Sheridan Science and Technology Park, 2800 Speakman Drive
Mississauga, Ontario, Canada L5K 2R7
Tel: +1 (905) 855 7600 www.hatch.com

February 1, 2021

Chief Engineer HVDC NTDC
Matiari-Lahore HVDC Transmission Project
618-WAPDA House,
Lahore

Subject: **+/-660KV 4000MW Bipole HVDC Matiari-Lahore Transmission Project to be Executed by EPC Contractor on BOOT Basis: Owner Engineer Consultancy Services:**

Updated Test Program (A3 to A6) submitted by CET according to Root Cause Analysis Report

Ref: **CET Letter PTC-04A-20210130-01 dated January 30, 2021**

Dear Sir:

We are in receipt of CET above referenced letter on Saturday (January 30, 2021) and offer the following comments:

1. We have reviewed the text in the documents highlighted in red and note that the only change is the following statement in the Pre-conditions:
   "There are no less than two low voltage reactors available in both Matiari and Lahore Converter Stations."
   We have changed this statement as follows:
   "There are four low voltage reactors available in Matiari and two low voltage reactors available at Lahore Converter Station."
2. We have also noted that the earlier approved revisions were conditionally approved and we have restated the same condition for approval.

In view of the minor changes to the procedures and to avoid the delay of another revision cycle, the documents have been Approved again. We are available to discuss and clarify the above if required.

Yours faithfully,

Iftikhar Khan, P.Eng.
OE Representative and Project Director,
Power Delivery and Integration, Hatch

Pete Kuffel,
HVDC Specialist/Lead
Commissioning Team

Bruno Bisewski,
OE Technical Team Lead

cc:
1. Managing Director, NTDC, Wapda House, Lahore
2. Deputy Managing Director, AD&M, NTDC, 413-Wapda House, Lahore
3. General Manager (GSC/PD) North, NTDC, Wapda House, Lahore
4. General Manager, System Operation, NTDC, Islambad
5. Chief Executive Officer, PMLTC, Lahore
6. Mr Aldo Danelli, SEnior Project Manager, CESI, Lahore
7. OE Team (Joanne Hu, Others)

OE notes that approval of this test procedure is conditional on the following:
a) CET to perform the additional tests identified by NPCC (letter General Manager System Operation 15476/80/GM(SO)/NPCC/NRCC dated Nov 24, 2020). CET will prepare in a new test procedure "A7-Matiari-Lahore ±660kV HVDC Transmission Project Commissioning Tests-Additional Tests" and submit for NTDC/OE review and approval.
b) CET to successfully complete all additional tests at a suitable time prior to the end of the commissioning period and start of commercial operation.

国家电网
STATE GRID
中国电力科学研究院有限公司
CHINA ELECTRIC POWER RESEARCH INSTITUTE

Approved RBJ RBJ Engineering Corporation 1-Feb-2021

报告编号：HXT2020-107

巴基斯坦默蒂亚里-拉合尔±660高压直流输电工程系统调试方案

（3）单极小功率系统调试方案

Matiari-Lahore ±660kV HVDC Transmission Project Commissioning Tests

(3) Monopole Low Power System Tests Program

China Electric Power Research Institute

2021.01

Version	Date	Modification
…	…	…
4.0	29 Jan 2021	Updated according to OE recommendations about low voltage reactor

工作单位： 中国电力科学研究院有限公司

项目负责人： 班连庚，谢国平

报告编写人： 谢国平,雷霄,庞广恒,林少伯,周亦夫,刘世成

中国电力科学研究院有限公司

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?@AB

巴基斯坦默蒂亚里-拉合尔高压直流输电工程单极小功率系统调试方案内容包括：初始运行试验、保护跳闸试验、监控功能检查试验、定电流控制试验、定功率控制试验、联合/独立控制、全压/降压运行试验、无功功率控制、大地/金属回线转换、功率反送试验、金属回线运行试验、丢失脉冲故障试验、干扰试验和后备面盘控制等。其中详细列出了每个试验项目内容、步骤及验收标准等。

关键词：巴基斯坦默拉直流；单极小功率系统调试方案；系统调试

ABSTRACT

Monopole Low Power System Tests Program for Pakistan Matiari-Lahore±660kV HVDC Transmission Project includes initial operation tests, protective trip tests, system supervision and switchover tests, joint current control, joint power control tests, joint/separate control tests, normal/reduced voltage tests, reactive power control tests, ground/metallic return transfer tests, reversed power direction tests, control pulse loss failure, disturbances, backup control tests, etc. The contents, test procedure and acceptance criteria of the test items are listed in this report.

KEYWORDS: Pakistan Matiari-Lahore HVDC Project, Monopole Low Power System Test Program, System Commissioning

Table of Contents

1 Preconditions

IMPORTANT: The bipole power of Matiari-Lahore HVDC project during the test shall not exceed 800 MW, corresponding to 1212 A. The AC voltage at all the two converter stations including Matiari and LAHORE shall be 505-525Kv or lower before and during all tests. The frequency at all the converter stations shall be 49.5-50.5Hz.

The following pre-conditions apply to all tests defined in this procedure. If any particular pre-condition is necessary for a specific test, it will be added in the test description.

Converter station test has been completed and qualified.

(1) The test leader from Owner and CEPRI must be appointed.

(2) All equipment tests and subsystem tests necessary to the energization must be completed.

(3) Protection settings and protective circuits trip sequences tests must be completed.

(4) Converter valve low voltage tests must be completed.

(5) AC-switchyard and associated protections and sequences, including breaker failure protection, must be tested.

(6) Final trip test is done on each area prior to energization.

(7) Verify list of remaining activities and make sure that the energization can proceed.

(8) Verify list of temporary connections and make sure that the energization can proceed.

(9) Verify Sequence of Events Recorder (SER) and make sure that no relevant alarms are present, and all systems are operational.

(10) Energization permission from the dispatch center is acquired.

(11) The switching sequence prepared by Owner is ready.

(12) There are four voltage reactors available at Matiari

and two LV reactors available at Lahore converter station.

Furthermore, prior to the commissioning test, the following tests shall be performed without energization at both stations:

（1） Inter-station telecommunication check of control and protection signals

（2） Dry run connect/isolate pole

（3） Repeat as above with system change over during sequence

（4） Dry run metallic/ground return transfer

（5） Repeat as above with system change over during sequence

（6） Emergency stop, dry run.

2 Initial Operation Tests, Joint Current Control, Normal Power Direction

2.1 Test Objective

Verify the basic function of deblock/block, manually switchover and ESOF, and check the correctness and accuracy of analog signal of control and protection system.

2.2 Preconditions

（1）OLT has been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system is capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[ ] Power Control	[X] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active

[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[ ] Power Control	[X] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

2.3 Ground Return, Test Content and Procedure.

2.3.1 Start /Stop Pole, Manual Block

（1） Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a '**Ready for Operation**' condition.

（2） Verify both stations in '**Ready for Operation**' condition.

（3） Start the pole at minimum current in Matiari, 303A (200MW), ramp rate 100A/min.

（4） Verify steady performance indicators

1） LAHORE: γ=17°

2） Matiari: from retard to α=15°±2.5° (these values are approximate). 3 ） Record the preliminary data of DC voltage and valve voltages.

（5） Verify stable operation at minimum current.

（6） Perform normal inspections (visual and acoustical) while pole is deblocked.

（7） Verify RPC operation and whether minimum filter connected in line with technical specification:

1) Matiari: one sub bank BP11/13 and one sub bank HP24/36

2) LAHORE: one sub bank HP12/24

（8） Stop the pole, verify

1） Matiari: Retard, Reduced current→Block without BPP

2） LAHORE: Order alpha as 90° →Block with BPP

（9） Record and save all test data.

2.3.2 Test of Emergency Stop

Matiari:

（1） Start the pole at minimum current in Matiari, 303A (200MW), ramp rate 100A/min.

（2） Activate the emergency stop push-button in Matiari Station.

（3） Verify in Matiari station:

1) Y-block
2) Trip of the AC circuit breaker(s) feeding the converter transformer
3) Open AC Filters breakers by RPC
4) Pole isolation
5) Start breaker failure protection
6) Set lockout relay for the tripped AC circuit breaker(s)

（4） Verify in LAHORE station

1) Normal Y-block sequence
2) Open AC Filters breakers by RPC

（5） Record and save test data.

LAHORE:

（6） Change the MASTER from Matiari station to Lahore station.

（7） Start the pole at minimum current in LAHORE, 303A (200MW), ramp rate 100A/min.

（8） Activate the emergency stop push-button in LAHORE Station

（9） Verify:

1) Y-block
2) Blocking of the converter with by-pass pair
3) Trip of the AC circuit breaker(s) feeding the converter transformer
4) Open AC Filters breakers by RPC
5) Pole Isolation
6) Set lockout relay for the AC circuit breaker

7) Start breaker failure protection

(10) Verify in Matiari station:

1) Normal Y-block sequence

2) Open AC Filters breakers by RPC

(11) Record and save test data.

2.3.3 Control System Switchover

(1) Start the pole at minimum current in Matiari, 303A (200MW), ramp rate 100A/min.

(2) Verify the PCPA system is active in Matiari station.

(3) Switch the active system from PCPA (active system) to PCPB in Matiari station.

(4) Verify continuing steady operation of the transmission and that PCPB is active, no transients at switchover.

(5) Switch the active system from PCPB (active system) to PCPA in Matiari station.

(6) Verify continuing steady operation of the transmission and that PCPA is active.

(7) Verify the SC A system is active in Matiari station.

(8) Switch the active system from SCA (active system) to SC B in Matiari station.

(9) Verify continuing steady operation of the transmission and that SC B is active, no transients at switchover.

(10) Switch the active system from SC B (active system) to SC A in Matiari station.

(11) Verify continuing steady operation of the transmission and that SC A is active.

(12) Repeat the above procedure in LAHORE.

(13) Record and save test data.

2.3.4 Pole Control, Analogue Input Check

The pole is operated at 303A (200MW) in current mode. Inspect the AC/DC analogue input signal of the pole control system at both converter station. Record measured values in test record.

2.3.5 DC Side Protections, Analogue Input Check

The pole is operated at 303A (200MW) in current mode. Inspect the AC/DC analogue input signal of the DC side protections system at both converter station. Record measured values in test record.

2.3.6 AC Side Protections, Analogue Input Check

The pole is operated at 303A (200MW) in current mode. Inspect the AC/DC analogue input signal of the AC side protections system at both converter station. Record measured values in test record

2.4 Metallic Return, Test Content and Procedure.

2.4.1 Start /Stop Pole, Manual Block

（1） Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a 'Ready for Operation' condition.

（2） Verify both stations in '**Ready for Operation**' condition.

（3） Start the pole at minimum current in Matiari, 303A (200MW), ramp rate 100A/min.

（4） Verify steady performance indicators

1） LAHORE: γ=17°

2） Matiari: from retard to α=15°±2.5° (these values are approximate).

3） Record the preliminary data of DC voltage and valve voltages and valve currents.

（5） Verify stable operation at minimum current.

（6） Perform normal inspections (visual and acoustical) while pole is deblocked.

（7） Verify RPC operation and whether minimum filter connected in line with technical specification:

1） Matiari: one sub bank BP11/13 and one sub bank HP24/36

2） LAHORE: one sub bank HP12/24

（8） Stop the pole, verify

1） Matiari: Retard, Reduced current→Block without BPP

2） LAHORE: Order alpha as 90° →Block with BPP

（9） Record and save all test data.

2.4.2 Test of Emergency Stop

Matiari:

（1） Start the pole at minimum current in Matiari, 303A (200MW), ramp rate 100A/min.

（2） Activate the emergency stop push-button in Matiari Station.

（3） Verify in Matiari station:

1) Y-block
2) Trip of the AC circuit breaker(s) feeding the converter transformer
3) Open AC Filters breakers by RPC
4) Pole isolation
5) Start breaker failure protection
6) Set lockout relay for the tripped AC circuit breaker(s)

（4） Verify in LAHORE station

1) Normal Y-block sequence
2) Open AC Filters breakers by RPC

（5） Record and save test data.

LAHORE:

（6） Start the pole at minimum current in LAHORE, 303A (200MW), ramp rate 100A/min.

（7） Activate the emergency stop push-button in LAHORE Station

（8） Verify:

1) Y-block

2) Blocking of the converter with by-pass pair

3) Trip of the AC circuit breaker(s) feeding the converter transformer

4) Open AC Filters breakers by RPC

5) Pole Isolation

6) Set lockout relay for the AC circuit breaker feeding the converter transformer

7) Start breaker failure protection

（9） Verify in Matiari station:

1) Normal Y-block sequence

2) Open AC Filters breakers by RPC

（10） Record and save test data.

2.4.3 Control System Switchover

（1） Start the pole at minimum current in Matiari, 303A (200MW), ramp rate 100A/min.

（2） Verify the PCPA system is active in Matiari station.

（3） Switch the active system from PCPA (active system) to PCPB in Matiari station.

（4） Verify continuing steady operation of the transmission and that PCPB is active, no transients at switchover.

（5） Switch the active system from PCPB (active system) to PCPA in Matiari station.

（6） Verify continuing steady operation of the transmission and that PCPA is active.

（7） Verify the SC A system is active in Matiari station.

（8） Switch the active system from SCA (active system) to SC B in Matiari station.

（9） Verify continuing steady operation of the transmission and that SC B is active, no transients at switchover.

（10） Switch the active system from SC B (active system) to SC A in Matiari station.

（11） Verify continuing steady operation of the transmission and that SC A is active.

（12） Repeat the above procedure in LAHORE.

（13） Record and save test data.

2.4.4 Pole Control, Analogue Input Check

The pole is operated at 303A (200MW) in current mode. Inspect the AC/DC analogue input signal of the pole control system at both converter station. Record measured values in test record.

2.4.5 DC Side Protections, Analogue Input Check

The pole is operated at 303A (200MW) in current mode. Inspect the AC/DC analogue input signal of the DC side protections system at both converter station. Record measured values in test record.

3 Protective Trip X, Y, and Z, Normal Power Direction

3.1 Test Objective

The test is carried on both sides and to check trip and block sequence.

3.2 Preconditions

（1）Deblock and block tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system is capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[ ] Power Control	[X] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM

[ ] Power Control	[X] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

3.3 Test Content and Procedure.

3.3.1 Protective Trip X in Rectifier with Telecommunication

(1) Start the pole at minimum current in Matiari, 303A (200MW), ramp rate 100A/min.

(2) Simulate **Valve short Circuit Protection Stage 2 TRIP** from the PPR/ O3_FUNCDCP2(8) software page in PPRA and PPRB in Matiari station. Change VSP_SETTING X3 from 1.5 to -1.5.

(3) Verify in Matiari station:

1) X-block.

2) Trip of the AC circuit breaker(s) feeding the converter transformer.

3) Open AC Filters breakers by RPC.

4) Set lockout relay for the tripped AC circuit breaker(s)

5) Start breaker failure protection.

6) Pole isolation.

(4) Verify in Lahore station.

1) Normal Y-stop sequence.

2) Open AC Filters breakers by RPC.

(5) Record and save all test data.

3.3.2 Protective Trip Y in Rectifier with Telecommunication

(1) Start the pole at minimum current in Matiari, 303A (200MW), ramp rate 100A/min.

(2) Verify the pump A is in operation.

（3） Switch off the AC power supply for the pump A in the valve cooling system

（4） Verify the pump B is put into operation.

（5） Restore the AC power supply for the pump A in the valve cooling system

（6） Switch off the AC power supply for the pump B in the valve cooling system

（7） Verify the pump A is put into operation.

（8） Switch off the AC power supply for the pump A in the valve cooling system to simulate **Valve Cooling System Fault** in Matiari.

