The Control System for Trim-Coil Relay-Selectors in J-PARC MR

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Abstract

In J-PARC main ring, each of the main magnets (Bending, Quadrupole, Sextupole) has a trim-coil. The basic aim of trim-coil is to correct small deviation of each magnetic field. In addition, we have used them for other purposes, for example: (1) in Beam-Based-Alignment studies, (2) as flux monitors, and (3) to make a short-circuit to reduce ripples of magnetic field. At a moment, trim-coils can be used for only one purpose. We introduced relay-switches to change trim-coil connection to a device, which corresponds to the selected purpose. When we switch the purpose, we have to change 1,200 on-site relays manually, distributed in three buildings.

Conslusion

Thus, a control system for trim-coil relay-selectors have been developed in winter, 2014-2015. EPICS tools and environment are used to develop the system. The system comprises PLC I/O modules with controller running EPICS on Linux. The system will be in operation after March, 2015. By using the system, we expect much easier switching of relay-switches than before.

Overview of Trim-coil relay selector

1. Trim-coils in MR main magnets

- Bending:96 Quadrupole:216 sextupole:72
- 3 power distribution buildings (D1,D2,D3)
- 6(B) + 11(Q) + 3(S) families
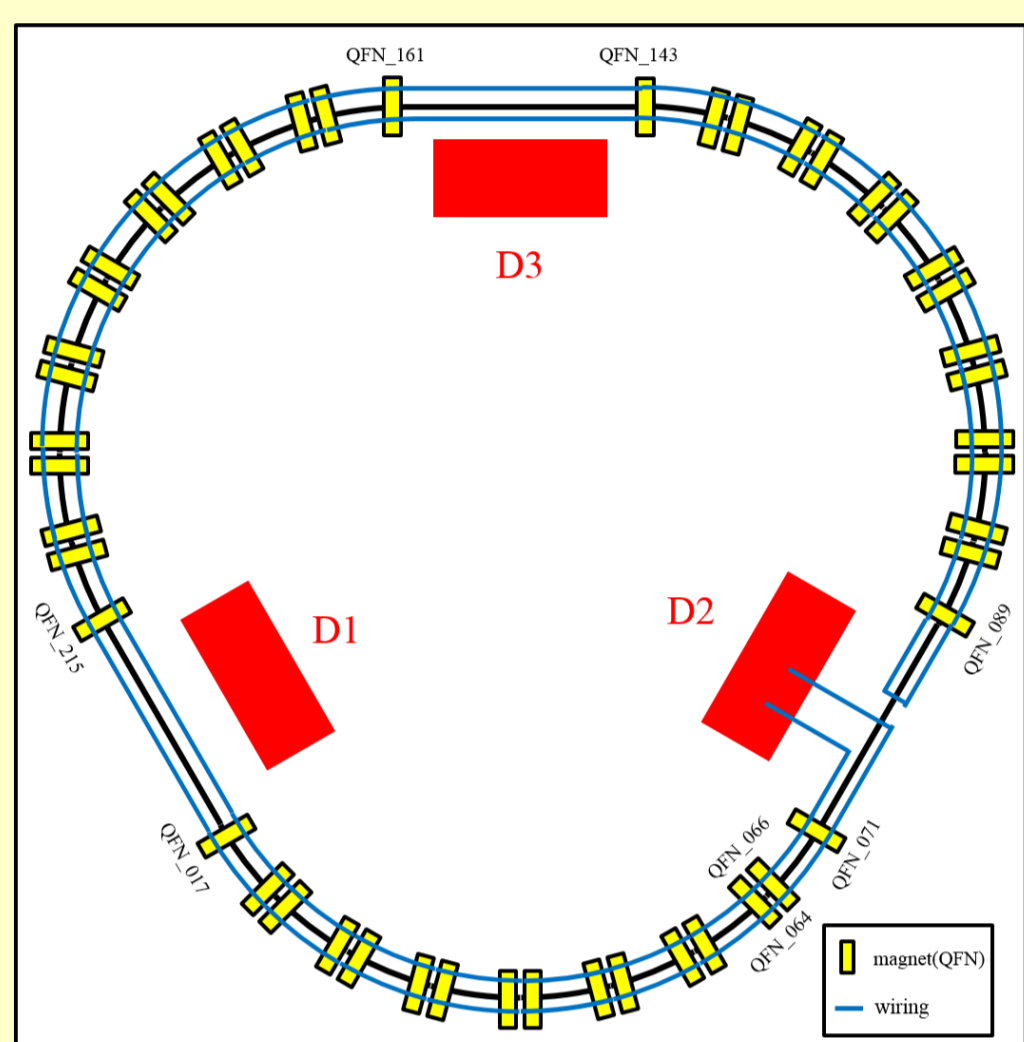
Typical wiring of MR main magnet. (QFN)

