MULTI-DEVICE KNOB UTILITY FOR LCLS AT SLAC*

Michael Zelazny#, Sergei Chevtsov, Chungming Paul Chu, Diane Fairley,
Patrick Krejcik, Deborah Rogind, Howard Smith, Greg White, Gerald Yocky,
SLAC National Accelerator Laboratory, Menlo Park, CA, U.S.A.

Abstract

At the SLAC National Accelerator Laboratory (SLAC) the Controls Department (CD) has developed a new Multi-Device Knob Utility (MKB) based on the Experimental Physics and Industrial Control System (EPICS)[1] toolkit for controlling one or more Process Variables (PVs) in unison, or simultaneously, from a physical knob located in the control room, or from various software tools such as the EPICS Extensible Display Manager (EDM)[2] or a Swing slider in Java. A group of devices are hooked up to a knob, and then the value written to the devices is a simple function of the value of the knob. This is used, most commonly, to create a bump in the electron beam for the Linac Coherent Light Source (LCLS)[3]. Control system variables typically controlled are magnetic fields, phases, and timing offsets. This paper describes the technologies used to implement this utility.

EPICS MULTI-DEVICE KNOB INPUT/OUTPUT CONTROLLER (IOC)

The Multi-Device Knob was implemented as an EPICS Soft IOC. That is, it runs on a host computer, as opposed to an embedded computer, and relies on Channel Access (CA)[4] connections to several other EPICS IOCs to control devices. For LCLS, the host computers are Dell Servers running Red Hat Enterprise Linux 4 (RHEL4). MKB configuration is implemented using files and an EPICS Sequence is used to control the behaviour of the Multi-Device Knob.

EPICS Database

The heart of the MKB EPICS database is an Analogue Out (AO) PV (see Figure 1). Initially 50 MKB units were created. It is unknown at this time whether that number is sufficient or deficient for long term use. Supporting PVs include sensitivity for the physical hardware knob, a label for the hardware knob, the date the MKB was assigned, the date the MKB was last used, the configuration file name, and an MKB status string. This database is quite small, and no inter-database connections were necessary.

*Work supported by the U.S. Department of Energy under contract number DE-AC02-76SF00515.
#zelazny@slac.stanford.edu

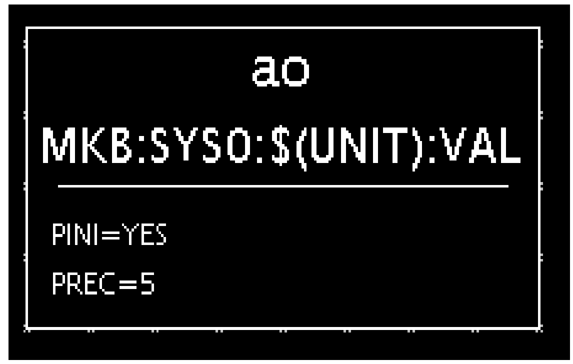
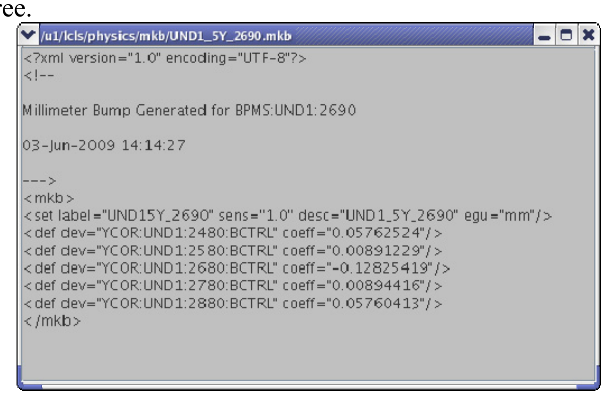


Figure 1: EPICS Visual Database Creation Tool (VDCT)[5] representation of the MKB PV.

