OAK RIDGE National Laboratory

EPICS Database

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Many slides from Andrew Johnson, APS/ANL

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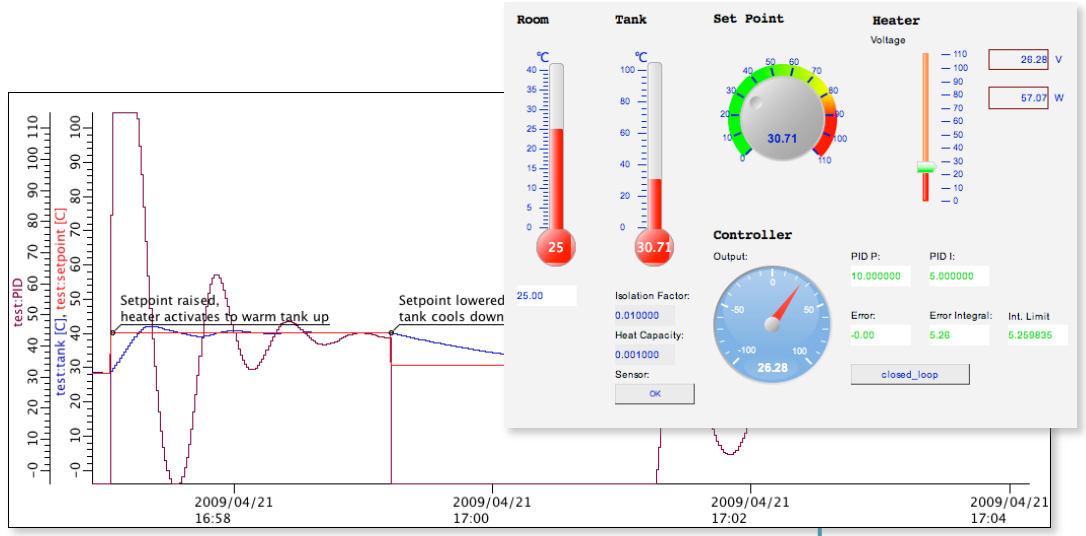
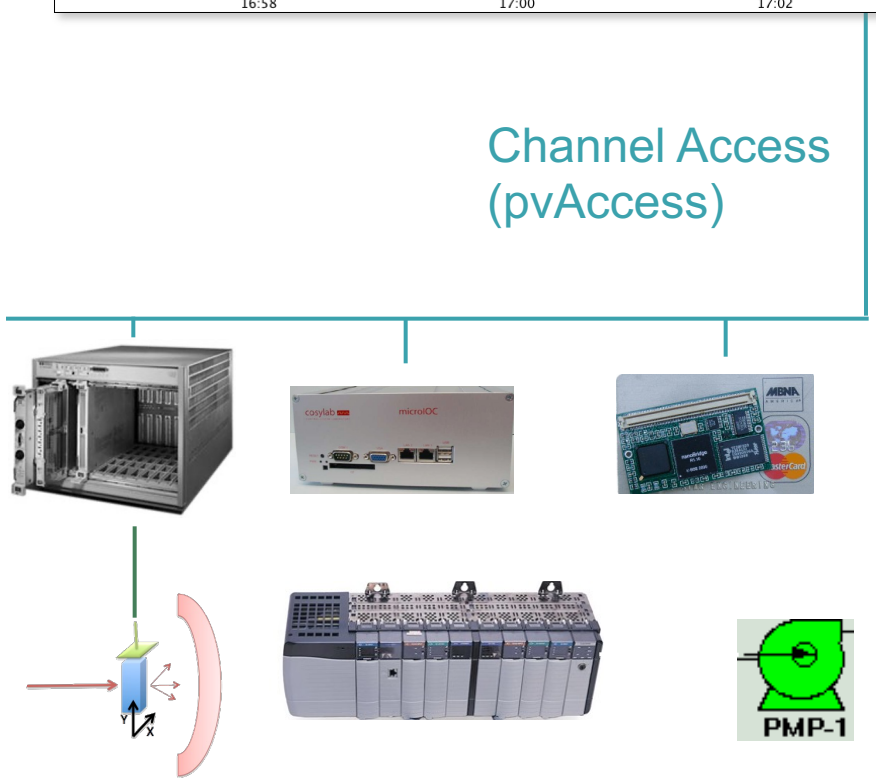
U.S. DEPARTMENT OF ENERGY

Distributed EPICS Setup

- Operator Interface



- Input/Output Controller (IOC)



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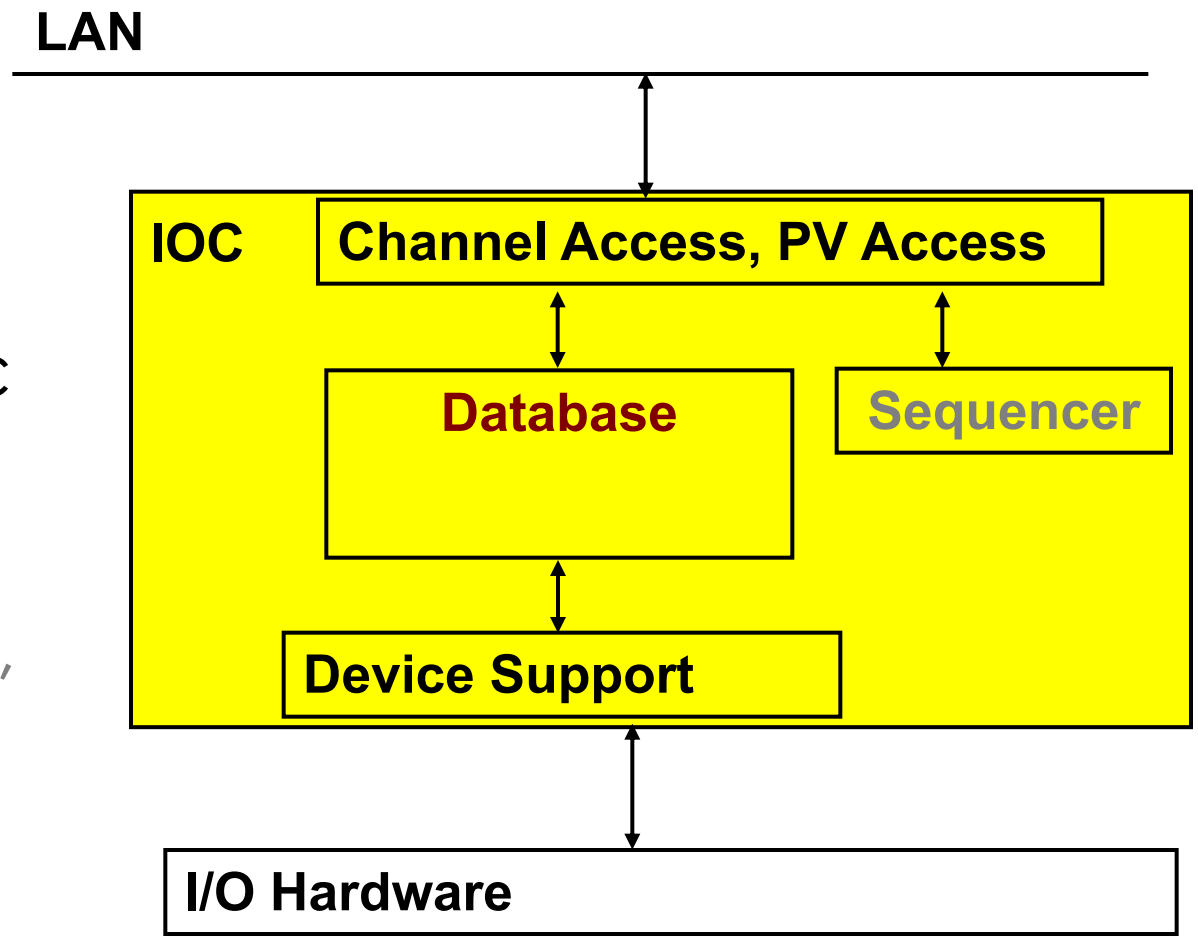
IOC

- Database: Data Flow, mostly periodic processing
- Sequencer: State machine, mostly on-demand



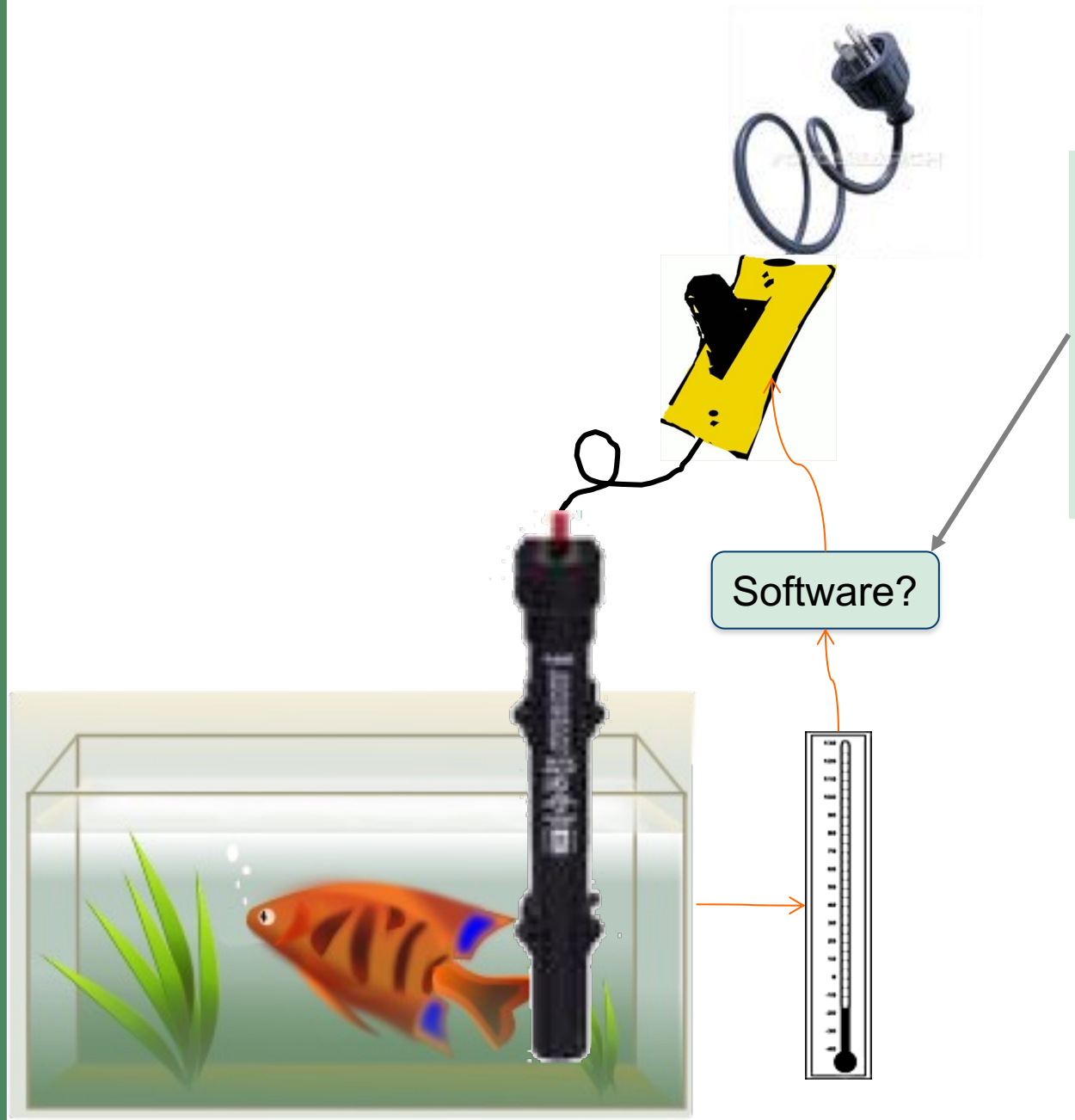
"Hard" IOCs run VxWorks/RTEMS/RT-Linux and directly interface to A/D, D/A, LLRF, … hardware.
"Soft" IOCs run on Linux and have no I/O Hardware other than serial or networked devices (Moxa to motor controller, …)

IOC Database

- 'iocCore' software loads and executes 'Records'
  - Configuration of records instead of custom Coding
- All control system toolboxes have (better?)
  - GUI tools
  - Network protocols
  - Hardware drivers

  but few have a comparable database!