（9） Verify in Matiari station:

1） Y-block

2） Trip of the AC circuit breaker(s) feeding the converter transformer 3

） Open AC Filters breakers by RPC

4) Pole isolation

5) Start breaker failure protection

6) Set lockout relay for the tripped AC circuit breaker(s)

（10） Verify in LAHORE station

1) Normal Y-stop sequence.

2) Open AC Filters breakers by RPC.

（11） Record and save the test data

3.3.3 Protective Trip Z in Rectifier with Telecommunication

（1） Start the pole at minimum current in Matiari, 303A (200MW), ramp rate 100A/min.

（2） Simulate **Pole Bus Differential Protection Stage 2 Action** from the **PPR** O3_FUNCDCP3(8) software page in PPRA and PPRC in Matiari station by alter **PBDP SETTING_X6** from ‘0.35’ to ‘**-0.35**’, **X7** from ‘0.2’ to ‘**0**’

（3） Verify in Matiari station:

1) Z-block

2) Trip of the AC circuit breaker(s) feeding the converter transformer

3） Open AC Filters breakers by RPC

4) Pole isolation

5) Start breaker failure protection

6) Set lockout relay for the tripped AC circuit breaker(s)

（4） Verify in LAHORE station 1

） Normal Y-stop sequence.

2） Open AC Filters breakers by RPC.

（5） Record and save all test data

3.3.4 Protective Trip X in Inverter with Telecommunication

（1） Start the pole at minimum current in LAHORE, 303A (200MW), ramp rate 100A/min.

（2） Simulate **Valve short Circuit Protection Stage 2 TRIP** from the PPR/ O3_FUNCDCP2(8) software page in PPRA and PPRB in LAHORE station. change VSP_SETTING X3 from 1.5 to -1.5.

（3） Verify in LAHORE station:

1) X-block

2) Blocking of the converter with by-pass pair.

3) Trip of the AC circuit breaker(s) feeding the converter transformer

4) Open AC Filters breakers by RPC

5) Pole isolation

6) Start of breaker failure protection

7) Set lockout relay for the tripped AC circuit breaker(s)

（4） Verify in Matiari station:

1) Normal Y-stop sequence.

2) Open AC Filters breakers by RPC.

（5） Record and save all test data

3.3.5 Protective Trip Y in Inverter with Telecommunication

（1） Start the pole at minimum current in LAHORE, 303A (200MW), ramp rate 100A/min.

（2） Verify the pump A is in operation.

（3） Switch off the AC power supply for the pump A in the valve cooling system

（4） Verify the pump B is put into operation.

（5） Restore the AC power supply for the pump A in the valve cooling system

（6） Switch off the AC power supply for the pump B in the valve cooling system

（7） Verify the pump A is put into operation.

（8） Switch off the AC power supply for the pump A in the valve cooling system to simulate **Valve Cooling System Fault** in LAHORE.

（9） Verify in LAHORE station:

1) Y-block
2) Retard and blocking of the converter with by-pass pair
3) Trip of the AC circuit breaker(s) feeding the converter transformer
4) Open AC Filters breakers by RPC
5) Pole isolation
6) Set lockout relay for the tripped AC circuit breaker(s)

（10） Verify in Matiari station:

1) Normal Y-stop sequence.
2) Open AC Filters breakers by RPC.

（11） Record and save the test data.

3.3.6 Protective Trip Z in Inverter with Telecommunication

（1） Start the pole at minimum current in LAHORE, 303A (200MW), ramp rate 100A/min.

（2） Simulate **Pole Bus Differential Protection Stage 2 Action** from the **PPR** O3_FUNCDCP3(8) software page in PPRA and PPRC in pole 2 in

LAHORE station by alter **PBDP SETTING_X6** from '0.35' to '**-0.35**', **X7** from '0.2' to '**0**'

（3） Verify in LAHORE station:

1) Z-block
2) Blocking of the converter with by-pass pair
3) Trip of the AC circuit breaker(s) feeding the converter transformer
4) Pole Isolation
5) Open AC Filters breakers by RPC.
6) Set lockout relay for the tripped AC circuit breaker(s)
7) Start breaker failure protection

（4） Verify in Matiari station:

1) Normal Y-stop sequence.
2) Open AC Filters breakers by RPC.

（5） Record and save test log

3.3.7 Protective Trip Y in Rectifier without Telecommunication

（1） Start the pole at minimum current in Matiari, 303A (200MW), ramp rate 100A/min.

（2） Disable the telecommunication (both channels).

（3） Simulate Neutral bus capacitor overcurrent protection Action from the O3_FUNCDCP3(13) software page in PPRB and PPRC in pole 1 in Matiari station by change NCP_SETTING X3 to -120.

（4） Verify in Matiari station:

1) Y-block
2) Trip of the AC circuit breaker(s) feeding the converter transformer
3) Open AC Filters breakers by RPC
4) Pole isolation
5) Start breaker failure protection
6) Set lockout relay for the tripped AC circuit breaker(s)

（5） Verify in LAHORE station

1) Trip from **DC control monitoring function.**

2) Z-block order.

3) Pole isolation

4) Open AC Filters breakers by RPC

（6） Restore the telecommunication

（7） Record and save all test data.

3.3.8 Protective Trip Y in Inverter without Telecommunication

（1） Start the pole at minimum current in LAHORE, 303A (200MW), ramp rate 100A/min.

（2） Disable the telecommunication (both channels).

（3） Simulate Neutral bus capacitor overcurrent protection Action from the O3_FUNCDCP3(13) software page in PPRB and PPRC in pole 1 in Matiari station by change NCP_SETTING X3 to -120.

（4） Verify LAHORE:

1) Y-block

2) Retard and blocking of the converter with by-pass pair

3) Trip of the AC circuit breaker(s) feeding the converter transformer

4) Open AC Filters breakers by RPC

5) Pole isolation

6) Set lockout relay for the tripped AC circuit breaker(s)

（5） Verify in Matiari station:

1) Trip from **Pole Undervoltage Protection Action.**

2) Y-block order.

3) Pole isolation

4) Open AC Filters breakers by RPC

（6） Restore the telecommunication

（7） Record and save all test data

3.3.9 VBE Fault Protection Trip – Rectifier

（1） Verify the two sets of VBE system in stable operation

（2） Verify HVDC system is blocked and the converter transformer in Matiari has been energized.

（3） Verify VBEA is active.

（4） Switch off the power supply of VBEA .

（5） Verify VBE active system switch to VBEB.

（6） Restore the VBEA to standby status.

（7） Switch off the power supply of VBEB.

（8） Verify VBE active system switch to VBEA.

（9） Restore the VBEB to standby status.

（10） Pull out a certain number of **IP Optical Fibre Signal** in VBE device to simulate the **VBE Fault Trip** in Pole in rectifier station

（11） Verify in Matiari station:

1) Y-block

2) Trip of the AC circuit breaker(s) feeding the converter transformer

3) Start breaker failure protection

4) Set lockout relay for the tripped AC circuit breaker(s)

5) Pole isolation

（12） Verify in LAHORE station

1) Normal Y-stop sequence. (Order alpha as 90°, then block with BPPO)

（13） Record and save the test data

3.3.10 VBE Fault Protection Trip – Inverter

（1） Verify the two sets of VBE system in stable operation

（2） Verify HVDC system is blocked and the converter transformer in LAHORE has been energized.

（3） Verify VBEA is active.

（4） Switch off the power supply of VBEA .

（5） Verify VBE active system switch to VBEB.

（6） Restore the VBEA to standby status.

（7） Switch off the power supply of VBEB.

（8） Verify VBE active system switch to VBEA.

（9） Restore the VBEB to standby status.

（10） Pull out a certain number of **IP Optical Fibre Signal** in VBE device to simulate the **VBE Fault Trip** in Pole in rectifier station

（11） Verify in LAHORE station:

1) Y-block

2) Trip of the AC circuit breaker(s) feeding the converter transformer

3) Start breaker failure protection

4) Set lockout relay for the tripped AC circuit breaker(s)

5) Pole isolation

（12） Verify in Matiari station

1） Normal Y-stop sequence. (Order alpha as 90°, then block with BPPO)

（13） Record and save the test data

4 System Supervision and Switchover

4.1 Test Objective

The test objective is to check system supervision and control and protection system function when active system power failure ,main computer and profibus bus fault happen.

4.2 Preconditions

（1）Deblock and block tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system is capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[ ] Power Control	[X] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active

[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[ ] Power Control	[X] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

The following tests should be performed in one station at a time in order to verify the control system response when detecting possible faults during the test. Start in Matiari when finished the same tests in LAHORE.

4.3 Test Content and Procedure.

4.3.1 Active System Power Failure

（1） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min.

Matiari & LAHORE:

Notice: this test would be done for both poles in Matiari and LAHORE converter station.

（2） Switch off the power supply to PCPA (active system).

（3） Verify continuing steady operation of the transmission and that PCPB is active.

（4） Switch on the power supply to PCPA and then restore PCPA to standby status.

（5） Switch off the power supply to PCPB (active system).

（6） Verify continuing steady operation of the transmission and that PCPA is active.

（7） Switch on the power supply to PCPB and then restore PCPB to standby status.

（8） Verify that the switchover is smooth, undisturbed and within the expected time delays.

（9） Record and save all test data.

4.3.2 Profibus bus Failure

（1） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min.

Matiari & LAHORE:

Notice: this test would be done for both poles in Matiari and LAHORE converter station.

（2） Provoke a Profibus failure by removing the Slot 19, port X3 Profibus connections in active system (PCPA).

（3） Verify continuing steady operation of the transmission and that PCPB is active.

（4） Re-establish normal operation of main computer in PCPA and set PCPA to stand-by.

（5） Provoke a Profibus bus failure by removing the Slot 19, port X3 Profibus connections in active system (PCPB).

（6） Verify continuing steady operation of the transmission and that PCPA is active.

（7） Re-establish normal operation of main computer in PCPA and set PCPB to stand-by.

（8） Verify that the switchover is smooth, undisturbed and within the expected time delays.

（9） Record and save all test data.

4.3.3 LAN bus Failure

（1） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min.

Matiari & LAHORE:

Notice: this test would be done for both poles in Matiari and LAHORE converter station.

（2） Provoke a Control LAN bus failure by removing one of the Control LAN connections (Slot 20, port X5) in active system PCPA

（3） Verify:

- Alarm
- continuing normal operation of the transmission and that PCPA is active

（4） Remove the second Control LAN bus (Slot 21, port X5)

（5） Verify:

- System changeover
- Continuing normal operation of the transmission and that PCPB is active

（6） Re-establish normal operation of main computer, PCPB active

（7） Provoke a Control LAN bus failure by removing one of the Control LAN connections (Slot 20, port X5) connections in active system PCPB

（8） Verify:

- Alarm
- continuing normal operation of the transmission and that PCPB is active

（9） Remove the second Control LAN bus (Slot 21, port X5)

（10） Verify:

- System changeover
- Continuing normal operation of the transmission and that PCPA is active

（11） Re-establish normal operation of main computer, PCPA active

（12） Record and save all test data.

5 Steady State Operation, Joint Current Control, Normal Power Direction

5.1 Test Objective

The test objective is to check the control system performance and dynamic performance of current controller under current control mode.

5.2 Preconditions

（1）Deblock and block tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system is capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[ ] Power Control	[X] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active

[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[ ] Power Control	[X] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

5.3 Test Content and Procedure.

5.3.1 Current Ramping and Hold on

（1） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min.

Matiari:

（2） Ramp current from 303A to 500A at 100A/min ramp speed.

（3） Verify that the current reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（4） Verify also that the ramp could stop while ramping is in progress by executing the following actions:

1) Order **STOP RAMPING**.

2) Transfer the MASTER station to LAHORE (to be carried out at LAHORE)

（5） Ramp current from 500A to 800A at 999A/min ramp speed.

（6） Verify that the current reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（7） Ramp current from 800A to 500A at 999A/min ramp speed.

（8） Verify that the current reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

LAHORE:

（9） Confirm Lahore is **MASTER** station.

（10） Order the current ramp down from 500A to 303A at 100A/min ramp rate.

（11） Verify that the current reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（12） Verify also that the ramp could stop while ramping is in progress by executing the following actions:

1) Order **STOP RAMPING**.

2) Transfer the MASTER station to Matiari (to be carried out at Matiari)

（13） Ramp current from 303A to 500A at 999A/min ramp speed.

（14） Verify that the current reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（15） Ramp current from 500A to 303A at 999A/min ramp speed.

（16） Verify that the current reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（17） Record and save test data.

5.3.2 System Switchover and Telecommunication Failure During Current Ramping

（1） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min.

LAHORE:

（2） Ramp current from 303A to 500A at 100A/min ramp speed.

（3） Initiate a manual switchover from PCPA to PCPB and then from PCPB to PCPA while ramping is in progress.

（4） Verify that the current reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（5） Order **TRANSFER TO POWER CONTROL** while ramping is in progress and verify that there is no transfer during the current ramping and no transient change in current.

Matiari:

（6） Initiate the sequence of **MASTER** station.

（7） Ramp current from 500A to 303A at 100A/min ramp speed.

（8） Initiate a manual switchover from PCPA to PCPB, and then from PCPB to PCPA while ramping is in progress.

（9） Disabled the telecommunication in both channels during the ramping process.

（10） Verify:

1) The BSC mode would be automatically activated.

2) The ramping rate would be reduced but the ramp would continue, and the current reference value would be reached when the telecommunication is disabled,

（11） Restore the telecommunication.

（12） Record and save all test data

5.3.3 Tap Changer Control, Manual Tap Changer Stepping

（1） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min.

Matiari:

（1） Set tap changer control in **MANUAL CONTROL** mode and raise two steps for increasing U_{di0}.

（2） Verify the firing angle is increased and the transmitted current is maintained.

（3） Set the tap changer control back to **AUTO CONTROL** mode.

（4） Verify that:

1) The tap changer would automatically decrease.
2) Firing angle back within control limits.
3) The transmitted current is maintained.

LAHORE:

（5） Set tap changer control in **MANUAL CONTROL** mode and lower two steps for decreasing U_{di0}.

（6） Verify:

1) Decreased DC voltage
2) Gamma (γ) in LAHORE is maintained.
3) The transmitted current is maintained.

（7） Set the tap changer control back to **AUTO CONTROL** mode.

（8） Verify that:

1) The tap changer would automatically increase.
2) Firing angle back within control limits.
3) DC voltage back to nominal value.
4) The transmitted current is maintained.

（9） Record and save test data.

5.3.4 Current Step Test

（1） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min.

（2） Ramp current from 303A to 500A at 100A/min ramp speed.

Matiari:

（3） Apply a +0.08 p.u. step in current order with the duration of 1000 ms in active PCP system by executing the following actions:

1) In **PCP/CPU3/C04_COCDC/P12** software page.
2) Change the **I_STP.X1** from **‘1.0’** to **‘0.245’**.(500/3030+0.08)
3) Change the **ISTP.I** from **‘0’** to **‘1’**.

（4） Record the current response and the overshoots.

（5） Change all the modified settings back to original value.

（6） Record and save all test data.

5.3.5 Voltage Step Test

（1） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min.

（2） Ramp current from 303A to 500A at 100A/min ramp speed.

LAHORE:

（3） Apply a -10% step in voltage order with the duration of 1000 ms in active PCP system by executing the following actions:

1) In **PCP/CPU3/ C08_WUD /P19** software page.
2) Change **WUDSTP.X2** from '**1.00**'to'**0.9**'.
3) Change the **USTEP.I from** '**0**'to '**1**'.

（4） Record the voltage response and the overshoots.

（5） Change all the modified settings back to original value.

（6） Record and save all test data.

5.3.6 Angle γ Step Test

（1） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min.

（2） Ramp current from 303A to 500A at 100A/min ramp speed.

