THE DESIGN AND DEVELOPMENT OF AN AUTO-CONDITIONING SRF CAVITIES SOFTWARE

Hu Cao, Y. Chen,

Institute of Modern Physics, Chinese Academy of Sciences, 730000 Lanzhou, China

Abstract

As one of the major components of ADS Injector II, SRF (Superconducting Radio Frequency) cavities are used to transmit the intense-beam proton reliably, stably and efficiently. Before starting the process of transmitting particle beams, SRF cavities are routinely conditioned to achieve its optimized status in the deliverable energy. The whole conditioning process is involved in various types of hardware devices and is also a heavy task for engineers to manually operate these equipment. In this paper, the software ANSC is presented in details, which is used to automatically condition SRF cavities. At the present, ANSC is in the stage of testing. During the testing, ANSC indeed can achieve comparative results compared with manually operated conditioning.

INTRODUCTION

As China Accelerator Driven System (C-ADS) Injector II achieved the expected target of 25 MeV[1], how to make an improvement in efficiency is our current focus[2]. In every accelerator physics experiment[3], engineers of SRF are always required to condition SRF cavities by manual operation to ensure that these cavities can reach their optimal deliverable energy. The task is heavy for the engineers and manual operation is also low in efficiency. In order to get rid of the difficult situation, our engineers in the ADS control group are developing an Auto-Conditioning SRF Cavities program called ANSC. Currently, ANSC is in the stage of testing and obtained some positive feedback during the testing process. ANSC is based on the distributed control system EPICS, which has been widely used in accelerator field. Therefore, it is totally compatible with current control system in ADS and is also convenient to update the software in the future. During the development of the program, python and Epics Qt are core components in which Epics Qt is used to customize GUI and python is exploited to carry out the autoconditioning process.

In the following sections, ANSC will be described in detail.

THE GUI OF ANSC

Because of flexibility and practicality of Qt, it is widely used in software development. At the same time, Epics Qt combines Qt's advantages with EPICS'. As a consequence, it is chosen as GUI design tool of ANSC. In reality, Epics Qt demonstrates its high performance in displaying PVs by Channel Access.

In ANSC, there are two main user interfaces: setting GUI and operation GUI. Setting GUI in Fig. 1 is responsible for setting some basic parameters; Operation GUI in

Fig. 2 is used as setting auto-conditioning related parameters and an entry for executing auto-conditioning process.

In the Setting GUI, the key status information is set such as vacuum fluctuation, vacuum protection status and MPS (Machine Protection System), which is key for engineers to execute the auto-conditioning process. Operation GUI is used before the beginning of the process. Its main function is to set important parameters and thresholds such as vacuum thresholds, auto-conditioning up steps and down steps, then start the auto-conditioning process. In addition, scanning frequency and phase can be executed.

低电平相关参量					联铁保护相关量						
城 度给定值:	0	265	幅度增加步长:	2.1	腔体保护 1	新夏位			ws保护	smis景位	1
林度增加模式:	Wannal _	Fannal	辅票降低步长:	2	🗌 快保护開新		0		二 失經温度	化的探旋	1
17激励开关:	 <i>म</i> (¥)	Off	幅度快降步长:	3	E 脸体真空保护的		•		□ 腔体真空		1
1 :2c304:81	ritsz 💌	PULSE	幅度增加频率:	1	 損合器共同算 損合器共同算 		•			に開京空間版 M Ready	
2:0403	Generated D	Self-excite	辅意降低频率:	1	DISTOCHAR		1.00		1.00+-05 1		
IF on 宽度:	1000000	1000000.00 w	4.1111(1)(1)(1)(1)(1)(1)(1)(1)(1)(1)(1)(1)	10	股件具空保护规则 概念因未愿真交信				1.00+051		
IF off 宽度:	1000000	-32768.00 us			4888天后井立18 4888天居真立6				6.00+-05 I		
雨调器上下限位的	状态:	•	调调器位置量:	2402		ISPA PARAMETER	1.004	-05	0.000 01 74		
南美器位置与数	定差:	100 %	调谐器速度/方向	0	構合習相关参量				1	_	
应体腔压相关参加	2				编压值:	500	_	795 V	Janana	_	
4回电场数定值	1	1 #V/n 当前峰1	00.501:	1 WV/m	编压开关:		×	066	温度:	1.90	200
峰值电场:与目标值差值:		0 x 1180401	04.15(02:	1 WV/m	夫屈真空度:	4.50+-05					
入財力家上閉鎖	100	0.78 ¥ ARtha	E feit MPIE	-99 X	真空低温相关量						
后射力车额定值	1	0.04 ¥ E810	CININ-	96 X	腔体温度:	5 X		腔体测	空度	2.40+-07	
1000年10日日		0.00 ¥ (10-386		0 vSv/h	氯压 :	8.93e+04	7.4	液位:		196.7 mm	
					恒温器夫居真空:	7.90e-05	74				
加马利量上限:	100 uSw/h	99 x 加马纳	ESCEUT:	10 uSv/h	相导致加机制定值	設置					
					经值电场数定值	1					
: 3/9/78	CavityEx			级体操作	功率要新出现定律			-	EARDINE:	1	