Configuration Files

It was desired by SLAC physicists to use disk files to store the definition of an MKB. This approach was chosen to be compatible with the legacy control system's Multi-Device Knob Facility and for ease when creating new configurations using tools they're familiar with, especially Matlab. Extensible Mark-up Language (XML) was chosen (see Figure 2) due to the wide availability of computing language support available for download for free.



/u1/lcls/physics/mkb/UND1_5Y_2690.mkb

```
<?xml version="1.0" encoding="UTF-8"?>
<!--

Millimeter Bump Generated for BPMS:UND1:2690

03-Jun-2009 14:14:27

--->
<mkb>
<set label="UND15Y_2690" sens="1.0" desc="UND1_5Y_2690" egu="mm"/>
<def dev="YCOR:UND1:2480:BCTRL" coeff="0.05762524"/>
<def dev="YCOR:UND1:2580:BCTRL" coeff="0.00891229"/>
<def dev="YCOR:UND1:2680:BCTRL" coeff="-0.12825419"/>
<def dev="YCOR:UND1:2780:BCTRL" coeff="0.00894416"/>
<def dev="YCOR:UND1:2880:BCTRL" coeff="0.05760413"/>
</mkb>
```

Figure 2: Typical MKB configuration file.

The XML tags for the MKB are described in Table 1. One requirement was to have virtually no limit to the number of constituent devices that define the MKB PV. SLAC physicists have defined MKB's that are composed of many dozens of PVs, for example, all Linac Quadrupoles. This particular MKB is used, for example, to help change the operating energy of the LCLS.

Table 1: MKB XML Tags

XML Tag	Definition
coeff	The amount the constituent device changes relative to the value of the MKB.
desc	The description of the MKB PV (i.e. it's .DESC field)
dev	Defines a constituent device for the MKB.
egu	The engineering units of the MKB itself.
label	The short label that goes on the hardware knob console. Note that SLAC hardware knobs display up to eight characters,
mkb	The MKB definition itself.
sens	The amount the MKB PV changes per turn of the physical hardware knob.

EPICS Sequence

The behaviour of the MKB is defined in an EPICS State Notation Language (SNL)[6] program running in the MKB Soft IOC. The SNL waits for an MKB configuration file to be assigned to an MKB PV. Then it attempts to connect to each of the constituent PVs. If successful, it will calculate the MKB PV operating range based on the current values of the constituent PVs, their operating range, and their coefficient as defined in the MKB configuration file (see Eqs. 1 & 2). The symbols used in Eqs. 1&2 are defined in Table 2. Note that it's possible to create an MKB that doesn't have the ability to control its constituent PVs. No checking is done on MKB assignment for write access to constituent PVs, so the MKB configuration file writer needs to be careful to select appropriate PVs for their MKB. Also note that it's possible that an assigned MKB have no operating range due to the current running condition of the accelerator. The initial value of the MKB PV is 0.0.

$$U_m = MIN\{MAX[\frac{U_n - V_n}{C_n}, \frac{L_n - V_n}{C_n}]\} \quad (1)$$

$$L_m = MAX\{MIN[\frac{U_n - V_n}{C_n}, \frac{L_n - V_n}{C_n}]\} \quad (2)$$

Table 2: MKB Operating Range

Eqs. 1&2's Symbol	Definition
C	Coefficient defined in the MKB Configuration File
L	Lower Operating Limit
n	Each Constituent Device PV
m	MKB PV
U	Upper Operating Limit
V	Current PV Value

Assuming the MKB PV has a valid operating range; the SNL program monitors or listens for changes to the MKB PV value. Whenever the MKB PV value changes, the SNL program will update the values of the constituent PVs according to Eq. 3. Table 3 defines the symbols used in Eq. 3. Note that each MKB PV has its own controlling SNL program.

$$V_n = V_{n(t=0)} + V_m \times C_n \quad (3)$$

Table 3: Constituent PV Values

Eq. 3 Symbol	Definition
C	Coefficient defined in the MKB Configuration File
m	MKB PV
n	Each Constituent Device PV
t	Time
V	PV Value

Once the SNL attempts to set each constituent device's PV, verification is performed to see if the constituent device made it to the desired value within some tolerance. Those tolerances can be as simple as within, say, 1% of the desired value or read from yet another EPICS PV. If the value of a constituent PV is changed by another CA client, those changes are ignored by the MKB, as is usually done when using the EPICS toolkit. No safe guards are in place. The last CA client to write a PV wins.