LAHORE:

（3） Apply a +10 deg step to the extinction angle with the duration of 1000 ms in active PCP system by executing the following actions:

1) In **PCP/CPU5/E04_AMAX/P6** software page.
2) Change the **AGAM35.X2** from '0.18889' to '**0.3**'.
3) Change **GAMMAS_STEP10.I** from '0'to '**1**'.

（4） Record the response time and overshoot of the extinction angle.

（5） Change all the modified settings back to original value.

（6） Record and save all test data.

5.3.7 Control Mode Shift, Current Margin Compensation

（1） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min.

（2） Ramp current from 303A to 500A at 100A/min ramp speed.

Matiari and LAHORE:

（3） Set tap changer control in **MANUAL CONTROL** mode.

Matiari:

（4） Force a control mode shift by decreasing the tap changer until the inverter starts to control current

（5） Verify:

Matiari:

1） Alarm(CMC active warning).

2） Firing angle in Matiari at the minimum value.

3） The transmitted current is maintained.

LAHORE:

1） The symbol **'DCON200/YCS'** in **PCP/CPU5/E05_CC_C1/Page 16** software page in LAHORE is turned to be 2.

2） The symbol '**CMC200/Y**' in **PCP/CPU3/C03_COC_PC/Page 5** software page in LAHORE turn to be '0.1p.u.'.

3） The transmitted current is maintained.

4） Current order is increased to compensate the current margin.

（6） Set the tap changer control back to **AUTO CONTROL** mode.

（7） Verify:

1） The tap changer would automatically increase. 2

） Firing angle back within control limits.

3） The transmitted current is maintained.

4） The rectifier starts to control the transmitted current.

（8） Ramp current from 500A to 303A at 100A/min ramp speed.

（9） Record and save all test data.

6 Steady State Operation, Joint Power Control, Normal Power Direction

6.1 Test Objective

The test objective is to check control system performance under power control mode.

6.2 Preconditions

（1）Deblock and block tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active

[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

6.3 Test Content and Procedure.

6.3.1 Start/Stop Pole

（1） Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a ‘Ready for Operation’ condition.

（2） Verify both stations in ‘Ready for Operation’ condition.

（3） Start the pole at minimum power, 200MW (303A), ramp rate 50MW/min.

（4） Verify steady performance indicators

（5） Stop the pole.

（6） Record and save all test data.

6.3.2 System Switchover and Telecommunication Failure During Power Ramping

（1） Start the pole at minimum power, 200MW (303A), ramp rate 50MW/min.

Matiari:

（2） Ramp power from 200MW to 400MW at 50MW/min ramp rate.

（3） Initiate a manual switchover from PCPA to PCPB and then from PCPB to PCPA while ramping is in progress.

（4） Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（5） Verify also that the ramp could stop while ramping is in progress by executing the following actions:

1) Order **STOP RAMPING**.

2) Transfer the MASTER station to LAHORE (to be carried out at LAHORE)

(6) Order **TRANSFER TO CURRENT CONTROL** while ramping is in progress and verify that there is no transfer during the power ramping and no transient change in power.

(7) Ramp power from 400MW to 500MW at 999MW/min ramp speed.

(8) Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

(9) Ramp power from 500MW to 400MW at 999MW/min ramp speed.

(10) Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

LAHORE:

(11) Confirm **MASTER** station at Lahore.

(12) Ramp power from 400MW to 200MW at 50MW/min ramp rate.

(13) Initiate a manual switchover from PCPA to PCPB, and then from PCPB to PCPA while ramping is in progress.

(14) Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

(15) Verify also that the ramp could stop while ramping is in progress by executing the following actions:

1) Order **STOP RAMPING**.

(16) Ramp power from 200MW to 400MW at 999MW/min ramp speed.

(17) Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（18） Ramp power from 400MW to 200MW at 999MW/min ramp speed.

（19） Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

Matiari:

（20） Initiate the sequence of **MASTER** station.

（21） Order the power ramp up and down at 50MW/min ramp rate, between 200MW and 400MW.

（22） Disabled the telecommunication in both channels during the ramping process

（23） Verify:

1) The **BSC** mode is automatically activated.

2) The ramping would be continuing and the power reference value would be reached when the telecommunication is disabled,

（24） Restore the telecommunication.

（25） Record and save all test data

6.3.3 Power Step Test

（1） Start the pole at minimum power, 200MW (303A), ramp rate 50MW/min.

（2） Ramp power from 200MW to 400MW at 50MW/min ramp rate.

Matiari:

（3） Apply a +0.08 p.u. step in power order with duration 1000ms in active system from **PCP/CPU3/C04_COCDC/P12** software page by executing the following actions:

4) Change the **SP_STP.X2** from **‘1.0’** to **‘0.28’ (400/2000+0.08)**.

5) Change the **ISTP.I** from ‘**0**’ to ‘**1**’.

（4） Record the power response and the overshoot.

（5） Record and save all test data

6.3.4 Control Mode Shift, Current Margin Compensation

（1） Start the pole at minimum power, 200MW (303A), ramp rate 50MW/min.

（2） Ramp power from 200MW to 400MW at 50MW/min ramp rate.

Matiari and LAHORE:

（3） Set tap changer control in **MANUAL CONTROL** mode.

Matiari:

（4） Force a control mode shift by decreasing the tap changer until the inverter starts to control current

（5） Verify:

Matiari:

1） Alarm(CMC active warning).

2） Firing angle in Matiari at the minimum value.

3） The transmitted current is maintained.

LAHORE:

1） The symbol **'DCON200/YCS'** in **PCP/CPU5/E05_CC_C1/Page 16** software page in LAHORE is turned to be 2.

2） The symbol '**CMC200/Y**' in **PCP/CPU3/C03_COC_PC/Page 5** software page in LAHORE turn to be '0.1p.u.'.

（6） Set the tap changer control back to **AUTO CONTROL** mode.

（7） Verify:

1） Tap changer would automatically increase. 2

） Firing angle back within control limits.

3） The rectifier starts to control the transmitted current.

（8） Ramp power from 400MW to 200MW at 50MW/min ramp rate.

（9） Record and save all test data.

7 Normal Operation, Separate Current Control without Telecommunication

7.1 Test Objective

The test objective is to check control system performance under BSC control mode.

7.2 Preconditions

（1）Deblock and block tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[ ] With TCOM	[X] Without TCOM
[ ] Power Control	[X] Current Control
[ ] Joint Control	[X] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X]Q control	[ ]U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.

[ ] With TCOM	[X] Without TCOM
[ ] Power Control	[X] Current Control
[ ] Joint Control	[X] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

7.3 Test Content and Procedure.

7.3.1 Start/Stop Pole

（1） Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a '**Ready for Operation**' condition.

（2） Disable the telecommunication with the guidance of the technical personnel from XUJI company.

（3） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min, communicating by phone. First deblock inverter, then deblock rectifier.

（4） Verify that a normal start occurred.

（5） Stop the pole. First block rectifier, then block inverter.

（6） Verify that a normal stop occurred.

（7） Restore the telecommunication.

（8） Record and save all test data.

7.3.2 System Switchover During Current Ramp

（1） Disable the telecommunication with the guidance of the technical personnel from XUJI company.

（2） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min, communicating by phone. First deblock inverter, then deblock rectifier.

Matiari:

（3） Ramp current from 303A to 500A at 100A/min ramp speed.

（4） Initiate a manual switchover from PCPA to PCPB and then from PCPB to PCPA while ramping is in progress.

（5） Verify that the current reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（6） Verify also that the ramp could stop while ramping is in progress by executing the following actions:

1） Order **STOP RAMPING**.

（7） Order **TRANSFER TO POWER CONTROL** while ramping is in progress and verify that there is no transfer during the current ramping and no transient change in DC current.

（8） Ramp current from 500A to 303A at 100A/min ramp speed.

（9） Record and save all test data.

8 Normal/Reduced Voltage, Normal Power Direction

8.1 Test Objective

The test objective is to check steady state and dynamic control system performance under reduced voltage operation mode.

8.2 Preconditions

（1）Deblock and block tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X]Q control	[ ] U control
[ ] Normal volt.	[X] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.

[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[ ] Normal volt.	[X] Reduced volt.
[X] Ground Return	[ ] Metallic Return

8.3 Test Content and Procedure.

8.3.1 Manual/Protection Triggering Reduced Voltage

We have advised that the second reduced voltage point is 85%

Matiari:

(1) Set manually **REDUCED VOLTAGE** mode (85% of nominal voltage).

(2) Start the pole at minimum power, 200MW 379A), ramp rate 50MW/min.

(3) Verify that the pole starts smoothly at the reduced voltage level specified above.

(4) Set manually **REDUCED VOLTAGE** mode (70% of nominal voltage).

(5) Verify that the DC voltage is ramping down from 85% to 70% without change in power

(6) Order **NORMAL VOLTAGE**.

(7) Verify that the DC voltage is ramping up to normal voltage without change in power.

(8) Stop the pole.

LAHORE:

(9) Initiate the sequence of **MASTER** station.

(10) Set manually **REDUCED VOLTAGE** mode (70% of nominal voltage).

(11) Start the pole at minimum power, 200MW (433A), ramp rate 50MW/min.

(12) Verify that the pole starts smoothly at the reduced voltage level specified above.

(13) Order **NORMAL VOLTAGE**.

(14) Verify that the DC voltage is ramping up to normal voltage without change in power.

Matiari:

(15) Initiate the sequence of **MASTER** station.

(16) Order **REDUCED VOLTAGE** (70% of nominal voltage).

(17) Verify that the DC voltage is ramping down to reduced voltage without change in power.

(18) Order **NORMAL VOLTAGE**.

(19) Verify that the DC voltage is ramping up to normal voltage without change in power.

LAHORE:

(20) Initiate the sequence of **MASTER** station.

(21) Order **REDUCED VOLTAGE** (70% of nominal voltage).

(22) Verify that the DC voltage is ramping down to reduced voltage without change in power.

(23) Order **NORMAL VOLTAGE**.

(24) Verify that the DC voltage is ramping up to normal voltage without change in power.

Matiari:

(25) Initiate the sequence of **MASTER** station.

(26) Set **REDUCED VOLTAGE** from the DC-line Protection (70% of nominal voltage) by executing the following actions:

1) In **Matiari/PCP/CPU3/C06_CONV_CONTORL/Page 18** software page, change UDSETTING/X1 from '**1.0**' to '**0.7**'.

2) In **Matiari/PCP/CPU3/C06_CONV_CONTORL/Page 11** software page, change TEST_DCLF30/I2 from '0' to '1'.

(27) Verify that the voltage is sharply ramping down to the reduced voltage without change in power.

(28) Change all the modified settings back to original value, verify no change in dc voltage.

(29) Disable the telecommunication.

(30) Verify:

1) No disturbances in the power transmission.

2) Voltage remained steady at **REDUCED VOLTAGE** level.

(31) Restore the telecommunication.

LAHORE:

(32) Initiate the sequence of **MASTER** station.

(33) Order **NORMAL VOLTAGE**.

(34) Verify that the DC voltage is ramping up to normal voltage without change in power.

(35) Stop the pole.

(36) Record and save all test data.

8.3.2 Power/Current Ramp

Matiari:

(1) Start the pole at minimum power, 200MW (303A), ramp rate 50MW/min.

(2) Order **REDUCED VOLTAGE** (70% of nominal voltage).

(3) Ramp power from 200MW to 400MW at 50MW/min ramp rate.

(4) Order **TRANSFER TO CURRENT CONTROL** while ramping is in progress and verify that there is no transfer during the ramping and no transient change in power.

(5) Verify:

1) No disturbances in the power transmission.

2) Voltage remained steady at **REDUCED VOLTAGE** level during ramping.

(6) Order **NORMAL VOLTAGE**.

(7) Manually switch from PCPA to PCBB and Back to PCPA during the voltage ramp.

LAHORE:

（8） Initiate the sequence of **MASTER** station.

（9） Order **REDUCED VOLTAGE** (70% of nominal voltage).

（10） Ramp power from 400MW to 200MW at 50MW/min ramp rate.

（11） Verify:

1) No disturbances in the power transmission.

2) Voltage remained steady at Reduced Voltage level during ramping.

（12） Order **NORMAL VOLTAGE**.

（13） Manually switch from PCPA to PCBB and Back to PCPA during the voltage ramp.

（14） Record and save all test data.

9 Reactive Power Control, Normal Power Direction

9.1 Test Objective

The test objective is to check reactive power and AC voltage control performance of DC system.

9.2 Preconditions

（1）Deblock and block tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control

[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

9.3 Test Content and Procedure.

9.3.1 Filter Requirement

（1） Start the pole at minimum power, 200MW (303A), ramp rate 50MW/min.

（2） Verify that the sub-banks corresponding to the minimum filter requirement are automatically connected before the converters are deblocked.

Matiari:

1） One sub bank BP11/13 and one sub bank HP24/36 connected.

LAHORE:

1） One sub bank HP12/24 connected.

（3） Ramp power from 200MW to 750MW at 50MW/min ramp rate.

（4） Verify the required filter in each station has been input by reactive power control.

（5） Ramp power from 750MW to 200MW at 50MW/min ramp rate.

（6） Record and save all test data.

9.3.2 Filter Replacement

（1） Start the pole at minimum power, 200MW (303A), ramp rate 50MW/min.

（2） Verify that the sub-banks corresponding to the minimum filter requirement are automatically connected before the converters are deblocked.

（3） Order **RPC MANUAL.**

Matiari:

1) Switch off one sub-bank BP11/13 that was connected by the RPC.
2) Verify that another sub-bank BP11/13 is connected within 1 sec.
3) Switch off one sub-bank HP24/36 that was connected by the RPC.
4) Verify that another sub-bank HP24/36 is connected within 1 sec.

LAHORE:

1) Switch off one sub-bank HP12/24 that was connected by the RPC.
2) Verify that another sub-bank HP12/24 is connected within 1 sec.

（4） Order **RPC AUTO.**

（5） Record and save all test data

9.3.3 Reactive Power Control

（1） Start the pole at minimum power, 200MW (303A), ramp rate 50MW/min.

（2） Ramp power from 200MW to 400MW at 50MW/min ramp rate.

（3） Verify Q control works in LAHORE station.

LAHORE:

1) With the guidance of the technical personnel from XUJI Company, change the Q-reference (Q-reference should subject to the prevailing situation) in order to provoke a filter switching ON by the RPC.
2) Verify that an AC filter is switched ON accordingly.
3) Restore the Q-reference,

（4） Record and save all test data.

（5） Sign test records after test completion.

9.3.4 Voltage Control

（1） Start the pole at minimum power, 200MW (303A), ramp rate 50MW/min.

（2） Ramp power from 200MW to 400MW at 50MW/min ramp rate.

（3） Verify U control works in Matiari station.

Matiari:

1) With the guidance of the technical personnel from XUJI Company, change the U-reference (U-reference should subject to the prevailing situation) in order to provoke a filter switching ON by the RPC

2) Verify that an AC filter is switched ON accordingly

3) Restore the U-reference

（4） Record and save all test data.

（5） Sign test records after test completion.

9.3.5 Umax Control

（1） Start the pole at minimum power, 200MW (303A), and order the power ramp to 500MW at 100MW/min.

Matiari:

1) Decrease the Umax upper limit value to a value which is lower than AC voltage.

2) With the guidance of the technical personnel from XUJI Company, change the U-reference in order to provoke a filter switching ON by the RPC.

3) Verify that there is no more input filter in Matiari station because of Umax limit.

4) Increase the Umax upper limit value to a value which is higher than AC voltage.

5) Verify that one sub bank BP11/13 in Matiari station switching on.

6) Restore the Umax upper limit value and U-reference to the initial setting value.

LAHORE:

1) Decrease the Umax upper limit value to a value which is lower than AC voltage.

2) With the guidance of the technical personnel from XUJI Company, change the U-reference in order to provoke a filter switching ON by the RPC.