Figure 1: Setting GUI of ANSC.

編集会社ない 00 00 人気は増加量 00 (C) 1 2 単分換表 100000 -2716 00 4 00 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		PULSE	• K	激励开关: [关 0f	f	开始时间	ā			吉来时间			
株式参加改選 0 0555 万年自己的意 7 供合器構正共用 供合器株正 500 (快任伊朗報 研想式 [Corright Corright 別記) 日本 1 日本 新指公式 (Corright Corright No. 1 2 1 日本 1 日本 1 日本 1 日本 1 日本 1 日本 1 日本 1 日本 1 日本 1 日本 1 日本 1 日本 1 日本	入射功率上限值:	100	1.06 ¥	取样功率目标	值: 1	0 0.	00 ¥ 1	腔体真空	保护调值	. 1	. 00e-05	•	高频波绪:	RF B	ead
USK表型[24] Schultzen Constructs DRC: DRA 参数を 所築 法行期時: 00 m Schultzen Constructs DRC: DRA 参数を 所築 法行期時: 00 m Schultzen Constructs DRC: DRA 参数を 所築 法行期時: 00 m Schultzen Constructs DRA 参数を Transformer Construction Schultzen Constructs DRA 参数 Schultzen Constru	喻度激励给定值:	0	273	低电平电压(1	0.00 V		末层真空	保护上调	íā: ī	. 00e-05	•	嚴炼监控	模拟测	lit.
新作気は、「weityをL = CevityをL 助化: 助化: 単本 ● 直え 例案 治行時計: 40 = 当前先気はの: 40 50 占式は電量(10): (1 2) 単分数 200000 - 50000 - 50000 - 50000 - 50000 - 500000 - 500000 - 50000 - 50000 - 50000 - 50000 - 50000 - 50000 - 500000 - 50000 - 50000 - 50000 - 50000 - 50000 - 50000 - 50000 - 50000 - 50000 - 50000 - 50000 - 50000 - 50000 - 50000 - 50000 - 500000 - 50000 - 50000 - 50000 - 500000 - 500000 - 500000 - 500000 - 500000 - 500000 - 500000 - 500000 - 500000 - 500000 - 500000 - 500000 - 500000 - 5000000 - 5000000 - 5000000 - 500000 - 500000 - 500000 - 500000 - 5000000 - 500000 - 500000 - 5000000 - 5000000 - 5000000 - 50000000 - 500000000	幅度激励范围:	0	65535			功率自动		✓ 耦合:	醫傭压关诉	6 Ø	合器偏压:	500	🗌 快保护屏蔽		
編成会社2010 00 00 会社2012増加度 00 G I 2 単分数 200000 - 2016 開発 1 B2 00 00 + 2012 開催 10 0 I 1 2 単分数 2 0 0 0000 - 2016 円 1 1 1 日本 10 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	锻炼流程控制														
新茶毎年平赦800 第/修理/使理多年ない:3月 2 3 での機能:1 約2 構築: 1000 当前高空策:2.344+07 第月2/使理が発展空間:1.00+07 5.00+06 0.00+06 金数:1 1 当前高空策:2.344+07 第月2/使理が発展空間:1.00+07 5.00+06 0.00+06 金数:1 1 当前取得が第:000 年 現代存得部計員(い: 1 1 TF#2.10+1 - 回時:1 1 一开始 停止 回時表記録式:自由 手払 Banal 運動记录: 約5210日は: 送行 10.4 出版注意: 5 trre	运行模式: Cavit	yĒx _▼	Cavit	_{PEx} 阶段:	◎ 脉4	• 直涼	0 \$	輝 运行	jORBj: 60) n	当前频挛:	1 KHz	功率扫描数:	100	6
当該高空度 2.344-07 第0月21份2125高空値 1.004-07 5.00-06 0.004-06 合数: 1 1 当該高校時か多。0.007 第0月21份22531(0): 1 1 73940式 前に 2mm m 開現: 1 1 开始 保止 回該教授時次: 自由 手助 Runal 東多记录: 約121日日は 当行 14.4 出版法書 36 trrer	当前占空比(%):	60 5	0 占3	比增值量 (%)	: < :	ı >[- i ku	脉宽:	1000000.	-32768.	中心频挛:	1 10fz	开始:	0	
日本日本 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	当前低电平激励	0	增/修	牌/快牌步长	(%): [i	2	2		3		范围+/-:	1 Hz	结束:	1400	
Anterna and Anterna an	当前真空度:	2.34e=07	增/因	/快降功车真	空值:	1.00e=07	5.0	0e-06	8.00e=0	6	点数:	1	步长 (%):	1	1
	当前取样功率:	0.00 #	増/除i	朝期时间(s):		1 1	Т	降模式:	Hix Dow	n 🔻	周期:	1 s	开始	傳」	Ł
手放射路: + - 当前即样功室: 0.00 % 新傳 禅体 前容 程序就绪:● 法行时间: 22.11	锻炼激励模式:	自动	手は) Hanual		更多词	录	银标题	1励自动:	运行	j Idle	出街	言息: No Erro		
	手动激励:	+	-	当前取村	印功率:	0.0	0 1	1	7億	维续	放弃	程序	就绪: • 运行时	ē]: 22	. 17
	100														
100	100 T														
	-													 取 	Ŧ功;
- 1000 80	80														
	80														

