EMBEDDED EPICS IOC FOR STANDALONE POWERPMAC MOTION CONTROLLER CAPABLE OF DRIVING UP TO 128 AXES

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TWG meeting
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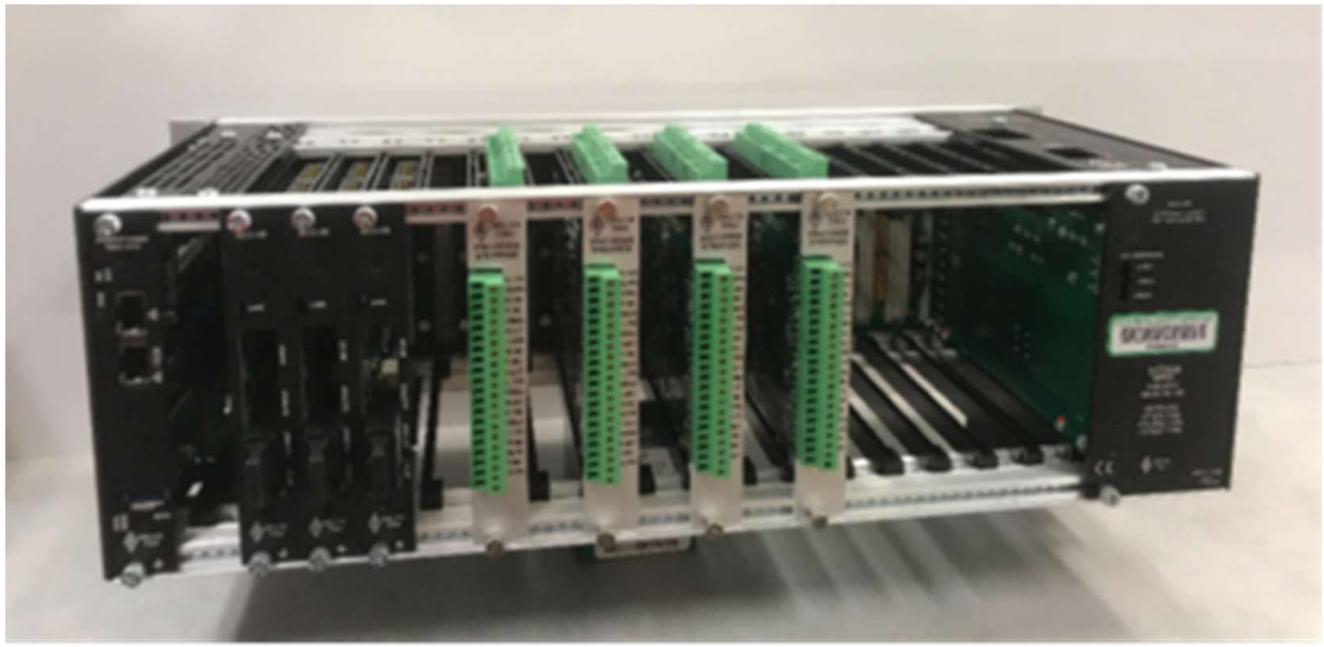
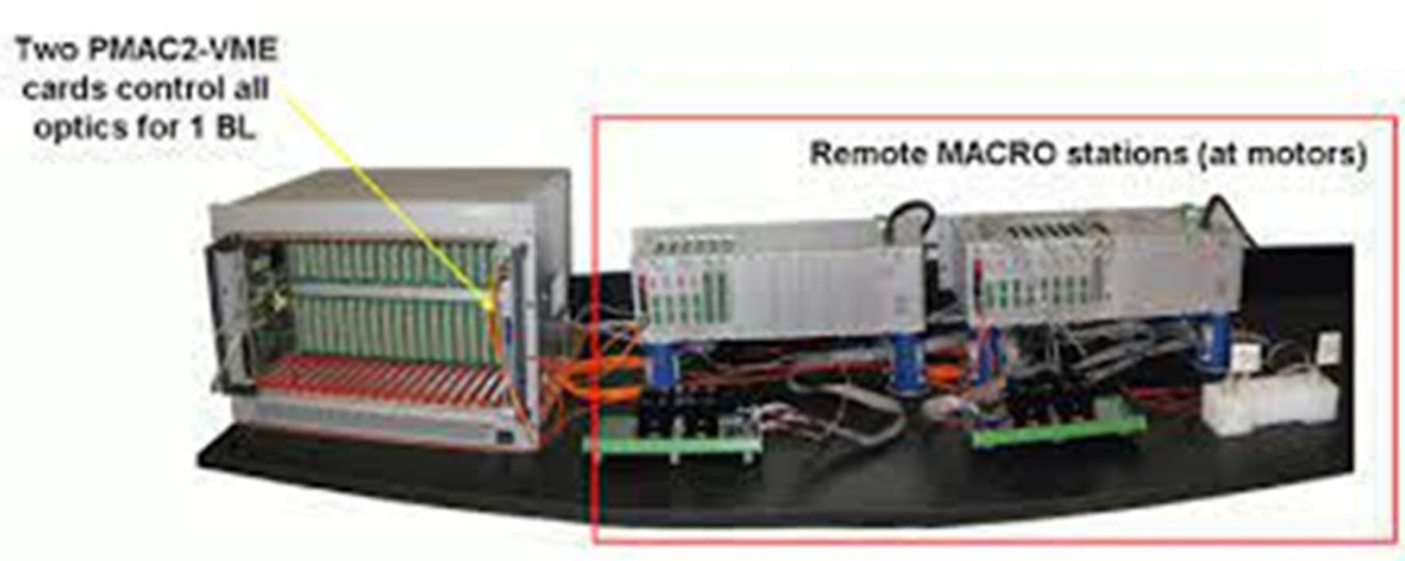
OUTLINE