GRAPHICAL USER INTERFACE (GUI)

As part of the MKB utility for LCLS a GUI was developed using Java, Swing, and Java Channel Access (JCA). The GUI consists of four main components: MKB Assignment, MKB Adjustment, MKB Creation, & MKB IOC Maintenance. A common GUI Framework (GFW)[7] developed at SLAC enabled this application to be prototyped and developed rapidly.

Assign Tab

The MKB GUI Assign tab (see Figure 3) presents a Swing file chooser of MKB Configuration files. One can preview the contents of the file by pressing the "Preview..." button (see Figure 2). Once the "Assign" button is pressed, the GUI automatically selects the Adjust Tab.

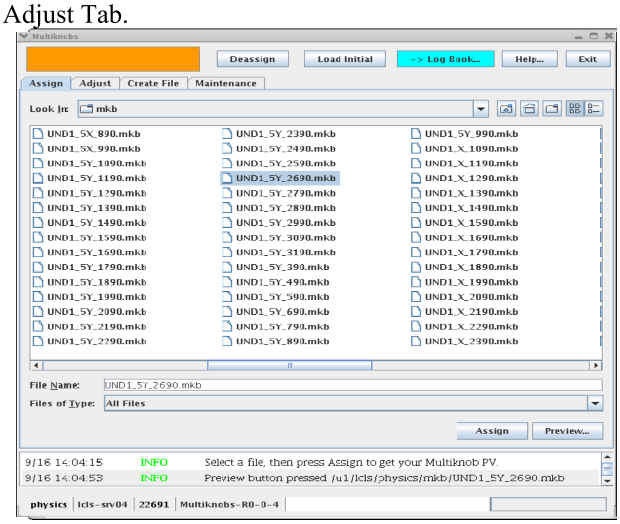


Figure 3: MKB GUI Assign Tab.

Adjust Tab

The MKB GUI Adjust Tab contains a Swing JTable showing the MKB PV and that MKB's constituent PVs, and a slider with which one can change the value of the MKB PV (see Figure 4). As you change the value of the MKB PV, you can watch the values of the constituent PVs change as the MKB IOC does its magic. The "Load Initial" button restores the MKB's initial conditions, if desired. The "Deassign" button returns the GUI back to the Assign Tab.

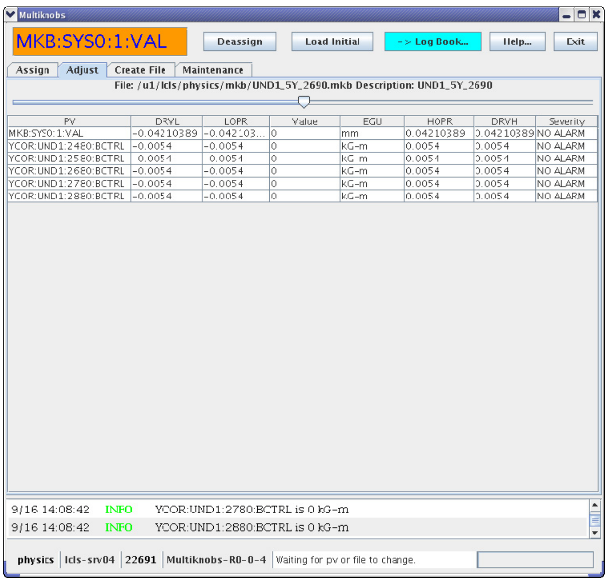


Figure 4: MKB GUI Adjust Tab.

Create / Edit File Tab

The Create / Edit File Tab helps guide the user to making MKB configuration files. The GUI hides the annoying XML syntax and provides an easy way to drag and drop PV names from one GUI to another to avoid errors and laborious typing (see Figure 5).