Figure 2: Operation GUI of ANSC.

REALIZATION OF AUTO-CONDITIONING PROCESS

The function of the GUIs is totally carried out by Python. Taking the complexity of auto-conditioning SRF cavities and restriction requirement in time into account, the program consists of four threads, including autoloading thread, protection thread, exception dealing thread and main thread. The auto-loading thread takes charge of increasing power; the protection thread is used to monitor status of devices and takes proper protection actions, and the exception dealing thread deals with other accidents such as disconnection of PVs.

DOD and

publisher.

must maintain attribution to the author(s), title of the work.

work

BY

20

the

be used under the terms of

work may

this v

from



Figure 3: The display of the result of ANSC.

In Fig. 3, the phenomenon of carrying out the autoconditioning process is displayed. Figure 4 is the user interface to display historical information in execution of ANSC.

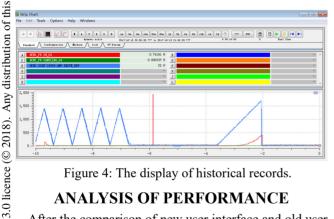


Figure 4: The display of historical records.

ANALYSIS OF PERFORMANCE

After the comparison of new user interface and old user interface in Fig. 5., it is definitely assured that the user interface of ANSC is more easy for users to use and is more beautiful than the old user interface.

