

# Development of Automatic LLRF control system for KIRAMS-30 Cyclotron



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## ABSTRACT

We have developed and installed KIRAMS-30 cyclotron at KAERI-ARTI(Korea Atomic Energy Research Institute / Advanced Radiation Technology Institute) of Jeongeup city area. KIRAMS-30 is able to accelerate proton particles from 15 to 30MeV, which will be primarily used for high current beam extraction. RF power with 63.96MHz frequency and max. 50kW at KIRAMS-30 is supplied to the 'push-push' type two Dees, and a cavity tuner automatically tunes to maintain the resonance.

We have been now commissioning and testing it to arrange and meet the required beam conditions after moving it to the main cyclotron building from temporary one. In this work, we developed automatic RF low-level control system for KIRAMS-30 cyclotron. RF low-level signal is constantly controlled during beam extraction by adjusting the motorized fine tuner automatically considering the feedback grid voltage signal of RF power amplifier. At this system, even if RF resonance condition is broken due to the unstable RF status like various fault occasion, it can be recovered automatically. Meanwhile, Automatic RF low-level control part has been realized as an application of software program using LabVIEW graphical language.

# **KIRAMS-30 Cyclotron**



## **RF system of KIRAMS-30**



Parameter	s of	RF	system	
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Number of Sector / Dee	4 / 2
Dee Angle	39 degree
RF Frequency	63.96 MHz
Harmonic Number	4 <sup>th</sup>
Resonant Mode	λ/2 mode
Coupling Type	Capacitive
Q Value	7525
Dee Voltage	58 kV
RF Amp Output	50 kW
Characteristic Impedance	50 Ω

#### **RF Power amplifier**



#### **RF Power Tube**





#### Specifications of RF amplifier

50,000 watts
63.96MHz±05MHz
50 Ohms
6-3/8″
-55 dB
at least 80 dB
-80 dB
380 VAC, 50/60 Hz, 3 Phase 2.5%
0℃ to 50℃
3CW40000A7
5CX1500B



#### PLC & Control panel for RF Power amp.



### LLRF Connection Diagram Main Control PC USB-6210 USB-6210 DQ Device USB-6210 Control PC USB-R5232 interface

# **Low-Level RF Control**

#### LLRF Feedback Controller

Imple:    United initial      Imple:    United initial      Imple:    Imple:      Motion Panel    Motor_ModeStatus      Imple:    Imple:      Motion Out-Motion    Motor_ModeStatus      Motor Moving    Imple:      Motor position    Imple:      Motor position    Imple:      Imple:    Imple:   <	😰 Main Function_20110831.vi 프	린드패널					
Image: Interpretent of the second	파일(E) 편집(E) 보기(V) 프로젝트(F		(H)				
Motor & PWM Control AutoTune Control Status TCP/IP Communication Status	◇ ⑧ ■ 12pt 대플리케이션 폰트 ▼ 12pt 대금▼ 12pt 12pt 12pt 12pt 12pt 12pt 12pt 12pt						
Motion Panel    Auto-Tune Panel    OK      Manual Initial    Initial    Manual mode    Target_Duty(%)    Target_Grid_Al(mV)    Initialize      IN-Motion    OUT-Motion    Motor Moving    2.6    14~16%(1)    3.1    18~22%(2)      Motor position (pulse)    0    0    24~26%(3)    0    24~26%(3)    0      Saved_Motor position    0    38~42%(6)    0    38~42%(6)    0    44~46%(7)	Motor & PWM Control	AutoTune Control Status	TCP/IP Communication St	atus			
Motion Panel    Auto-Tune Panel      Manual Initial    Motor_ModeStatus      N-Motion    OUT-Motion      Motor position (pulse)    0      0							
Manual Initial    Motor_ModeStatus    Target_Outy(%)    Target_Grid_Al(mV)      Manual mode    0    2.1    10~12%(0)      Motor_Status    Motor_Moving    2.6    14~16%(1)      Motor position (pulse)    3.1    18~22%(2)    Auto Tune OFF    0    28~32%(4)      Motor position    0    34~36%(5)    0    34~36%(5)    0    34~46%(7)	Motion Panel		Auto-Tune Panel		UK		
0 40 32/0(0)	Manual Initial IN-Motion OUT-Motion	Motor_ModeStatus Manual mode Motor_Status Motor Moving Motor position (pulse) d 0 Saved_Motor position d 0	Target_Duty(%)      Target_Grid_Al(n        20      €      0      2.1        2.6      3.1      2.6      3.1        AutoTune OFF      0      0      0        0      0      0      0        0      0      0      0        0      0      0      0        0      0      0      0	nV) 10~12%(0) 14~16%(1) 18~22%(2) 24~26%(3) 28~32%(4) 34~36%(5) 38~42%(6) 44~46%(7) 48~52%(8)	Initialize		
0 54~56%(9) <b>PWM Panel</b> 0 58~62%(10)	PWM Panel		0	54~56%(9) 58~62%(10)			
0 64~66%(11)		DWM ModeStatus	0	64~66%(11)			
PWM CW PWM mode 0 68~72%(12)	PWM CW	PWM mode	0	68~72%(12)			
0 74~76%(13)		Oscillator_status	0	74~76%(13)			
	Int-OSC Ext-OSC	External OSC	0	78~82%(14)			

#### View of LLRF Controller





#### **PWM & Motorized Tuner Controller**





- Control of pulse duty cycle
- Maintaining of cavity resonance using
  control of motorized fine-tuner
  feedback of PA Grid voltage
- Recovery of cavity resonance condition from fault occasion

#### **RF Source Generator**