Example: Basic Temperature Control



Task:

1. Read temperature
2. Open/close switch as needed
3. Repeat

One Fishy Database

```
record(ai, temp) {
  field(DESC, "Read Temperature")
  field(SCAN, "1 second")
  field(DTYP, "XYZ ADC")
  field(INP, "#C1 S4")
  field(PREC, "1")
  field(LINR, "typeJdegC")
  field(EGU, "Celsius")
  field(HOPR, "100")
  field(LOPR, "0")
  field(SMOO, "0.5")
  field(HIGH, "15")
  field(HSV, "MAJOR")
}


record(calcout, check) {
  field(DESC, "Control Heater")
  field(CALC, "A<10")
  field(INPA, "temp CP MS")
  field(OUT, "switch")
  field(OOPT, "On Change")
}


record(bo, switch) {
  field(DESC, "Heater switch")
  field(DTYP, "XYZ DAC")
  field(OUT, "#C1 S3")
  field(ZNAM, "Open")
  field(ONAM, "Closed")
  field(IVOA, "Set output to IVOV")
  field(IVOV, "0")
}
```

Analog Input Record

SCAN Field

Binary Output Record

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Database = Records + Fields + Links

- IOC loads and executes one or more databases
- Each database has records
- Each record has
  - Name (unique on the whole network)
  - Type (determines fields and their functionality)
  - Fields (properties, can be read, most also written at runtime)
  - Often device support to interface to hardware
  - Links to other records

Records are Active

- Records ‘do’ things
  - Get data from other records or hardware
  - Perform calculations
  - Check value ranges, raise alarms
  - Write to other records or hardware

  What they do depends on record type, field values, device support
- … when they are processed
  - Records process periodically or when triggered by events or other records

  No action occurs unless a record is processed

/ics/examples/01_first_steps/very_first.db

```
# The simplest record that 'does' something
# and produces changing numbers
#
#. softIoc -m S=training -d very_first.db
record(calc, "$(S):random")
{
   field(SCAN, "1 second")
   field(INPA, "10")
   field(CALC, "RNDM*A")
}
```

- **Execute:** `softIoc -m S=training -d very_first.db`
- **Try:** `help, dbl, dbpr, dbpf`
- **In another terminal:** `camonitor training:random`

Macros

```
record(calc, "$(S):random")
{
    field(SCAN, "1 second")
    field(INPA, "10")
    field(CALC, "RNDM*A")
}
```

Can have only one “training:random” on the network!

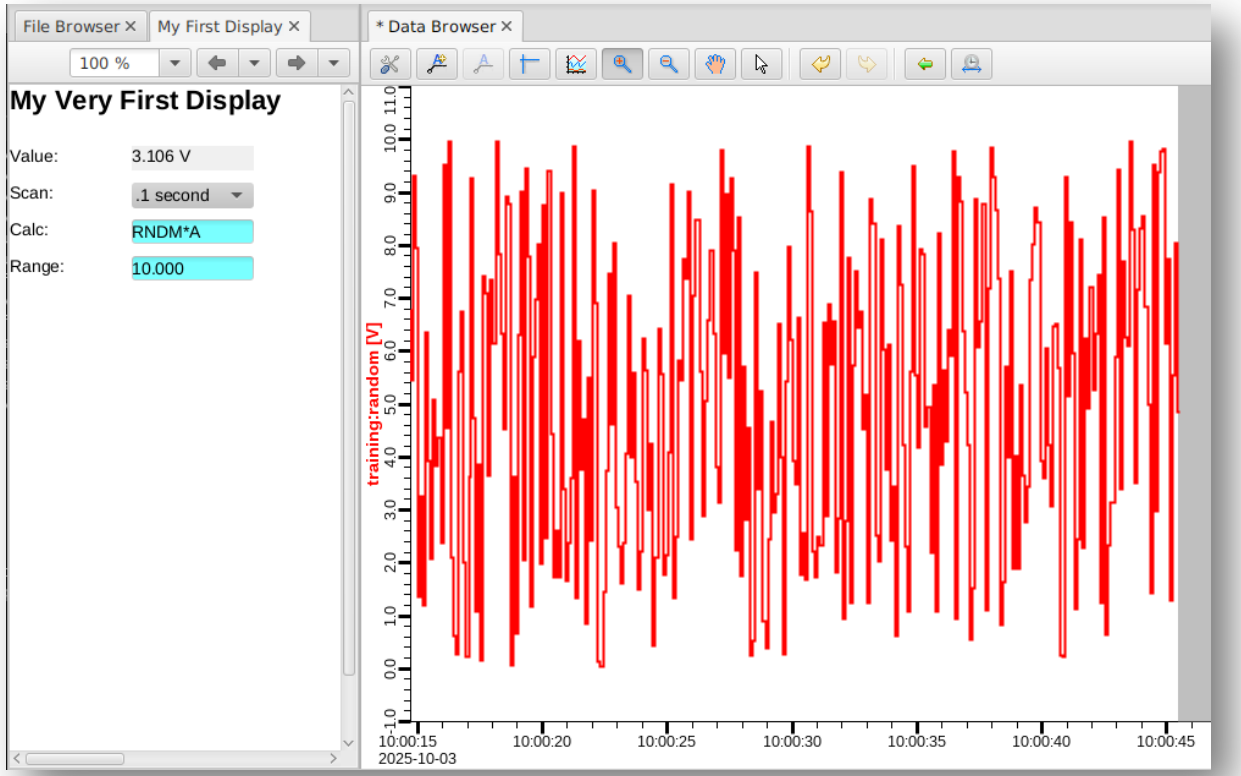
Use macro “$(S)” to create unique names:
S=demo1
S=demo2
…

- **Execute:** `softIoc -m S=demo1 -d very_first.db`
- **In another terminal:** `camonitor demo1:random`

Excursion: 04a User Interfaces

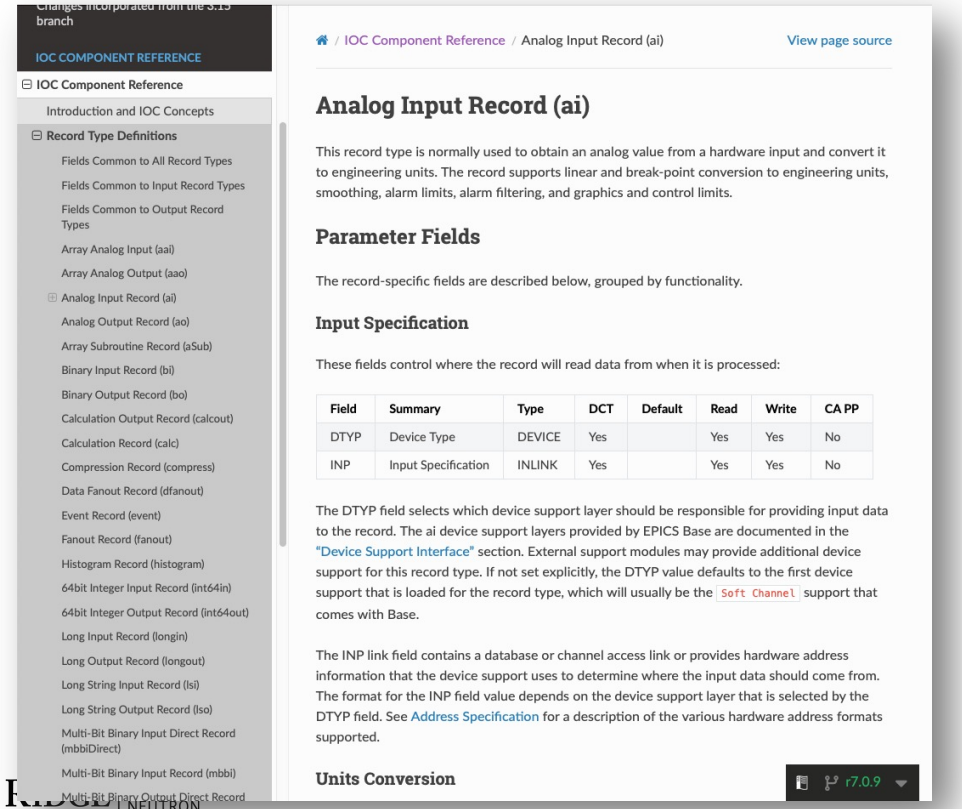
- Follow those instructions to create display
- Set fields
  'PREC' to 3 and
  'EGU' to 'V'

→

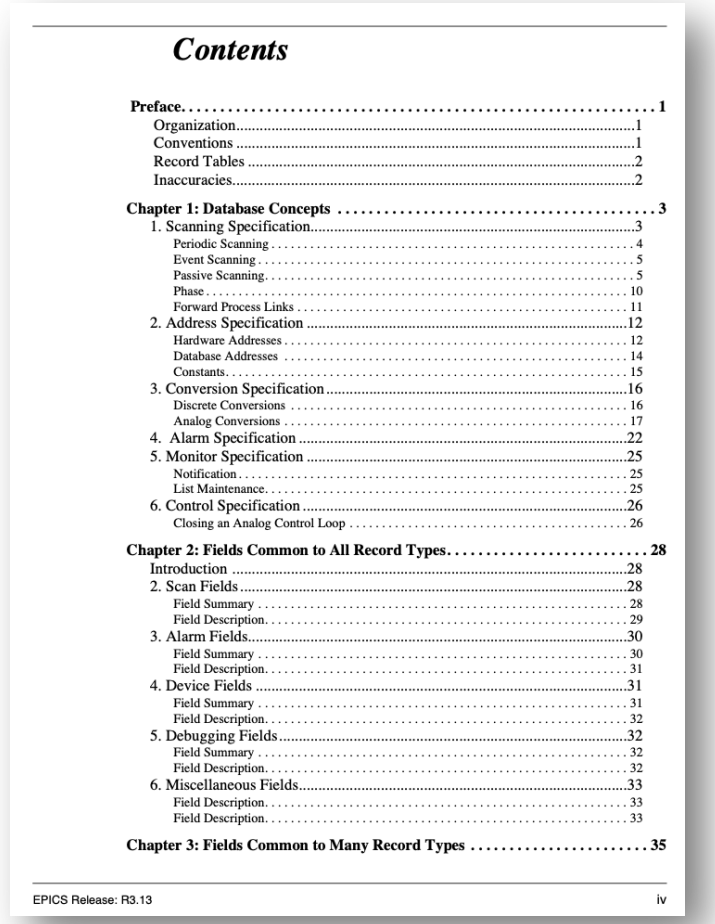


Record Reference Manual

- Current:
  Link from https://docs.epics-controls.org
  for each version of EPICS base
  https://docs.epics-controls.org/projects/base/en/latest/ComponentReference.html#record-type-definitions



- Sometimes more convenient:
  Older "recordref_*.pdf" copy in presentation material



Contents

Record Types

- ai/ao: Analog input/output
  - Read/write number, map to engineering units
- bi/bo: Binary in/out
  - Read/write bit, map to string (0 →Off, 1 →On)
- calc: Formula
- mbbi/mbbo: Multi-bit-binary in/out
  - Read/write 16-bit number, map bit patterns to strings
- stringin/out, longin/out, seq, compress, histogram, waveform, sub, …

