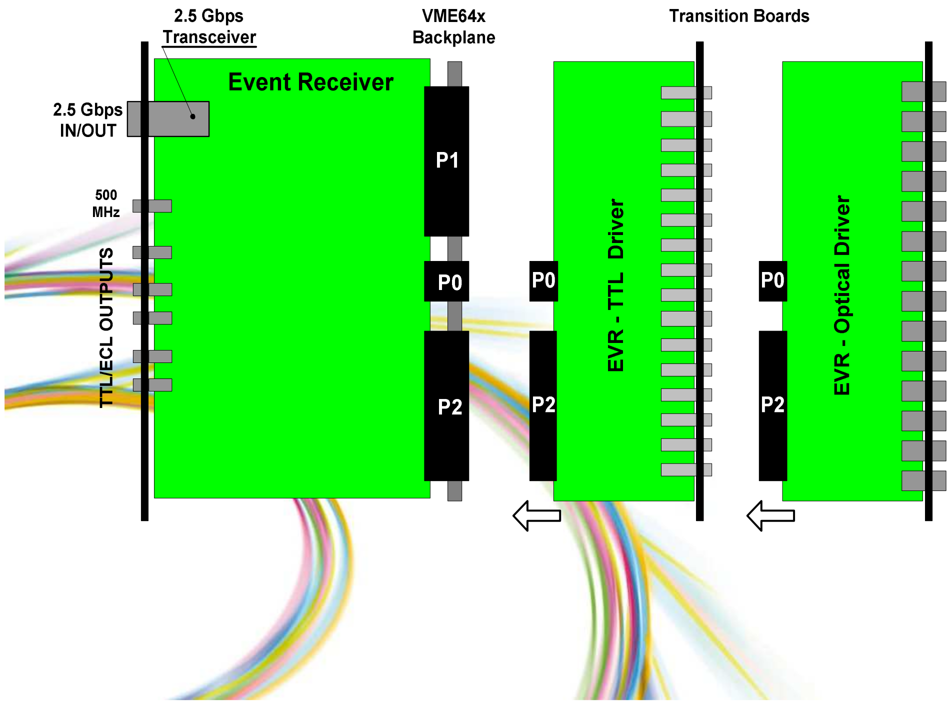
Event Receiver

- Part of machine timing system from Micro-Research Finland
- Triggers Fire-wire cameras on the machine.
- All beamlines have access to all machine clock
  - Not widely used at the moment.
  - Pulse-probe experiment actually triggered off machine analogue RF.
- A subset of all events is allocated to each beamline
  - However, the beamline would have to trigger the event on the machine's master event generator.

Event Receiver





- **BASIC FUNCTIONS:**
  - detecting external bus data
  - decoding event codes with following operations:
    - external pulse generation (programmable delay and width controlled)
    - software requests
  - updating a time stamping counter by special events or internal clocks
  - monitoring the validity of incoming data stream
  - recovering 500 MHz clock from beat stream

- **SPECIFICATION:**
  - Input/output ports:
    - Event CLK: Optical, 2.5Gbps
    - 500 MHz CLK: ECL
    - event pulses:TTL, ECL or optical
  - Form factor: VME, 6U or PMC card
  - System bus: VME64x / PMC
  - Software support : EPICS