2. Trim-coil relay selector

- There are 4 purpose to use the trim-coil.
  1. To correct small deviation of each magnetic field
  2. Beam-Based-Alignment study
  3. Magnetic flux monitors
  4. To make a short-circuit to reduce ripples of magnetic field
- Switch these 4 purpose by relay control.
- 1 relay and 1 purpose are one-to-one relationship.

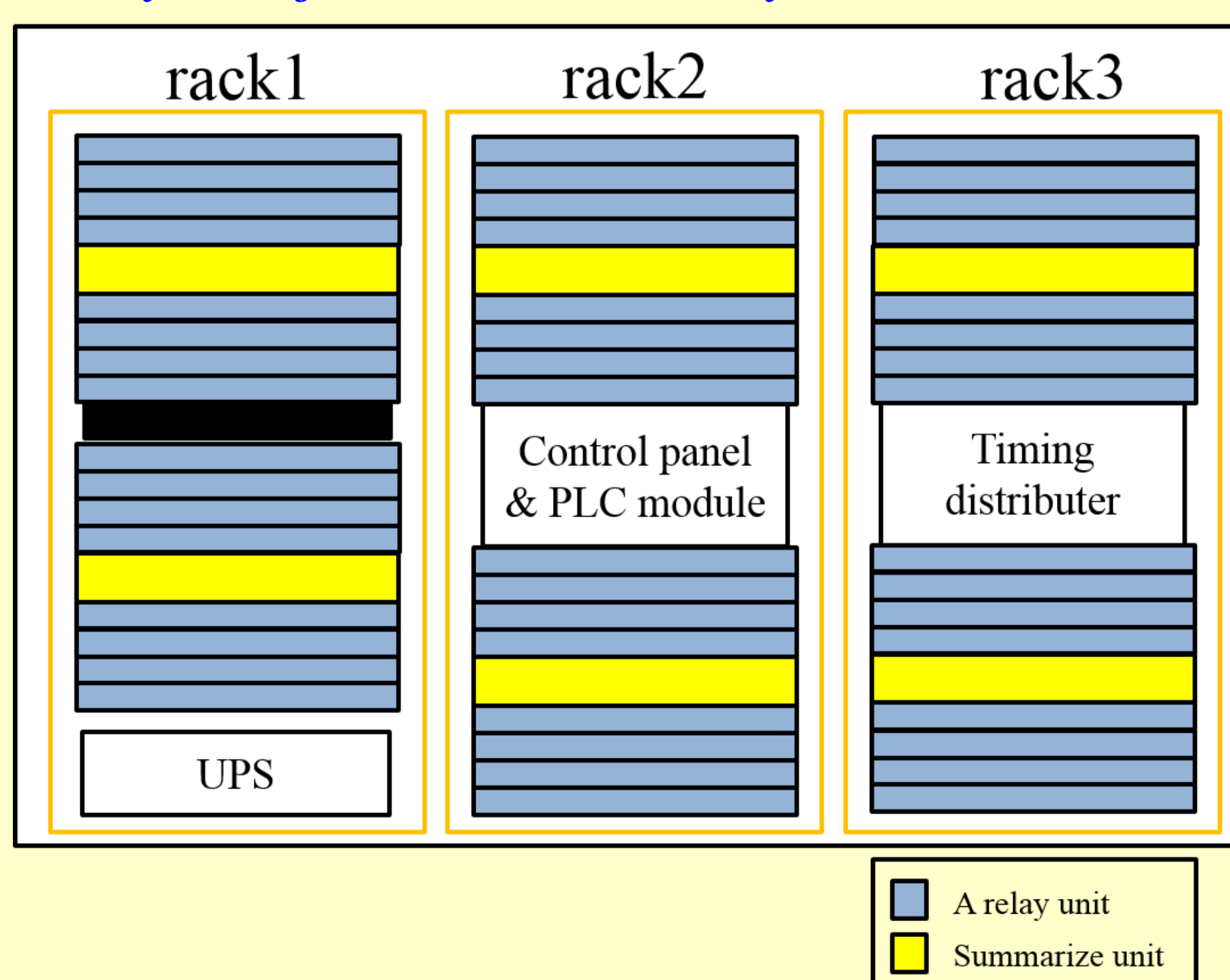### 3. Control system

- EPICS control system use PLC-IOC(F3RP61)