Common Fields

- Design Time
  - NAME: Record name, unique on network!
  - DESC: Description
  - SCAN: Scan mechanism
  - PHAS: Scan phase
  - PINI: Process once on initialization?
  - FLNK: Forward link
- Runtime
  - TIME: Time stamp
  - SEVR, STAT: Alarm Severity, Status
  - PACT: Process active
  - UDF: Undefined? Never processed?
  - PROC: Force processing
- Either
  - TPRO: Trace processing, set to 1 to debug record processing

Record Scanning

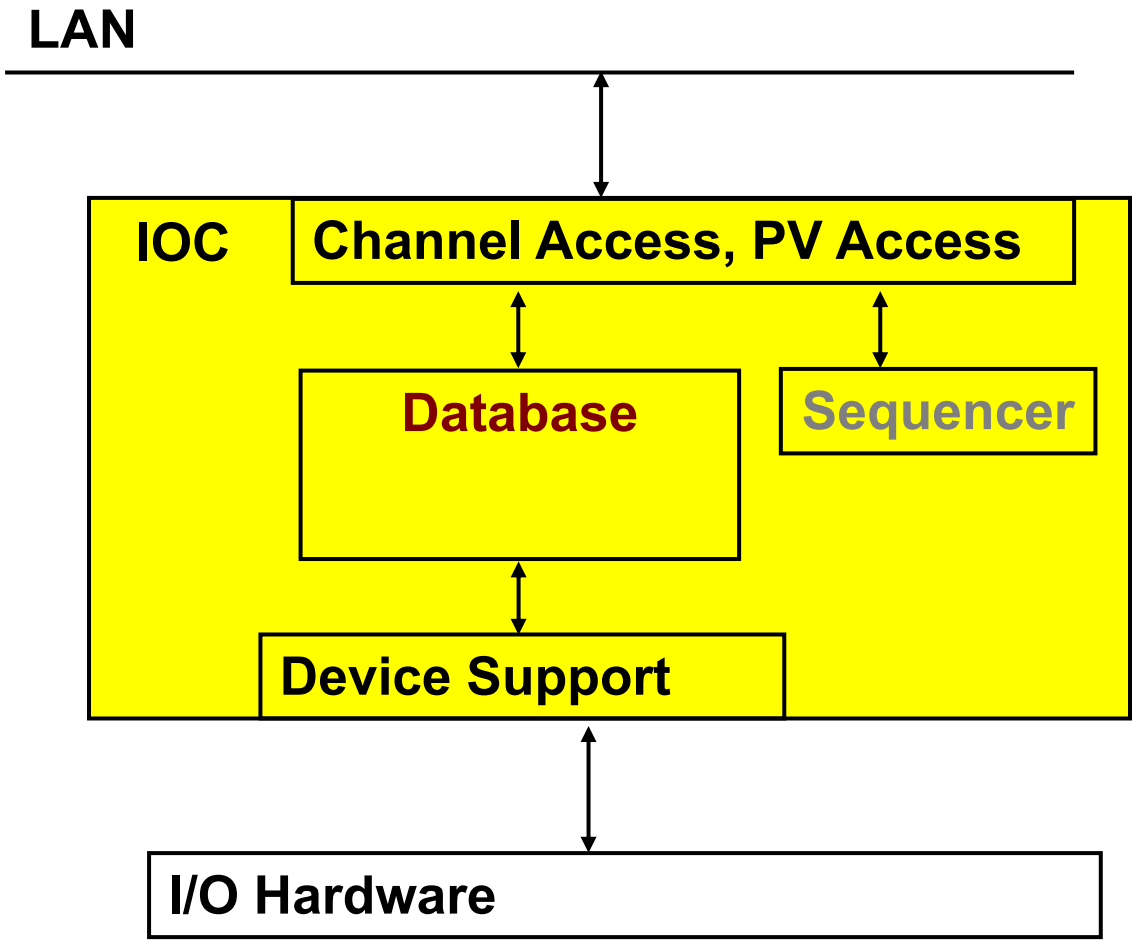
- SCAN field:
  - When processed by other records:
    "Passive" (default)
  - Periodically:
    ".1 second", ".2 second", ".5 second",
    "1 second", "2 second", "5 second", "10 second"
  - On event:
    "Event" (EVNT field selects the event),
    "I/O Intr" (if device support allows this)
- PHAS field
  - Adds order to records that are on the same periodic scan
    - First PHAS=0, then PHAS=1, …
- PINI
  - Set to "YES" to force record once on startup.
    Good idea for "operator input" records that are hardly ever changed, so they have an initial value.
- PROC
  - Writing to this field will process a record

Database vs. the Rest of the IOC

- Record scanning runs at higher priority than Channel Access or PV Access
  - At high CPU load, PVs might not connect while records are still processed
- 0.1 second scan runs at higher priority than 10 second scan
- PRIO field selects priority for async. completion and event-scanned record

Your mileage might vary

- RTOS or plain Linux?



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Thread Priorities

cd /ics/examples/01_first_steps

Compare

a) softIoc … as before, epicsThreadShow

b) sudo ./run_rt.sh, epicsThreadShow

Compare with ‘htop’

Main I/O

PID	USER	PRI△	NI	VIRT	RES	SHR	S	CPU%	MEM%	TIME+	Command
778	rtkit	RT	1	150M	3072	2944	S	0.0	0.0	0:00.04	/usr/libexec/rtkit-daemon
17706	epics-dev	-71	0	1281M	257M	219M	S	0.0	2.9	0:00.00	cbHigh
17703	epics-dev	-70	0	1281M	257M	219M	S	0.0	2.9	0:00.00	timerQueue
17708	epics-dev	-67	0	1281M	257M	219M	S	0.0	2.9	0:00.00	scanOnce
17715	epics-dev	-66	0	1281M	257M	219M	S	0.0	2.9	0:00.07	scan-0.1
17714	epics-dev	-65	0	1281M	257M	219M	S	0.0	2.9	0:00.02	scan-0.2
17705	epics-dev	-64	0	1281M	257M	219M	S	0.0	2.9	0:00.00	cbMedium
17713	epics-dev	-64	0	1281M	257M	219M	S	0.0	2.9	0:00.01	scan-0.5
17712	epics-dev	-63	0	1281M	257M	219M	S	0.0	2.9	0:00.00	scan-1
17711	epics-dev	-62	0	1281M	257M	219M	S	0.0	2.9	0:00.00	scan-2
17710	epics-dev	-61	0	1281M	257M	219M	S	0.0	2.9	0:00.04	scan-5
17709	epics-dev	-60	0	1281M	257M	219M	S	0.0	2.9	0:00.00	scan-10
17704	epics-dev	-59	0	1281M	257M	219M	S	0.0	2.9	0:00.00	cbLow
17707	epics-dev	-51	0	1281M	257M	219M	S	0.0	2.9	0:00.00	dbCaLink
1928	epics-dev	-21	0	540M	19584	12544	S	0.0	0.2	0:00.00	pw-data-loop
1930	epics-dev	-21	0	359M	39424	11392	S	0.0	0.4	0:00.03	pw-data-loop
1931	epics-dev	-21	0	367M	17280	8960	S	0.7	0.2	0:09.27	pw-data-loop
17716	epics-dev	-17	0	1281M	257M	219M	S	0.0	2.9	0:00.00	CAS-TCP
17718	epics-dev	-15	0	1281M	257M	219M	S	0.0	2.9	0:00.00	CAS-beacon
17717	epics-dev	-13	0	1281M	257M	219M	S	0.0	2.9	0:00.00	CAS-UDP
17701	epics-dev	-11	0	1281M	257M	219M	S	0.0	2.9	0:00.00	errlog
17702	epics-dev	-11	0	1281M	257M	219M	S	0.0	2.9	0:00.00	taskwd
1918	epics-dev	9	-11	367M	17280	8960	S	0.0	0.2	0:00.28	/usr/bin/pipewire
1919	epics-dev	9	-11	540M	19584	12544	S	0.0	0.2	0:01.37	/usr/bin/wireplumber
1920	epics-dev	9	-11	359M	39424	11392	S	0.0	0.4	0:00.33	/usr/bin/pipewire-pulse
733	root	16	-4	92680	2220	1664	S	0.0	0.0	0:00.01	/sbin/auditd

Common Input/Output Record Fields

- DTYP: Device type (“stream”, “ether_ip”, …)
- INP/OUT: How to read/write, format depends on DTYP
- RVAL: Raw value (e.g. 16 bit integer)
- VAL: Engineering unit value (e.g. 64bit float)

Output Only:

- DOL: Desired Output Link.
  Output records read this link to get VAL, then write to OUT…
- OMSL: .. if Output Mode SeLect = closed_loop
- IVOA: Invalid Output Action
- DRVL, DRVH: Drive limits of analog output

Is OMSL set to closed_loop?
DOL → VAL → OUT
Otherwise
VAL → OUT

/ics/examples/01_*/first.db

```
# Run as
#       softIoc -m S=demo -d first.db
#
# A ramp from 0 to 'limit', were limit
# can be configured via a separate record
record(ao, "$(S):limit")
{
   field(DRVH, "100")
   field(DOL,  "10")
   field(PINI, "YES")
}

record(calc, "$(S):ramp")
{
   field(SCAN, "1 second")
   field(INPA, "$(S):ramp")
   field(INPB, "$(S):limit")
   field(CALC, "A<B ? A+1 : 0")
}
```

Using ‘output’.
‘input’ would also work, since there’s no hardware to read or write, but only ‘output’ has DRVH…

Reading inputs:
A = my own current value
B = value of ..limit record

1. **Which record is scanned?**
2. **Use camonitor to show value**
3. **Use caput to change limit**
4. **Create display**
5. **View database in vdct**
   (see vdct presentation, then come back here)

Analog Record Fields

- EGU: Engineering units
- PREC: Display precision
- SMOO: Smoothing
  - `VAL = (1-SMOO)*new_value + SMOO*last_value`
  - SMOO=0: VAL=new_value, default behavior
  - SMOO=1: VAL=last_value, defunct behavior
  - 0<SMOO<1: VAL 'smoothly' follows latest reading
- LINR: Linearization (None, Slope, breakpoint table)
  - EGUL, EGUF, ESLO, EOFF: Parameters for LINR
- LOLO, LOW, HIGH, HIHI: Alarm Limits
  - LLSV, LSV, HSV, HHSV: Associated alarm severities

Binary Record Fields

- ZNAM, ONAM: State name for “zero”, “one”
- ZSV, OSV: Alarm severities

Links

- Input or Output links may be
  - Name of other record's field: "other", "other.VAL", "other.A"
    - If other record is in same IOC: "Database link"
    - If name doesn't match any local record: "Channel Access link"
  - Hardware link
    - Details depend on device support
    - DTYP field selects device support
    - Example formats: "@plc12 some_tag", "#C1 S4"
- Input links may be
  - Constant number: "0", "3.14". "-1.6e-19"
- A record's FLNK field processes another record after current record is 'done'

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Database Links

- Format: “record.field {flags}”
  - VAL is default for field
- Flags:
  - PP: Process a passive target record
    - INP, DOL: Before reading
    - OUT: After writing
  - NPP: non-process-passive (default)
  - MS: Maximize severity (should be the default?)
  - NMS: non-MS (default)
  - MSS: Maximize Severity and Status
  - MSI: .. when severity = INVALID (should be the default?)
- Example:

```
field(“INP”, “other_rec.VAL PP MS”)
```

Channel Access Links

When a linked record is not in this IOC, EPICS automatically uses a Channel Access link

- Flags:
  - PP: Ignored. Not triggering processing on other IOC
  - MS, MSI: Maximize severity (when INVALID)

- `dbcar` lists number of (not) connected CA links
- `dbcar "", 1` shows detail of missing links

1. **See the two record in first.db split into first1.db and first2.db**
2. **Run both in one IOC, then run them in two IOCs**
   1. **Use camonitor to show value**
   2. **Use caput to change limit**
   3. **Any difference for 1 vs 2 IOCs?**
3. **Break a link: caput demo:ramp.INPB bogus**
   What indications do you get?
4. **Why would you split databases into separate files?**