3) Verify that there is no more input filter in LAHORE station because of Umax limit.

4) Increase the Umax upper limit value to a value which is higher than AC voltage.

5) Verify that one sub bank HP12/24 in LAHORE station switching on.

6) Restore the Umax upper limit value and U-reference to the initial setting value.

（2） Record and save all test data.

10 Ground/Metallic Return Transfer

10.1 Test Objective

The test objective is to check transfer sequence of Ground/Metallic Return configuration.

10.2 Preconditions

（1）Deblock and block tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system is capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[ ] Power Control	[X] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.

[X] With TCOM	[ ] Without TCOM
[ ] Power Control	[X] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

10.3 Test Content and Procedure

10.3.1 Ground/Metallic Return Transfer

（1） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min.

（2） Verify that the other pole is isolated and both stations are ready for metallic return operation.

（3） Order **TRANSFER TO METALLIC RETURN**.

（4） Verify:

1） Correct sequential operation of switches and breakers.

2） Correct operation of **MRTB** in Matiari (The operation of the breaker should be visually observed carefully in case that the sequence is interrupted by maloperation)

3） No disturbance in power transfer.

4） Check whether all related switches and breakers in Matiari and LAHORE are correctly operated in line with the technical specification.

（5） Order **TRANSFER TO GROUND RETURN**.

（6） Verify:

1） Correct sequential operation of switches and breakers.

2） No disturbance in power transfer.

3） Correct operation of **GRTS** in Matiari (The operation of the breaker should be visually observed carefully in case that the sequence is interrupted by maloperation).

4） Check whether all related switches and breakers in Matiari and LAHORE are correctly operated in line with the technical specification.

（7） Order **TRANSFER TO METALLIC RETURN** again.

（8） During GR→MR, Initiate a manual switchover from PCPA to PCPB, and then from PCPB to PCPA in Matiari station.

（9） Verify:

1） System GR/MR transfer Normally and no transient changes in DC current in Matiari.

（10） Order **TRANSFER TO GROUND RETURN** again.

（11） Verify:

1） System MR/GR transfer Normally and no transient changes in DC current in LAHORE.

（12） Record and save all test data

10.3.2 Metallic Return Operation with Station Ground at LAHORE Converter Station

（1） Order **TRANSFER TO METALLIC RETURN**.

（2） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min..

（3） Simulate **Electrode Line Open Circuit Protection Zone I Action** by executing the following action, and then the NBGS would be automatically closed in LAHORE:

1) In **POLE_PROT/POLEPR/ELOCP_1** software page, alter **ELOCP_TM1_1** from '**60s**' to '**6s**'

2) Alter **ELOCP_TM1_2** from '**90s**' to '**900s**'

3) In **POLE_PROT/POLEPR/ELOCP_SETP,** Alter **ELOCP_REF1_2** from '**22kV**' to '**0**'

（4） Order **OPEN (WN3Q11)** manually.

（5） Stop the pole.

（6） Verify DC system is in metallic return mode and LAHORE station operates with station ground

（7） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min..

（8） Verify that a normal start occurred

（9） Stop the pole.

（10） Restore the settings.

（11） Manually order **Close WN3Q11** and then **Open NBGS.**

（12） Record and save all test data.

11 Initial Operation Tests, Ground Return Operation, Reversed Power Direction

11.1 Test Objective

Verify the basic function of deblock/block, manually switchover of control and protection system.

11.2 Preconditions

（1）Deblock and block tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[ ] Normal Pow. Dir.	[X] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[ ] Power Control	[X] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active

[ ] Normal Pow. Dir.	[X] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[ ] Power Control	[X] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

11.3 Test Content and Procedure

11.3.1 Start/Stop Pole

（1） Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a **'Ready for Operation'** condition.

（2） Verify both stations in **'Ready for Operation'** condition.

（3） Start the pole at minimum current, reversed power direction, 303A (200MW), ramp rate 100A/min.

（4） Verify steady performance indicators

1） Matiari: γ=17°

2） LAHORE: from retard to α=15°±2.5° (these values are approximate).

3） Record the preliminary data of DC voltage and valve voltages.

（5） Verify stable operation at minimum current.

（6） Perform normal inspections (visual and acoustical) while pole is deblocked.

（7） Verify RPC operation and whether minimum filter connected in line with technical specification:

1) LAHORE: one sub bank HP12/24

2) Matiari: one sub bank BP11/13 and one sub bank HP24/36

（8） Stop the pole, verify

1) LAHORE: Retard, Reduced current→Block without BPP

2) Matiari: Order alpha as 90° →Block with BPP

（9） Record and save all test data.

11.3.2 Control System Switchover

（1） Start the pole at minimum current in Matiari, reversed power direction, 303A (200MW), ramp rate 100A/min.

（2） Verify the PCPA system is active in Matiari station.

（3） Switch the active system from PCPA (active system) to PCPB, from SCA (active system) to SCB in Matiari station.

（4） Verify continuing steady operation of the transmission and that PCPB is active, no transients at switchover.

（5） Switch the active system from PCPB (active system) to PCPA, from SCB (active system) to SCA in Matiari station.

（6） Verify continuing steady operation of the transmission and that PCPA is active.

（7） Repeat the above procedure in LAHORE.

（8） Record and save test data.

（9） Sign test record after test completion.

11.3.3 Ground/Metallic Return Transfer

（1） Start the pole at minimum current in Matiari, reversed power direction, 303A (200MW), ramp rate 100A/min.

（2） Verify that the other pole is isolated and both stations are ready for metallic return operation.

（3） Order **TRANSFER TO METALLIC RETURN.**

（4） Verify:

1) Correct sequential operation of switches and breakers.

2) Correct operation of **MRTB** in Matiari (The operation of the breaker should be visually observed carefully in case that the sequence is interrupted by maloperation)

3) No disturbance in power transfer.

4) Check whether all related switches and breakers in Matiari and LAHORE are correctly operated in line with the technical specification.

（5） Order **TRANSFER TO GROUND RETURN.**

（6） Verify:

1） Correct sequential operation of switches and breakers. 2

） No disturbance in power transfer.

3) Correct operation of **GRTS** in Matiari (The operation of the breaker should be visually observed carefully in case that the sequence is interrupted by maloperation).

4) Check whether all related switches and breakers in Matiari and LAHORE are correctly operated in line with the technical specification.

（7） Record and save all test data

12 Joint Power Control, Metallic Return Operation, Reversed Power Direction

12.1 Test Objective

Verify the basic function of deblock/block, manually switchover of control and protection system.

12.2 Preconditions

（1）Deblock and block tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[ ] Normal Pow. Dir.	[X] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X]Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[ ] Ground Return	[X] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active

[X] PCP A Active	[ ] PCP B Active
[ ] Normal Pow. Dir.	[X] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[ ] Ground Return	[X] Metallic Return

12.3 Test Content and Procedure

12.3.1 Start/Stop Pole, Joint Power Control

（1） Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a ‘Ready for Operation’ condition.

（2） Verify both stations in ‘Ready for Operation’ condition.

（3） Order **TRANSFER TO METALLIC RETURN.**

（4） Start the pole at minimum power, reversed power direction, metallic return operation, 200MW (303A), ramp rate 50MW/min.

（5） Verify steady performance indicators

1） Matiari: γ=17°

2） LAHORE: from retard to α=15°±2.5° (these values are approximate).

3） Record the preliminary data of DC voltage and valve voltages.

（6） Verify stable operation at minimum power.

（7） Perform normal inspections (visual and acoustical) while pole is deblocked.

（8） Verify RPC operation and whether minimum filter connected in line with technical specification:

1） LAHORE: one sub bank HP12/24

2） Matiari: one sub bank BP11/13 and one sub bank HP24/36

（9） Record and save all test data

12.3.2 Control System Switchover

（1） Start the pole at minimum power in Matiari, reversed power direction, 200MW (303A), ramp rate 50MW/min.

（2） Verify the PCPA system is active in Matiari station.

（3） Switch the active system from PCPA (active system) to PCPB, from SCA (active system) to SCB in Matiari station.

（4） Verify continuing steady operation of the transmission and that PCPB is active, no transients at switchover.

（5） Switch the active system from PCPB (active system) to PCPA, from SCB (active system) to SCA in Matiari station.

（6） Verify continuing steady operation of the transmission and that PCPA is active.

（7） Verify the PCPA system is active in LAHORE station.

（8） Switch the active system from PCPA (active system) to PCPB, from SCA (active system) to SCB in LAHORE station.

（9） Verify continuing steady operation of the transmission and that PCPB is active, no transients at switchover.

（10） Switch the active system from PCPB (active system) to PCPA, from SCB (active system) to SCA in LAHORE station.

（11） Verify continuing steady operation of the transmission and that PCPA is active.

（12） Stop the pole, verify

1） LAHORE: Retard, Reduced current→Block without BPP

2） Matiari: Order alpha as 90° →Block with BPP

（13） Record and save all test data.

13 Control Pulse Loss Failure, Normal Power Direction

13.1 Test Objective

The test objective is to check the DC system operation and system switchover during control pulse loss failure.

13.2 Preconditions

（1）Deblock and block tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.

[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

13.3 Test Content and Procedure

13.3.1 Multiple (>5) Pulses Loss Fault at Inverter in Ground Return

LAHORE:

(1) Start the pole at minimum power, 200MW (303A)

(2) With the guidance of technical personnel from XUJI Company, Simulate more than five consecutive firing pulses loss in LAHORE by pulling out a CP signal optical fiber from PCP A system to VBE A system. PCP B system is out of service.

(3) Verify:

LAHORE:

1) Advancing of γ

2) Switch to the standby pole control system

3) Y-block of the converter.

4) Trip of the AC circuit breaker(s) feeding the converter transformer.

5) Pole isolation.

6) Open AC Filters breakers by RPC.

7) Start breaker failure protection.

8) Set lockout relay for the tripped AC circuit breaker(s).

Matiari:

1) Lock the DC-line protection.

2) Y-block of the converter.

3) Open AC Filters breakers by RPC.

(4) Restore the optical fibre(s).

(5) Record and save all test data.

13.3.2 Multiple (>5) Pulses Loss Fault at Inverter in Metallic Return

(1) Transfer the pole from ground return to metallic return mode when the pole is blocked.

(2) Start the pole at minimum power, 200MW (303A)

(3) Simulate more than five consecutive firing pulses loss in LAHORE. by pulling out a CP signal optical fiber from PCP B system to VBE B system. PCP A system is out of service.

(4) Verify:

LAHORE:

1) Advancing of γ

2) Switch to the standby pole control system

3) Y-block of the converter.

4) Trip of the AC circuit breaker(s) feeding the converter transformer.

5) Pole isolation.

6) Open AC Filters breakers by RPC.

7) Start breaker failure protection.

8) Set lockout relay for the tripped AC circuit breaker(s).

Matiari:

1) Lock the DC-line protection.

2) Y-block of the converter.

3) Open AC Filters breakers by RPC.

(5) Restore the optical fibre(s).

(6) Record and save all test data.

13.3.3 Multiple (>5) Pulses Loss Fault at Rectifier in Ground Return

(1) Start the pole at minimum power, 200MW (303A)

(2) With the guidance of technical personnel from XUJI Company, Simulate more than five consecutive firing pulses loss in **Matiari**. by pulling out a CP signal optical fiber from PCP B system to VBE B system. PCP A system is out of service.

(3) Verify:

Matiari:`

1) Switch to the standby pole control system
2) Y-block of the converter.
3) Trip of the AC circuit breaker(s) feeding the converter transformer.
4) Pole isolation.
5) Open AC Filters breakers by RPC.
6) Start breaker failure protection.
7) Set lockout relay for the tripped AC circuit breaker(s).

Lahore:

1) Normal Y-stop sequence.
2) Open AC Filters breakers by RPC.

(4) Restore the optical fibre(s).

(5) Record and save all test data.

14 Disturbances

14.1 Test Objective

The test objective is to check the DC system to keep steady operation during disturbance.

14.2 Preconditions

（1）Deblock and block tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.

[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

14.3 Test Content and Procedure

14.3.1 DC Filter Switching

Notice: this test would be done in Matiari and LAHORE for both poles.

（1） Set manually **REDUCED VOLTAGE** mode (70% of nominal voltage).

（2） Start the pole at minimum power, 200MW (433A), ramp rate 50MW/min.

（3） Verify that the pole starts smoothly at the reduced voltage level specified above.

LAHORE and Matiari:

1) Verify the switches of DC filter are closed.
2) Initiate the sequence of **DC Filter Isolation**;
3) Initiate the sequence of **DC Filter Connection**;
4) Verify that there are no disturbances to the power transmission.

（3） Order **NORMAL VOLTAGE.**

（4） Verify that the DC voltage is ramping up to normal voltage without change in power.

（5） Record and save all test data

14.3.2 Loss of 125V DC System C of Pole

（1） Start the pole at minimum power, 200MW (303A)

Matiari and LAHORE:

（2） Switch the incoming to 125 V DC distribution board C (EC1), from system A (U1) to system B (U2), alternative from system B to system A depending on present pre-conditions.

（3） Verify:

1） Continuing Normal operation of power transmission.

（4） Switch the incoming to 125 V DC distribution board C (EC1), from system B (U2) to system A (U1), alternative from system A to system B depending on present pre-conditions.

（5） Verify:

1） Continuing Normal operation of power transmission.

（6） Record and save all test data.

14.3.3 Loss of 125V DC System A of Pole

（1） Start pole at minimum power, 200MW (303A), ramp to 300MW at 50MW/min.

Matiari and LAHORE:

（2） Open the 125 V DC system A main switch.

（3） Verify:

1) Continuing Normal operation of power transmission.

（4） Re-close the 125 V DC system A main switch.

（5） Verify:

1) Continuing Normal operation of power transmission.

（6） Record and save all test data.

14.3.4 Loss of 125V DC System B of Pole

（1） Start pole at min power, ramp to 300MW at 50MW/min.

Matiari and LAHORE:

（2） Open the 125 V DC system B main switch.

（3） Verify:

1） Continuing Normal operation of power transmission.

（4） Re-close the 125 V DC system B main switch.

（5） Verify:

2） Continuing Normal operation of power transmission.

（6） Record and save all test data.

14.3.5 Simulated DC Line Fault (only Matiari)

Note: This test could with advantage be performed in DC line fault test.

（1） Start the pole at minimum current, 303A (200MW), ramp rate 100A/min.

（2） Simulate a **DC Line Fault** by activating the DC line protection in PCPA in Matiari by executing the following action:

2) In **MATIARI/PCP/CPU3/C06_CONV_CONTORL/Page 11** software page, change TEST_DCLF30/I2 from ‘0’ to ‘1’.

（1） Verify the firing angle has been retarded in Matiari station.

（2） Verify that the system quickly recovers within the expected time delays.

（3） Change all the modified settings back to original value.

（4） Record and save all test data.

14.3.6 Simulate Fault of Converter Transformer PT Breaking at Matiari station

（1） Start the Pole at minimum power, 200MW (303A), ramp rate 50MW/min.

（2） Verify pole in **Power Control Mode** respectively.

（3） Switchover the active system to check the PCPA and PCPB are healthy.

Matiari:

（4） Verify the PCPA system is active in pole.

（5） Simulate **Fault of Converter Transformer PT Breaking** in active system at Matiari station by pulling out the cable which connected the secondary circuit of converter phase A PT and **CTP A** with the guidance of technical personnel from XUJI and HDPTTE.

（6） Verify:

1) Low AC Voltage Detected On

2) Pole System Switchover by Low AC Voltage On

（7） Restore the cable, and then verify the PCPA would automatically restore to standby status and PCPB is the active system.

（8） Simulate **Fault of Converter Transformer PT Breaking** in active system at Matiari station by pulling out the cable which connected the secondary circuit of converter phase A PT and **CTP B** with the guidance of technical personnel from XUJI and HDPTTE.