Photo of the trim-coil relay selector
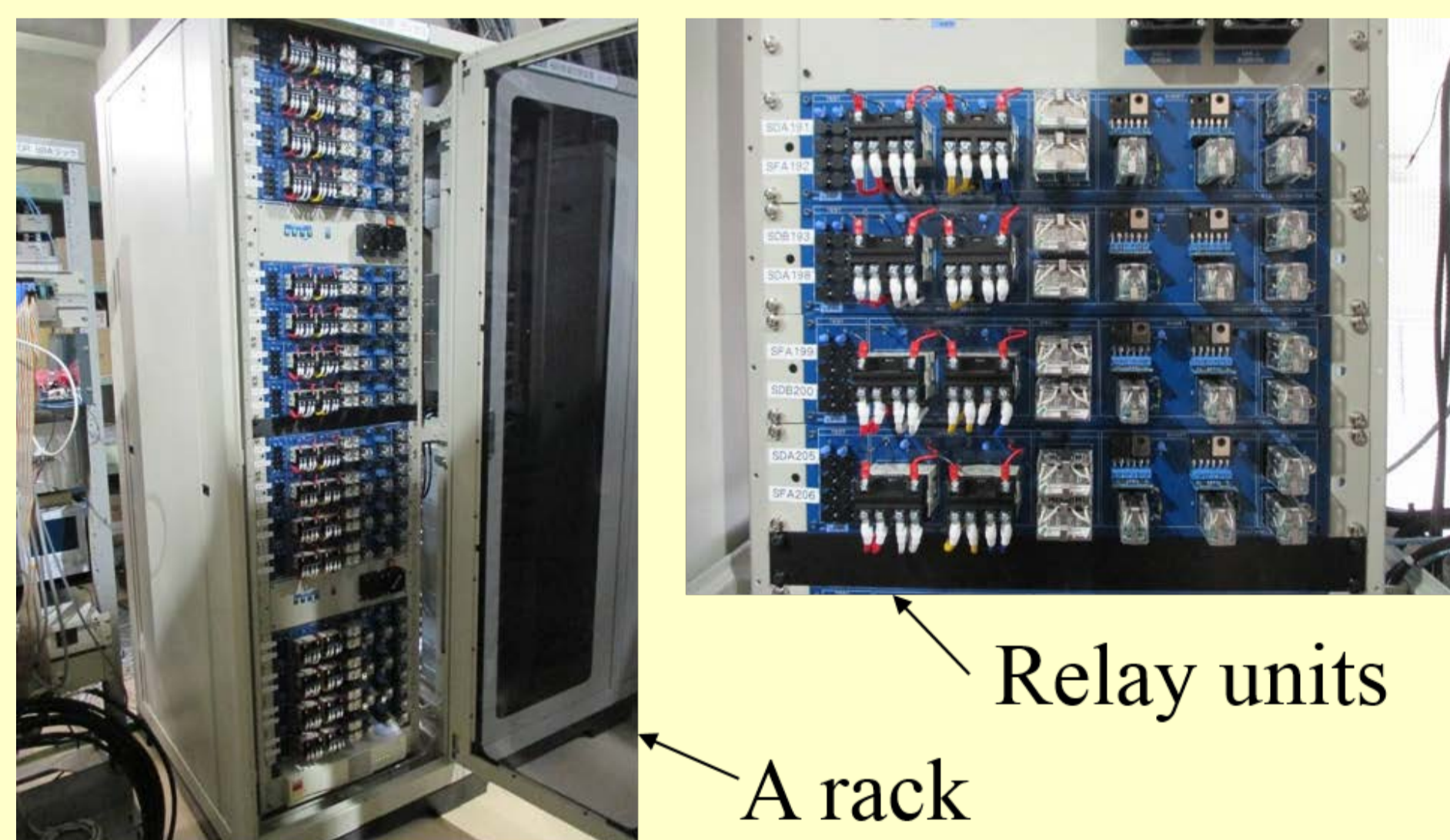
Relay units

