EXPERIENCE GAINED DURING THE COMMISSIONING OF THE UNDU-LATOR CONTROL SYSTEM AT THE EUROPEAN XFEL

S. Karabekyan[†], S. Abeghyan, J. Pflueger, M. Yakopov, European XFEL, Hamburg, Germany

Abstract

The European XFEL is a fourth-generation light source, which will start the operation in spring 2017. Three undulator systems - SASE 1, SASE 2 and SASE 3 - will be used to produce photon beams. For operation of all undulator systems, in total 91 undulators have been produced and commissioned. SASE 1 and SASE 3 undulator systems, consisting of total 56 undulator cells, have been installed and prepared for the operation in the tunnel in spring and summer 2016. SASE 2 will be installed by the end of 2016. This paper describes the commissioning process of the whole undulator control system and reports about the experience gained over the entire duration of undulator control system commissioning.

INTRODUCTION

Commissioning of the undulator control system was a multilayer task and was carried out in several steps. The strategy of commissioning was to test all hardware components at least once before those components would be installed in the tunnel. The same is true for the software development. Each release of software has been tested first using a simulation software and then on the undulator system test setup, before using it for the real undulator system.

COMMISSIONING OF THE HARDWARE

Undulator System Test Setup

An undulator system consists of an array of up to 35 undulator cells installed in a row in the tunnel along the electron beam. It consists of up to 35 undulator segments and intersections. The system is controlled by a central control node (CCN). It is installed in the control room, which is located about 1 km away from the undulator system. CCN communicates with the undulator cells over optical fibers, and the communication between individual cells is implemented using copper Ethernet and EtherCAT cables. Two media converter racks (MCR) installed from both sides of the system are used to convert signals from copper carriers to optical fiber carriers and vice versa. These two MCR racks are necessary for implementation of the redundant ring topology used for control of the undulator system.

It was obvious that all the envisaged components were to be tested before installation in the tunnel. For this purpose, an undulator system test setup was built in the undulator hall (see Fig. 1). The only difference between the real undulator system and test setup was the amount of undulator cells, which was reduced to four in the test setup. This test setup allowed to test the complete hard-

A

and

ware components before installation in a tunnel. It also allowed developing the global control system software three years ahead of the installation of the system in the tunnel.



Figure 1: Undulator system test setup in the hall.

Control Components For Undulator Segments

The undulator control system needed to be commissioned before the magnetic commissioning of the undulator. This process is described in details in reference [1]. The undulator control hardware contains components installed on the undulator frame, as well as in the undulator control rack (UCR). The rack is connected to the undulator using a cable bundle. The first operation of the undulators and UCRs took place at the companies producing the undulator frame. It included only the operation of the motors, encoders and limit switches installed on the frame.

For the magnetic commissioning of the undulator it was necessary to bring it into the magnetic measurement hutch. After placing it in the hutch, the undulator had to be connected to the control rack installed on the rooftop of the hutch. Control of all undulators introduced to the hutch can be carried out using the same rack. Nevertheless, it was decided to commission the undulator with the assigned control rack. During this commissioning, a complete set of tests was carried out. This strategy allowed to check the whole undulator control system before installation in the tunnel and helped to discover of hardwarerelated problems in more relaxed situation on about 5% of the system.

Intersection Control Components

The intersection control components consist of the hardware installed on the Quadrupole Mover (QM) and Phase Shifter (PS) as well as Intersection Control Rack (ICR). The phase shifters have been produced by three different companies. For production and adjustment pur-

[†] suren.karabekyan@xfel.eu

poses, as well as for the factory acceptance tests (FAT), dedicated PS control cabinets were produced and delivered to these companies. In a similar way, companies producing the QMs were assisted. The ICRs were produced by one company and also needed to be tested before the delivery to European XFEL. Therefore, one PS and one QM were provided to the company for the FAT.

After delivery of all components to the European XFEL, site acceptance tests (SATs) were arranged. A separate, air conditioned hutch was prepared for the SATs. The hutch was equipped with a granite stone to fix the QM and PS. The tests with QMs and PSs were carried out in full compliance with technical specifications [2, 3]. If any of the components didn't match the specifications, this component was sent back to the manufacturer. Our experience has demonstrated that after the SAT only 1% of the delivered QMs and PSs needed to be returned. Approximately the same failure rate has been observed for ICRs.