- History of motion control at GM/CA
- Omron Delta Tau Power PMAC
- Embedded EPICS IOC
- IOC boot configuration
- Motion control screens
- References
- Acknowledgements



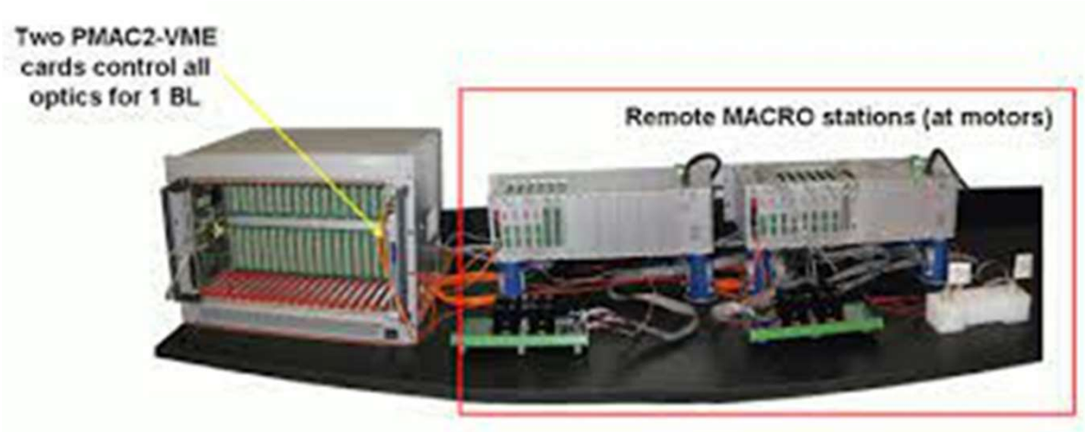
HISTORY OF MOTION CONTROL AT GM/CA

- Predecessor – 8 axis PMAC (Programmable Motion and Automation Controller)
  - Vendor: Delta Tau Data Systems
  - EPICS driver: VME based by Thomas A. Coleman
  - Implemented at BIO CAT
- Turbo PMAC2-VME UltraLite – 32 axis motion controller
  - EPICS driver: VME based by Oleg Makarov and Sergey Stepanov
  - Used at GM/CA, LS-CAT, IMCA at the APS and 500+ PMACs at DIAMOND
  - Driver distributed through the GM/CA web site with EPICS license