A rack

layout of the trim-coil relay selector

rack1	rack2	rack3

Control panel & PLC module

Timing distributer

UPS

- A relay unit
- Summarize unit

System development and configuration

1. PLC-module (YOKOGAWA)

- Consist of a CPU module and I/O modules.
- Operate a control panel with a digital I/O module. The panel manages power and interlock.
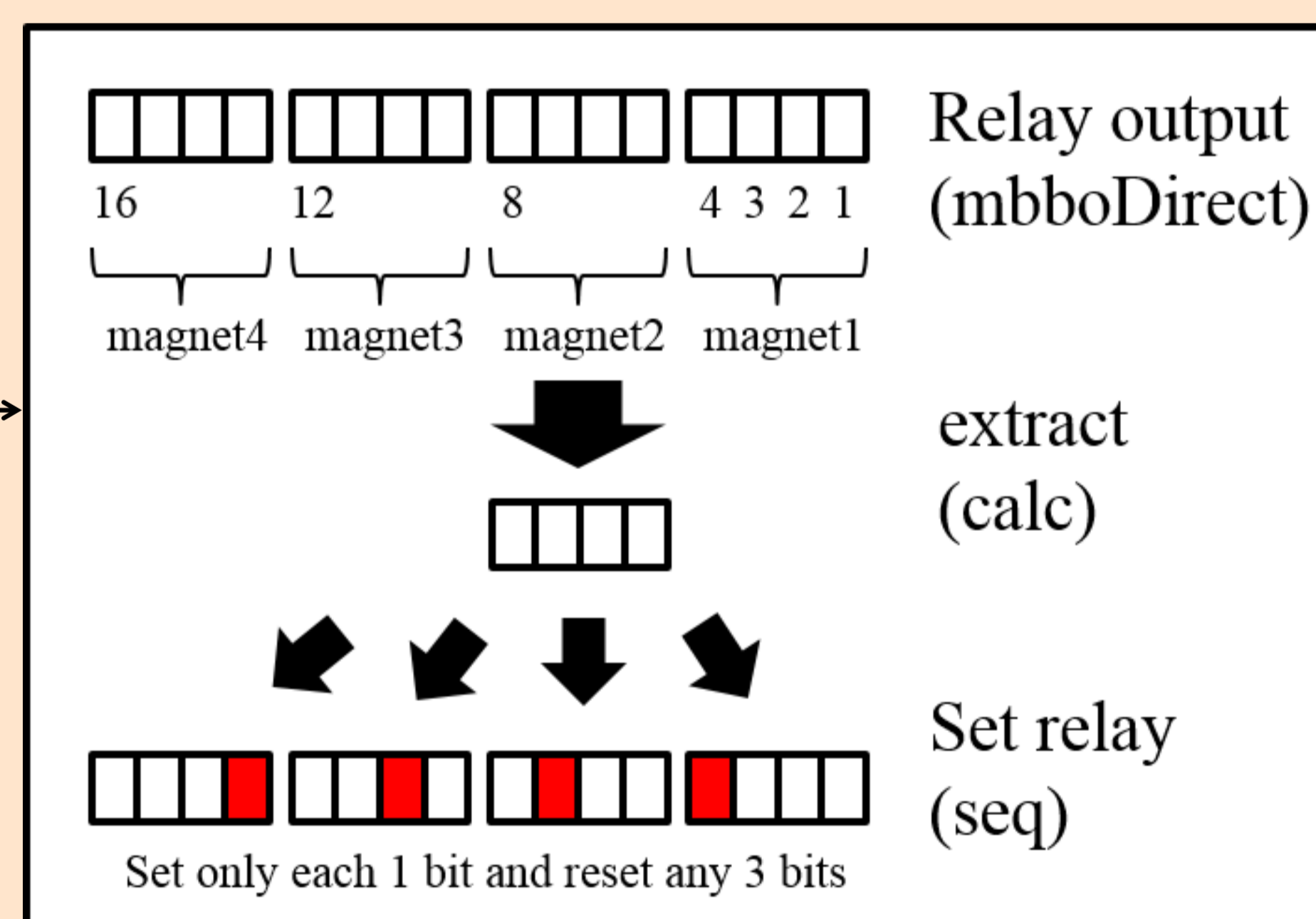- Control many relays with 6 digital output modules.