SOFTWARE FOR COMMISSIONING OF AN UNDULATOR SYSTEM

A specific feature of undulator systems for free-electron lasers is the large number of recurring elements. Each undulator cell in the system at European XFEL is controlled by a local control node (LCN). The LCN is an industrial PC produced by Beckhoff Automation GmbH running a Programmable Logic Controller (PLC) implemented in the TwinCAT system. The TwinCAT runs under the Windows operating system. The software running on each LCN must be identical, although each cell component has its individual settings. The other aspect which should be taken into account is the need to have possibilities to update the version of the TwinCAT software as well as specific firmware. These arguments lead to the decision to develop software which will automate this process.

Setup, Configuration and Maintenance of the Undulator Control System

The Image Deployment Automation (IDA) software was developed in preparation of making the system operational [4]. The main objectives of IDA are following:

- Minimize the time used to set up, configure and maintain undulator systems;
- Interlink the configuration to the Undulator Systems Database (USD);
- Automate as many operations as possible;
- Provide possibility to create a master image and follow the version numbering of the images;
- Distribute the master image to the LCNs;
- Provide capability to quickly update Beckhoff Twin-CAT, whenever an update is released
- Minimize presence in the tunnel;
- Eliminate errors arising from manual work.

IDA components are distributed between CCN, LCN and database (see Fig. 2). The DESY network and the

private LAN of the undulator system are separated from each other, but interlinked by the CCN. DB Proxy is establishing communication between the Undulator Systems Database and the Client, which is residing on the LCN. The Image Manager is issuing different commands to the Client. Preboot eXecution Environment (PXE) technology, implemented in the BIOS of the LCN, made it possible to develop IDA. A tiny Linux Distro, which is loaded on LCN through PXE, is intended to write or clone images. At the same time the CCN is serving as storage for LCN images. The Client application is performing the actual work of configuration.

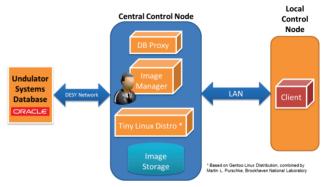


Figure 2: Schematic layout of the components of IDA.

One of the main functionalities of IDA is updating the images on the LCNs. The actual command is issued from the Image Manager application. The Image Manager is triggering an update command to LCN and rebooting it. As a result of the master boot record (MBR) handling, the LCN is not booting from compact flash, but starts to boot the operating system from the network using PXE. Afterwards, Tiny Linux distribution is booting on the LCN and running a dedicated script. The script, in this particular case, is reading an image from CCN Image Storage and writing it onto the LCN disk. Then LCN reboots into normal Windows. Lastly, the Client application starts running on the LCN, connecting to DB through the DB Proxy and configuring LCN according to its location. The main user interface after accomplishing the update of LCNs is illustrated in Fig. 3.