92.168.40.9_CM2	0.2 PI % PI future 000				Step
familie Vachganu, fl. Ga, hynnu, fl. Achganu, fl. Ga, hynnu, fl. Achganu, fl. Vachganu, fl. Achganu, fl. Vachganu, fl. Vachganu, fl. Vachganu, fl. Achganu, fl. Vachganu, fl. Vachganu, fl. Vachganu, fl. Achganu, f	bitchi 1 phick Joynes bitchi 1 mick Joynes bitchi 1 mick bitchi 1 mick bitchi 1 mick bitchi 1 mick bitchi 2 mick bitchi 3 mick bitchi 4 mick			meth & methods and states reser(1) = 80 (Vr),1 Preser(2) = 81 (Vr),2 Preser(2) = 81 (Vr),2 Preser(3) = 81 (Vr),3 Preser(4) = 81 (Vr),3 Preser(5) = 81 (Vr),3 Preser(5) = 81 (Vr),3 Preser(6) = 81 (Vr)	limit nat, vant init 5.01-5 UP Jimit 2.01-6 Oosen, limit 1.01-6
Add 1	Image: state of the s	L8 4 Vacus L8 5 2 L8 6	vec1 vec3 vec4 vec44 vec44 <t< td=""><td>Vac0 01 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410</td><td>Diamel Voltage Channel 3 10,000 Channel 3 10,000 Channel 4 10,000 Channel 5 10,000 Channel 5 10,000 Channel 6 10,000 Channel 6</td></t<>	Vac0 01 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.210 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410 0.410	Diamel Voltage Channel 3 10,000 Channel 3 10,000 Channel 4 10,000 Channel 5 10,000 Channel 5 10,000 Channel 6 10,000 Channel 6

Figure 5: The user interface of old conditioning program.

During the testing, ANSC can meet basic requirement of auto-conditioning SRF cavities. It is used to increase power by automatically operating PVs and also monitors all kinds of alarms in the proceeding. To a great extent, ANSC can reduce the burden of engineers taking charge

of SRF and also improve the efficiency in conditioning SRF cavities. Therefore, it demonstrates that autocondition program is certainly alleviate the burden of engineers.

On the other hand, conditioning SRF cavities is complex and is extremely restricted in speed in some aspect. For example, when ARCA happens in the process, it is dealt instantly within a few µs, which is beyond the capability of software. Thus, it is necessary to come up with a new solution to complement EPICS's shortage in microsecond time. In addition, how to ensure multi threads harmoniously is another practical problem.

CONCLUSION

Until now, the testing task of ANSC is mostly completed. there are some serious prolems needed to be tackled; otherwise, the reliability of ANSC would be threatened greatly. For example, when ARCA is detected, ANSC is asked to cut down power supply within a few us which is beyond python because python is incapable of dealing with the special situation in such short time. As for the emergencies described above, some methods are being tried.

How to build a well model in theory is our final goal so that ANSC can totally replace humans and set them free from boring and repeated task. Meanwhile, increasing the robustness and reliability of ANSC is also critical for our future work. According to these difficulties, full automatic process is a long way.

ACKNOWLEGEMENT

During carrying out the work referred in the paper, we get many help form co-workers in ADS Linac control group. The authors wish to thank the numerous persons who participated in activities on ADS control group.

REFERENCES

- [1] M. Stirbe et al., "RF Conditioning and Testing of Fundamental Power Couplers for SNS Superconducting Cavity Production", in Proc. PAC'05, Knoxville, Tennessee, paper USA. Mav 2005. TPPT083. p. 4132. doi: 10.1109/PAC.2005.1591741
- [2] S. Liu et al., "OPTIMIZATION OF THE SUPERCON-DUCTION SECTION OF INJECTOR II FOR C-ADS", in Proc. HB'12, Beijing, China, Sep. 2012, paper MOP232, p. 122.
- [3] Y. Guo et al., "Design of Software Platform for Injector II Control System in ADS", Atomic Energy Science and Technology, vol. 48, pp. 704-707, Oct. 2014, doi: 10.7538/yzk.2014.48.S0.0704