



# EPICS Interlock Experience

Kay-Uwe Kasemir, Los Alamos National Laboratory

Presented at the  
EPICS Collaboration Meeting - June 18-20, 2003  
Diamond Light Source  
The Cosener's House  
Abbey Close, Abingdon  
Oxon, OX14 3JD, England

# General Idea



- Interlock: Permit certain operations only if all underlying conditions are met
  - $RF\_Permit = Vac\_OK \ \&\& \ Cooling\_OK \ \&\& \dots$
- Interlocks critical to personnel safety or machine protection often require a hardware implementation
  - fast logic, key switches, locks
- Whenever ~1 second response is acceptable or “override” should be allowed:  
Software (EPICS) interlocks



# Usable Inputs

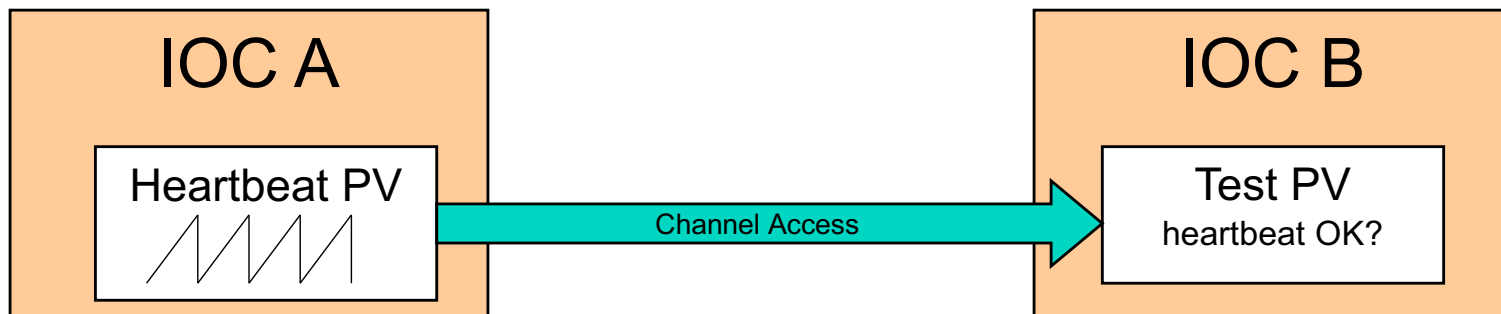


- Criteria for Process Variables used as Interlock inputs
  - Vac\_OK, ... are not only Yes/No but also provide SEVR=INVALID in case of errors
  - Driver/Device support should set SEVR in case of missing I/O hardware or communication errors
  - *Rip-all-Cables-Out* Test (Bob Dalesio):  
Missing cabling might require additional checks.  
Vac = 0.000000  $\Leftrightarrow$  Sensor disconnected?

# Heartbeats



- Interlocks often span across several IOCs
- Input from another IOC via ChannelAccess: default timeout `EPICS_CA_CONN_TMO=30.0` is too long
- “Heartbeats” detect communication errors on critical IOC links (Pam Gurd, Carl Lionberger, ORNL):
  - Sawtooth calc in IOC A, updates at 1Hz
  - Calc. records in IOC B check incoming counts, configurable trip limit, commonly a few seconds



# First Cut: Single calcout record



- Permit is granted if
  - All inputs are OK (CALC)
  - No input is invalid (MS, IVOA, IVOV)

```
record (calcout, "RF_Permit")
{
    field (DESC, "RF Permit Interlock")
    field (INPA, "Vac_OK MS")
    field (INPB, "Vac_Beat_OK MS")
    field (INPC, "Cool_OK MS")
    field (INPD, "Cool_Beat_OK MS")
    field (CALC, "A&&B&&C&&D")
    field (IVOA, "Set output to IVOV")
    field (IVOV, "0")
    field (SCAN, ".1 second")
}
```

# Overrides



- Idea:  
Records set from Operator Interface allow Override
- This doesn't work:

```
# Allow override of Vacuum input to RF Permit:
record (bi, "Vac_Ovr")
{
    field (ZNAM, "Operational")
    field (ONAM, "Override")
}
record (calcout, "RF_Permit")
{
    field (INPA, "Vac_OK MS")
    field (INPB, "Vac_Beat_OK MS")
    field (INPC, "Vac_Ovr")
    field (CALC, "(A&&B)||C")
    field (IVOA, "Set output to IVOV")
    field (IVOV, "0")
    field (SCAN, ".1 second")
}
```

(Make all fail that can fail, then try to override)

# Combine Orig. OK & Override



- No 'MS', handle SEVR yourself:

```
# Pre-Calc Interlock Input XXX: OK or in Override?
record (bo, "XXX_Ovr")
{
    field (ZNAM, "Oper.")
    field (ONAM, "Override")
    field (OSV , "MINOR")
    field (FLNK, "XXX_Sts")
}
record (calc, "XXX_Sts")
{
    field (INPA, "XXX_OK")
    field (INPB, "XXX_OK.SEVR")
    field (INPC, "XXX_Ovr")
    field (CALC, "(A&&(B#3))||C")
}

# Combine all Inputs XXX, YYY, ... into the Interlock
record (calcout, "RF_Permit")
{
    field (INPA, "XXX_Sts MS")
    ...
    field (CALC, "A&&B&&...")
    field (IVOA, "Set output to IVOV")
    field (IVOV, "0")
    field (SCAN, ".1 second")
}
```

# Example: SNS RF Permit Screen



**LLRF HPM Interlocks**

**LLRF HPM RF Permit, DTL\_LLRF 3**

Chatter Fault	RCCS	RF Window	Coupler	Cryo Permit
<input type="button" value="Reset"/>	<input checked="" type="checkbox"/> Oper.	<input checked="" type="checkbox"/> Oper.	<input type="checkbox"/> Oper.	<input type="checkbox"/> Oper.
# of Faults M	<input type="checkbox"/> Override (NC Only)	<input type="checkbox"/> Override (NC Only)	<input checked="" type="checkbox"/> Override (SC Only)	<input checked="" type="checkbox"/> Override (SC Only)
<input type="text" value="400 faults"/>	Overall RCCS OK: Water flow,...	Dissipated Power check from HPRF IOC	Coupler inner conductor cooling water check from HPRF IOC	Overall Cryo OK
Time Limit N				
<input type="text" value="5.000"/>				
Chatter Fault: M faults (or more) in N seconds. Set M=0 to disable.	<b>Heartbeats</b>			
	RCCS IOC	HPRF IOC	Cryo IOC	This IOC
	<input type="text" value="50"/>	<input type="text" value="50"/>	<input type="text" value="&lt;DTL_LL"/>	<input type="text" value="50 faults"/>
	<input type="button" value="Reset"/>	<input type="button" value="Reset"/>		
	<input checked="" type="checkbox"/> Oper.	<input checked="" type="checkbox"/> Oper.	<input type="checkbox"/> Oper.	
	<input type="checkbox"/> Override (NC Only)	<input type="checkbox"/> Override	<input checked="" type="checkbox"/> Override (SC Only)	

**Summary**

Software RF Permit

**Overrides enabled**