□ 0.101.12 NAA 0.0000511E2E 1.1 0.7 0.0000511E2E 0.1 0.7 0.00005122022PM □ 1.0 0.0000511E2E 1.0 0.7 0.0000511E2E 0.000051E	₹	Cell	IP Address	Serial	MAC Address	Version	Status	Ping	Operation	Last Status	
□ 2 010112 NA 00000511E28 113-7 ○ Successful year 010/2015 128022 PM ▼ 4 101014 X465402 00000511E28 113-7 ○ Successful year 100/2015 128022 PM ▼ 4 101014 X465402 00000513084 113-7 ○ Successful year 100/2015 12802 PM ▼ 101016 X4084002 00000513084 113-7 ○ Successful year 100/2015 1420 PM ▼ 101016 X4044004 00005976423 113-7 ○ Successful year 100/2015 1420 PM ▼ 101017 X4004002 00005976423 113-7 ○ Successful year 100/2015 1420 PM ▼ 1010111 X4054003 00005976442 113-7 ○ Successful year 100/2015 1420 PM ▼ 10101111 X4054003 00005976442 113-7 ○ Successful year 100/2015 1420 PM ▼ 10101113 X4054012 00005976442 113-7 ○ Succesful year<	Г	1	10.10.1.1	N/A	0001051A56F0	1.0	~	0		10/10/2016 9:25:52 AM	
F 4 101014 XM284022 000105112644 11.9e7 C Succently down 105/2015114:38PH F 101016 XM284002 00010513384 11.9e7 C Succently down 105/2015114:20FH F 101016 XM284004 0001057012842 11.9e7 C Succently down 105/2015114:20FH F 101016 XM284004 0001057012842 11.9e7 C Succently down 105/201511:20FH F 1010118 XM284004 0001057012533 11.9e7 C Succently down 105/20151:120FH F 1010113 XM284004 0001057012542 11.9e7 C Succently down 105/20151:120FH F 1010113 XM284001 0001057012444 11.9e7 C Succently down 105/20151:120FH F 11010113 XM284002 000105714442 11.9e7 C Succently down 105/20151:120FH F 11010113 XM284002 000105714442 11.9e7 C Succently down 105/201		2	10.10.1.2	N/A	0001051A57C0	1.0	1	Ø		9/14/2016 12:50:23 PM	
F 4 101014 XM242022 00010511244 11.9c7 C Succently down 005/2015114:58 PM F 101016 XM244004 00010513394 11.9c7 C Succently down 005/2015114:205 PM F 101016 XM244004 000105161258 11.9c7 C Succently down 005/2015114:205 PM F 101016 XM244004 000105160153 11.9c7 C Succently down 005/2015114:205 PM F 1010118 XM244004 000105160153 11.9c7 C Succently down 005/2015114:205 PM F 1010111 XM244004 000105161523 11.9c7 C Succently down 005/201514:205 PM F1 1010111 XM244005 000105161523 11.9c7 C Succently down 005/201514:205 PM F1 1010111 XM244005 000105161523 11.9c7 C Succently down 005/201514:21 PM F1 1010111 XM254012 000105165243 11.9c7 C Succently down		3	10.10.1.3	X069-K029	00010511EE3E	1.1.9rc7	0	0	Successfully done	10/12/2016 3:08:23 PM	
F 6 1010.16 X0444004 0000057E422 11.9e7 C Successful gove 104/2011 14.26 PH F 1010.16 X0424002 000050E525 11.9e7 C Successful gove 104/2011 14.26 PH F 1010.18 X0454002 000050E525 11.9e7 C Successful gove 104/2011 14.26 PH F 1010.118 X0454004 000050E525 11.9e7 C Successful gove 104/2011 14.26 PH F 1010.111 X0454004 000050E525 11.9e7 C Successful gove 104/2011 14.26 PH F 1010.112 X0454005 0000557E424 11.9e7 C Successful gove 104/2011 14.26 PH F 1010.113 X0454005 0000557E442 11.8e7 C Successful gove 104/2011 14.21 PH F 11010.113 X0454005 0000557E442 11.8e7 C Successful gove 104/2011 14.21 PH F 11010.113 X0454005 0000557E442 11.8e7 C Succesful gove	5	4	10.10.1.4	X062-K022	00010511EEA4	1.1.9rc7	Ö	Ö	Successfully done	10/6/2016 1:41:59 PM	
