

The Refurbishment of I&C Systems of TRIGA Research Reactors

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1. Introduction

Based on that KAERI had constructed a 5-MWth research and training reactor in Jordan, called the JRTR, KAERI refurbished the instrumentation and control (I&C) systems of TRIGA research reactors. KAERI also now constructing the Ki-Jang research reactor, called the KJRR and performing the design of next generation research reactors for the University of Missouri in the USA, called the NGM.

Approximately 60 TRIGA research reactors have been constructed by General Atomics (GA) in 24 countries since 1950s [1]. It's been demanded to refurbish the I&C systems of TRIGA research reactors due to aging and obsolescence problems. For example, UC Irvine TRIGA RR was refurbished in 2014 since its first criticality in 1969 [2]. KAERI refurbished the I&C systems of two TRIGA RRs in Malaysia and Bangladesh respectively since 2010s.

2. The refurbishment of I&C systems of TRIGA research reactors

KAERI refurbished the I&C systems of Malaysia 1 MW TRIGA Mark II called RTP in 2014 as shown in Figure 1. KAERI supplied the following scope of works for Malaysia I&C systems refurbishment:

- Operation console in main control room (MCR)
- Data Acquisition and Control System (DACS): for reactor operation / redundancy design
- Reactor Protection System (RPS): 2 channels, Analog
- Control rod drive mechanism (CRDM) motors and drivers

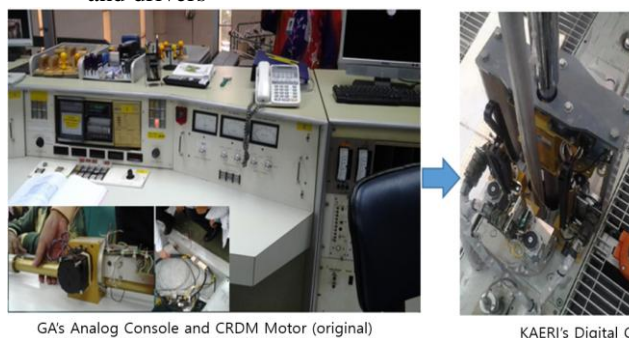


Figure 1. I&C systems refurbishment of Malaysia 1 MW TRIGA Mark II research reactor

KAERI refurbished the I&C systems of Bangladesh 3 MW TRIGA Mark II called BTRR in 2024 as shown in Figure 2.



Figure 2. I&C systems refurbishment of Bangladesh 3 MW TRIGA Mark II research reactor

KAERI supplied the following scope of works for Bangladesh I&C systems refurbishment:

- Operation console in main control room (MCR)
- Data Acquisition and Control System (DACS): for reactor operation / redundancy design
- Reactor Protection System (RPS): 2 channels, Analog
- Control rod drive mechanism (CRDM) motors and drivers
- Field Instruments: temperatures, pressures, levels, etc.
- Neutron Measurement System : for RPS and DACS
- Thermal Power Calculator: 2 channel for RPS
- Computer-based Digital Reactivity Calculator
- Self-Powered Neutron Detector with a monitor

In Bangladesh I&C systems refurbishment, neutron measurement system (NMS) modernization was a very challenging work. The NMS signals play important role for DACS and RPS. Mirion's digital NMS was adopted for the modernization as shown in Figure 3. The existing ion chamber (IC) was reused but the existing fission chamber (FC) was refurbished with Mirion's 0.7 cps/nv wide range guarded fission chamber. Mirion's digital DGK250 signal processor is to provide linear power 0 to 150%FP (full power) and digital DWK250 signal processor is to provide linear power 0 to 150%FP, log power 1.0e-8 to 150%FP, and log rate -15 to 15%PP/s (present power per second). The DGK250 provides the high power trip contact signal to the RPS for reactor trip purpose. The DWK250/DGK250 generate the linear power and log power analog signal to the DACS for reactor power regulation purpose.

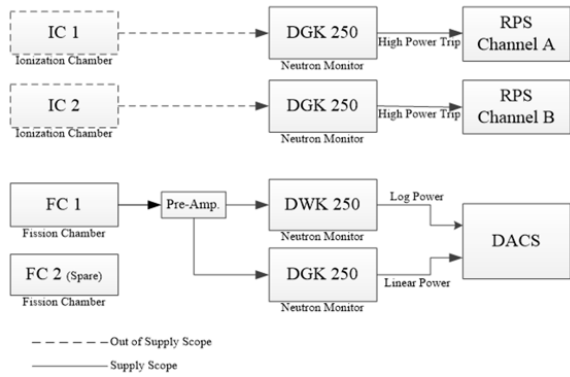


Figure 3. Mirion's NMS (DGK250 and DWK250) for processing neutron signals

The DACS regulates reactor power manually and automatically (i.e., MANUAL/AUTO) as shown in Figure 4. RTPKorea's triple redundant programmable logic controller (PLC) was adopted for the DACS. The operator should withdraw the control rods manually up to 1.0e-4%FP and then the DACS withdraws the control rods automatically up to the full power using neutron signals from the NMS. This is innovative and modernized reactor power operation technology.

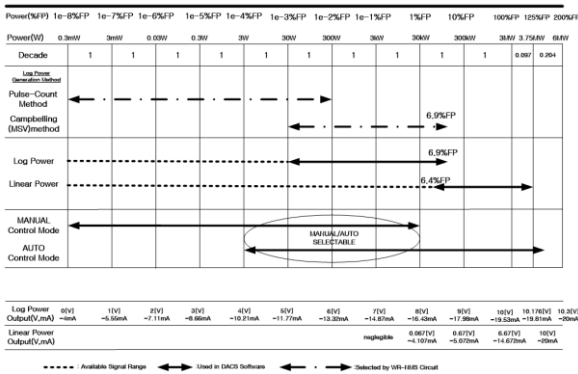


Figure 4. Reactor power regulation range and control mode by DACS

Especially world nuclear news published BTRR I&C upgrade as shown in Figure 5.



Figure 5. World nuclear news of BTRR I&C upgrade

3. Conclusions

KAERI secured the standard refurbishment model and package of I&C systems of TRIGA research reactor after the two I&C systems refurbishment projects. The refurbishment information of nuclear instrumentation is described in KAERI/OT-3556/2024 [3].

KAERI will make an effort to acquire a new project to refurbish the I&C systems of TRIGA research reactors. The refurbishment experience is used for the KJRR and NMG projects.

Acknowledgement

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