Karabo and Tango interoperability

Gabriele Giovanetti, Michael Smith,

Ana Garcia-Tabares Valdivieso, Andrea Parenti, Ayaz Samadli, Dennis Goeries, Florian Sohn, Ivars Karpics, Wajid Ehsan **European XFEL** 

# **Device integration in the European XFEL Control System (Karabo)**

The Karabo control system [1] [2] is used on photon systems at European XFEL (EuXFEL) to steer experiments and collect scientific data.

As a user-centered facility, EuXFEL deals with ever-changing requirements and often faces the need to integrate new instrumentation, or even to cope with user-provided hardware on relatively short notice. In 2023, a total 89 user experiments took place in the seven beamlines [3].

Karabo integration is mandatory for any device producing data used at EuXFEL, in order to have the data acquired and stored in the EuXFEL DAQ system. This ensures reliability, synchronization, and compliance with the data policy [4]. Additionally, Karabo integration is also convenient for devices whose main purpose is not data acquisition (e.g. motor positioners) to take advantage of the Karabo infrastructure like data logging, scans, distributed remote control, etc.

# Tango devices at EuXFEL

Tango [5] is a well-established control system, and many hardware devices that are new in the EuXFEL context, have a Tango server available. For this reason, a Karabo device package has been implemented to provide a generic interface to any Tango server. This way the potential number of components that can be easily integrated at EuXFEL has been increased with a relatively small effort.

## The TangoMotor device

A more specific Karabo device has been implemented, to control motor controllers which come with a Tango server through Karabo: the TangoMotor. It implements the standardized Karabo motor interface, which makes the motor user interface more familiar to EuXFEL beamline scientists [Fig. 3].

More importantly, it also allows the motor controllers to be operated seamlessly by other Karabo software, the primary example being Karabacon, the Karabo scan tool [7].

The mapping of Tango motor parameters to the standard Karabo ones is user-configurable, as well as the mapping between state machine states [Fig. 4].

	SPB_IR	D_RRN/MOTOR/IN	MIC_Y default_	scene	-		$\times$
	✓ 🗙   🚔				5	<u></u>	♥
	SPB_IRD_RRN/MOTOR/IN	MIC_Y	MOVING		Reset		
	At CW Limit 🛛 At CCW L	.imit 🔵			Stop		
	Position	-0.07	mm				
	Target Position	0.5 mm 0.5	mr	n	Move		
SPB_	IRD_RRN/MOTOR/INMIC_X d	efault_scene	- • ×		Chara Mar		
🗸 🗙 1 🚔			🔊 🛎 🔶				
SPB_IRD_RRN/MOTOR/	/INMIC_X		Reset				
At CW Limit 🔵 At CCV	N Limit			mm/s			
Position Target Position	1.47         mm           0.5         mm         0.5	mm	Move	Tango State	MOV	/ING	-
Step Down	Step Size 0.7 mm 0.7	mm	Step Up				
SW Limit High	-7.7430078mm -7.7430078125	mm					
SW Limit Low	12.256953mm 12.256953125	mm					
Epsilon 0.001 mm 0.001 mm	Target Velocity 2	mm/s 2.0 mm/s					
Tango Motor Id	spb/motor/rr.12	Tango State	ON				
Tango Status	The device is in C	DN state.					



### The TangoMirror device

The TangoMirror is a Karabo device that takes full advantage of the PyTango API [6]. It can be configured to connect to a Tango Server and expose any Tango attribute to the Karabo world. The Tango devices and parameters to be exposed are not hard coded, but can be entered by the user in the Karabo device configuration [Fig. 1], as well as the synchronization mode (polled, on a periodic event, or event-driven) [Fig. 2]. A nested view of the tango device and parameters is then injected at runtime in the Karabo device schema upon connection with the tango server. They can then be read or written just like any other Karabo parameter.