F 6 101016 X0444004 000050FE42 11.9c7 C Successful gives Successful gives F 101017 X04024002 000050FE32 11.9c7 C Successful gives No42x012 12.052781 13.057 C Successful gives 10.052781 12.052781 13.057 C Successful gives 10.052781 13.057 C Succesful gives </td <td>N</td> <td>5</td> <td>10.10.1.5</td> <td>X008-N006</td> <td>000105130984</td> <td>1.1.9rc7</td> <td>0</td> <td>0</td> <td>Successfully done</td> <td>10/6/2016 1:42:02 PM</td> <td></td>	N	5	10.10.1.5	X008-N006	000105130984	1.1.9rc7	0	0	Successfully done	10/6/2016 1:42:02 PM	
F 1 101017 X0024002 00000501252 11.9e7 C Successful down 005/20114.200 PM F 0 101019 X0544002 00000501252 11.9e7 C Successful down 005/20114.200 PM F 0 101019 X0544003 0000050761424 11.9e7 C Successful down 005/20114.200 PM F 10 1010111 X0554000 0000050767444 11.9e7 C Successful down 005/20114.200 PM F 11 1010111 X0554000 0000050767444 11.9e7 C Successful down 005/20114.200 PM T 10101113 X0524002 0000050768282 11.9e7 C Successful down 005/20114.211 PM T 1010113 X0224012 00000578282 11.9e7 C Successful down 005/20114.211 PM T 1010113 X0224012 000005782824 11.9e7 C Successful down 005/20114.21 PM T 1010116 X0544003 00010578444	N	6	10.10.1.6	X044-K004	0001050FE4B2	1.1.9rc7	0	0	Successfully done	10/6/2016 1:42:05 PM	
P 1010.19 XM954001 0000050EC22 11.19c7 C Successful year 104/2011 14.20 PM F1 1010.11 XM954000 0000507E444 11.9c7 C Successful year 106/2011 14.20 PM F1 1010.11 XM954000 0000507E444 11.9c7 C Successful year 106/2011 14.20 PM F1 1010.11 XM954000 0000507E442 11.9c7 C Successful year 106/2011 14.20 PM F1 1010.113 XM254002 0000507E442 11.9c7 C Successful year 106/2011 14.21 PM F1 1010.113 XM254012 000057E442 11.9c7 C Successful year 108/2011 14.21 PM F1 1010.115 XM354019 0000157E444 11.9c7 C Successful year 108/2011 14.21 PM F1 1010.117 XM354009 0000157E444 11.9c7 C Successful year 108/2011 14.21 PM F1 1010.117 XM354000 0001057E444 11.9c7 C Succesful year 108	7	7	10.10.1.7	X002-K002	0001050DEC9C	1.1.9rc7			Successfully done	10/6/2016 1:42:05 PM	
F 9 10101 9 X058000 0000507ECE2 11.9c7 C Successful docs F 10 10101 10 X058000 0000507EC44 11.9c7 C Successful docs 106/2015 11.201 PM F 11 10101 11 X058000 0000507EF44 11.9c7 C Successful docs 106/2015 11.201 PM F 11 10101 11 X058000 0000507EF442 11.9c7 C Successful docs 106/2015 11.201 PM F 10 10101 13 X052000 000059FE442 11.9c7 C Successful docs 106/2015 14.211 PM F 10 10101 13 X052000 000059FE442 11.9c7 C Successful docs 106/2015 14.211 PM F 16 10101 15 X054003 0000169FE442 11.9c7 C Successful docs 106/2015 14.21 PM F 16 10101 16 X0544003 000169FE442 11.9c7 C Successful docs 106/2015 14.21 PM F 19 10101 14	N	8	10.10.1.8	X064-K024	00010511B3A4	1.1.9rc7	0	0	Successfully done	10/6/2016 1:42:08 PM	
FU 1010.110 XM56000 000056FE82 11.3e7 C Successful year 108/201614.20E PH F1 1010.112 XM56000 000056FE82 11.3e7 C Successful year 108/201614.20E PH F1 1010.112 XM56000 000056FE82 11.3e7 C Successful year 108/201614.20E PH F1 1010.112 XM56000 000056FE82 11.3e7 C Successful year 108/201614.21E PH F1 1010.114 XM58000 000056FE42 11.3e7 C Successful year 108/201611.21E PH F1 1010.116 XM58001 000056FE428 11.3e7 C Successful year 108/201611.21E PH F1 1010.116 XM58001 000056FE888 11.3e7 C Successful year 108/201611.21E PH F1 1010.116 XM58005 000056FE888 11.3e7 C Successful year 108/20161.21E PH F1 1010.118 XM58005 000056FE848 11.3e7 C Successful year 108/20161.22	N	9	10.10.1.9	X058-K018	0001050DEC62	1.1.9rc7			Successfully done	10/6/2016 1:42:08 PM	