Channel Access Link Flags

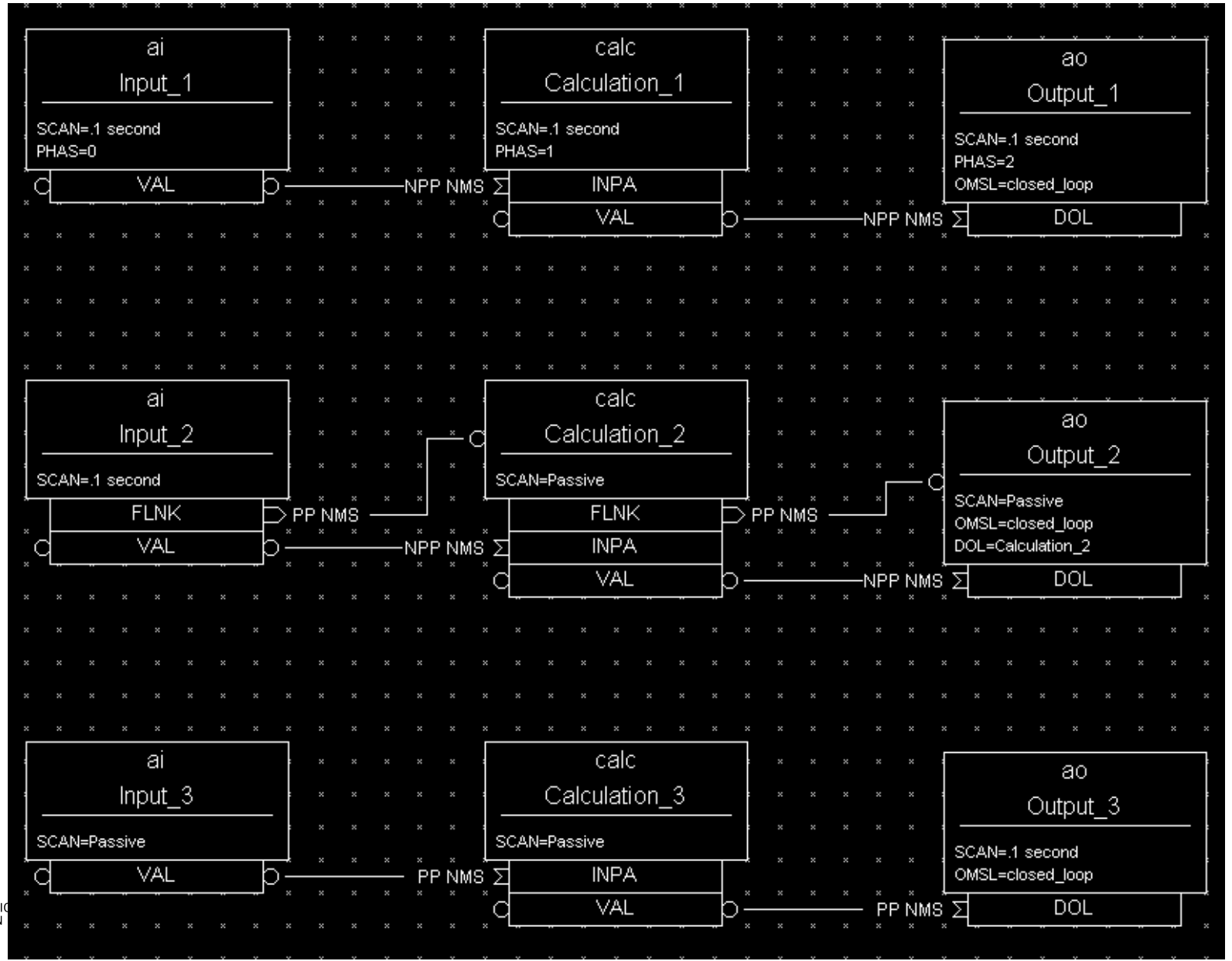
- CA: Force CA link, even though target in same IOC
  - Can be used to break 'lock sets'
- CP: For INP link, process on received CA monitor
  - Cause processing when linked value changes. Details depend on MDEL of source.
- CPP: CP, but only if SCAN=Passive

Forward Links

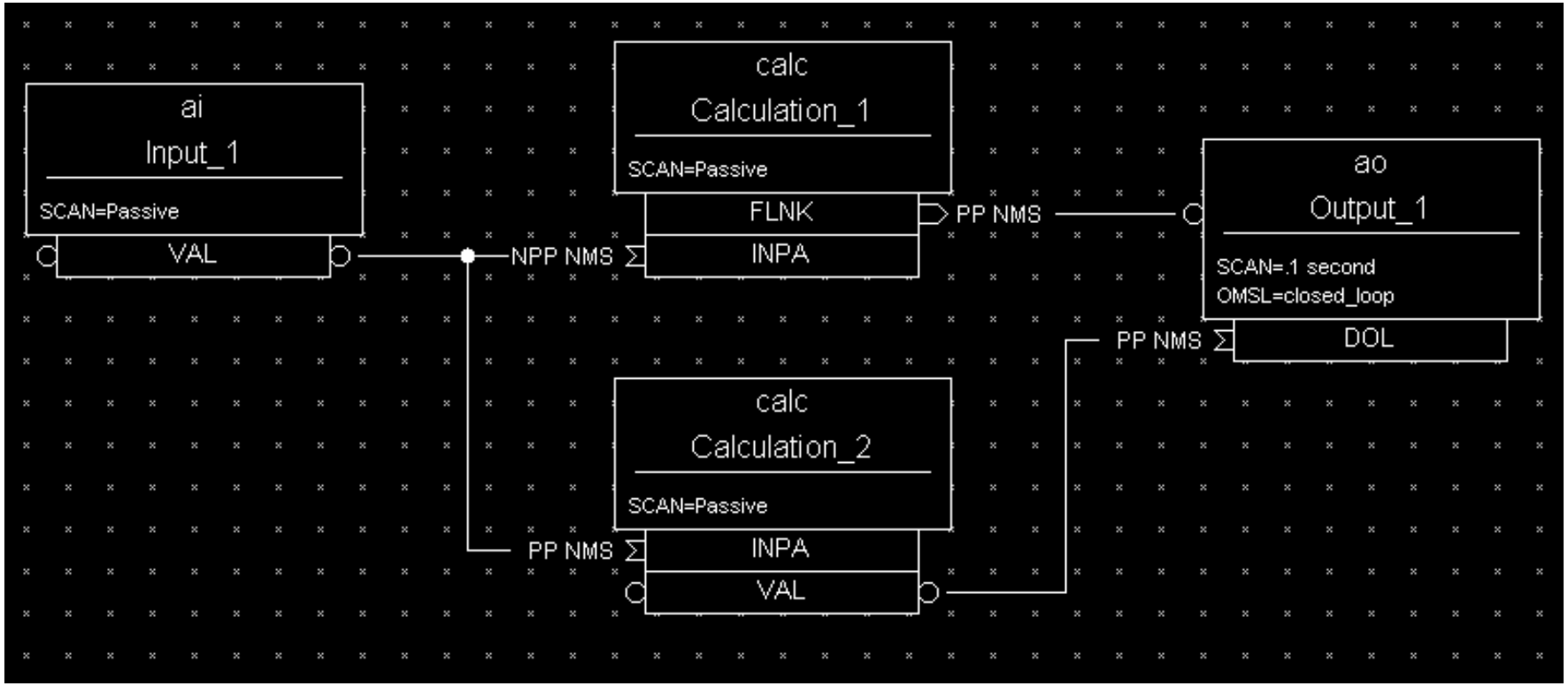
- Trigger processing, not passing data
- Destination processed if SCAN=Passive

- May use CA links
  - Must use FLNK="other.PROC" (other IOC)
    or FLNK="other.PROC CA" (same IOC)
  - Always triggers processing even for SCAN!=Passive

Processing chains



Which record is never processed?



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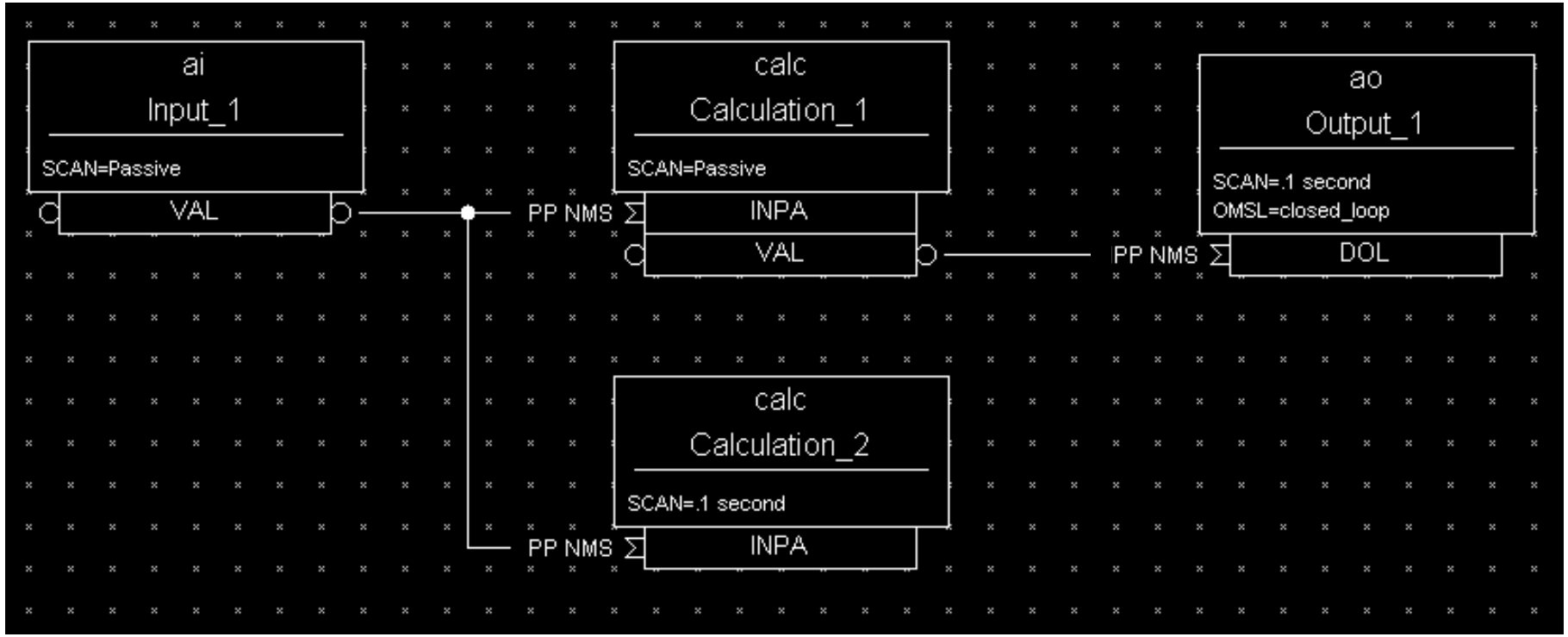
How often is Input_1 processed?



