

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



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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

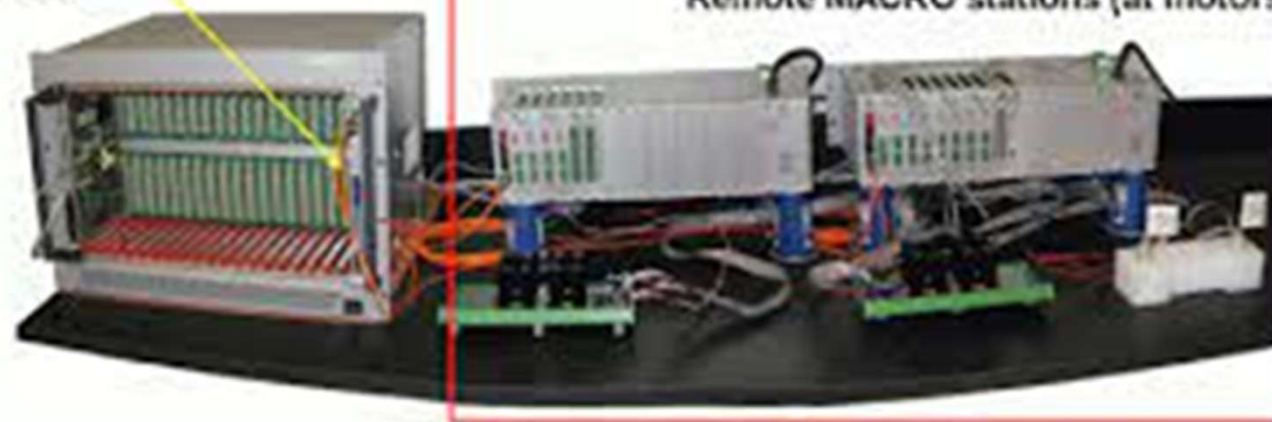


HISTORY OF MOTION CONTROL AT GM/CA

- 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

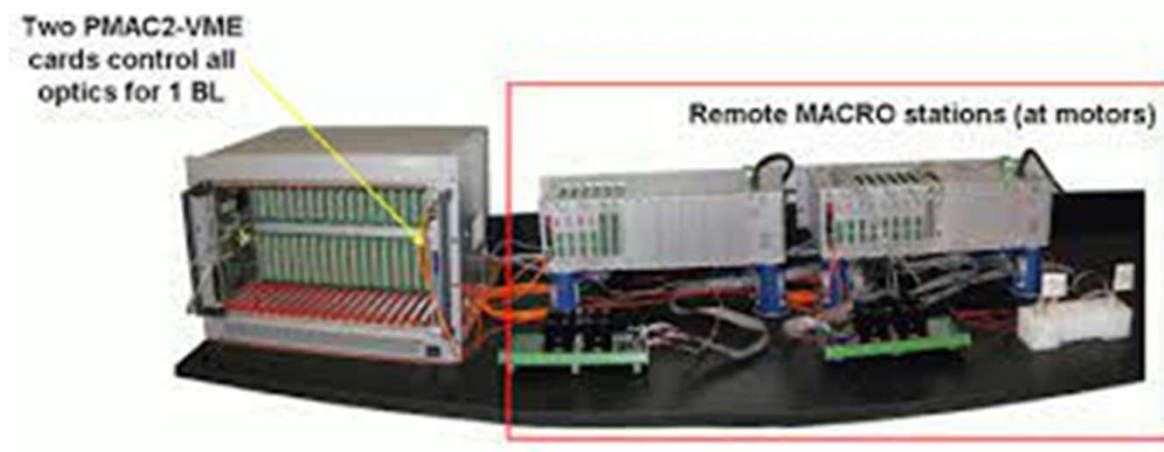


Two PMAC2-VME
cards control all
optics for 1 BL



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



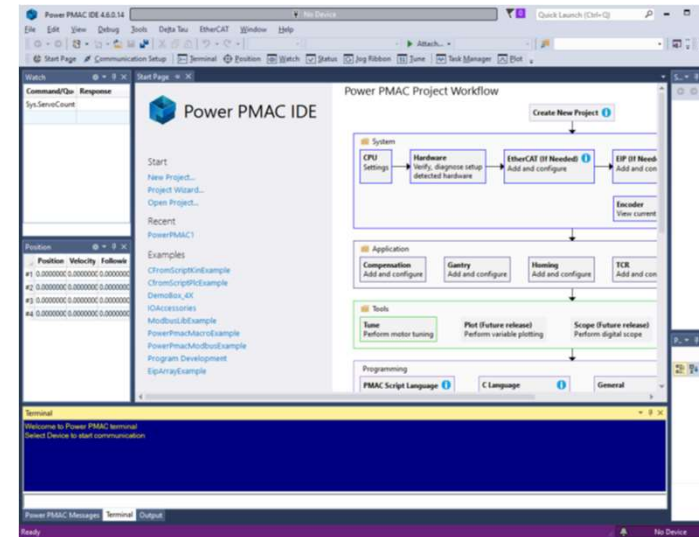
OMRON DELTA TAU POWER PMAC

- 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)



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)

P_CoordSta3.ui

23o:P1:KBMVV: C.S. Status

In Position

L- A HM CL L+

vert, mm yaw, mrad pitch, mrad

0.0000 -0.0000 0.0000 ->Pos

0.0000 0.0000 0.0000

1.0000 0.0000 0.0000 ^ v

0.0000 0.0000 0.0000 recall

Idle

Slew

Man Auto Start

Abort

TriggerMove, HomeInProgress, MinusLimit, PlusLimit, FeWarn, FeFatal, LimitStop, AmpFault, SoftMinusLimit, SoftPlusLimit, I2tFault, TriggerNotFound, AmpWarn, EncLoss, AuxFault, TimerEnabled, HomeComplete, DesVelZero, ClosedLoop, AmpEna, InPos, BlockRequest, TimersEnabled, RadiusError (bit 1), RadiusError (bit 0), SoftLimit, RunTimeError, PvtError, LinToPvtError, ErrorStatus (bit 1), ErrorStatus (bit 0), Csolve, LinToPvtBuf, FeedHold (bit 1), FeedHold (bit 0), BlockActive, ContMotion, CCMode (bit 1), CCMode (bit 0), MoveMode (bit 1), MoveMode (bit 0), SegMove (bit 1), SegMove (bit 0), SegMoveAccel, SegMoveDecel, SegEnabled, SegStopReq, LookAheadWrap, LookAheadLookBack, LookAheadDir, LookAheadStop, LookAheadChange, LookAheadReCalc, LookAheadFlush, LookAheadActive, CCAddedArc, CCOffReq, CCMoveType (bit 1), CCMoveType (bit 0), EndDelayActive, CC3Active, SharpCornerStop, AddedDwellDis