（9） Verify:

1) Low AC Voltage Detected On

2) Pole System Switchover by Low AC Voltage On

（10） Restore the cable, and then verify the PCPB would automatically restore to standby status and PCPA is the active system.

（11） Record and save all test data

14.3.7 Simulate Fault of Converter Transformer PT Breaking at LAHORE station

（1） Start the Pole at minimum power, 200MW (303A), ramp rate 50MW/min.

（2） Verify pole in **Power Control Mode** respectively.

（3） Switchover the active system to check the PCPA and PCPB are healthy.

Lahore:

（4） Verify the PCPA system is active in pole.

（5） Simulate **Fault of Converter Transformer PT Breaking** in active system at Matiari station by pulling out the cable which connected the secondary circuit of converter phase A PT and **CTP A** with the guidance of technical personnel from XUJI and HDPTTE.

（6） Verify:

1) Low AC Voltage Detected On

2) Pole System Switchover by Low AC Voltage On

（7） Restore the cable, and then verify the PCPA would automatically restore to standby status and PCPB is the active system.

（8） Simulate **Fault of Converter Transformer PT Breaking** in active system at Matiari station by pulling out the cable which connected the secondary

circuit of converter phase A PT and **CTP B** with the guidance of technical personnel from XUJI and HDPTTE.

（9） Verify:

1) Low AC Voltage Detected On

2) Pole System Switchover by Low AC Voltage On

（10） Restore the cable, and then verify the PCPB would automatically restore to standby status and PCPA is the active system.

（11） Record and save all test data

14.3.8 Simulate Fault of DC Line PT Breaking at Matiari station

（1） Start the Pole at minimum power, 200MW (303A), ramp rate 50MW/min.

（2） Verify pole in **Power Control Mode** respectively.

（3） Switchover the active system to check the PCPA and PCPB are healthy.

Matiari:

（4） Verify the PCPA system is active in pole.

（5） **Simulate Fault of DC Line PT Breaking** in active system at Matiari station by pulling out the signal which connected the secondary circuit of DC line PT and **PCPA** with the guidance of technical personnel from XUJI and HDPTTE.

（6） Verify:

1) Pole DC Line Voltage Measurement Value Error

2) Pole Active System Switchover.

（7） Restore the cable, and then verify the PCPA would automatically restore to standby status and PCPB is the active system.

（8） **Simulate Fault of DC Line PT Breaking** in active system at Matiari station by pulling out the signal which connected the secondary circuit of DC line PT and **PCPB** with the guidance of technical personnel from XUJI and HDPTTE.

（9） Verify:

1) Pole DC Line Voltage Measurement Value Error

2) Pole Active System Switchover.

（10） Restore the cable, and then verify the PCPB would automatically restore to standby status and PCPA is the active system.

（11） Record and save all test data

14.3.9 Simulate Fault of DC Line PT Breaking at LAHORE station

（1） Start the Pole at minimum power, 200MW (303A), ramp rate 50MW/min.

（2） Verify pole in **Power Control Mode** respectively.

（3） Switchover the active system to check the PCPA and PCPB are healthy.

Lahore:

（4） Verify the PCPA system is active in pole .

（5） **Simulate Fault of DC Line PT Breaking** in active system at Lahore station by pulling out the signal which connected the secondary circuit of DC line PT and **PCPA** with the guidance of technical personnel from XUJI and HDPTTE.

（6） Verify:

1) Pole DC Line Voltage Measurement Value Error

2) Pole Active System Switchover.

（7） Restore the cable, and then verify the PCPA would automatically restore to standby status and PCPB is the active system.

（8） **Simulate Fault of DC Line PT Breaking** in active system at Lahore station by pulling out the signal which connected the secondary circuit of DC line PT and **PCPB** with the guidance of technical personnel from XUJI and HDPTTE.

（9） Verify:

1) Pole DC Line Voltage Measurement Value Error

2) Pole Active System Switchover.

（10） Restore the cable, and then verify the PCPB would automatically restore to standby status and PCPA is the active system.

（11） Record and save all test data

14.3.10 Simulate ACTIVE signal loss of pole control changeover device

（1） Start the POLE at minimum power, 200MW (303A), ramp rate 50MW/min.

（2） Verify pole in **Power Control Mode** respectively.

（3） Switchover the active system to check the PCPA and PCPB are healthy.

Matiari and Lahore:

（4） Verify the PCPA system is active in pole.

（5） **Simulate ACTIVE signal loss of pole control changeover device** at Matiari station by pulling out the signal which send the ACTIVE signal cable.

（6） Verify:

1) Pole keep stable operation.

（7） Restore the cable.

（8） **Simulate ACTIVE signal loss of pole control changeover device** at Lahore station by pulling out the signal which send the ACTIVE signal cable.

（9） Verify:

1) Pole keep stable operation.

（10） Restore the cable.

（11） Record and save all test data

15 Backup Control

15.1 Test Objective

The test objective is to check the DEBLOCK/BLOCK function from backup control panel.

15.2 Preconditions

（1）Deblock and block tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition.

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM

[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

15.3 Test Content and Procedure

15.3.1 Monopole Start/Stop in Backup Panel

（1） Turn the switch on the **DC Local Control Interface** from '**REMOTE**' to '**LOCAL**'.

（2） Verify both stations in '**Ready for Operation**' condition.

（3） Start the pole at minimum power, 200MW (303A), ramp rate 50MW/min.

（4） Verify the a normal start occurred.

（5） Stop the pole.

（6） Verify the a normal start occurred.

（7） Turn the switch on the **DC Local Control Interface** from '**LOCAL**' to '**REMOTE**'.

（8） Record and save all test data.

（9） Sign test record after test completion.

15.3.2 Monopole Ramp up/down in Backup Panel

（1） Turn the switch on the **DC Local Control Interface** from '**REMOTE**' to '**LOCAL**'.

（2） Start the pole at minimum power, 200MW (303A), ramp rate 50MW/min.

Matiari:

（3） Ramp power from 200MW to 400MW at 50MW/min ramp rate.

（4） Verify that the power reaches the reference value after each ramping is completed in both stations and that the ramping process is smooth and without disturbances.

（5） Verify also that the ramp could stop while ramping is in progress by executing the following actions:

1）Order **STOP RAMPING**.

LAHORE:

（6） Initiate the sequence of **MASTER** station.

（7） Order the power ramp down at 50MW/min rate from 400MW to 200MW

（8） Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（9） Verify also that the ramp could stop while ramping is in progress by executing the following actions:

1）Order **STOP RAMPING**.

（10） Turn the switch on the **DC Local Control Interface** from '**LOCAL**' to '**REMOTE**'.

（11） Record and save all test data.

16 Safety measures and special points for the station tests

16.1 For HVDC system

(1) All personnel who take part in the test shall follow all the safety regulations for the Owner and any Special Safety related requirements of CET strictly.

(2) In the station a qualified engineer should be appointed as a test leader from the Owner, who shall be a coordinator with CEPRI commissioning engineers.

(3) In the station, qualified technicians from the Owner, the assembly companies or the manufacture companies with mobile phone have to be appointed to watch the equipment in AC yard, in DC yard and in valve hall separately when a test proceeds. They ought to report immediately to the test leader as they find any abnormality or fault of the equipment.

(4) No person is allowed to enter into the test area without permission.

(5) All the high voltage area shall be isolated with closed fence and a notice board with 'HV DANGER!' should be put on it.

(6) In the station, an emergent maintenance team with mobile phone shall be ready for any repair or inspection work when needed.

(7) Only the personnel with the test identity are allowed to enter the test area.

(8) The qualified operators are only allowed to carry out the operation.

(9) All the operations shall be done strictly according to the Operation Instructions.

(10) The temporary test wiring and maintenance of main circuit equipment in site and control & protection cubicles should be proceeded and corresponding safety measures should be carried out by the qualified personnel under the supervision of qualified specialists.

(11) The test wiring to control or protection cubicles shall be demonstrated and supervised by qualified specialists.

16.2 For AC system

All the regulations and safety measures for the AC system operation have to be followed strictly.

17 Annex

BSC -

HVDC--High Voltage Direct Current

DC-- Direct Current

AC--Alternative Current

CEPRI--China Electric Power Research Institute

TFR --Transient Fault Recorder

PCP--Pole Control & Protection

SCM--SCADA and Monitoring

SC--Station Control

ESOF-- Emergency Stop Function

RPC--Reactive Power Control

PPR--Pole Protection

VSCP--Valve short Circuit Protection

PBDP--Pole Bus Differential Protection

SGOCP--Station Ground Overcurrent Protection

IP--Indication Pulse

LAN--Local Aera Network

CMC--Current Margin Compensation

VBE--Valve Base Electronic

ELOCP-- Electrode Line Open Circuit Protection

MRTB-- Metallic Return Transfer Breaker

GRTS-- Ground Return Transfer switch

NBGS-- Neutral Bus Ground Switch

NBS--Neutral Bus Switch

CP--Control Pulse

PT--Voltage transducer

CTP--Converter Transformer Protection

Appendix:

Table for GR Return transfer to MR Return of pole1

Pre-condition: pole 2 is isolated

Switch Operation Sequence	Transfer from GR Return to MR Return			
	Matiari CS		Lahore CS	
1	NE11	OPEN	NE11	OPEN
2	WNQ11	CLOSED	WNQ11	CLOSED
3	WP2Q10	CLOSED	WP2Q10	CLOSED
4	WNQ1(GRTS)	CLOSED	/	/
5	WN3Q1(MRTB)	OPEN	/	/
6	WN3Q11	OPEN	/	/
7	WN3Q12	OPEN	/	/
Switch Operation Sequence	Transfer from MR Return to GR Return			
	Matiari CS		Lahore CS	
1	WN3Q11	CLOSED	/	/
2	WN3Q12	CLOSED	/	/
3	WN3Q1(MRTB)	CLOSED	/	/
4	WNQ1(GRTS)	OPEN	/	/
5	WP2Q10	OPEN	WP2Q10	OPEN
6	WNQ11	OPEN	WNQ11	OPEN
7	NE11	CLOSED	NE11	CLOSED

Table for GR Return transfer to MR Return of pole2

Pre-condition: pole 1 is isolated

Switch Operation Sequence	Transfer from GR Return to MR Return			
	Matiari CS		Lahore CS	
1	NE11	OPEN	NE11	OPEN
2	WNQ11	CLOSED	WNQ11	CLOSED
3	WP1Q10	CLOSED	WP1Q10	CLOSED
4	WNQ1(GRTS)	CLOSED	/	/
5	WN3Q1(MRTB)	OPEN	/	/
6	WN3Q11	OPEN	/	/
7	WN3Q12	OPEN	/	/
Switch Operation Sequence	Transfer from MR Return to GR Return			
	Matiari CS		Lahore CS	
1	WN3Q11	CLOSED	/	/
2	WN3Q12	CLOSED	/	/
3	WN3Q1(MRTB)	CLOSED	/	/
4	WNQ1(GRTS)	OPEN	/	/
5	WP1Q10	OPEN	WP1Q10	OPEN
6	WNQ11	OPEN	WNQ11	OPEN
7	NE11	CLOSED	NE11	CLOSED