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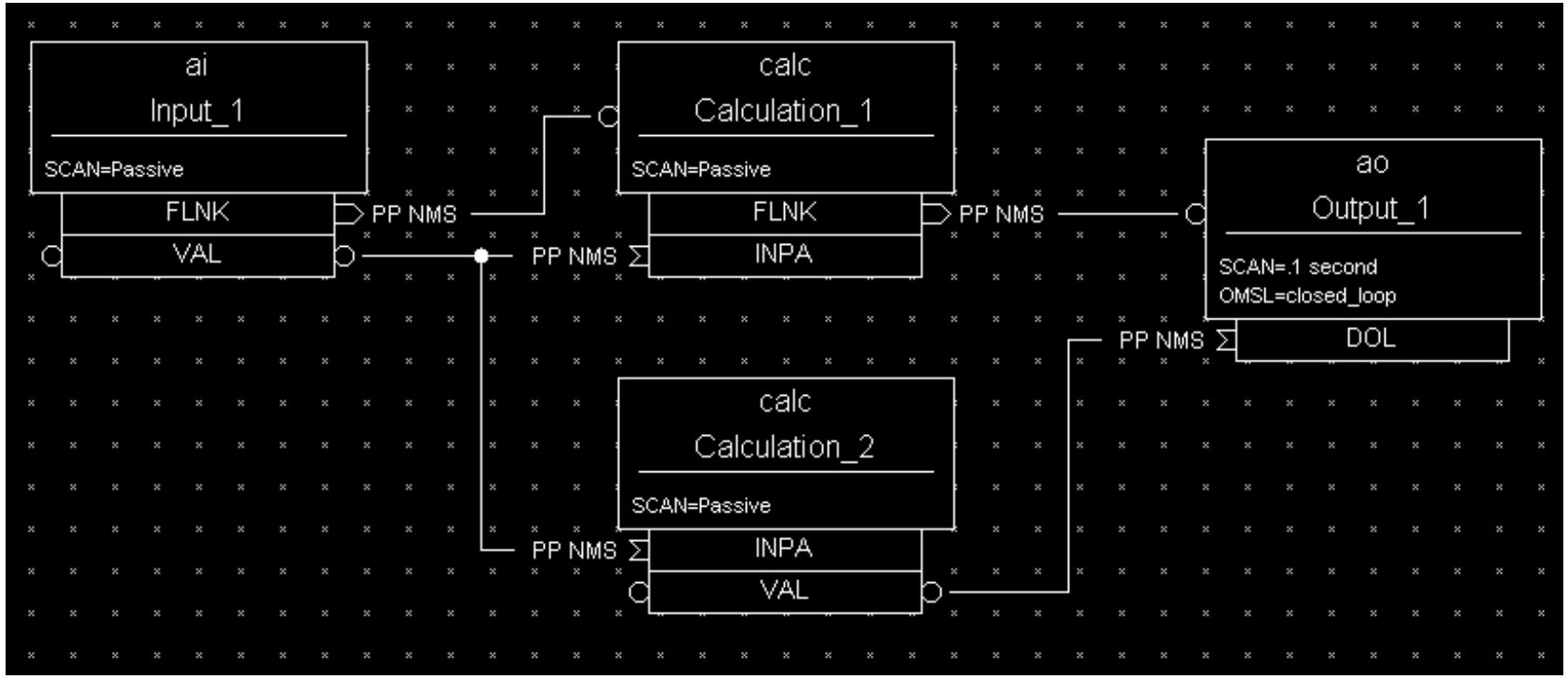
How long will this take?



- PACT: Processing Active

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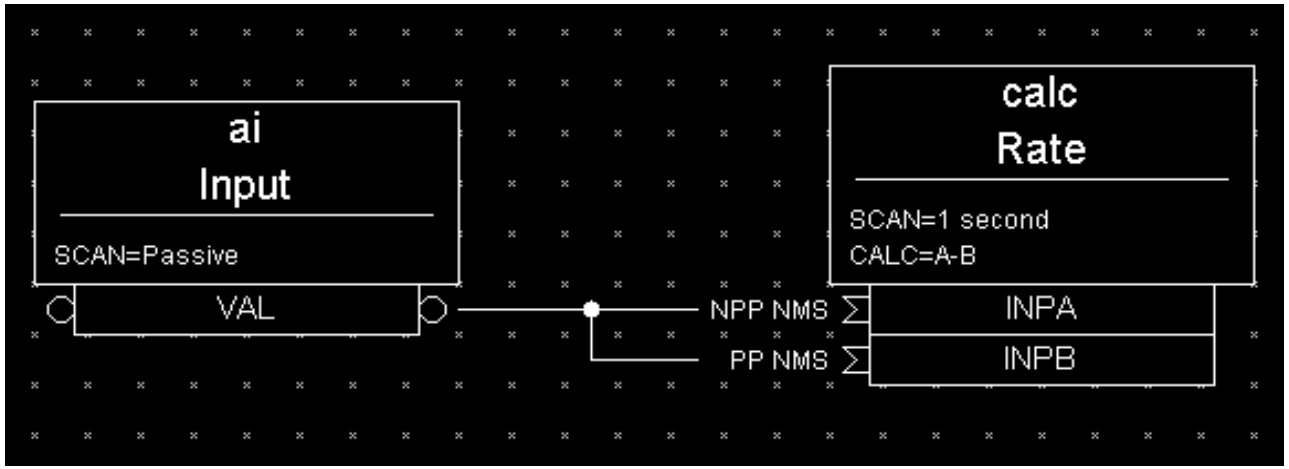
Rate Of Change Example

Calculating “Rate-of-Change” of an Input



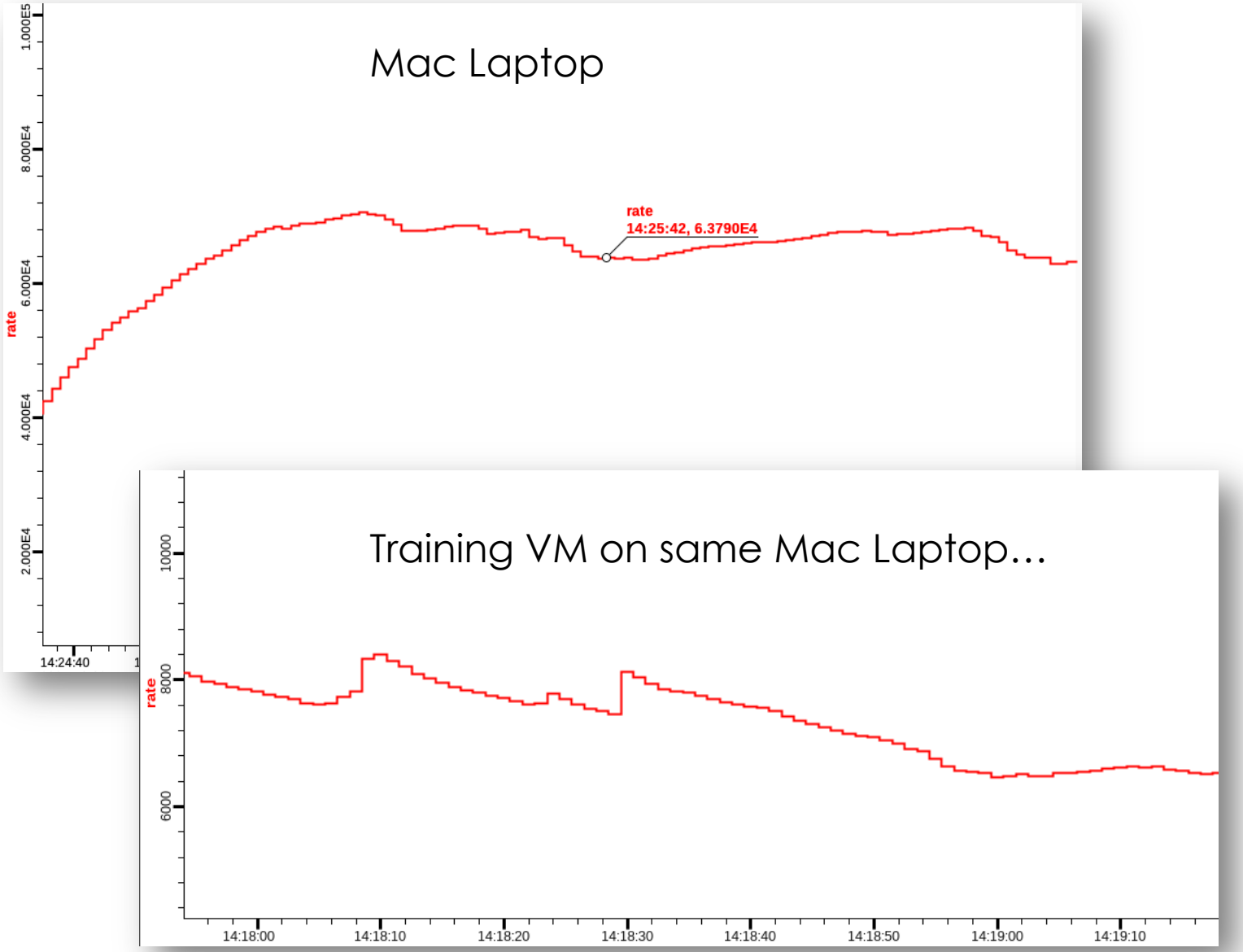
Should it be
CALC=B-A
?

10 second average:
SCAN=10 second
CALC=(B-A)/10

INPA fetches data that is 1 second old because it does not request processing of the AI record. INPB fetches current data because it requests the AI record to process. The subtraction of these two values reflects the ‘rate of change’ (difference/sec) of the pressure reading.

/ics/examples/01_first_steps: speed.db

1. **Study speed.db**
2. **Use camonitor or display to track rate**
3. **What do you get?**



Simulation Mode

Enable by setting SIMM=1 or YES

Might read SIMM from SIML, for example `field(SIML, "SomeGlobalSimEnableRecord")`

Input record?

- Instead of reading VAL from INP, VAL is now set to SVAL
- Either set SVAL directly, or read from SIOL

  (SIOL → SVAL), SVAL → VAL

Output record?

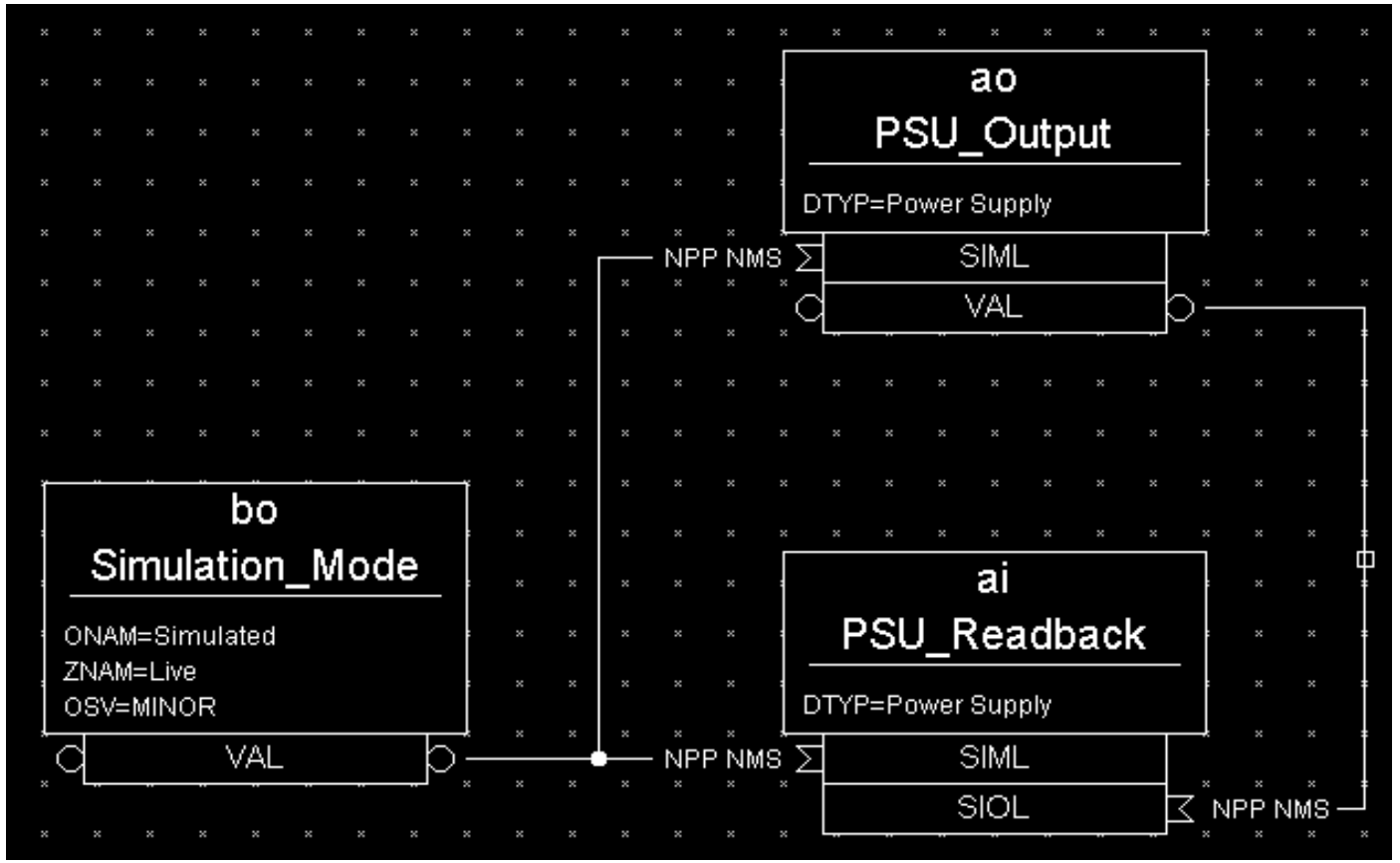
- Instead of writing VAL to OUT link, VAL is written to SIOL