A Tango Host Nam	exflqr53837
1 Tango Host Port	10000
11 Connection Time	eout 10.0 s
💷 Polling Time Inte	rval 0.2 s
Tango Devices	Table Element

Figure 1 - The TangoMirror connection configuration

Image: True       rm/motor/xfel.09       Position/Velocity/Acceleration,SoftCwLimit,SoftCowLimit,SoftCowLimitFault,SoftCowLimitFault,CowLimitFault,CowLimitFault,SottCowLimitFault,CowLimitFault,SoftCowLimitFault,CowLimitFault,SoftCowLimitFault,CowLimitFault,SoftCowLimitFault,CowLimitFault,SoftCowLimitFault,CowLimitFault,SoftCowLimitFault,So						Table Element			×
Image: True       rr/motor/xdel.10       Position/Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,CcwLimitFault,Scte,Status       Polling         Image: True       rr/motor/xdel.11       Position/Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,CcwLimitFault,Scte,Status       Polling         Image: True       rr/motor/xdel.12       Position/Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,CcwLimitFault,Scte,Status       Polling         Image: True       rr/motor/xdel.12       Position/Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,CcwLimitFault,Scte,Status       Polling         Image: True       rr/motor/xdel.13       Position/Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,Scte,Status       Polling         Image: True       rr/motor/xdel.14       Position/Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,Scte,Status       Polling         Image: True       rr/motor/xdel.15       Position/Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,Scte,Status       Polling         Image: True       rr/motor/xdel.15       Position/Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,Scte,Status       Polling         Image: True       rr/motor/xdel.15       Position/Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCccwLimitFault,CcwLimitFault,SoftCcwLimitFault,SoftCcwLimitFault,So			Active	Device Name	Alias	Properties		*	-
Image: True       rr/motor/xdel.10       Position/Velocity.Acceleration,SoftCwLimit,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CwLimitFault,CwLimitFault,CwLimitFault,CwLimitFault,SoftCwLimitFault,SoftCwLimitFault,SoftCwLimitFault,CwLimitFault,CwLimitFault,SoftCwLimitFault,SoftCwLimitFault,SoftCwLimitFault,CwLimitFault,CwLimitFault,SoftCwLimitFault,SoftCwLimitFault,SoftCwLimitFault,CwLimitFault,CwLimitFault,SoftCwLimitFault,SoftCwLimitFault,SoftCwLimitFault,CwLimitFault,CwLimitFault,SoftCwLim	0	1	True	rr/motor/xfel.09		${\sf Position, Velocity, Acceleration, SoftCwLimit, SoftCcwLimit, SoftCwLimitFault, SoftCcwLimitFault, CwLimitFault, CcwLimitFault, State, Status, Sta$	Polling		4
Image: Control       microl       Position,Velocity,Acceleration,SoftCwLimit,SoftCwLimit,SoftCwLimitFault,SoftCwLimitFault,Cw	1	V	True	rr/motor/xfel.10		Position, Velocity, Acceleration, Soft CwLimit, Soft CcwLimit, Soft CwLimitFault, Soft CcwLimitFault, So	Polling		
Image: True       rr/motor/xdel.13       Position/Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,CcwLimitFault,Scate,Status       Polling         Image: True       rr/motor/xdel.14       Position/Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,CcwLimitFault,Scate,Status       Polling         Image: True       rr/motor/xdel.15       Position/Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,CcwLimitFault,Scate,Status       Polling         Image: True       rr/motor/xdel.15       Position,Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,CcwLimitFault,Scate,Status       Polling         Image: True       rr/motor/xdel.16       Position,Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,CcwLimitFault,Scate,Status       Polling         Image: True       rr/motor/xdel.16       Position,Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,Scate,Status       Polling         Image: True       rr/motor/xdel.17       Position,Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,SoftCcwLimitFault,Scate,Status       Polling	2	V	True	rr/motor/xfel.11		Position, Velocity, Acceleration, SoftCwLimit, SoftCcwLimit, SoftCwLimitFault, SoftCcwLimitFault, CcwLimitFault, State, Status, Stat	Polling		
Image: Control of the second secon	3	V	True	rr/motor/xfel.12		Position, Velocity, Acceleration, Soft CwLimit, Soft CcwLimit, Soft CwLimitFault, Soft CcwLimitFault, So	Polling		18
True       rr/motor/xfel.15       Position/Velocity,Acceleration,SoftCwLimit,SoftCwLimit,SoftCwLimitFault,SoftCwLimitFault,CwLimitFault,CwLimitFault,State,Status       Polling         True       rr/motor/xfel.16       Position,Velocity,Acceleration,SoftCwLimit,SoftCwLimit,SoftCwLimitFault,SoftCwLimitFault,CwLimitFault,CwLimitFault,State,Status       Polling         True       rr/motor/xfel.17       Position,Velocity,Acceleration,SoftCwLimit,SoftCwLimit,SoftCwLimitFault,SoftCwLimitFault,CwLimitFault,CwLimitFault,State,Status       Polling	4	V	True	rr/motor/xfel.13		Position, Velocity, Acceleration, SoftCwLimit, SoftCcwLimit, SoftCwLimitFault, SoftCcwLimitFault, CcwLimitFault, State, Status, Stat	Polling		
True       rr/motor/xfel.16       Position,Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,CcwLimitFault,State,Status       Polling         True       rr/motor/xfel.17       Position,Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,CcwLimitFault,CcwLimitFault,ScheckStatus       Polling	5	V	True	rr/motor/xfel.14		Position, Velocity, Acceleration, Soft CwLimit, Soft CcwLimit, Soft CwLimitFault, Soft CcwLimitFault, So	Polling		
True rr/motor/xfel.17 Position,Velocity,Acceleration,SoftCwLimit,SoftCcwLimitFault,SoftCcwLimitFault,CcwLimitFault,CcwLimitFault,Sctee,Status Polling	5	V	True	rr/motor/xfel.15		Position, Velocity, Acceleration, SoftCwLimit, SoftCcwLimit, SoftCwLimitFault, SoftCcwLimitFault, CcwLimitFault, State, Status, Stat	Polling		
	7	V	True	rr/motor/xfel.16		Position, Velocity, Acceleration, Soft CwLimit, Soft CcwLimit, Soft CwLimitFault, Soft CcwLimitFault, So	Polling		
	8	V	True	rr/motor/xfel.17		$eq:position_velocity_Acceleration_softCwLimit_softCwLimitFault_so$	Polling	-	
	4							) F	