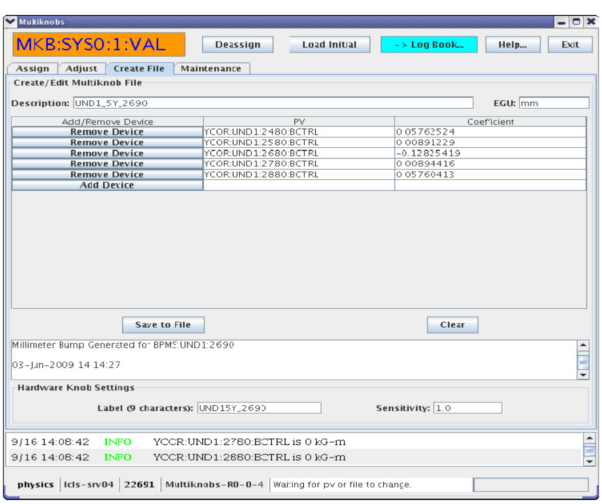


Figure 5: MKB GUI Create / Edit File Tab.

The MKB Maintenance Tab allows the user to monitor the health of the MKB IOC or, more likely, deassign any MKB PVs no longer in use. A customizable Swing JTable is used to present the information (see Figure 6).

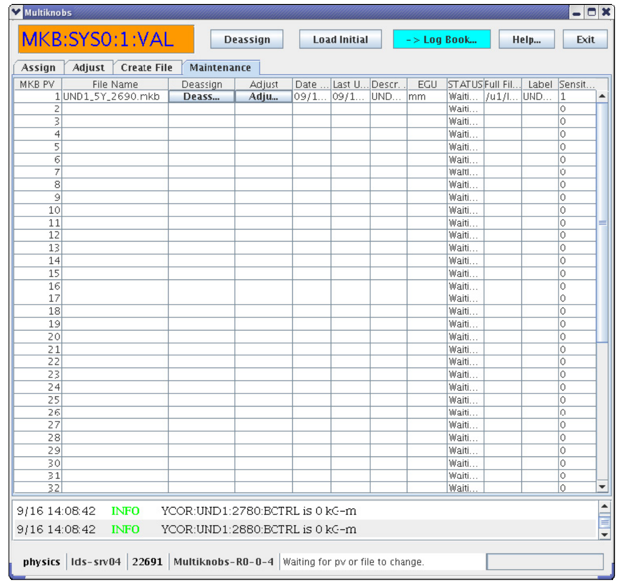


Figure 6: MKB GUI Maintenance Tab.

REFERENCES

[1] P. Stanley, J. Anderson, M. Kraimer, "EPICS Record Reference Manual", Copyright © 1995 The University of California, The University of Chicago. http://www.aps.anl.gov/epics/wiki/index.php/RRM_3-14.

[2] J. Sinclair, "Extensible Display Manager (EDM)", Copyright © 2007 John Sinclair. http://ics-web.sns.ornl.gov/edm/edmUserManual/index.html.

[3] Linac Coherent Light Source (LCLS), http://lcls.slac.stanford.edu

[4] J.O. Hill and R. Lange, "EPICS Channel Access Reference Manual", Copyright © 2002 The University of Chicago, as Operator of Argonne National Laboratory. http://www.aps.anl.gov/epics/base/R3-14/10-docs/CAref.html.

[5] Rok Šabjan, "Visual Database Configuration Tool". http://www.cosylab.com/solutions/particle_accelerators/VisualDCT.

[6] N. Arnold, "State Notation Language (SNL)", Advanced Photon Source (APS). http://www.slac.stanford.edu/comp/unix/package/epics/training/documents/06_SNL.pdf.

[7] S. Chevtsov, "GFW – A New GUI Framework at SLAC", ICALEPCS'09, Kobe, October 2009, THP103, p. unk (2009); http://www.JACoW.org.