  VAL → SIOL

Record will be in STAT=SIMM_ALARM with SEVR read from SIMS (default: NO_ALARM)

More: https://epics.anl.gov/base/R7-0/6-docs/dbCommonInput.html, https://epics.anl.gov/base/R7-0/6-docs/dbCommonOutput.html

Simulation Mode

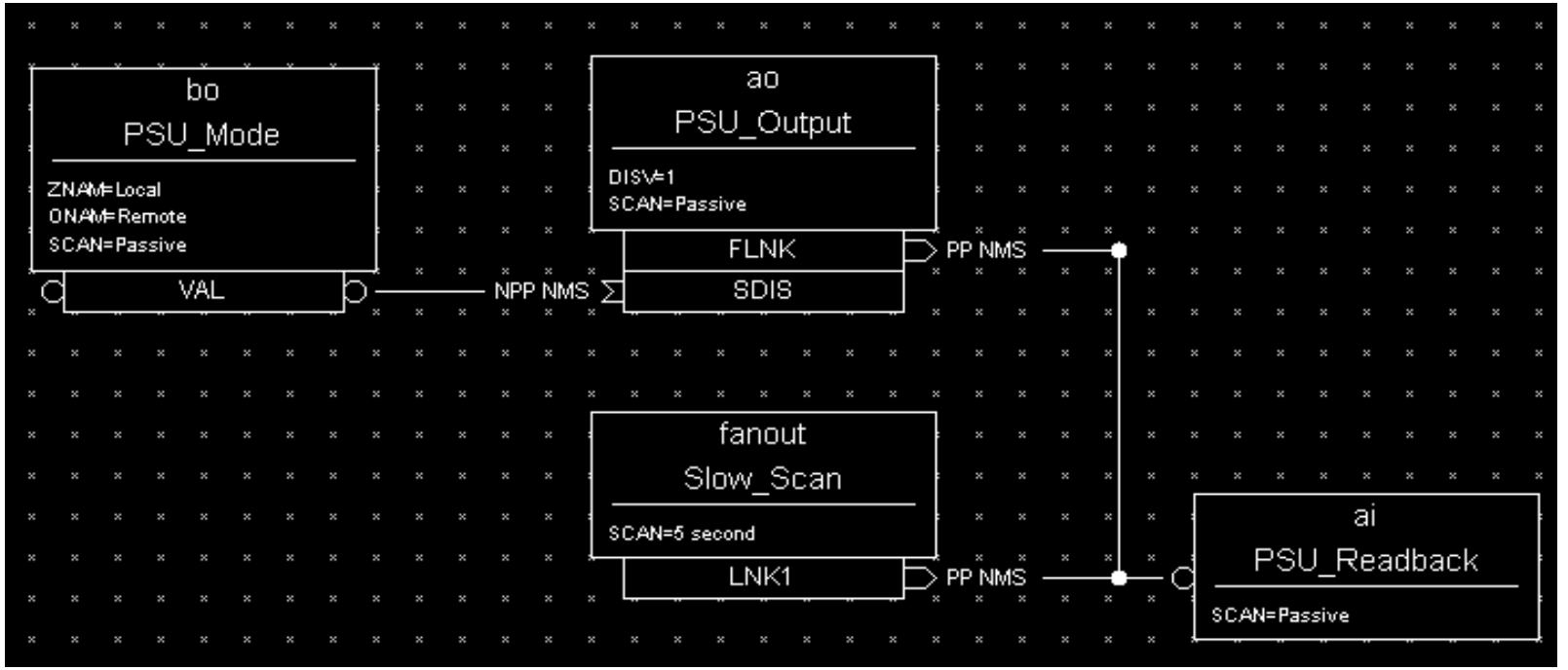


When in simulation mode, the AO record does not call device support and the AI record fetches its input from the AO record.

Not shown: How are any of these records processed? (SCAN, FLNK, …)
How do they read or write when NOT in simulation? (DTYP, INP, OUT)

Multiple Scan Triggers

Slow Periodic Scan with Fast Change Response

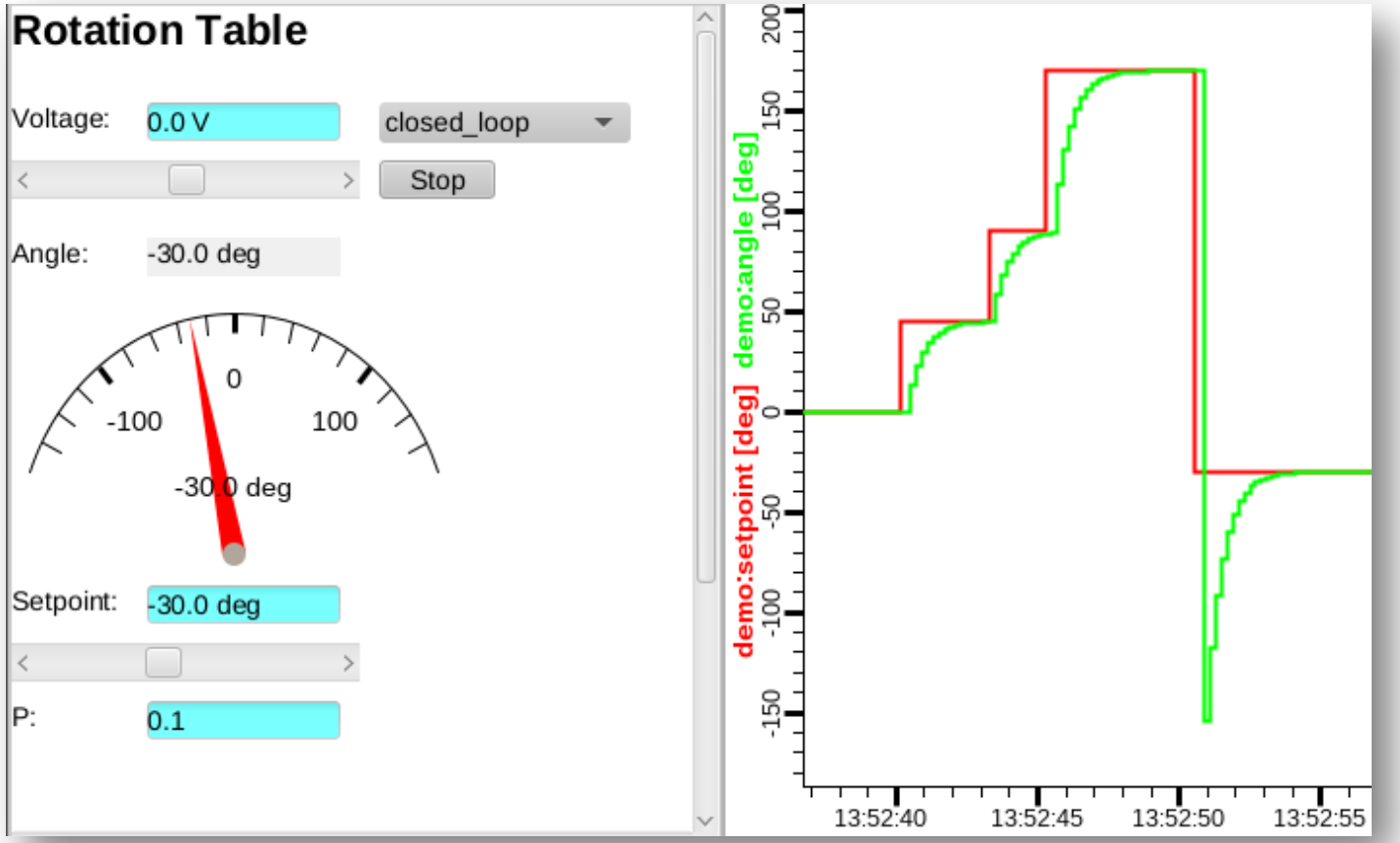


The AI record gets processed every 5 seconds AND whenever the AO record is changed. This provides immediate response to an operator's changes even though the normal scan rate is very slow. Changes to the power supply settings are inhibited by the BO record, which represents a Local/Remote switch.

/ics/examples/02_simple_control

- Study rotation_table.db and display

- Study rotation_control.db and display



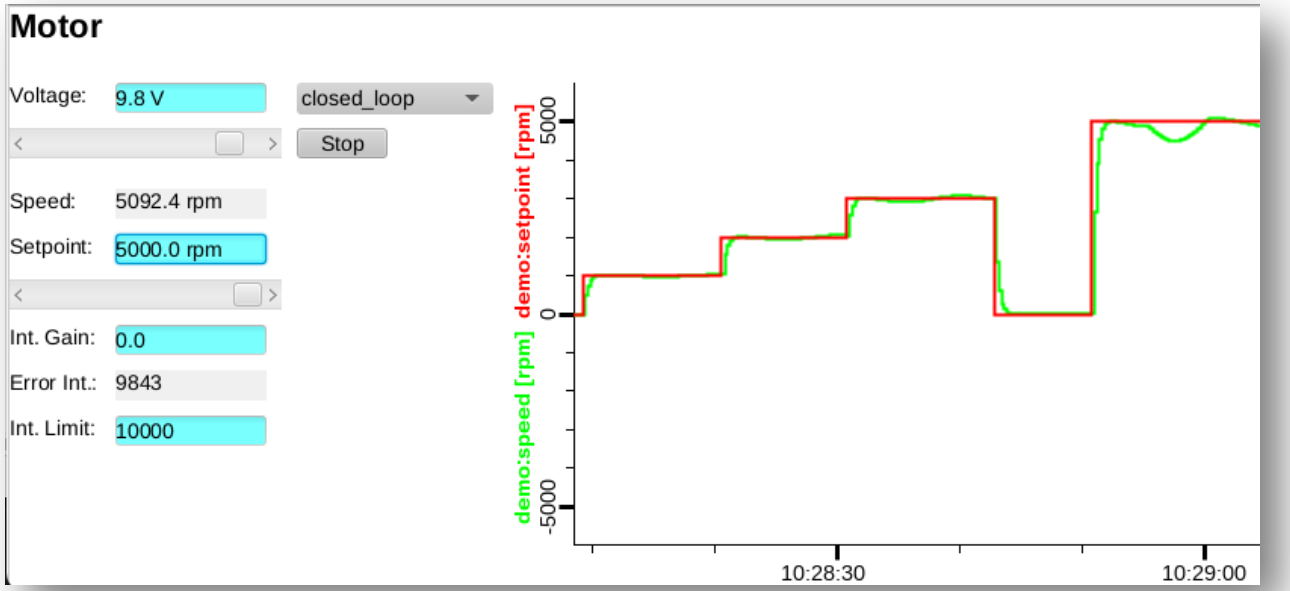
Basic "Proportional" Control:

What happens if P is too small?
… too large?