2. Many relays

- A relay unit have 8 relay (for 2 magnets).
- A summarize unit gather signal of 8 relay units.
- A system have 6 summarize units.
- So, a PLC have to control 384 relays. (at a building)

3. EPICS PVs (Process variable)

- An EPICS IOC makes many PVs.

PV	types	explain	number
status	bi	power, timing	5
interlock	bi	temperature, fan	12
operate	bo	power, remote	6
test switch	bo	test sw, timing	7
relay output	mbboDirect	PLC output	24
extract	calc	16 --> 4 bits	96
set relay	seq	set only 1-bit	384
reset relay	seq	reset 4-bit	96
soft key	bo	software key	1

Relay output (mbboDirect)

16   12   8   4 3 2 1

magnet4 magnet3 magnet2 magnet1

extract (calc)

Set relay (seq)

Set only each 1 bit and reset any 3 bits
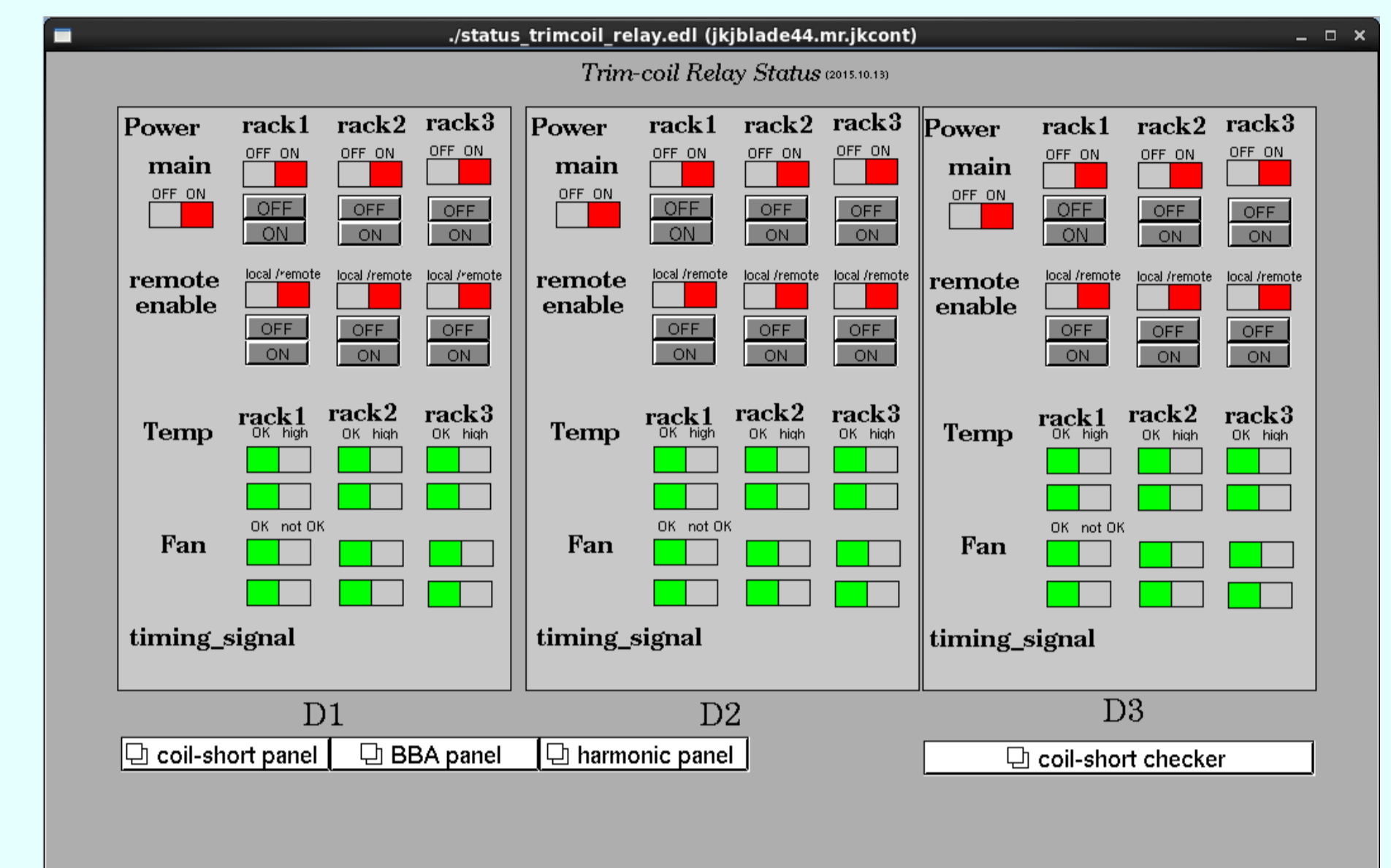
precautions