Figure 2 - The TangoMirror table for Tango devices and parameters configuration

#### Figure 3 - The TangoMotor user interface

	Karabo Key	ingo Property Nan	Tango Measurement Unit	Sync Mode	Polling Time [s]	Is Enabled	
0	actualPosition	Position	micrometer	Polling	0.05	✓ True	
1	velocity	Velocity	micrometer_per_second	Polling	1.0	✓ True	
2	acceleration	Acceleration	micrometer	Polling	1.0	✓ True	
3	swLimitLow	SoftCwLimit	micrometer	Polling	1.0	✓ True	
4	swLimitHigh	SoftCcwLimit	micrometer	Polling	1.0	✓ True	
5	isSWLimitLow	SoftCwLimitFa	None	Polling	0.05	✓ True	
6	isSWLimitHigh	SoftCcwLimitF	None	Polling	0.05	✓ True	
7	isCWLimit	CwLimitFault	None	Polling	0.05	✓ True	
8	isCCWLimit	CcwLimitFault	None	Polling	0.05	✓ True	
9	tangoState	State	None	Polling	0.05	✓ True	
10	tangoStatus	Status	None	Polling	0.05	✓ True	

Figure 4 - The TangoMotor parameter mapping table

### **Exposing Karabo devices to other control systems**

For the inverse process, i.e. exposing Karabo software devices to other control systems, including Tango, the Karabo Proxy is available [8]. It exposes Karabo device properties by means of a REST API and can be configured to provide read-only or read-write access. An EpicsMirror device has been recently developed as well, to provide a similar interface with the EPICS control system [9].

[6]: pytango.readthedocs.io/en/stable

[7]: https://indico.psi.ch/event/12738/contributions/38938

[8]: https://github.com/European-XFEL/karabo\_proxy

### References

- [1]: 10.1107/s1600577519006696
- [2]: www.karabo.eu
- [3]: European XFEL Annual Report 2023 [9]: epics-controls.org
- [4]: https://www.xfel.eu/users/policies/index\_eng.html
- [5]: www.tango-controls.org

### Acknowledgements

We would like to thank the Controls and SPB instrument colleagues at EuXFEL as well as colleagues of the BMX group at CFEL for the collaboration during the development and test phases. And of course thanks to the community of Tango developers.

European XFEL GmbH, Gabriele Giovanetti, Holzkoppel 4, 22869 Schenefeld, Germany, Phone +49 40 8998-6732, gabriele.giovanetti@xfel.eu