PMAC FAMILY OF CONTROLLERS ADVANTAGES

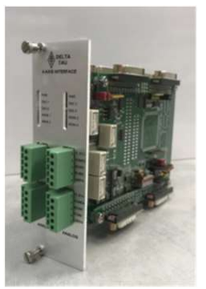
- Distributed motion control system with components connected over fiber link
- Coordinated motions of multiple axes and custom motion programs
- Controls wide variety of motors:
  - Brushed and brushless servo
  - Stepper motors with and without encoders
  - Piezo motors
- Supports incremental and absolute encoders
- Includes digital and analog I/O modules
- Supports PLC logic programming:
  - Synchronizing motion with data acquisition including area detectors (PILATUS, EIGER, …)
  - Hardware synchronized on-the-fly scans



OMRON DELTA TAU POWER PMAC

- DeltaTau became a part of OMRON Automation (September, 2015)
  - With more than 30 years of experience and 1,000,000 axes of motion, Delta Tau is committed to providing solutions for the simplest to most complex applications
  - Omron Automation is an industrial automation partner that creates, sells and services fully integrated automation solutions in more than 80 countries.
- As a part of the GM/CA plan to eliminate VME from beamline controls we selected to upgrade with Power PMAC Dual Core ARM CPU made by ODT.
  - Provides distributed motion control system.
  - Allows us to reuse existing PMAC components:
    - UMAC chassis
    - MACRO CPUs
    - Numerous interface cards (motor/encoder/digital IO/analog IO)



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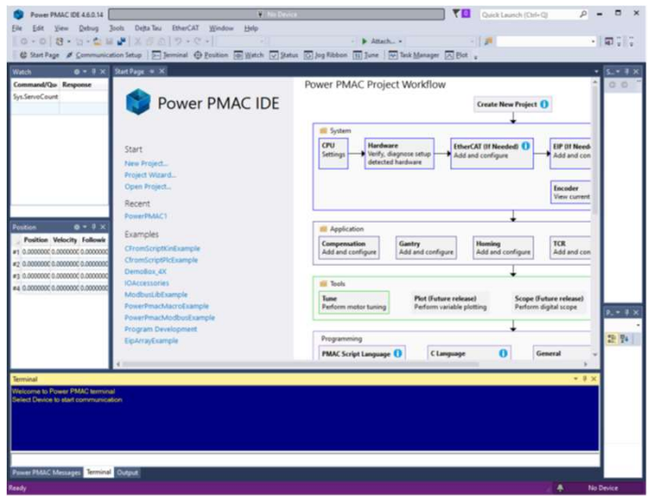
EMBEDDED EPICS IOC

- Power PMAC motion controller has Debian GNU/Linux 8 (jessie) installed.
  - 4.1.18-ipipe #133 SMP Fri May 15 10:20:51 PDT 2020 armv7l GNU/Linux
- I have installed:
  - EPICS BASE R7.0.7
  - ASYN R4-44-2 framework (Mark Rivers, …)
  - PPMAC-R1-0
- PPMAC-1-0 is built with ASYN port driver (file ppmacDrv.cpp):

  ppmacDrv::ppmacDrv (const char *portName, int autoconnect, int mNum, int mCS, int mIO)
  : asynPortDriver (…) {…}
- Motion controller configuration is done with “PowerPMAC IDE 4” Integrated Development Environment software, it allows:
  - Hardware configuration
  - Setting encoders
  - Setting motors
  - Setting coordinate systems
  - Tuning motors



IOC BOOT CONFIGURATION

Configuration example: 3-motor vertical positioner of the KB vertical focusing mirror

- File config_CS.cfg:

```
…
&7 //KBM_V_vert: 530mm pitch base, 210mm yaw base, X(mm)-vertical, Y(mrad)-yaw, Z(mrad)-pitch
  #1->200000X-53000Z+5200000 // Y US
  #2->200000X+21000Y+53000Z+5200000 // Y DS OB
  #3->200000X-21000Y+53000Z+5200000 // Y DS IB
```