/ics/examples/02_simple_control

- Study motor_demo.db and display

- Study motor_control.db and display



Basic "Integral" Control:

Why does "Proportional" control not work here?
Speed setpoint of 5000 rpm isn't reached/held.
How can you fix this?

Device Support

- Records (AI, AO, ..) on their own only read/write from other records
- Device support connects them to hardware
- Hardware Device support is outside of EPICS ‘base’. Added to IOC as needed.
- DTYP selects a device support module
- INP/OUT provides detail

Synchronous vs. Asynchronous I/O

- "Fast", synchronous device support reads or writes the VAL of a record when the record is processed.
- "Slow", async support starts reading or writing when the record is processed. The record remains in PACT=true state, and device support triggers completion of processing when data has been read/written.
- Channel Access 'get/put' reads/writes current VAL, no matter if record is processing
- Channel Access 'get/put callback' will complete once processing completes

Read or write register via VME or PCI bus

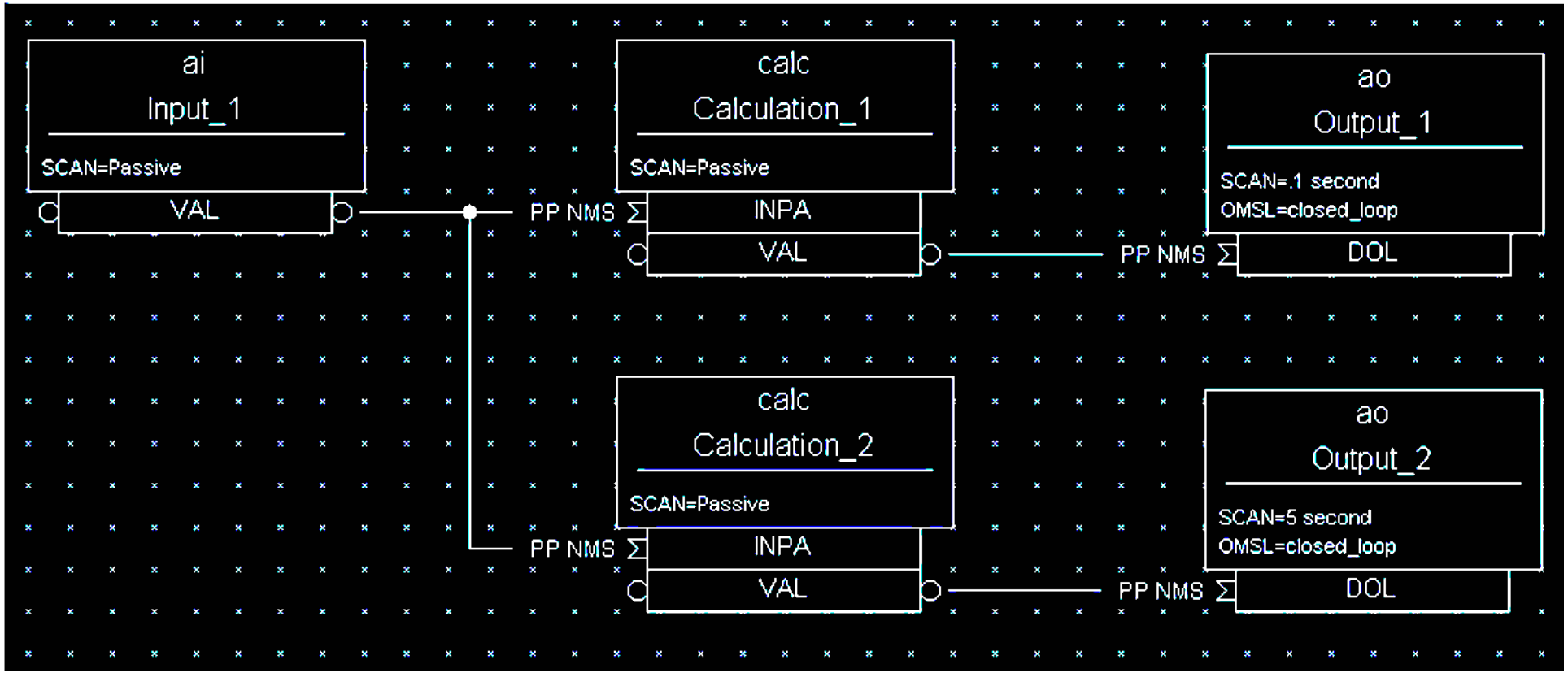
Send read-request to networked device, await reply, parse value from received message

‘Soft’ Device Support

EPICS base includes DTYP=

- “Soft Channel” for AI, AO, BI, BO, ..
  - Reads/writes the VAL field
- “Raw Soft Channel” for AI, AO, BI, BO, ..
  - Reads/writes the RVAL field, converts to/from VAL
- “Async Soft Channel” for AI, AO, BI, BO, ..
  - Performs a get/put callback, waits for completion

What could go wrong here?



Lock-Sets

- Group of records connected by links
- Processing a record locks its lock-set
  - Prevents processing by multiple threads
  - Similar but technically separate from PACT

Tends to transparently avoid problems

.. Unless you are very unlucky.

Then use “CA” flag to break lock set

Record Locking vs. PACT

Depending on its device support, a record can “process” for a long time

- Processing sets PACT and triggers driver to fetch data.
  Some time later driver processes the record again, and clears PACT.

Records in lock-set are locked while

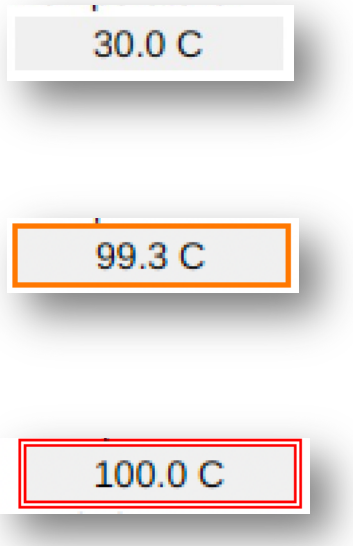
- Processing starts, then again when it completes, but not in the in-between times
- Reading a field
- Writing a field

Alarms

- Common fields:
  - SEVR: Alarm Severity
    - NONE, MINOR, MAJOR, INVALID
  - STAT: Alarm Status
    - UDF, READ, WRITE, CALC, HIGH, STATE, …
- Binary records:
  - ZSV, OSV: Severity for ‘zero’ and ‘one’ state
- Analog records:
  - LOLO, LOW, HIGH, HIHI: Thresholds
  - LLSV, LSV, HSV, HHSV: Associated severities
  - HYST: Hysteresis

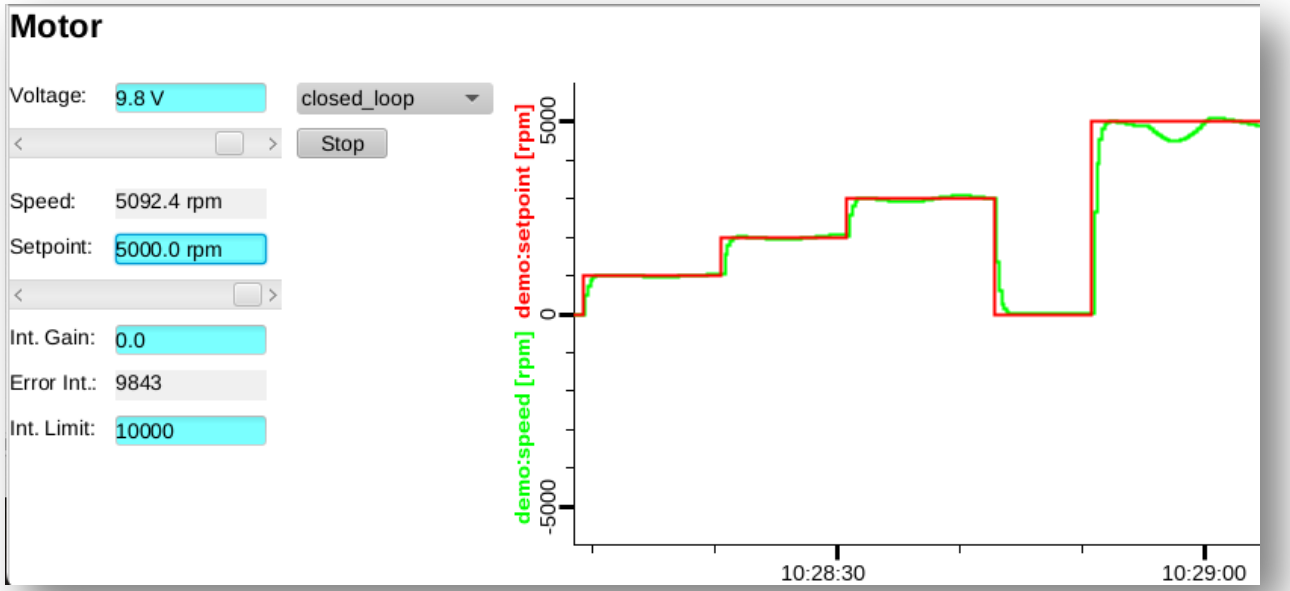
Alarm Example

```
# Raise alarms when temperature near boiling point
record(ai, "$(user):tank")
{
    field(DESC,"Water Temperature")
    field(SCAN, "…
    field(INP, "…
    field(EGU, "C")
    field(PREC, "1")
    field(HIGH, "90")
    field(HSV, "MINOR")
    field(HIHI, "100")
    field(HHSV, "MAJOR")
}
```



/ics/examples/02_simple_control

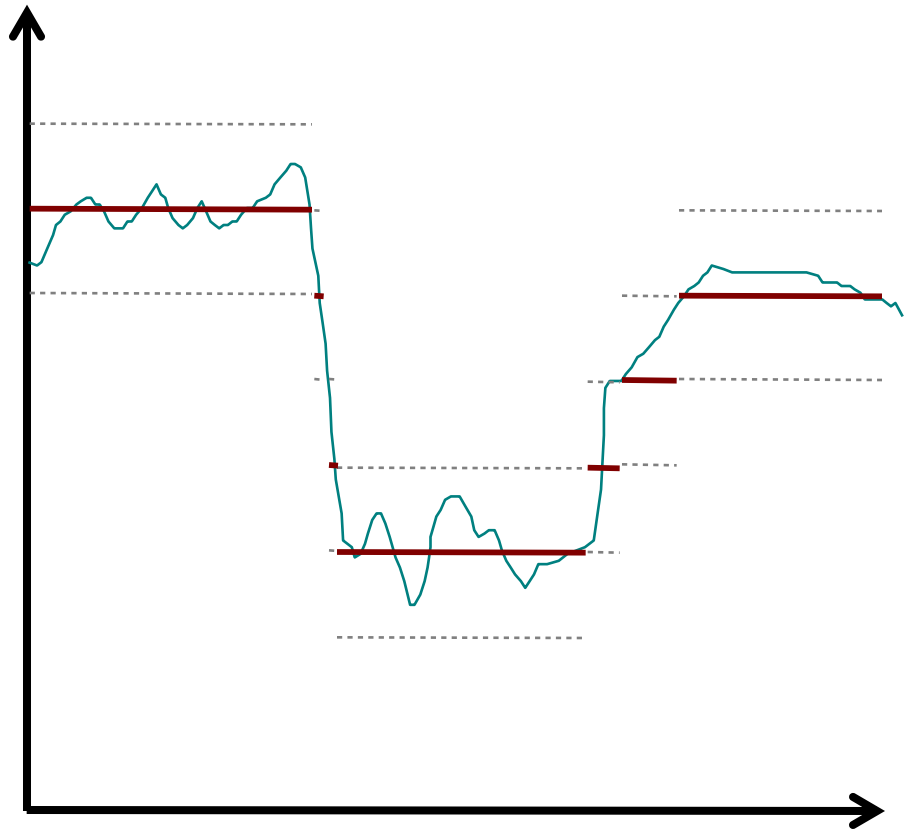
- Add alarms to motor_demo.db
  - MINOR alarm when reaching 4000 or -4000 rpm
  - MAJOR alarm at +5000 rpm



How does the display change?