P_MotorSta.ui

23o:P1:M01: Motor_1 Status

#1->200000x-53000z+5200000

#1->

FB Gains FF Gains NonLinearities

Kp Kvff BreakPosErr MaxSpeed InvAmax PMAC

Kvfb Kvff KBreak JogSpeed InvOmax CPU ToC

Kvfb Kvff OutDbOn HomeVel InvJmax Output Lim

Ki Kff OutDbOff JogTa JogTs Warn. FE Lim

Int. Mode OutDbSeed AbortTa AbortTs W FE Lim

Swzint InPosBand C.S. Fatal FE Lim F FE Lim

L- A HM CL L+

Position 519997.95

Velocity -4.517

Fol. Error 2.05

< > Kill Enable

<< >> Home HomeZ

<<< >>> Push- Push+

<<<< >>>> Jog- Jog+ Stop

TriggerMove, HomeInProgress, MinusLimit, PlusLimit, FeWarn, FeFatal, LimitStop, AmpFault, SoftMinusLimit, SoftPlusLimit, I2tFault, TriggerNotFound, AmpWarn, EncLoss, AuxFault, HomeComplete, DesVelZero, ClosedLoop, AmpEna, InPos, BlockRequest, PhaseFound, TriggerSpeedSel, GantryHomed, SpindleMotor (bit 1), SpindleMotor (bit 0), Csolve, SoftLimit, DacLimit, BDir, SoftLimitDir

PLANS BY THE APS BEAM-BACK

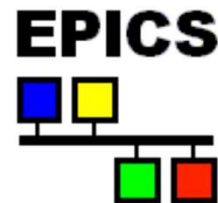
- Implement beamlines motion controls for new GM/CA end station and beamline optics
- Redesign synchronization with PILATUS 6M, EIGER 16M and EIGER2 CdTe area detectors
- Re-implement hardware-synchronized on-the-fly scanning with Measurement Computing USB-CTR08 counters
- Develop full set of MEDM/caQtDM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