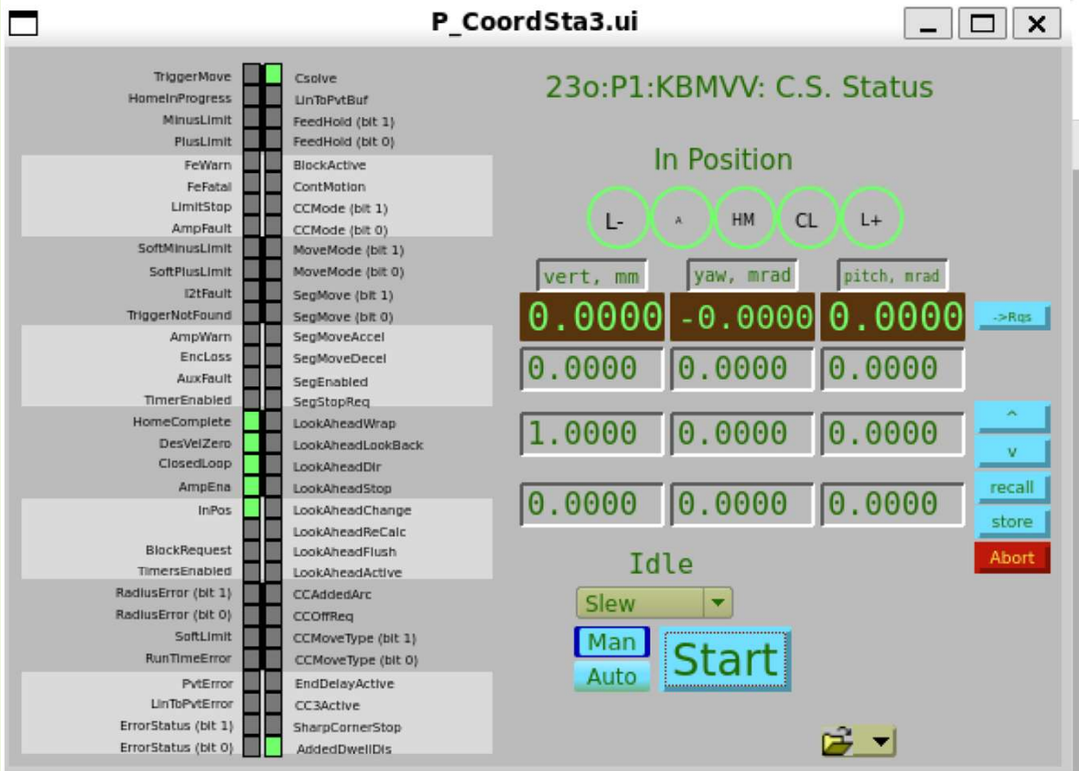
- File st.cmd:

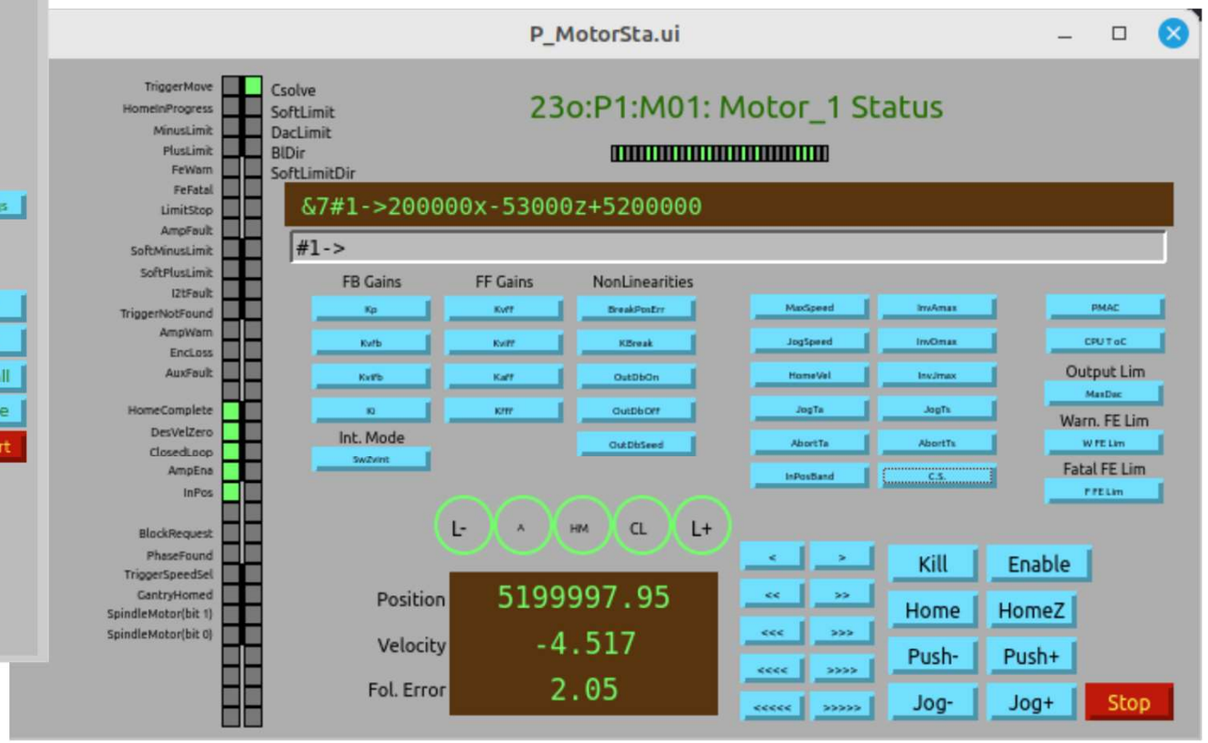
```
…
dbLoadRecords "db/MTR.db" "PORT=mc,P=23o:P1:,M=M01:,N=1,TIMEOUT=1"
dbLoadRecords "db/MTR.db" "PORT=mc,P=23o:P1:,M=M02:,N=2,TIMEOUT=1"
dbLoadRecords "db/MTR.db" "PORT=mc,P=23o:P1:,M=M03:,N=3,TIMEOUT=1"

dbLoadRecords "db/CS.db"  "PORT=mc,P=23o:P1:,CS=KBMVV:,N=7,TIMEOUT=1"
dbLoadRecords "db/CSA.db" "PORT=mc,P=23o:P1:,CS=KBMVV:,N=7,A=V:,PA=X,TIMEOUT=1"
dbLoadRecords "db/CSA.db" "PORT=mc,P=23o:P1:,CS=KBMVV:,N=7,A=W:,PA=Y,TIMEOUT=1"
dbLoadRecords "db/CSA.db" "PORT=mc,P=23o:P1:,CS=KBMVV:,N=7,A=P:,PA=Z,TIMEOUT=1"
```

MOTION CONTROL SCREENS

Control screens (MEDM, caQtDM)





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PLANS BY THE APS BEAM-BACK

- Implement beamlines motion controls for new GM/CA end station and beamline optics
- Redesign synchronization with PILATUS 6M, EIGER 16M and EIGER2 CdTe area detectors
- Re-implement hardware-synchronized on-the-fly scanning with Measurement Computing USB-CTR08 counters
- Develop full set of MEDM/caQtDM control screens
- Re-implement motor homing scripts

REFERENCES

- Power PMAC CPU motion controller
  https://automation.omron.com/en/us/products/family/UMAC%20CPU
- Power PMAC IDE setup software
  https://automation.omron.com/en/us/products/family/PMAC%20IDE
- Experimental Physics and Industrial Control System, EPICS BASE
  https://epics.anl.gov/download/base
- ASYN - a general purpose facility for interfacing device specific code to low level drivers.
  https://github.com/epics-modules/asyn
- EPICS Power PMAC embedded driver
  https://www.gmca.aps.anl.gov/PPMAC
- EPICS Power PMAC driver - Diamond Light Source version
  https://github.com/dls-controls/pmac

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Thank you for your attention!

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