MULTI-DEVICE KNOB UTILITY FOR LCLS AT SLAC*

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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.

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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.

V /u1/lcls/physics/mkb/UND1_5Y_2690.mkb
xml version="1.0" encoding="UTF-8"? </td
Millimeter Bump Generated for BPMS:UND1:2690
03-Jun-2009 14:14:27
> <mkb> <set desc="UND1.5Y_2690" egu="mm" label="UND15Y_2690" sens="1.0"></set> <def coeff="0.05762524" dev="YCOR:UND1:2480:BCTRL"></def> <def coeff="0.12825419" dev="YCOR:UND1:2580:BCTRL"></def> <def coeff="0.00894416" dev="YCOR:UND1:2780:BCTRL"></def> <def coeff="0.05760413" dev="YCOR:UND1:2780:BCTRL"></def> <def coeff="0.05760413" dev="YCOR:UND1:2880:BCTRL"></def> </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.

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Table 1: MKB XML Tags
Definition
The amount the constituent device changes
relative to the value of the MKB.
The description of the MKB PV (i.e. it's
.DESC field)
Defines a constituent device for the MKB.
The engineering units of the MKB itself.
The short label that goes on the hardware
knob console. Note that SLAC hardware
knobs display up to eight characters,
The MKB definition itself.
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.

$$\mathbf{U}_{\mathrm{m}} = MIN\{MAX[\frac{\mathbf{U}_{\mathrm{n}} - \mathbf{V}_{\mathrm{n}}}{\mathbf{C}_{\mathrm{n}}}, \frac{\mathbf{L}_{\mathrm{n}} - \mathbf{V}_{\mathrm{n}}}{\mathbf{C}_{\mathrm{n}}}]\} \qquad (1)$$

$$L_{m} = MAX\{MIN[\frac{U_{n} - V_{n}}{C_{n}}, \frac{L_{n} - V_{n}}{C_{n}}]\}$$
(2)

Та	ble 2: MKB Operating Range
Eqs. 1&2's Symbol	Definition
С	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

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in Eq. 3. Note that each MKB PV has its own controlling SNL program.

$$\mathbf{V}_{\mathrm{n}} = \mathbf{V}_{\mathrm{n}(\mathrm{t}=0)} + \mathbf{V}_{\mathrm{m}} \times \mathbf{C}_{\mathrm{n}}$$
(3)

Eq. 3	Definition
Symbol	
С	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.

 Multiknebs 		
	Deassign Load Initial	-> Log Book Help Exit
Assign Adjust Create File M	aintenance	
Look Irr		
UND1_5X_890.mkb	UND1_5Y_2390.mkb	UND1_5Y_990.mkb
UND1_5X_990.mkb	🗋 UND1_5Y_2490.mkb	UND1_X_1090.mkb
UND1_5Y_1090.mkb	🗋 UND1_5Y_2590.mkb	UND1_X_1190.mkb
UND1_5Y_1190.mkb	UND1_5Y_2690.mkb	UND1_X_1290.mkb
UND1_5Y_1290.mkb	UND1_5Y_2790.mkb	UND1_X_1390.mkb
UND1_5Y_1390.mkb	🗋 UND1_5Y_2890.mkb	UND1_X_1490.mkb
UND1_5Y_1490.mkb	UND1_5Y_2990.mkb	UND1_X_1590.mkb
UND1_5Y_1590.mkb	🗋 UND1_5Y_3090.mkb	UND1_X_1690.mkb
UND1_5Y_1690.mkb	UND1_5Y_3190.mkb	UND1_X_1790.mkb
UND1_5Y_1790.mkb	UND1_5Y_390.mkb	UND1_X_1890.mkb
UND1_5Y_1890.mkb	UND1_5Y_490.mkb	UND1_X_1990.mkb
UND1_5Y_1990.mkb	UND1_5Y_590.mkb	UND1_X_2090.mkb
UND1_5Y_2090.mkb	UND1_5Y_690.mkb	UND1_X_2190.mkb
UND1_5Y_2190.mkb	UND1_5Y_790.mkb	UND1_X_2290.mkb
UND1_5Y_2290.mkb	🗋 UND1_5Y_890.mkb	UND1_X_2390.mkb
		•
File Name: UND1_57_2690.mkb		
Files of Type: All Files		·
		Assign Preview
9/16 14:04:15 INFO	Select a file, then press Assign to :	get your Multiknob PV.
9/16 14:04:53 INFO	Preview button pressed /u1/lcls/	ohysics/mkb/UND1_5Y_2690.mkb
nbysics lcls=sp/04 22691 Mult	knobs_80_0_4	

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.