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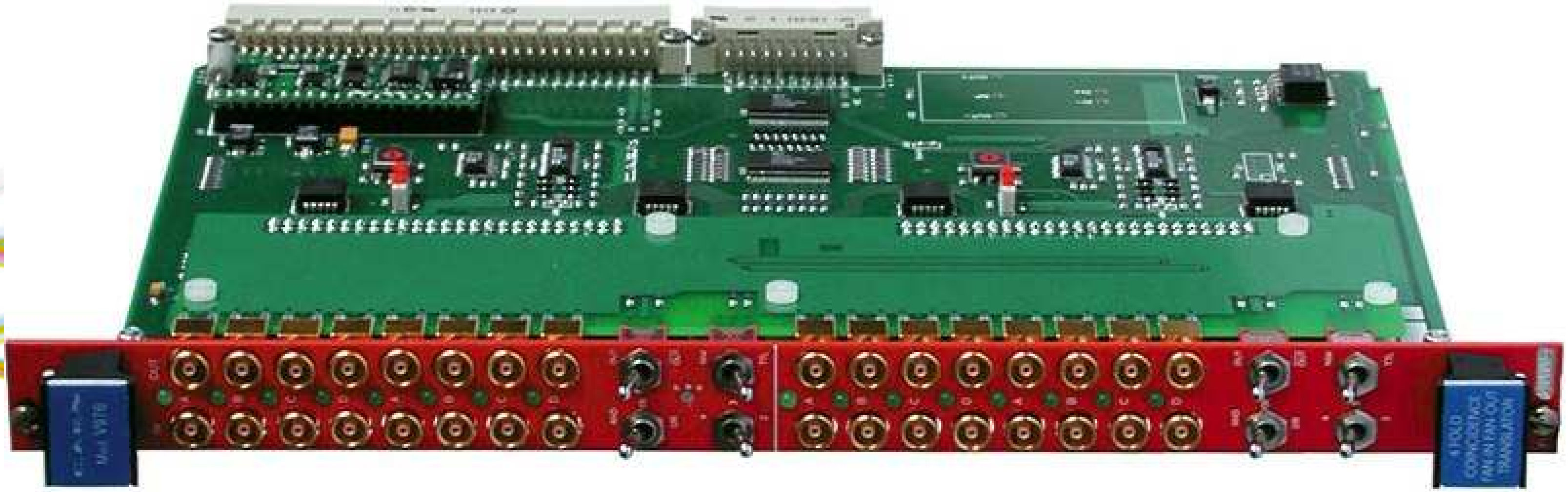
Discrete wiring

- **Some direct connection and through patch panels.**
- **At least one beamline uses the CAEN V976 for fanout**
  - **4 channel**
  - **Can do NIM/TTL translation, negation and 2 signal AND's and OR's.**

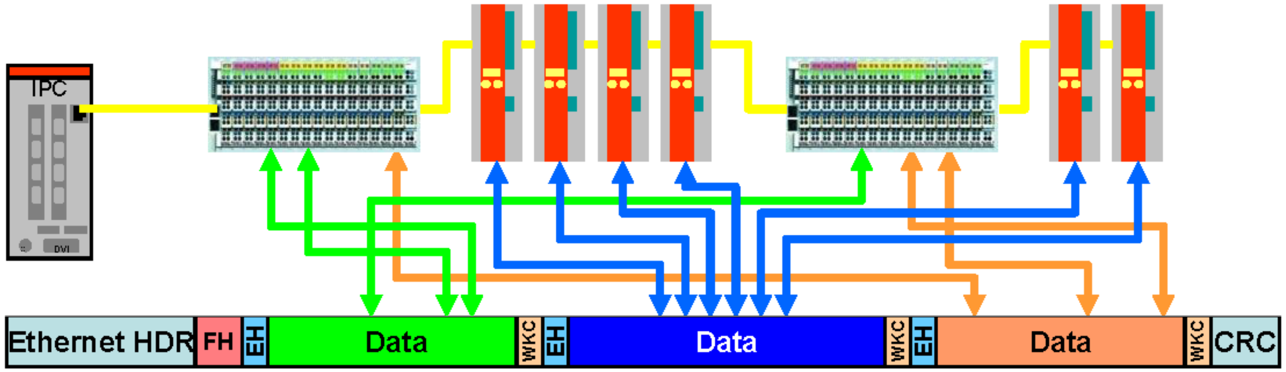


Ethercat

- Relatively open PLC fieldbus from Beckhoff
- Open source Linux drivers exist
- No special hardware required for controller
- High performance (if controller O/S supports it)
  - 256 digital I/O in 11 µs
  - 1000 digital I/O distributed to 100 nodes in 30 µs
  - 200 analog I/O (16 bit) in 50 µs, 20 kHz Sampling Rate
  - 100 Servo-Axis (each 8 Byte IN+OUT) in 100 µs
  - 12000 digital I/O in 350 µs
- System wide synchronisation to << 1 µs

Functional Principle: Ethernet "on the Fly"

- Minimal protocol overhead via implicit addressing



- Optimized telegram structure for decentralized I/O
- Communication completely in hardware: maximum performance
- No switches required if only EtherCAT devices in the network
- Outstanding diagnostic features
- Ethernet-compatibility maintained

The End