IV 1010.112 X010.0000 00000511E202 11.9e7 C Succently down 005/201514.211 PM IV 10.101.114 X052.001 0000507E442 11.9e7 C Succently down 005/201514.211 PM IV 10.101.114 X052.001 0000507E442 11.9e7 C Succently down 005/201514.211 PM IV 10.101.114 X052.001 0000507E442 11.9e7 C Succently down 005/201514.211 PM IV 10.101.16 X055.401 0000507E388 11.9e7 C Succently down 005/201514.211 PM IV 10.101.16 X055.4001 0000507E388 11.9e7 C Succently down 005/201514.211 PM IV 10.101.18 X055.4005 0000507E488 11.9e7 C Succently down 005/201514.213 PM IV 10.101.18 X055.4005 0000507E444 11.9e7 C Succently down 005/201514.223 PM IV 10.101.12 X065.4007 0000507E444 11.9e7 C Succently down	7	10	10.10.1.10	X050-K010	0001050FE4AA	1.1.9rc7	Ö		Successfully done	10/6/2016 1:42:08 PM	
F1 1010113 2002/012 0001057E442 11.9c7 C Successful gove 105/2011421FM F1 1010115 X052/001 0001057E442 11.9c7 C Successful gove 105/2011421FM F1 1010115 X055/001 0001057E442 11.9c7 C Successful gove 105/2011421FM F1 1010115 X055/001 0001057E488 11.9c7 C Successful gove 105/2011421FM F1 1010117 X055/001 0001057E888 11.9c7 C Successful gove 105/2011421FM F1 1010118 X055/005 00010571888 11.9c7 C Successful gove 105/2011421FM F1 1010118 X055/005 00010571888 11.9c7 C Successful gove 105/2011422FM F1 1010118 X055/005 00010571858 11.9c7 C Successful gove 105/2011422FM F1 1010112 X056/005 000105716586 11.9c7 C Succesful gove 105/2011422FM	N	11	10.10.1.11	×045-K005	0001050FE3B2	1.1.9rc7	0	0	Successfully done	10/6/2016 1:42:10 PM	
Fill 1010113 X052002 0000597E442 11.9c7 C Successful gives Fill 1010114 X052001 0000597E442 11.9c7 C Successful gives Fill 1010115 X052001 0000597E444 11.9c7 C Successful gives Successful gives Fill 1010115 X055001 0000597E444 11.9c7 C Successful gives Successful gives Fill 1010117 X051001 0000597E348 11.9c7 C Successful gives Successful gives Fill 1010117 X051001 0000597E348 11.9c7 C Successful gives Successful gives Fill 1010112 X0551002 0001597E444 11.9c7 C Successful gives Successful gives Fill 1010112 X0551002 0001597E444 11.9c7 C Successful gives Successful gives Fill 1010112 X0551002 0001597E444 11.9c7 C Successful gives Succesful gives Fill	N	12	10.10.1.12	X010-N008	00010511EE02	1.1.9rc7	0	0	Successfully done	10/6/2016 1:42:11 PM	
Fit 1010114 XIB20101 0000567E442 11.9c7 C Successful year 108/201511.217 PM Fit 1010116 XIB54001 00005671844 11.9c7 C Successful year 108/201511.217 PM Fit 1010116 XIB54001 00005671838 11.9c7 C Successful year 108/201511.217 PM Fit 1010116 XIB54001 00005671838 11.9c7 C Successful year 108/201511.217 PM Fit 10101118 XIB54005 00005671838 11.9c7 C Successful year 108/201511.217 PM Fit 10101118 XIB54005 00005671846 11.9c7 C Successful year 108/201511.217 PM Fit 1010112 XIB54005 00005671846 11.9c7 C Successful year 108/201511.227 PM Fit 1010112 XIB54005 00005671648 11.9c7 C Successful year 108/201511.224 PM Fit 21010112 XIB54005 000056716485 11.9c7 C Successful year	7	13	10.10.1.13	X052-K012	0001050FE4A2	1.1.9rc7	Ö		Successfully done	10/6/2016 1:42:14 PM	