MKB:SYS0:1:	VAL	Deassign	Lo	ad Initial	-> Log Book	Help	Dxit
Assian Adjust Cre	ate File Mai	ntenance					
File	:/u1/lcls/phy	sics/mkb/UN	D1_5Y_26	0.mkb Descrip	tion: UND1_5Y_3	2690	
P\/	DEVI	LOPE	Value	EGU	HOPR	DRVH	Security
IKB:SYS0:1:VAL	-0.04210389	-0.042103	0	mm	0.04210389	0.04210389	NO ALARM
COR:UND1:2480:BCTRL	-0.0054	-0.0054	0	kG-m	0.0054	0.0054	NO ALARM
COR:UND1:2580:BCTRL	0.0051	0.0051	0	kG m	0.0054	0.0051	NO ALARM
COR:UND1:2680:BCTRL	-0.0054	-0.0054	0	kG-m	0.0054	0.0054	NO ALARM
COR:UND1:2780:BCTRL	-0.0054	-0.0054	0	kG-m	0.0054	0.0054	NO ALARM
COR:UND1:2880:BCTRL	-0.0054	-0.0054	0	kG-m	0.0054	0.0054	NO ALARM

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).

MKR:2420:1:AV	Deassign Load Initial	-≻ Log Book	Help Exi
Assign Adjust Create File	Maintenance		
reate/Edit Multiknob File			
escription: UND1 5Y 2690			EGU: mm
company joint 210 file 000			
Add/Remove Device	PV		Ioef'icient
Remove Device	YCOR:UND1:2480:BCTRL	0 05762524	
Remove Device	YCOR:UND1:2580:BCTRL	0 00891229	
Remove Device	YCOR:UND1:2680:BCTRL	-0.12825419	
Remove Device	YCOR:UND 1:2780:BCTRL	0 00894416	
Remove Device	TCOR:UND1:2880:BCTRL	0.05760413	
Save to	-116	Clear]
Save to Allimeter Bump Generated for BPMS	11e UND 1:2690	Clear]
Save to 1 Allimeter Bump Generated for BPMS 33-Jm-2009 14 14:27	TILE UND 1:2690	Clear	
Save to Millineter Bump Generated for BPMS 33-Jun-2009 14 14 27 Handware Knob Settings	716 UND 1 2690	Clear	
Save to Allimeter Bump Generated for BPMS 93-Jun-2009 14 14:27 Hardware Knob Settings Labet Ø characte	HIC UND 1 2690	Clear Sensitivity: 1.0	
Save to Millimeter Bump Generated for BPMS 33-Jun-2009 14 14:27 Hardware Knob Settings Label Ø charactu 9/16 14:08:42 INFO VCC	ILE UND12690 HSK [UND157,2690 R. UND1:2780.BCTRL is 0 kG-m	Ctear Sensitivity: 1.0	

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

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MKB PVs no longer in use. A customizable Swing JTable is used to present the information (see Figure 6).

MKB	SYS0:1:VA	De	assign	Lo	ad Initial		-> Log	Book	H	elp	Exi	ι
Assign	Adjust Create Fi	le Maintena	nce									
MKB PV	File Name	Deassign	Adjust	Date	. Last U	Descr.	. EGU	STATUS	Full Fil.	Label	Sensit.	
1	JND1_5Y_2690.mkb	Deass	Adju	09/1	09/1	UND	mm	Waiti	/u1/I	UND	1	1
2								Waiti			0	
3								Waiti			0	
4								Waiti			0	
5								Waiti			0	
б								Waiti			0	
7								Walti			0	
8								Waiti			0	
9								Waiti			0	
10								Waiti			0	
11								Waiti			0	
12								Waiti			0	
13								Waiti			0	
14								Waiti			0	
15								Waiti			0	
16								Waiti			0	
17								Waiti			0	
18								Waiti			0	
19								Waiti			0	
20								Waiti			0	
21								Waiti			0	
22								Waiti			0	
23								Waiti			0	
24								Waiti			0	
25								Waiti			0	
26								Waiti			0	
27								Waiti			0	
28								Waiti			0	
29								Waiti			0	
30								Waiti			0	
31								Waiti			0	
32								Waiti			0	
110.14	09.40 NEO 3		200.000	DI ia O	146							
110 14	08.42 1110	COR UND1.2	PRO.BCT	RL IS O	ke-m							
91614:	08:42 INPO :	YCOR:UND1:2	2880:BCI	RL IS U	KG-III							

Figure 6: MKB GUI Maintenance Tab.

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