1. Two or more relays must not be turned ON in a magnet.
2. If a relay is OFF, no current flows to the instrument.
3. Do not change a relay when main magnet is in pattern operation.

soft-key
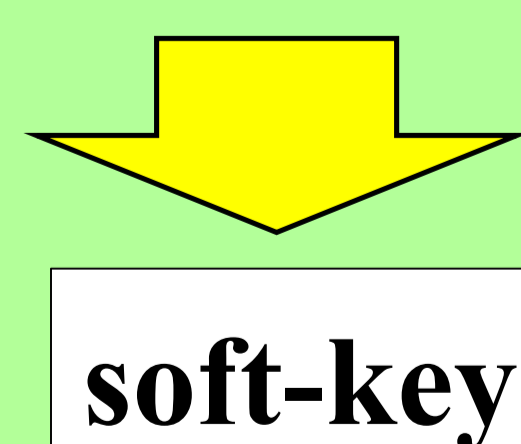
- To avoid pushing the wrong button.
- To prevent erroneous operation by combining other conditions

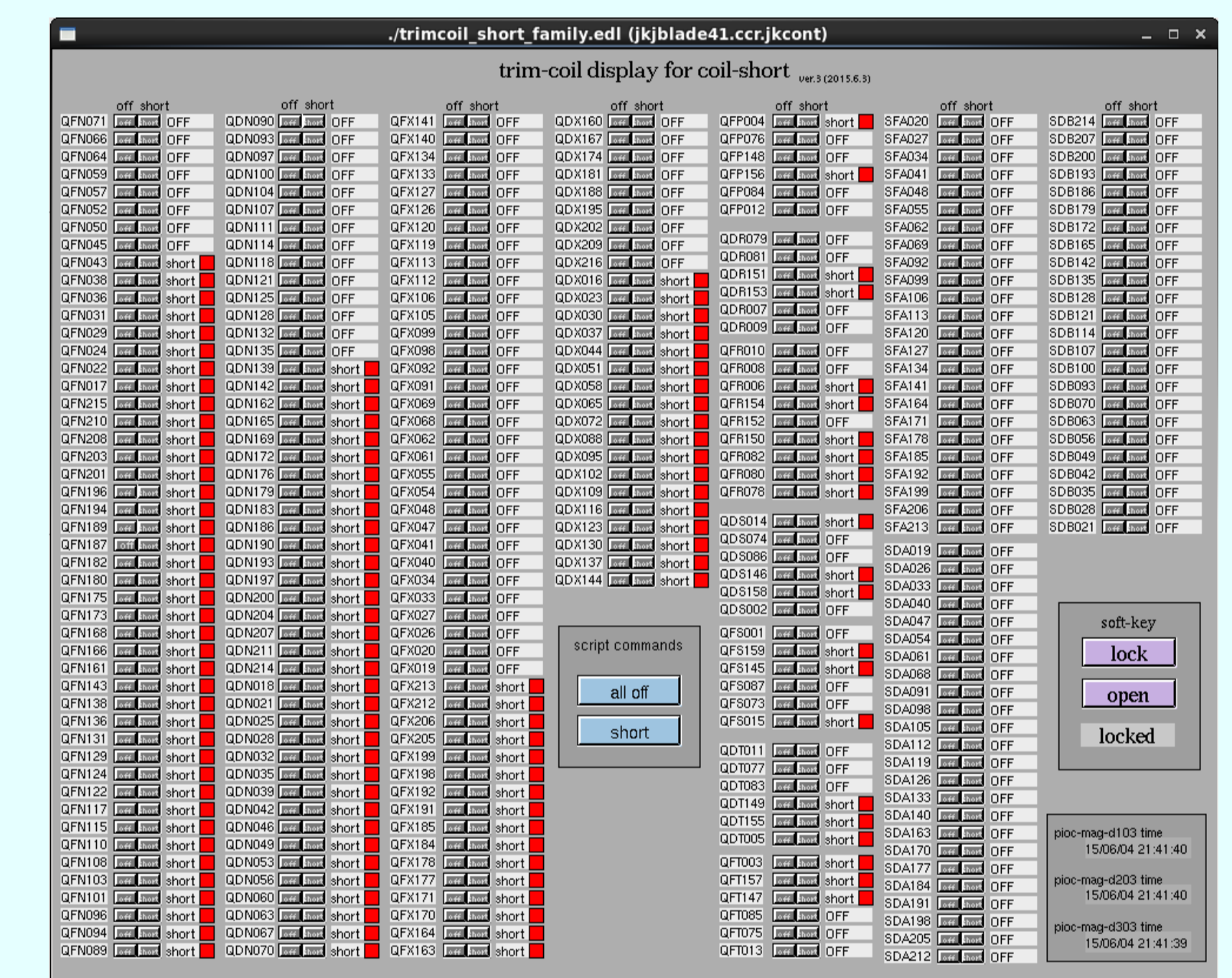## Control display development

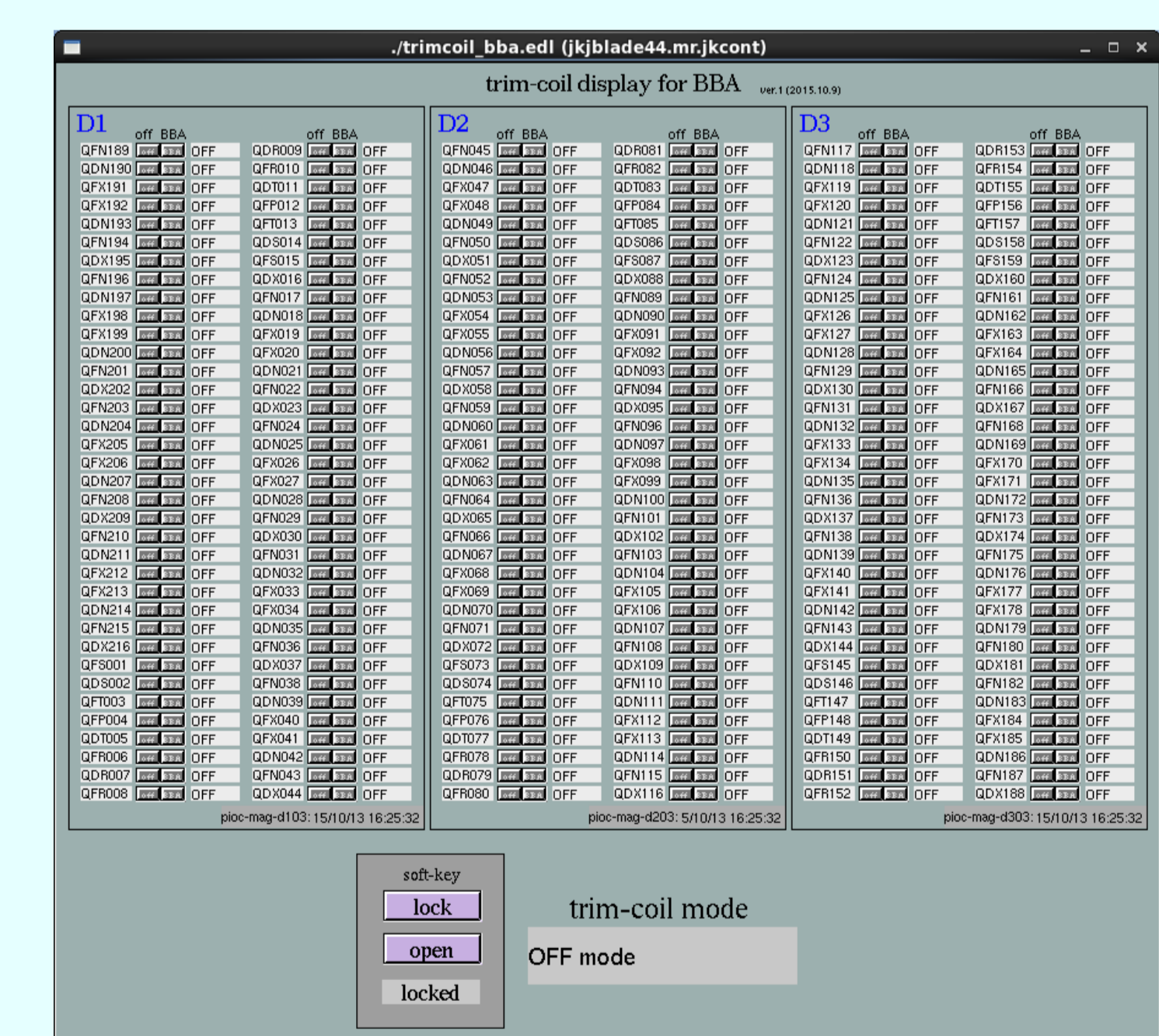- **Status of Trim-coil relay selector system**

- Operator see only this display.
- If necessary, open displays below.