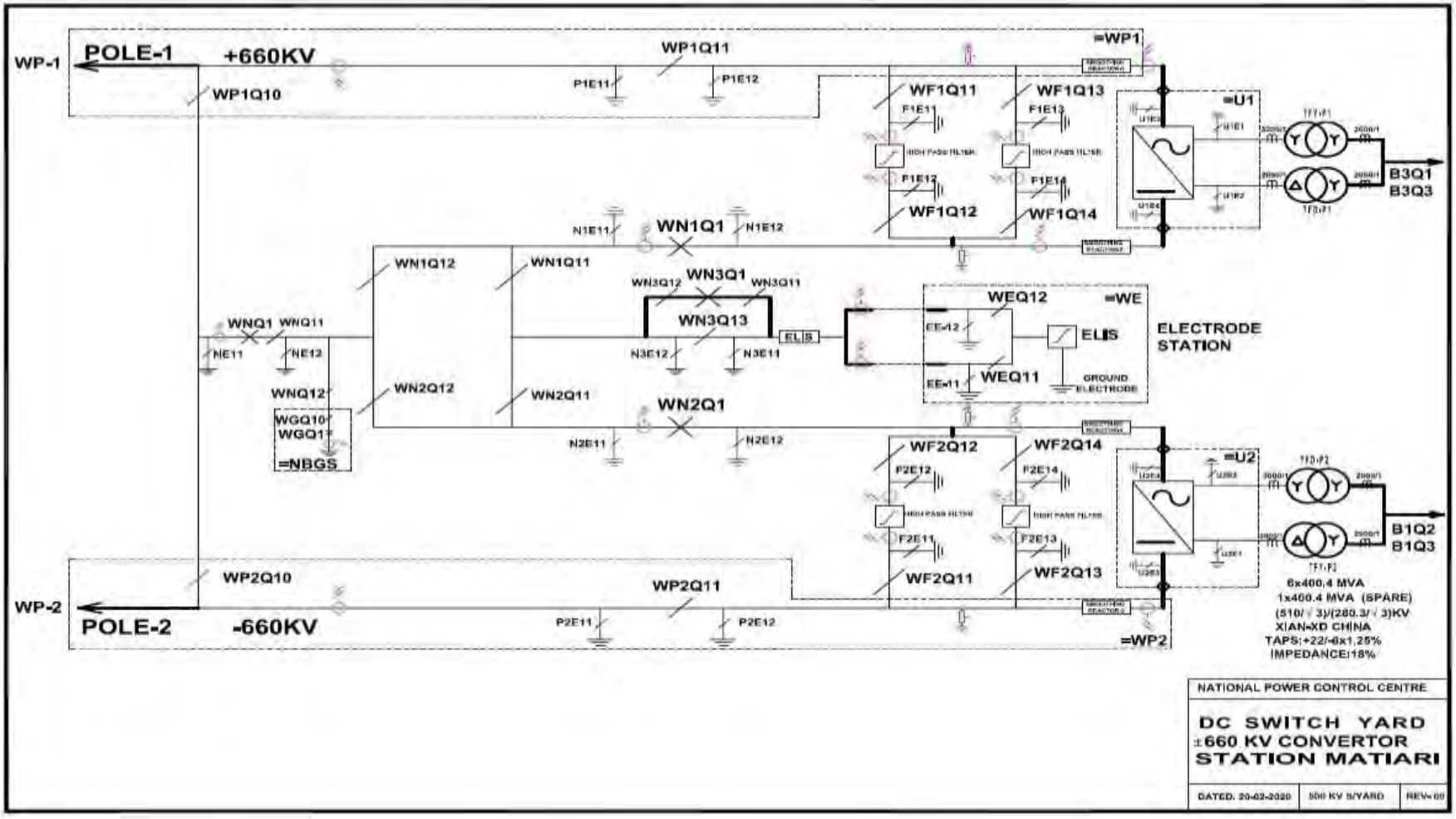

Figure1 General single line diagram of DC switch yard of Matiari Station

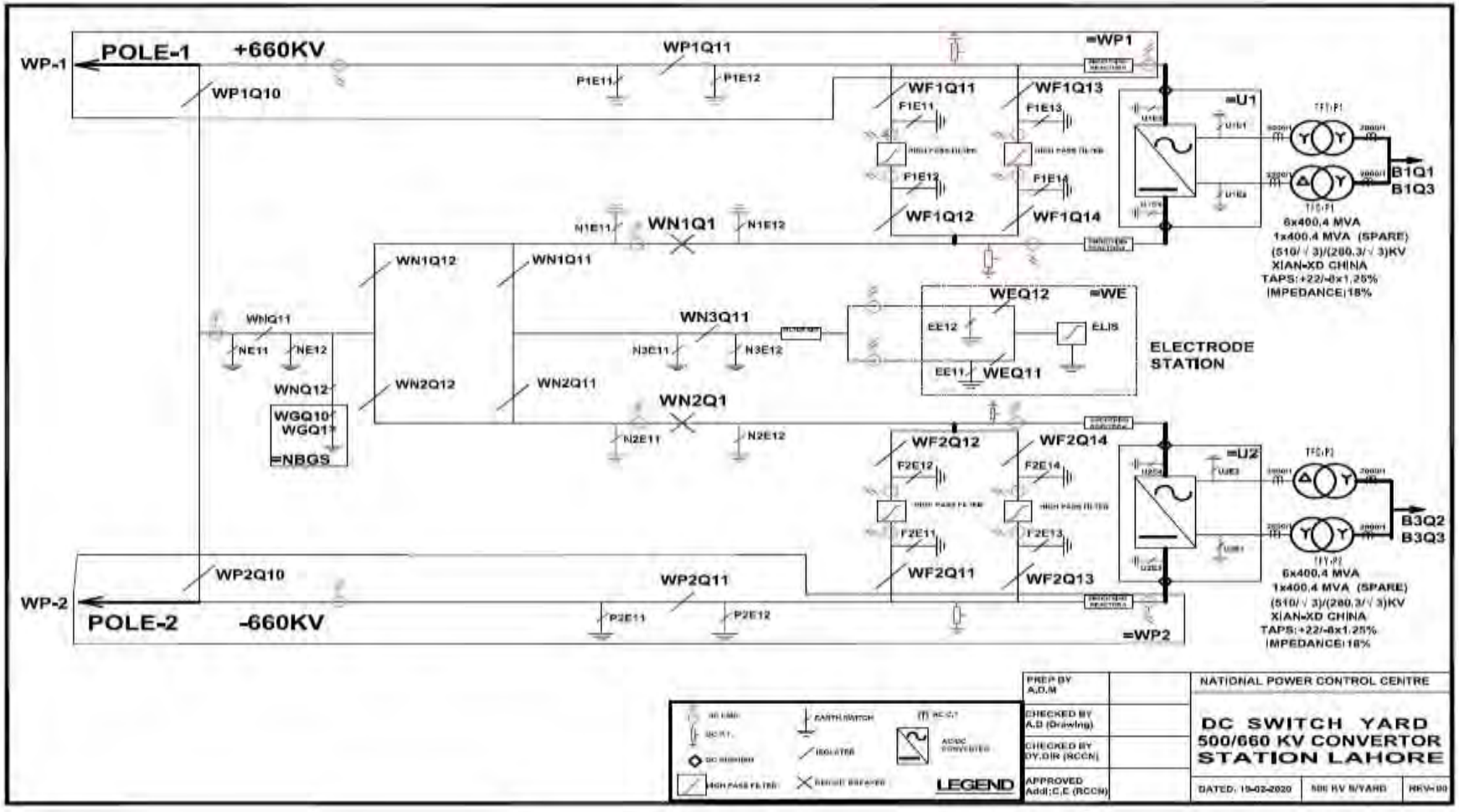

Figure 2 General single line diagram of DC switch yard of Lahore Station

OE notes that approval of this test procedure is conditional on the following:
a) CET to perform the additional tests identified by NPCC (letter General Manager System Operation 15476/80/GM(SO)/NPCC/NRCC dated Nov 24, 2020). CET will prepare in a new test procedure "A7-Matiari-Lahore ±660kV HVDC Transmission Project Commissioning Tests-Additional Tests" and submit for NTDC/OE review and approval.
b) CET to successfully complete all additional tests at a suitable time prior to the end of the commissioning period and start of commercial operation.

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中国电力科学研究院有限公司
CHINA ELECTRIC POWER RESEARCH INSTITUTE

Approved RBJ RBJ Engineering Corporation 1-Feb-2021

报告编号：HXT2020-110

巴基斯坦默蒂亚里–拉合尔±660高压直流输电工程系统调试方案

（4）双极小功率系统调试方案

Matiari-Lahore ±660kV HVDC Transmission Project Commissioning Tests

(4) Bipole Low Power System Tests Program

China Electric Power Research Institute

2021.01

Version	Date	Modification
…	…	…
4.0	29 Jan 2021	Updated according to OE recommendations about low voltage reactor

工作单位： 中国电力科学研究院有限公司

项目负责人： 班连庚，谢国平

报告编写人： 谢国平,雷霄,庞广恒,林少伯,周亦夫,刘世成

中国电力科学研究院有限公司

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内容摘要

巴基斯坦默蒂亚里-拉合尔高压直流输电工程双极小功率系统调试方案内容包括：初始运行试验、极补偿试验、接地极平衡试验、降压运行试验、干扰试验、后备面盘控制试验、初始运行试验（反送方式）、保护跳闸试验（反送方式）、极补偿（反送方式）、直流线路故障试验。其中详细列出了每个试验项目内容、步骤及验收标准等。

关键词：巴基斯坦默拉直流；双极小功率系统调试方案；系统调试

ABSTRACT

Bipole Low Power System Tests Program of Pakistan Matiari-Lahore±660kV HVDC Transmission Project includes initial operation tests, pole compensation, electrode line balancing, reduced voltage operation, disturbance, backup control panel, initial operation tests (reversed direction), protective trip test (reversed direction), pole compensation (reversed direction), DC line faults. The contents, test procedure and acceptance criteria of the test items are listed in this report.

KEYWORDS: Pakistan Matiari-Lahore HVDC Project, Bipole Low Power System Test Program, System Commissioning

Table of Contents

1 Preconditions

IMPORTANT: The bipole power of Matiari-Lahore HVDC project during the test shall not exceed 800 MW, corresponding to 606 A. The AC voltage at all the two converter stations including Matiari and LAHORE shall be 505-525kV or lower before and during all tests. The frequency at all the converter stations shall be 49.5-50.5Hz.

The following pre-conditions apply to all tests defined in this procedure. If any particular precondition is necessary for a specific test, it will be added in the test description.

Converter station test has been completed and qualified.

(1) Converter station test has been completed and qualified.

(2) The test leader from Owner and CEPRI must be appointed.

(3) All equipment tests and subsystem tests necessary to the energization must be completed.

(4) Protection settings and protective circuits trip sequences tests must be completed.

(5) Converter valve low voltage tests must be completed.

(6) AC-switchyard and associated protections and sequences, including breaker failure protection, must be tested.

(7) Verify list of remaining activities and make sure that the energization can proceed.

(8) Verify list of temporary connections and make sure that the energization can proceed.

(9) Verify Sequence of Events Recorder (SER) and make sure that no relevant alarms are present, and all systems are operational.

(10) Energization permission from the DISPATCH CENTER is acquired.

(11) The switching sequence prepared by Owner is ready.

(12) There four low voltage reactors available at Matiari and and two low voltage reactors available at Lahore converter station.

（13） Monopolar low power tests have been successfully completed

2 Initial Operation Tests, Normal Power Direction

2.1 Test Objective

The objective is to check the function of bipole deblock and block.

2.2 Preconditions

（1）all monopole low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM

[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

2.3 Test Content and Procedure

2.3.1 Start/Stop Pole, Manual Deblock/Block

（1） Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a '**Ready for Operation**' condition.

（2） Verify both stations in in '**Ready for Operation**' condition.

（3） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（4） Start the bipole at minimum power in Matiari, 400MW (303A), ramp rate 50MW/min.

（5） Verify normal start behaviour and stable operation at minimum power

1） LAHORE: γ=17°

2） Matiari: from retard to α=15°±2.5° (these values are approximate). 3 ） Record the preliminary data of DC voltage and valve voltages.

（6） Verify stable operation at minimum power.

（7） Perform normal inspections (visual and acoustical) while two poles are deblocked.

（8） Verify RPC operation and whether minimum filter connected in line with technical specification:

1) Matiari: one sub bank BP11/13 and one sub bank HP24/36

2) LAHORE: two sub banks HP12/24

（9） Stop bipole, verify

1) Matiari: Retard, Reduced current→Block without BPP

2） LAHORE: Order alpha as 90° →Block with BPP

（10） Record and save all test data.

3 Pole Compensation

3.1 Test Objective

The test objective is to check the pole compensation function.

3.2Preconditions

（1）all monopole low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control

[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

3.3 Test Content and Procedure

3.3.1 Normal Power Direction, Bipolar Power Ramping

（1） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（2） Start the bipole at minimum power in Matiari, 400MW (303A), ramp rate 50MW/min.

（3） Ramp bipolar power from 400MW to 600MW at 50MW/min ramp rate.

（4） Initiate a manual switchover from PCPA to PCPB and then from PCPB to PCPA , from SCA to SCB and then from SCB to SCA in both stations while ramping is in progress.

（5） Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（6） Ramp power from 600MW to 800MW at 999MW/min ramp speed.

（7） Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（8） Ramp bipolar power from 800MW to 600MW at 50MW/min ramp rate.

（9） Initiate a manual switchover from PCPA to PCPB and then from PCPB to PCPA ,from SCA to SCB and then from SCB to SCA in both stations while ramping is in progress.

（10） Ramp power from 600MW to 400MW at 999MW/min ramp speed.

（11） Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（12） Ramp bipolar power from 400MW to 800MW at 50MW/min ramp rate.

（13） Record and save all test data

3.3.2 Normal Power Direction, Bipole Operation, Pole 2 Power Ramping

Matiari:

(1) Two poles are in stable operation at 800MW, order pole 2 in **POLE Power Control Mode.**

(2) Verify there is no transient change in bipole power.

(3) Order pole 2 in POLE **Current Control Mode.**

(4) Verify there is no transient change in bipole power.

LAHORE:

(5) Ramp the current in pole 2 from 606A to 800A at 100A/min ramp speed.

(6) Initiate a manual switchover from PCPA to PCPB and then from PCPB to PCPA, from SCA to SCB and then from SCB to SCA while ramping is in progress.

(7) Verify that the current reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

(8) Order TRANSFER TO POWER CONTROL while ramping is in progress and verify that there is no transfer during the current ramping and no transient change in current.

Matiari:

(9) Initiate the sequence of MASTER station.

(10) Ramp the current in pole 2 from 800A to 606A at 100A/min ramp speed.

(11) Initiate a manual switchover from PCPA to PCPB, and then from PCPB to PCPA , from SCA to SCB and then from SCB to SCA while ramping is in progress.

(12) verify no power disturbance and no stop of ramping.

(13) Disabled the telecommunication in both channels during the ramping process.

(14) Pole control cubicle：D20：X2 and D21：2；

(15) DC station control ：D20：X2 and D21：2

(16) Verify:

(17) The Emergency Current Control mode would be automatically activated in pole 2.

(18) The ramping of pole2 would be continued at a reduced ramp rate， and the current reference value would be reached when the telecommunication is disabled,

(19) Verify that the bipolar power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

(20) Two poles are in stable operation at 800MW, Restore Telecom in Pole2, order pole 2 in Bipolar Power Control Mode.

(21) Record and save all test data

3.3.3 Normal Power Direction, Bipole Operation, Pole 1 Power Ramping

Matiari:

(22) Two poles are in stable operation at 800MW, order pole 1 in **POLE Power Control Mode.**

(23) Verify there is no transient change in bipole power.

(24) Order pole 1 in POLE **Current Control Mode.**

(25) Verify there is no transient change in bipole power.

LAHORE:

(26) Ramp the current in pole 1 from 606A to 800A at 100A/min ramp speed.

(27) Initiate a manual switchover from PCPA to PCPB and then from PCPB to PCPA, from SCA to SCB and then from SCB to SCA while ramping is in progress.

（28） Verify that the current reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（29） Order TRANSFER TO POLE POWER CONTROL while ramping is in progress and verify that there is no transfer during the current ramping and no transient change in current.

Matiari:

（1） Initiate the sequence of **MASTER** station.

（2） Ramp the current in pole 1 from 800A to 606A at 100A/min ramp speed.

（3） Initiate a manual switchover from PCPA to PCPB, and then from PCPB to PCPA, from SCA to SCB and then from SCB to SCA while ramping is in progress.

（4） Disabled the telecommunication in both channels during the ramping process.

Pole control cubicle：D20：X2 and D21：2；

DC station control ：D20：X2 and D21：2

（5） Verify:

1) The Emergency Current Control mode would be automatically activated.

2) The ramping of pole1 would be continued at a reduced ramp rate, and the current reference value would be reached when the telecommunication is disabled,

（6） Verify that the bipolar power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（7） Two poles are in stable operation at 800MW, Restore Telecom in Pole1, order pole 1 in **Bipolar Power Control Mode.**

（8） Record and save all test data

3.3.4 One Pole Trip, Power Transfer at Normal Voltage

(1) Two poles are in stable operation at 800MW

(2) Verify both pole 1 and pole 2 in **Bipolar Power Control Mode**.

(3) Switch off the AC power supply for the pump A in the valve cooling system in pole 2

(4) Verify the pump B is put into operation.

(5) Restore the AC power supply for the pump A in the valve cooling system in pole 2.

(6) Switch off the AC power supply for the pump B in the valve cooling system in pole 2.

(7) Verify the pump A is put into operation.

(8) Switch off the AC power supply for the pump A in the valve cooling system to simulate **Valve Cooling System Fault** in Matiari in pole 2..

Pole control CPU4/D05-VCIO/P4/VCCP_A_TNA02/I1

(9) Verify in Matiari station:

1) Y-block

2) Trip of the AC circuit breaker(s) feeding the converter transformer of pole2

3) Pole isolation

4) Start breaker failure protection

5) Set lockout relay for the tripped AC circuit breaker(s)

(10) Verify in LAHORE station

1) Normal Y-stop sequence.

(11) Verify there is no influence on the transmitted bipolar power.

(12) De-energize the converter transformer at pole 2 in LAHORE station.

(13) Energize the converter transformer at pole 2 in both two stations.

(14) Verify that energization of converter transformer has no influence on the transmitted bipole power.

(15) Order pole 2 in **Pole Power Control.**

(16) Start pole 2 at minimum power in Matiari, 200MW (303A), ramp rate 50MW/min.

(17) Order pole 2 in **Bipolar Power Control Model**.

(18) Verify that the power of pole 2 will rapidly ramp to 400MW for sharing the bipole power.

(19) Verify that there is no influence on the transmitted bipole power.

(20) Record and save all test data

3.3.5 One Pole Trip, Power Transfer at Reduced Voltage

(1) Two poles are in stable operation at 800MW

(2) Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

(3) Order pole 2 in **REDUCED VOLTAGE** (70% of nominal voltage).

(4) Verify there is no influence on the transmitted bipolar power.

(5) Simulate pole1 **Pole Bus Differential Protection Stage 2 Action** from the **PPR** O3_FUNCDCP3(8) software page in PPRA and PPRC in LAHORE station by alter **PBDP SETTING_X6** from '0.35' to '**-0.35**', **X7** from '0.2' to '**0**'.

(6) Verify in LAHORE station:

1) Z-block
2) Blocking of the converter with by-pass pair
3) Trip of the AC circuit breaker(s) feeding the converter transformer
4) Pole Isolation
5) Set lockout relay for the tripped AC circuit breaker(s)
6) Start breaker failure protection

(7) Verify in Matiari station:

1) Normal Y-stop sequence.

(8) Verify there is no influence on the transmitted bipolar power and the HVDC system is still in operation.

(9) Switch pole 1 into **Pole Power Control** mode**.**

(10)

(11) Start pole 1 at minimum power in Matiari, 200MW (303A), ramp rate 50MW/min.

(12) Switch pole 1 into **Bipolar Power Control Model** mode**.**

(13) Verify that the power of pole 1 will rapidly ramp to 470MW for sharing the bipole power and ensuring electrode balancing.

(14) Verify there is no influence on the transmitted bipolar power.

(15) Order pole 2 in **NORMAL VOLTAGE**.