Monitor Dead-Bands

- Analog records send updates to CA/PVA clients
  - MDEL Change threshold for most clients, incl. displays
  - ADEL .. for archive client



Record Hints

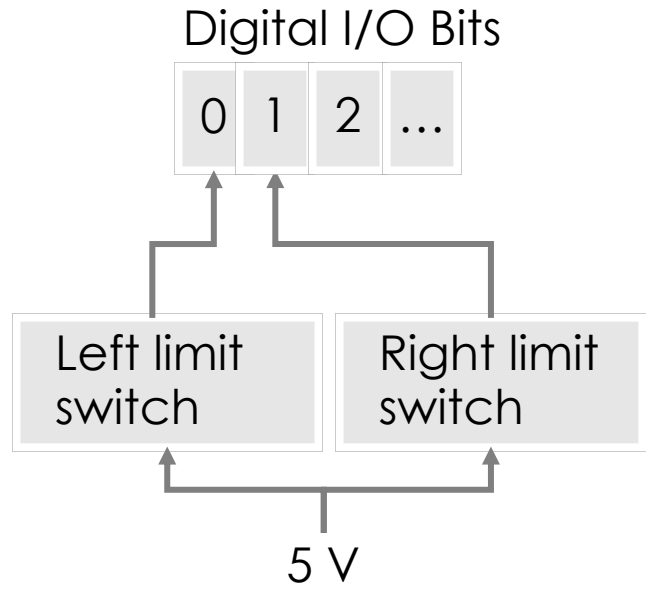
- Use AO, analog output, for user input
  - DRVL, DRVH can limit the value range

- BO record can be used as timer
  - HIGH field:
    When writing VAL=1, remains 1 for HIGH seconds
  - Useful for operator interface buttons:
    Button writes 1, record reverts to 0 after HIGH=1

Record Hints

MBBI, MBBO records map states

- Define values and states via
  ZRVL/ZRST, ONVL/ONST, TWVL/TWST, …
- Can be used like BI/BO:
  ZRVL=0, ONVL=1, ZRST ⇔ ZNAM, ONST ⇔ ONAM
- .. For values other than 0, 1:
  ZRVL=0, ONVL=255
- Decode Limit Switch state from bits:
  ZRVL = 0 ZRST = "Moving"
  ONVL= 1 ONST="At Left Limit"
  TWVL = 2 TWST="At Right Limit"
  THVL = 3 THST = "Broken", THSV=MAJOR



Record Hints

- COMPRESS record can
  - Keep last N values in circular buffer
  - Compute average, min or max of array
- ASUB record can call C code
  - INAM, SNAM: Name of initial() and sub()
  - Many INP* and VAL* fields
- EVENT record can post database event
  - Trigger records with SCAN=Event and EVNT=that event

Record Hints

- Use CALCOUT for if-then-else logic
  - INP* and CALC as in CALC record
  - OOPT “On Change”, “When Zero”, “Transition to Zero” etc.
  - Output can either use CALC or a separate OCAL

- SEQ, FANOUT, DFANOUT can process a list of records
  - Simply process or write values
  - SEL can change from processing all to processing selected records

Calcout Record Details

- Combines calc record with analog output functionality
  - INPA, INPB, …, INPL and CALC to compute VAL
  - OUT to which VAL is written
- OOPT determines if/when OUT is written
  - "Every Time", "On Change", "When Non-zero", "Transition to Zero", …
- By default, VAL is written, but can also configure
  - field(OCAL, "A/B+…") computes alternate OVAL
  - field(DOPT, "Use OCAL") selects writing OVAL instead of VAL to OUT

➔ Two calculations and an 'if' type selector within one record

Calcout Example

```
record(calcout, "Corrector")
{
    field(SCAN, ".1 second")
    field(INPA, "Enable")
    field(INPB, "Setpoint")
    field(INPC, "Readback")
    field(INPD, "17.54")
    field(CALC, "A")
    field(OOPT, "When Non-zero")
    field(DOPT, "Use OCAL")
    field(OCAL, "D*(B-C)")
    field(OUT,  "SteeringMagnet PP")
}
```

➔ CALC to determine if we should do anything, OCAL for computation (proportional control)

‘synApps’ Records outside of EPICS base

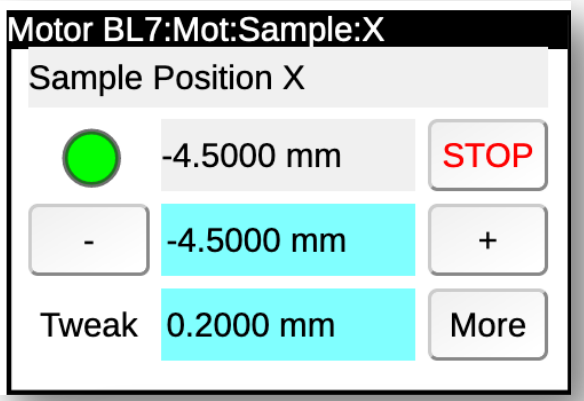
- MOTOR record
  - A whole ecosystem for controlling motors

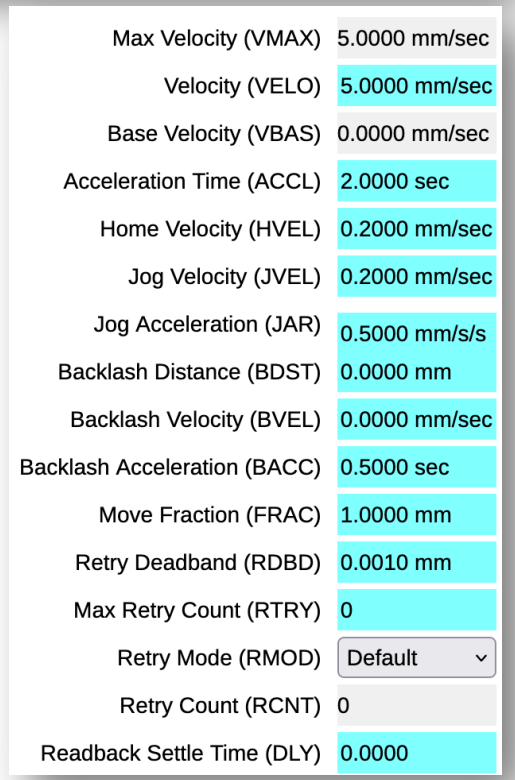
- BUSY record can be used to support put-callback
  1. Some Setpoint record FLNKs to logic that sets BUSY record = 1
  2. When device reaches setpoint, set BUSY record VAL=0

  ➔ CA ‘put-callback’ to setpoint will complete after device reached the setpoint

Motor Record Details

- Record of 100+ fields https://epics.anl.gov/bcda/synApps/motor/motorRecord.html
- Basic control
  - VAL Desired motor position. Supports put-callback
  - RBV Readback value, actual motor position
  - DONE Are we done moving the motor?
  - HLS, LLS Are we at the high or low limit?
  - STOP
- Resolution
  - MRES, DIR, OFF, EGU… Turn motor ticks into "mm" or "degrees"
  - Is it a stepper motor or servo? Do we have an encoder, how is it calibrated?
- Motion
  - VBAS, VMAX, ACCL, HVEL, JVEL, … Speed, acceleration
  - HLM, LLM, … Limits of motion range
  - BDST, BACC, RTRY, .. Backlash compensation, retries
- More: Homing, "jog", "tweak", status,





Large or small Records?

One Motor Record?

motor.VAL	Setpoint
motor.RBV	Readback
motor.DONE	Done?
motor.HLS	At high limit?
motor.MRES	Steps per unit
…	

Collection of Records?

```
record(ao, "$(M)_Set")
record(ai, "$(M)_Pos")
record(bi, "$(M)_Done")
record(bi, "$(M)_AtHighLim")
record(ao, "$(M)_StepsPerUnit")
record(waveform, "$(M)_Profile")
```

A servo motor doesn't use steps per unit.

A stepper might support a motion profile

➔ There is no commonly shared "Power Supply", "Camera" .. record.
Preferred approach is collection-of-records.

Time Stamps

- TIME is generally set to the time when the record last processed
- TSE=-2
  - Device support already set the TIME, for example to the exact trigger time obtained from hardware
- TSE=1…255
  - Set TIME to the last occurrence of event 1..255, obtained from timing system
- TSEL
  - Allows fetching the time stamp from another record

Linear Conversion

Analog records convert RVAL ⇔ VAL

LINR=NO CONVERSION

VAL = RVAL

LINR=SLOPE

VAL = (RVAL)*ESLO + EOFF

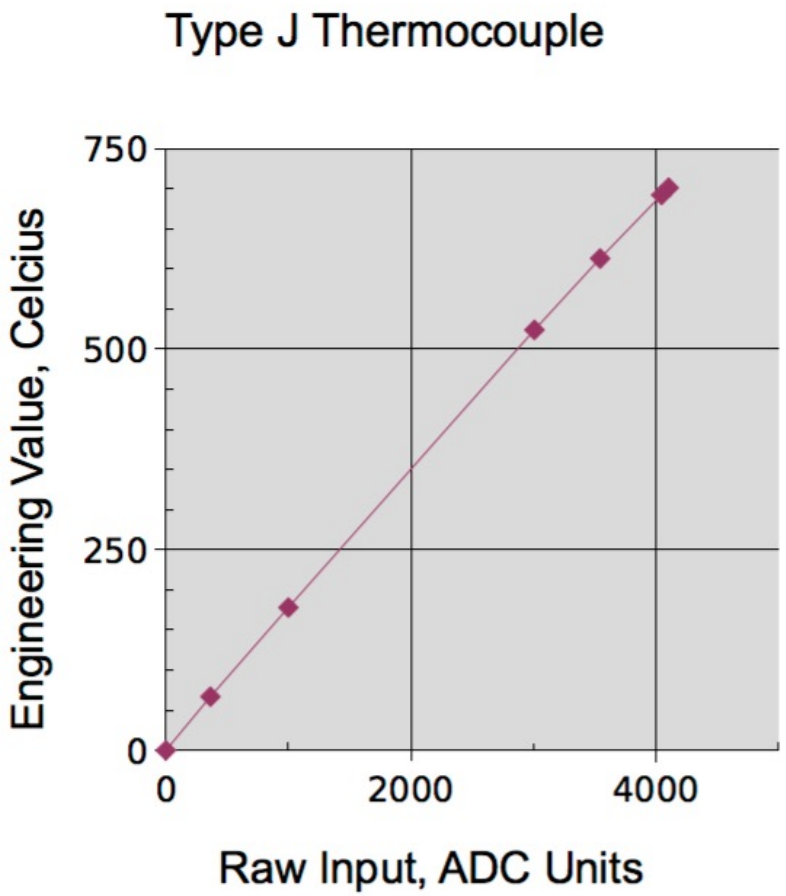
This assumes device support populates the (integer) RVAL field.
If device support already has a floating-point value, it places that in the (double) VAL field.
For additional conversions, then use a CALC record.

Breakpoint Tables

Analog records can set LINR= typeKdegC

with this in a *.dbd file:

```
breaktable(typeKdegC)
{
        0.000000   0.000000
      299.268700  74.000000
      660.752744 163.000000
     1104.793671 274.000000
     1702.338802 418.000000
     2902.787322 703.000000
     3427.599045 831.000000
     ...
}
```



Summary

Database Records configure the IOC's data flow

- Fields, links instead of custom code

See

- Record Reference Manual, https://docs.epics-controls.org/projects/base/en/latest/ComponentReference.html#record-type-definitions
- Older IOC Application Developers' Guide, https://epics.anl.gov/base/R3-15/6-docs/AppDevGuide/AppDevGuide.html
- New documentation, https://epics-controls.org