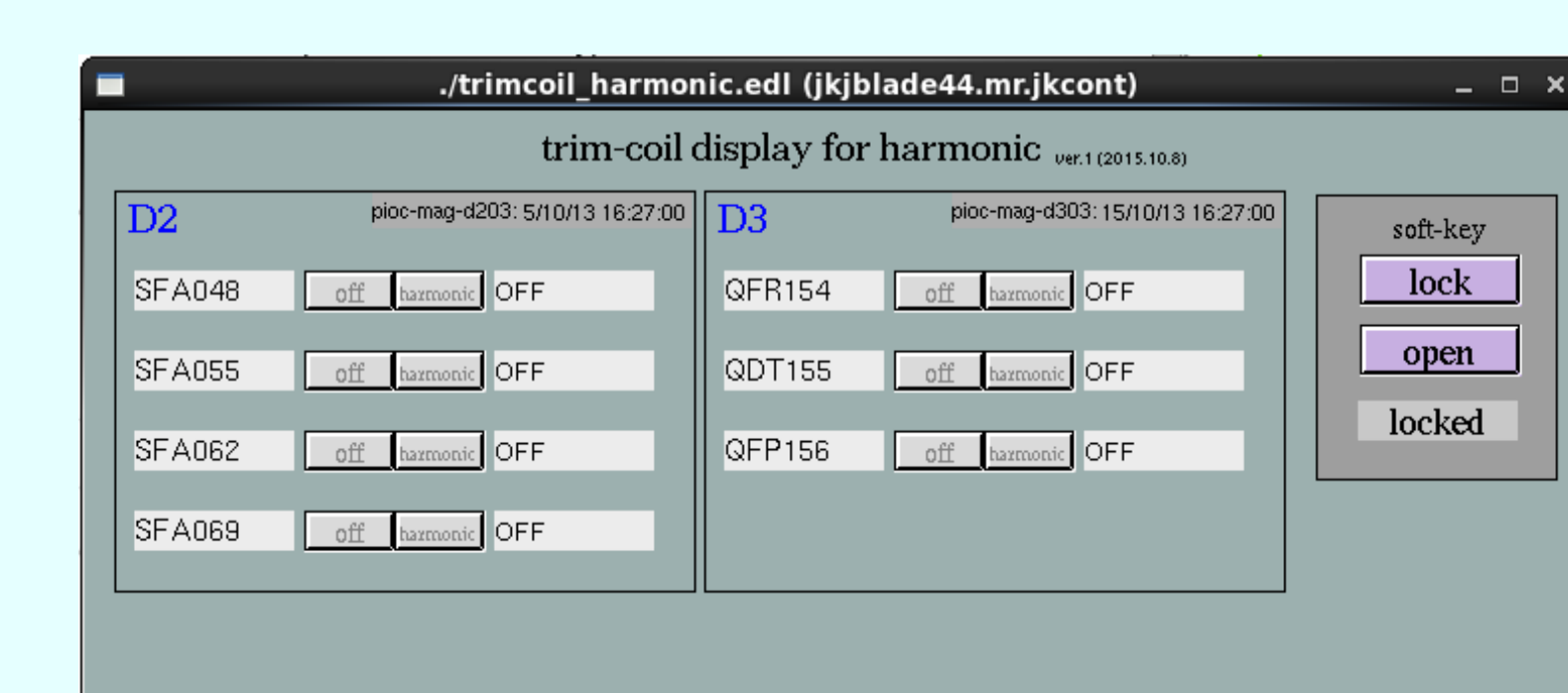- **Trim-coil set to "short"**

- The top is close to the power supply for each family
- The magnet pattern of "short" is stabled.

- **Trim-coil set to "BBA"**

- Button placement is ascending address order of quadrupole magnets.
- Don't select 2 or more "BBA" relays in a building.

- **Trim-coil set to "Trim-coil correction"**

- Select 7 magnets only.
- These magnets don't use "short".