(16) Verify that each pole is operating at 400MW.

(17) Ramp bipolar power from 800MW to 400MW at 50MW/min ramp rate.

(18) Stop bipole.

(19) Record and save all test data

4 Operation with Station Ground Test

4.1 Test Objective

The test objective is to check the function of electrode line balancing.

4.2 Preconditions

（1）all monopole low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM

[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

4.3 Test Content and Procedure

4.3.1 Start/Stop Bipole with Station Grounding at Matiari & LAHORE Converter Station

(1) Verify the converters are blocked in Matiari and LAHORE stations.

Matiari:

(2) Order to **CLOSE the NBGS** by manual

(3) Order to **OPEN the MRTB** by manual, and now Matiari is at station grounding.

LAHORE:

(4) Order to **CLOSE the NBGS** by manual

(5) Order to **OPEN the (WN3Q11)** by manual and now LAHORE is at station grounding.

(6) Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

(7) Start bipole at minimum power in Matiari, station grounding, 400MW (303A), ramp rate 50MW/min.

(8) Verify stable operation at minimum power.

(9) Ramp from 400MW to 600MW and from 600MW back to 400MW. Verify stable operation during ramping and NBGS current remains below 30A

(10) Stop bipole.

Matiari & LAHORE:

(11) Order to **CLOSE the MRTB in Matiari and WN3Q11 in LAHORE.**

(12) Order to **OPEN the NBGS in both stations.**.

(13) Record and save all test data

5 Reduced Voltage Operation

5.1 Test Objective

The test objective is to check the DC system performance during reduced voltage operation.

5.2 Preconditions

（1）all monopole low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[ ] Normal volt.	[X] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.

[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[ ] Normal volt.	[X] Reduced volt.
[X] Ground Return	[ ] Metallic Return

5.3 Test Content and Procedure

5.3.1 Reduced Voltage Operation Test

（1） Set manually **REDUCED VOLTAGE** mode (70% of nominal voltage) in pole 1 from Matiari.

（2） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（3） Start the bipole at minimum power in Matiari, 400MW, ramp rate 50MW/min

（4） Verify:

1) Voltage 462kV in pole 1
2) Voltage 660kV in pole 2
3) Electrode current < 30A

（5） Order **REDUCED VOLTAGE** (70% of nominal voltage) in pole 2 in Matiari.

（6） Verify:

1) Voltage 462kV in pole 1
2) Voltage 462kV in pole 2
3) No change in power transmission
4) Electrode current < 30A

（7） Order bipole power ramping up to 600MW in Matiari.

（8） Order bipole power ramping down to 400MW in Lahore.

（9） Stop bipole.

（10） Record and save all test data

6 Disturbances

6.1 Test Objective

The test is to check the DC system performance during the disturbance.

6.2 Preconditions

（1）All monopole low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X]Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM

[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

6.3 Test Content and Procedure

6.3.1 Pole Trip, Open Line Fault at Electrode at Lahore

(1) Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

(2) Start the bipole at minimum power in Matiari, 400MW (303A), ramp rate 50MW/min.

(3) Following these steps to simulate **Electrode Line Open Circuit Protection Stage 2 Action**, and then the NBGS would be automatically closed in LAHORE

1) In PPRA and PPRC O3_FUNCDCP3(14) software page, alter **ELOCP_SETTING_1_X5** from '**60s**' to '**6s**'

2) Alter **ELOCP_ SETTING_1_X6 _** from '**90s**' to '**900s**'

3) alter **ELOCP_ SETTING_1_X3** from '20**kV**' to '**0**'

(4) Order to **OPEN WN3Q11** manually.

(5) Verify stable operation with Station ground at Lahore

(6) Simulate **Pole Bus Differential Protection Stage 2 Action** from the **PPR/** O3_FUNCDCP3(8) software page in PPRA and PPRC in Matiari station pole 1 by alter **PBDP SETTING_X6** from '0.35' to '**-0.35**', **X7** from '0.2' to '**0**'

(7) Verify:

1) Pole 1 trip .

2) Pole 2 consecutively trip because of overcurrent on the **NBGS at Lahore.**

（8） Record and save all test data

6.3.2 One Pole in Operation while the Other Undergoing Open Line Test

（1） Start the bipole at minimum power in Matiari, 400MW (303A), ramp rate 50MW/min.

（2） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（3） Stop pole 2, and then pole 1 rapidly boosts power for compensation.

（4） Verify there is no influence on the transmitted bipolar power.

（5） Perform breakers and switches conducted by sequential control to deenergize the converter transformers in pole 2 at both Matiari and Lahore, initiate **the sequence of Closing Valve Hall Ground Switches**, and the pole2 converters in both stations are in **GROUNDED condition**.

（6） Verify:

1) Steady operation in pole 1
2) No transient change in bipole power.
3) Sequential control fulfilled

（7） Restore pole 2 into **Ready for Operation** condition.

（8） Open WP2Q11 of S2P2, and set S1P2 in separate control and OLT automatic control mode.

（9） Verify the WP2Q11 of S2P2 is open, and the WP2Q11 of S1P2 is closed.

（10） Initiate the automatic open line test with line on pole 2 of Matiari station.

（11） Verify that there is no transient change on transmitted power when one pole in operation and the other undergoing open line test.

（12） Verify the WP2Q11 of S2P2 is closed, and the WP2Q11 of S1P2 is open.

（13） Initiate the automatic open line test with line on pole 2 of Lahore station.

（14） Record and save all test data

6.3.3 Bipole Operation, Simulate Electrode Line Unbalance Fault

（1） Start the bipole at minimum power in Matiari, 400MW (303A), ramp rate 50MW/min.

（2） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（3） Order pole 2 in **Pole Power Control.**

（4） Ramp the power of pole 2 from 200MW to 400MW, at 50MW/min rate.

（5） At inverter side, simulate the **Electrode Line Unbalance Fault** from the O2_FUNCDCP4 (4)software page in PPRA and PPRC in LAHORE station pole 1 by alter **ELUS_ SETTING_X4** from ‘0.134’ to ‘**-0.134**’

（6） Verify：

1) Electrode line unbalance protection acts correctly

2) Electrode line current < 30A

3) The power of pole 2 would decrease to 200MW for balancing the electrode line current.

（7） Record and save all test data

6.3.4 Simulation of IDNC CTTransmitter Power Source Fault

（1） Start the bipole at minimum power in Matiari, 400MW (303A), ramp rate 50MW/min.

（2） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（3） Simulate fault of PI IDNC CT transmitter power source in active system (e.g. PCPA) at Matiari/Terminal LAHORE station separately by turn off the corresponding power source with the guidance of technical personnel from the IDNC CT transmitter manufacturer.

（4） Verify continuing steady operation of the transmission and that active system is switched.

（5） Record and save all test data

6.3.5 AC Auxiliary Power 400 V Switchover

（1） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（2） Start the bipole at minimum power at Matiari station, normal power direction, 400MW (303A), ramp rate 50MW/min.

Matiari and Lahore:

（3） Manually open switch 111, verify the switch 411 automatically switches off and the switch 410 automatically switches on.

（4） Manually close switch 111, verify the switch 410 automatically switches off and the switch 411 automatically switches on.

（5） Manually open switch 112, verify the switch 412 automatically switches off and the switch 410 automatically switches on.

（6） Manually close switch 112, verify the switch 410 automatically switches off and the switch 412 automatically switches on.

（7） Manually open switch 121, verify the switch 421 automatically switches off and the switch 420 automatically switches on.

（8） Manually close switch 121, verify the switch 420 automatically switches off and the switch 421 automatically switches on.

（9） Manually open switch 122, verify the switch 422 automatically switches off and the switch 420 automatically switches on.

（10） Manually close switch 122, verify the switch 420 automatically switches off and the switch 422 automatically switches on.

（11） Record and save all test data.

7 Automatic Power Curve Control Test

7.1 Test Objective

The test is to check the basic function of automatic power curve control of DC system.

7.2 Preconditions

（1）All monopole low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X]Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control

[X] Normal volt. [ ] Reduced volt.

[X] Ground Return [ ] Metallic Return

7.3 Test Content and Procedure

7.3.1 Automatic Power Curve Control test in Matiari Converter Station

（1） Verify :

- pole 1 and pole 2 in Bipolar Power Control Mode respectively.
- Matiari converter station is the “MASTER” station

（2） Verify:

- bipole power is 400MW, manual power control is set for bipole.

（3） For the follow-up test, set the bipole power curve and then switch the bipolar power control to automatic power control:

- Bipolar power 400MW lasts for 15 minutes.
- The power ramps up from 400MW to 500MW at a rate of 7MW/min. Manually switch the system during the power ramping up, including pole control and DC station control system.
- The bipolar power 500MW lasts for 30 minutes.
- The power ramps up from 500MW to 600MW at a rate of 7MW/min.
- Bipolar power 600MW lasts for 30 minutes.
- The power ramps down from 600MW to 500MW at a rate of 7MW/min.
- The bipolar power 500MW lasts for 30 minutes.
- The power ramps down from 500MW to 400MW at a rate of 7MW/min. During the power ramping down, click the "Hold" button on OWS to verify that the power stops ramping down. And switch the bipolar power control to manual power control.

（4） Manually ramp down the power to 400MW.

（5） Record and save all test data

7.3.2 Automatic Power Curve Control test in Lahore Converter Station

（1） Verify :

- pole 1 and pole 2 in Bipolar Power Control Mode respectively.
- Lahore converter station is the “MASTER” station

（2） Verify:

- bipole power is 400MW, manual power control is set for bipole.

（3） For the follow-up test, set the bipole power curve and then switch the bipolar power control to automatic power control:

- Bipolar power 400MW lasts for 15 minutes.
- The power ramps up from 400MW to 500MW at a rate of 7MW/min. Manually switch the system during the power ramping up, including pole control and DC station control system.
- The bipolar power 500MW lasts for 30 minutes.
- The power ramps up from 500MW to 600MW at a rate of 7MW/min.
- Bipolar power 600MW lasts for 30 minutes.
- The power ramps down from 600MW to 500MW at a rate of 7MW/min.
- The bipolar power 500MW lasts for 30 minutes.
- The power ramps down from 500MW to 400MW at a rate of 7MW/min. During the power ramping down, click the "Hold" button on OWS(OPERATOR WORKSTATION) to verify that the power stops ramping down. And switch the bipolar power control to manual power control.

（4） Manually ramp down the power to 400MW.

（5） Record and save all test data

8 Frequency Control Test

8.1 Test Objective

The test is to check the basic function of frequency control of DC system.

8.2 Preconditions

（1）All monopole low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X]Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control

[X] Normal volt. [ ] Reduced volt.

[X] Ground Return [ ] Metallic Return

8.3 Test Content and Procedure

8.3.1 Frequency Control test in Matiari Converter Station

（1） Verify :

- Matiari converter station is the “MASTER” station
- pole 1 and pole 2 in Bipolar Power Control Mode respectively.
- bipole power is 500MW

（2） Verify:

- The DC power corresponding to 1Hz of frequency change is 1000MW.
- The frequency deviation deadband is ±0.1Hz.
- Upper and lower output limits of frequency control is ±200MW.

（3） Simulate the frequency of the AC power grid connected the Matiari station to 49.8Hz, with a difference of 0.1Hz (0.1Hz has been subtracted from the deadband), and the duration is 5000ms.

（4） Verify:

- The DC power ramps down about 100MW. After the frequency deviation disappears, the DC transmission power will automatically return to the value before the test.

（5） Simulate the frequency of the AC power grid connected the Matiari station to 50.2Hz, with a difference of 0.1Hz (0.1Hz has been subtracted from the deadband), and the duration is 5000ms.

（6） Verify:

- The DC power ramps up about 100MW. After the frequency deviation disappears, the DC transmission power will automatically return to the value before the test.

（7） Record and save all test data

8.3.2 Frequency Control test in Lahore Converter Station

（1） Verify :

- Lahore converter station is the “MASTER” station
- pole 1 and pole 2 in Bipolar Power Control Mode respectively.
- bipole power is 500MW

（2） Verify:

- The DC power corresponding to 1Hz of frequency change is 1000MW.
- The frequency deviation deadband is ±0.1Hz.
- Upper and lower output limits of frequency control is ±200MW.

（3） Simulate the frequency of the AC power grid connected the Lahore station to 49.8Hz, with a difference of 0.1Hz (0.1Hz has been subtracted from the deadband), and the duration is 5000ms.

（4） Verify:

- The DC power ramps up about 100MW. After the frequency deviation disappears, the DC transmission power will automatically return to the value before the test.

（5） Simulate the frequency of the AC power grid connected the Lahore station to 50.2Hz, with a difference of 0.1Hz (0.1Hz has been subtracted from the deadband), and the duration is 5000ms.

（6） Verify:

- The DC power ramps down about 100MW. After the frequency deviation disappears, the DC transmission power will automatically return to the value before the test.

（7） Record and save all test data

9 Backup Control

9.1 Test Objective

The test is to check the deblock/block function from backup control.

9.2 Preconditions

（1）All monopole low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control

[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

9.3 Test Content and Procedure

Bipole Start/Stop in Backup Panel will be done both Matiari and Lahore Converter Station.

9.3.1 Bipole Start/Stop in Backup Panel

（1） Turn the switch on the **DC Local Control Interface** from '**REMOTE**' to '**LOCAL**'.

（2） Verify both stations in 'Ready for Operation' condition.

（3） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（4） Start the bipole at minimum power, 400MW (303A), ramp rate 50MW/min.

（5） Verify normal start behavior and stable operation at minimum power

（6） Stop bipole.

（7） Verify normal stop behaviour.

（8） Turn the switch on the **DC Local Control Interface** from '**LOCAL**' to '**REMOTE**'.

（9） Record and save all test data.

9.3.2 Bipole Ramp up/down in Backup Panel

（1） Turn the switch on the **DC Local Control Interface** from '**REMOTE**' to '**LOCAL**'.

（2） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（3） Start the bipole at minimum power, 400MW (303A), ramp rate 50MW/min.

Matiari:

（4） Ramp bipolar power from 400MW to 600MW at 50MW/min ramp rate.

（5） Verify that the current reaches the reference value after each ramping is completed in both stations and that the ramping process is smooth and without disturbances.

（6） Verify also that the ramp could stop while ramping is in progress by executing the following actions:

1） Order **STOP RAMPING**.

LAHORE:

（7） Initiate the sequence of **MASTER** station.

（8） Ramp bipolar power from 600MW to 400MW at 50MW/min ramp rate.

（9） Verify that the current reaches the reference value after each ramping is completed in both stations and that the ramping process is smooth and without disturbances.

（10） Verify also that the ramp could stop while ramping is in progress by executing the following actions:

1） Order **STOP RAMPING**.

（11） Stop bipole.

（12） Turn the switch on the **DC Local Control Interface** from '**LOCAL**' to '**REMOTE**'.

（13） Record and save all test data.

10 Initial Operation Tests, Reversed Power Direction

10.1 Test Objective

The test is to check the basic function of DC system during reversed power direction.

10.2 Preconditions

（1）All monopole low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[ ] Normal Pow. Dir.	[X] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[ ] Normal Pow. Dir.	[X] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM

[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

10.3 Test Content and Procedure

10.3.1 Start/Stop Bipole

（1） Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a ‘Ready for Operation’ condition.

（2） Verify both stations in ‘Ready for Operation’ condition.

（3） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（4） Start pole at minimum power in reversed direction, 400MW (303A), ramp rate 50MW/min.

（5） Verify steady performance indicators

1） Matiari: γ=17°

2） LAHORE: from retard to α=15°±2.5° (these values are approximate).

3） Record the preliminary data of DC voltage and valve voltages.

（6） Verify stable operation at minimum power.

（7） Perform normal inspections (visual and acoustical) while the two poles are deblocked.