Fit 1010115 X055001 0000571844 11.9c7 C Successful doce 005/20151221PM Fit 1010115 X0551001 0000567E888 11.9c7 C Successful doce 106/201511221PM Fit 1010117 X0054001 0000567E888 11.9c7 C Successful doce 106/201511421PM Fit 1010118 X0554005 0000567E888 11.9c7 C Successful doce 106/201511421PM Fit 1010118 X0554005 00005718462 11.9c7 C Successful doce 106/2015114201PM Fit 1010118 X0564005 00005718462 11.9c7 C Successful doce 106/2015114201PM Fit 20101122 X0654005 00005718563 11.9c7 C Successful doce 106/201514201PM Fit 20101122 X0654005 00005718568 11.9c7 C Successful doce 106/201514234PM Fit 20101122 X0654005 00005718564 11.9c7 C Successful doce 106/2015142	N	14	10.10.1.14	×092-1001	0001050FE4AC	1.1.9rc7	0	0	Successfully done	10/6/2016 1:42:17 PM	
Fit 1010116 X0551001 0000567E388 11.9c7 ✓ Successful year 108/201511217PH Fit 1010116 X065400 0000567E388 11.9c7 ✓ Successful year 108/20151121PH Fit 10101118 X065400 0000567E388 11.9c7 ✓ Successful year 108/20151121PH Fit 1010112 X065400 0000567E388 11.9c7 ✓ Successful year 108/20151122PH Fit 1010112 X065400 0000567E484 11.9c7 ✓ Successful year 1012/2015 33:34 PM Fit 211010122 X066400 0000567E484 11.9c7 ✓ Successful year 1012/2015 33:34 PM Fit 211010122 X066400 0000567E484 11.9c7 ✓ Successful year 108/2015112:34 PM Fit 211010122 X066400 0000567E485 11.9c7 ✓ Successful year 108/2015112:34 PM Fit 211010124 X0484000 0000567E485 11.9c7 ✓ Successful year 108/	₹	15	10.10.1.15	X059-K019	000105118446	1.1.9rc7	O	0	Successfully done	10/6/2016 1:42:16 PM	
Pi 1010117 2001/00711840 11.3e7 C Successful does 108/201511221PM Pi 1010118 X465K02 0001/65118462 11.3e7 C Successful does 108/201511221PM Pi 1010118 X465K02 0001/65118462 11.3e7 C Successful does 108/201511221PM Pi 1010112 X467K02 0001/65118462 11.3e7 C Successful does 108/201511220PM Pi 1010112 X467K02 0001/6511642 11.3e7 C Successful does 108/201511220PM Pi 1010112 X467K02 0001/6511642 11.3e7 C Successful does 108/201511220PM Pi 1010112 X467K02 0001/6511642 11.3e7 C Successful does 108/201511229PM Pi 1010112 X407K003 0001/6511642 11.3e7 C Successful does 108/201511240PM Pi 1010112 X407K003 0001/6511642 11.3e7 C Successful does 108/201511240PM	7	16	10.10.1.16	X051-K011	0001050FE3B8	1.1.9rc7	Ö	Ö	Successfully done	10/6/2016 1:42:17 PM	
File 1010119 X065K025 00005119452 11.9c7 C Successful yooc 108/201611.219 PM T 1010112 X065K025 000056119452 11.9c7 C Successful yooc 108/20161.12.19 PM T 1010112 X065K025 000056119452 11.9c7 C Successful yooc 1012/2015.32.34 PM T 21.010112 X065K025 000056112763 11.9c7 C Successful yooc 108/20161.12.24 PM T 21.010112 X065K025 000056112763 11.9c7 C Successful yooc 108/20161.12.24 PM T 21.010112 X065K025 000056176163 11.9c7 C Successful yooc 108/20161.12.24 PM T 21.010112 X065K025 00005676442 11.9c7 C Successful yooc 108/20161.12.24 PM T 21.010112 X065K035 00005676442 11.9c7 C Successful yooc 108/20161.12.42 PM T 21.010124 X045K035 000056714255 11.9c7 C Successful yooc	N	17	10.10.1.17	X001-K001	0001050FE3B0	1.1.9rc7	0	0	Successfully done	10/6/2016 1:42:18 PM	
□ □	N	18	10.10.1.18	X065-K025	00010511B46C	1.1.9rc7	0	0	Successfully done	10/6/2016 1:42:19 PM	
7 21 10101.21 X4084.002 00010511E278 1.1 3e7 C Successful down 1067/01514.22.8 PM 7 21 0101.21 X4084.002 00010510E88 1.1 3e7 C Successful down 1067/01514.22.8 PM 72 24 10101.22 X4084.003 00010510E88 1.1 3e7 C Successful down 1067/01514.24 PM 72 24 10101.22 X4084.003 00010511E528 1.1 3e7 C Successful down 1067/01514.24 PM 72 24 10101.25 X0714.003 00010511E288 1.1 3e7 C Successful down 1067/01514.24 PM 72 5 10101.25 X0714.003 00010511E28 1.1 3e7 C Successful down 1087/01514.245 PM 72 10101.25 X0714.003 00010511E24 1.1 3e7 C Successful down 1087/01514.245 PM 72 10101.25 X0714.003 00010511E244 1.1 3e7 C Successful down 1087/01514.245 PM 72 10101.25	7	19	10.10.1.19	X066-K026	00010511B46E	1.1.9rc7			Successfully done	10/6/2016 1:42:20 PM	
7 21 0101.2 X0804000 000105112783 1.1 %c7 ♥ Successfully down 108/2015114.2.2 FM 7 22 0101.01 X0814000 000105116788 1.1 %c7 ♥ Successfully down 108/2015114.2.2 FM 72 21 0101.02 X0844006 000105116788 1.1 %c7 ♥ Successfully down 108/2015114.24 FM 72 24 10101.25 X0914006 000105116288 1.1 %c7 ♥ Successfully down 108/2015114.24 FM 72 24 10101.25 X0914006 000105116288 1.1 %c7 ♥ Ø Successfully down 108/201514.24 FPM 72 5 10101.25 X0714031 000105116288 1.1 %c7 Ø Successfully down 108/201514.25 FM 72 5 10101.25 X0714031 000105116288 1.1 %c7 Ø Ø Successfully down 108/201514.255 FM 72 10101.27 X08740303 000105176248 1.1 %c7 Ø Ø Successfully down 108/2		20	10.10.1.20	X067-K027	0001050FE4B4	1.1.9rc7	0	0	Successfully done	10/12/2016 3:36:24 PM	
ID	₹	21	10.10.1.21	X060-K020	00010511EF28	1.1.9rc7			Successfully done	10/6/2016 1:42:24 PM	
72 10:10:12 X044003 0000511E58 11:3e7 C Successful year 104/201611e249 PM 72 51:01:01:25 X0714:031 0000511E570 11:3e7 C Successful year 104/201611e255 PM 77 51:01:01:25 X0574:031 0000511E720 11:3e7 C Successful year 104/201611e255 PM 77 51:01:01:25 X0744:031 0000517E724 11:3e7 C Successful year 104/20161:12:55 PM 77 10:10:12 X0744:031 0000517E724 11:3e7 C Successful year 104/20161:12:55 PM	N	22	10.10.1.22	X061-K021	00010510F086	1.1.9rc7	0	0	Successfully done	10/6/2016 1:42:34 PM	
	7	23	10.10.1.23	X046-K006	0001050FE49C	1.1.9rc7	0	0	Successfully done	10/6/2016 1:42:41 PM	
17 26 10.10.1,26 X053-K013 00010511F224 1.1.9x7 ⊘ ⊘ Successfully dome 10/6/2016 1.42:55 PM 17 27 10.10.1.27 X073-K033 0001050FE44E 1.1.9x7 ⊘ ⊘ Successfully dome 10/6/2016 1.42:59 PM			10.10.1.24	X049-K009	00010511EE9E	1.1.9rc7			Successfully done	10/6/2016 1:42:49 PM	
🗹 27 10.10.1.27 X073-K033 0001050FE44E 1.1.9rc7 🧟 🧟 Successfully done 10/6/2016 1:42:59 PM			10.10.1.25	X071-K031	00010511EF30	1.1.9rc7		- 📀 -	Successfully done	10/6/2016 1:42:55 PM	
	7	26	10.10.1.26	X053-K013	00010511F22A	1.1.9rc7	0	0	Successfully done	10/6/2016 1:42:55 PM	
🔽 28 10101128 X063-K023 00010511EE18 11.9x7 🧖 🧟 Successfully done 10/6/20161:43:00 PM			10.10.1.27	X073-K033	0001050FE4AE	1.1.9rc7			Successfully done	10/6/2016 1:42:59 PM	
	P	28	10.10.1.28	X063-K023	00010511EF18	1.1.9rc7	0	0	Successfully done	10/6/2016 1:43:00 PM	

Figure 3: Main user interface of the IDA.

ISBN 978-3-95450-189-2

After the assembly of the undulator system in the tunnel the procedure of putting the system into operation took two working days. The main problems encountered were related to the quality of the Ethernet connections between the LCNs. The performance of IDA for distribution of an image to LCNs, is strongly dependent on the network bandwidth. For an undulator system with 35 cells, it takes approximately 3 hours.

Undulator System Tester (UST)

The next step after putting the undulator system into operation is the commissioning of all control components that belong to it.

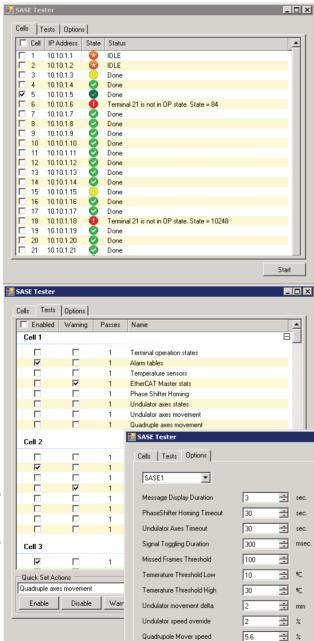


Figure 4: Main user interface of the UST as well as interfaces for configuration of the test scenarios and the setting values of the tests.

This task could be time consuming, taking into account, that several hundred values per system must be examined. This was a motivation to create a supervisory control and data acquisition (SCADA) program. This program is running on the CCN and is sending commands to the LCNs. After the execution of the commands, the program receives a feedback value. If the value is inside of an expected range, then the test is accepted; otherwise the test is marked as not successful. A double-click on the individual cell brings a popup log window. The error log provides precise information about the failure. The program provides a possibility to configure the test scenario for each individual cell. One can select what kind of tests must be carried out on which cell, how the feedback results must be interpreted, or in which case the test must be stopped. These are the settings of parameters, parameter ranges and timeouts for the test (see Fig. 4).

The executions of these tests are taking place simultaneously on each undulator cell. Depending on the test scenario, the complete test of the undulator system may take, only 10 to 30 minutes.

CONCLUSIONS

Our experience shows that after the assembly of the two undulator systems - SASE 1 and SASE 3 - in the tunnel, the full process of commissioning of the undulator control system takes approximately one week per system. This time was spent for fixing the problems with hardware used for the first time, in particular improving the quality of Ethernet and EtherCAT copper cables or fixing problems with wrongly swapped optical fibers.

The selected strategy - to test each piece of hardware before installation in the tunnel - fully justified itself, since the problems were solved during several years of hardware production and commissioning, in a more relaxed situation.

The software developed for setting up, configuration, commissioning and maintenance of the undulator control system allowed to reduce the final work in the tunnel to a couple of weeks instead of several months.

REFERENCES

- S. Karabekyan *et al.*, "Use of Automation in Commissioning Process of the Undulators of the European X-Ray Free Electron Laser", in *Proc. ICALEPCS'15*, Melbourne, Australia, Oct. 2015, p 64.
- [2] J.Munilla *et al.*, "Experience On Serial Production of the Quadrupole Movers with Submicrometric Repeatability for The European XFEL", in *Proc IPAC'15*, Richmond, VA, USA, May 2015, paper TUPWI015, p 2271.
- [3] P. Moreno-Torres *et al.*, "Design Process and Series Production of the Intersection Control Rack for the European XFEL Linear Accelerator", Power Electronics and Applications (EPE'15 ECCE-Europe), 2015 17th European Conference on, 8-10 Sept. 2015
- [4] S. Abeghyan *et al.*, "Image Deployment Automation", European XFEL, Schenefeld, Germany, Rep. WP71/2016/01, Jan. 2016.