（8） Verify RPC operation and whether minimum filter connected in line with technical specification:

1） LAHORE: one sub bank BP11/13 and one sub bankHP24/36

2） Matiari: two sub bank HP12/24

（9） Stop the Bipole, verify

1） LAHORE: Y-block, Reduced current→Block without BPP

2） Matiari: Y-block, γ→90°→Block with BPP

（10） Record and save all test data.

10.3.2 Control System Switchover

（1） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（2） Start pole at minimum power in reversed direction, 400MW (303A), ramp rate 50MW/min.

（3） Verify the PCPA system is active in Matiari station.

（4） Switch the active system from PCPA (active system) to PCPB, from SCA (active system) to SCB in Matiari station.

（5） Verify continuing steady operation of the transmission and that PCPB is active, no transients at switchover.

（6） Switch the active system from PCPB (active system) to PCPA, from SCB (active system) to SCA in Matiari station.

（7） Verify continuing steady operation of the transmission and that PCPA is active.

（8） Repeat the above procedure in LAHORE.

（9） Stop bipole.

（10） Record and save all test data.

11 Protective Trip X, Y, and Z, Reversed Power Direction

11.1 Test Objective

The test objective is to check the protection trip function.

11.2 Preconditions

（1）All monopole low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[ ] Normal Pow. Dir.	[X] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[ ] Normal Pow. Dir.	[X] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM

[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

11.3 Test Content and Procedure

11.3.1 Protective Trip X in Rectifier with Telecommunication

（1） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（2） Start bipole at minimum power in reversed direction, 400MW (303A), ramp rate 50MW//min.

（3） Simulate **Valve short Circuit Protection Stage 2 TRIP** from the PPR/ O3_FUNCDCP2(8) software page in PPRA and PPRB in pole 1 in LAHORE station by change VSP_SETTING X3 from 1.5 to -1.5.

（4） Verify in LAHORE station:

1） X-block.

2） Start breaker failure protection.

3） Trip of the AC circuit breaker(s) feeding the converter transformer.

4）Set lockout relay for the tripped AC circuit breaker(s)

5） Pole isolation.

（5） Verify in Matiari station.

1） Normal Y-stop sequence. (Order alpha as 90°, then block with BPPO).

（6） Verify there is no influence on the transmitted bipolar power.

（7） Record and save all test data.

11.3.2 Protective Trip Y in Inverter with Telecommunication

（1） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（2） Start bipole at minimum power in reversed direction, 400MW (303A), ramp rate 50MW/min.

（3） Simulate Neutral bus capacitor overcurrent protection Action from the O3_FUNCDCP3(13) software page in PPRB and PPRC in pole 1 in Matiari station by change NCP_SETTING X3 to -120.

（4） Verify Matiari:

1) Y-block

2) Retard and start by-pass pair

3) Trip of the AC circuit breaker(s) feeding the converter transformer

4） Pole isolation

5） Set lockout relay for the tripped AC circuit breaker(s)

（5） Verify in Matiari station:

1） Normal Y-stop sequence. (Order alpha as 90°, then block with BPPO).

（6） Verify there is no influence on the transmitted bipolar power.

（7） Record and save all test data

11.3.3 Protective Trip Z in Rectifier with Telecommunication

（1） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（2） Start pole at minimum power in reversed direction, 400MW (303A), ramp rate 50MW/min.

（3） Simulate **Pole Bus Differential Protection Stage 2 Action** from the **PPR** O3_FUNCDCP3(8) software page in PPRA and PPRC in pole 2 in LAHORE station by alter **PBDP SETTING_X6** from '0.35' to '**-0.35**', **X7** from '0.2' to '**0**'

（4） Verify in LAHORE station:

1) Z-block

2) Trip of the AC circuit breaker(s) feeding the converter transformer

3） Pole isolation

4） Start breaker failure protection

5） Set lockout relay for the tripped AC circuit breaker(s)

（5） Verify in Matiari station

1） Normal Y-block sequence.

（6） Verify there is no influence on the transmitted bipolar power.

（7） Record and save all test data

12 Pole Compensation and disturbance test, Reversed Power Direction

12.1 Test Objective

The test objective is to check the pole compensation during reversed power direction.

12.1 Preconditions

（1）All monopole low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[ ] Normal Pow. Dir.	[X] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[ ] Q control	[X] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active

[ ] Normal Pow. Dir.	[X] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

12.3 Test Content and Procedure

12.3.1 Bipole Power Ramping

(1) Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

(2) Start the bipole at minimum power in reversed direction, 400MW (303A), ramp rate 50MW/min.

(3) Activate the emergency stop push-button in pole 2 in Matiari Station.

(4) Verify there is no influence on the transmitted bipolar power.

(5) Verify the control mode of pole 2 is **Monopolar Power Control.**

(6) Start pole 2 at minimum power in Matiari, 200MW (303A), ramp rate 50MW/min.

(7) Order pole 2 in **Bipolar Power Control Model**.

(8) Verify there is no influence on the transmitted bipolar power.

(9) Ramp bipolar power from 400MW to 800MW at 50MW/min ramp rate.

(10) Initiate a manual switchover from PCPA to PCPB and then from PCPB to PCPA in both stations while ramping is in progress.

(11) Verify the ramping continues without transient changes in the power order.

(12) Ramp bipolar power from 800MW to 400MW at 50MW/min ramp rate.

(13) Initiate a manual switchover from PCPA to PCPB and then from PCPB to PCPA in both stations while ramping is in progress.

（14） Ramp bipolar power from 400MW to 800MW at 50MW/min ramp rate.

（15） Record and save all test data

12.3.2 Bipole Operation, Pole 2 Power Ramping with/without Telecommunication

（1） Two poles are in stable operation at 800MW, order pole 2 in **Monopolar Power Control Mode.**

（2） Order pole 2 in **Current Control Mode.**

（3） Verify there is no influence on the transmitted bipolar power.

（4） Ramp the current of pole 2 from 606A to 800A at 100A/min ramp speed.

（5） Initiate a manual switchover from PCPA to PCPB and then from PCPB to PCPA in both stations while ramping is in progress.

（6） Verify that there is no influence on the transmitted bipolar power, and that the bipolar power is 800MW

（7） Ramp the current of pole 2 from 800A to 606A at 50A/min ramp speed.

（8） Disabled the telecommunication in both channels during the ramping process in both channels simultaneously.

Pole control：D20：X2 and D21：2；

DC station control：D20：X2 and D21：2

（9） Verify:

1) The **Emergency Pole Current Control** mode would be automatically activated In Pole2. Pole 1 telecom remains on and Pole 1 is in Bipole Power Control.

2) The ramping would be continuing with a reduced ramp rate and the current reference value would be reached when the telecommunication is disabled,

（10） Restore the telecommunication of Pole2.

（11） Record and save all test data

12.3.3 Simulated Pole1 DC Line Fault (only Lahore)

（1） Start the bipole at minimum power in reversed direction, 400MW (303A), ramp rate 50MW/min.

（2） Simulate Pole1 a **DC Line Fault** by activating the DC line protection in PCPA in Lahore by executing the following action:

In **Lahore/PCP/CPU3/C06_CONV_CONTORL/Page 11** software page, change TEST_DCLF30/I2 from ‘0’ to ‘1’.

（3） Verify the firing angle has been retarded in **Lahore** station.

（4） Verify that pole1 quickly recovers within the expected time delays.

（5） Change all the modified settings back to original value.

（6） Record and save all test data.

12.3.4 Simulated Pole2 DC Line Fault (only Lahore)

（1） Start the bipole at minimum power in reversed direction, 400MW (303A), ramp rate 50MW/min.

（2） Simulate Pole2 a **DC Line Fault** by activating the DC line protection in PCPA in Lahore by executing the following action:

In **Lahore/PCP/CPU3/C06_CONV_CONTORL/Page 11** software page, change TEST_DCLF30/I2 from ‘0’ to ‘1’.

（3） Verify the firing angle has been retarded in **Lahore** station.

（4） Verify that pole2 quickly recovers within the expected time delays.

（5） Change all the modified settings back to original value.

（6） Record and save all test data.

13 AC/DC Line Faults

13.1 Test Objective

The test objective is to check DC control and protection system function during the DC line fault.

13.2 Preconditions

（1）All monopole low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV or lower.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active	[ ] SC B Active
[X] PCP A Active	[ ] PCP B Active
[X] Normal Pow. Dir.	[ ] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM

[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Normal volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

13.3 Test Content and Procedure

Before the test, we Confirm DC line restart function is enabled.

13.3.1 DC Line Faults at Pole 1 near Rectifier, Normal Power Direction

（1） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（2） Start the bipole at minimum power in normal direction, 400MW (303A), ramp rate 50MW/min.

（3） **DC Line Faults at Pole 1 near Rectifier** should be initiated in line with the guidance in DC Line Faults Tests Program.

（4） Verify

1） DC line traveling wave protection and derivative protection would act

2） Order down in rectifier from DC line protections.

3） DC line would restart successfully to full voltage on first attempt if DC line restart function is enabled.

4） The actual distance is same as that shown on the LFL indication

（5） Record and save all test data

13.3.2 Pole 2 Reduced Voltage, DC Line Faults at Pole 2 near Rectifier, Normal Power Direction

（1） Verify pole 1 and pole 2 in Bipolar Power Control Mode respectively.

（2） Start the bipole at minimum power in normal direction, 400MW (303A), ramp rate 50MW/min.

（3） Order pole 2 in REDUCED VOLTAGE (70% of nominal voltage).

（4） **DC Line Faults at Pole 2 near Rectifier** should be initiated in line with the guidance in DC Line Faults Tests Program.

（5） Verify

5） DC line traveling wave protection and derivative protection would act

6） Order down in rectifier from DC line protections.

7） DC line would restart successfully to reduced voltage on first attempt if DC line restart function is enabled.

8） The actual distance is same as that shown on the LFL indication

（6） Record and save all test data

13.3.3 DC Line Faults at Pole 1 near Inverter, Normal Power Direction

（1） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（2） Start the bipole at minimum power in normal direction, 400MW (303A), ramp rate 50MW/min.

（3） **DC Line Faults at Pole 1 near Inverter** should be initiated in line with the guidance in DC Line Faults Tests Program.

（4） Verify

1） DC line traveling wave protection and derivative protection would act

2） Order down in rectifier from DC line protections.

3） DC line would restart successfully to full voltage on first attempt if DC line restart function is enabled.

4） The actual distance is same as that shown on the LFL indication.

（5） Record and save all test data

13.3.4 Pole 1 Reduced Voltage, DC Line Faults at Pole 1 near Inverter, Normal Power Direction

（1） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（2） Start the bipole at minimum power in normal direction, 400MW (303A), ramp rate 50MW/min.

（3） Order pole 1 in **REDUCED VOLTAGE** (70% of nominal voltage).

（4） **DC Line Faults at Pole 1 near Inverter** should be initiated in line with the guidance in DC Line Faults Tests Program.

（5） Verify

1） DC line traveling wave protection and derivative protection would act

2） Order down and forced retard in rectifier.

3） DC line would restart successfully to reduced voltage on first attempt if DC line restart function is enabled.

4） The actual distance is same as that shown on the LFL indication.

（6） Record and save all test data

13.3.5 Pole 1 Reduced Voltage, DC Line Faults at Pole 2 near Inverter, Normal Power Direction

（1） Verify pole 1 and pole 2 in **Bipolar Power Control Mode** respectively.

（2） Start the bipole at minimum power in normal direction, 400MW (303A), ramp rate 50MW/min.

（3） Order pole 1 in **REDUCED VOLTAGE** (70% of nominal voltage).

（4） **DC Line Faults at Pole 2 near Inverter** should be initiated in line with the guidance in DC Line Faults Tests Program.

（5） Verify

1） DC line traveling wave protection and derivative protection would act

2） Order down in rectifier from DC line protections.

3） DC line would restart successfully to reduced voltage on first attempt if DC line restart function is enabled.

4） The actual distance is same as that shown on the LFL indication.

（6） Record and save all test data

13.3.6 DC Line Faults at Pole 2 near Inverter, Metallic Return Operation, Normal Power Direction

（1） Order pole 2 **TRANSFER TO METALLIC RETURN**.

（2） Start pole at minimum power in normal direction, 200MW (303A)

（3） **DC Line Faults at Pole 2 near Inverter** should be initiated in line with the guidance in DC Line Faults Tests Program.

（4） Verify

1） DC line traveling wave protection and derivative protection would act

2） Order down in rectifier from DC line protections.

3） DC line would restart successfully to full voltage on first attempt if DC line restart function is enabled.

4） The actual distance is same as that shown on the LFL indication.

（5） Record and save all test data

13.3.7 AC Line Faults at Rectifier, Normal Power Direction (Optional)

（1） Verify pole 1 and pole 2 in Bipolar Power Control Mode respectively.

（2） Start the bipole at minimum power in normal direction, 400MW (303A), ramp rate 50MW/min.

（3） **AC Line Faults at Rectifier** should be initiated in line with the guidance in AC Line Faults Tests Program.

（4） Verify

1） Low AC voltage at rectifier is detected.

2） DC system restores to normal operation after the clearance of AC line fault.

（5） Record and save all test data

13.3.8 AC Line Faults at Inverter, Normal Power Direction (Optional)

(1) Verify pole 1 and pole 2 in Bipolar Power Control Mode respectively.

(2) Start the bipole at minimum power in normal direction, 400MW (303A), ramp rate 50MW/min.

(3) **AC Line Faults at Inverter** should be initiated in line with the guidance in AC Line Faults Tests Program.

(4) Verify

1) Low AC voltage at rectifier is detected.

2） Commutation failure occurs.

3） DC system restores to normal operation after the clearance of AC line fault.

（5） Record and save all test

14 Safety measures and special points for the station tests

14.1 For HVDC system

（1） All personnel who take part in the test shall follow all the safety regulations for the electrical works strictly.

（2） In the station a qualified engineer should be appointed as a test leader from the Owner, who shall be a coordinator with CEPRI commissioning engineers.

（3） In the station, qualified technicians from the Owner, the assembly companies or the manufacture companies with mobile phone have to be appointed to watch the equipment in AC yard, in DC yard and in valve hall separately when a test proceeds. They ought to report immediately to the test leader as they find any abnormality or fault of the equipment.

（4） No person is allowed to enter into the test area without permission.

（5） All the high voltage area shall be isolated with closed fence and a notice board with ‘HV DANGER!’ should be put on it.

（6） In the station, an emergent maintenance team with mobile phone shall be ready for any repair or inspection work when needed.

（7） Only the personnel with the test identity are allowed to enter the test area.

（8） The qualified operators are only allowed to carry out the operation.

（9） All the operations shall be done strictly according to the Operation Instructions.

（10） The temporary test wiring and maintenance of main circuit equipment in site and control & protection cubicles should be proceeded and corresponding safety measures should be carried out by the qualified personnel under the supervision of qualified specialists.

（11） The test wiring to control or protection cubicles shall be demonstrated and supervised by qualified specialists.

14.2 For AC system

All the regulations and safety measures for the AC system operation have to be followed strictly.

15 Annex

HVDC--High Voltage Direct Current

DC-- Direct Current

AC--Alternative Current

CEPRI--China Electric Power Research Institute

TFR --Transient Fault Recorder

PCP--Pole Control & Protection

SCM--SCADA and Monitoring

SC --Station Control

RPC--Reactive Power Control

PPR--Pole Protection

PBDP--Pole Bus Differential Protection

SGOCP--Station Ground Overcurrent Protection

VSCP--Valve short Circuit Protection

PBDP--Pole Bus Differential Protection

ELUS --Electrode Line Unbalance Supervision

MRTB-- Metallic Return Transfer Breaker

GRTS-- Ground Return Transfer switch

NBGS-- Neutral Bus Ground Switch

OE notes that approval of this test procedure is conditional on the following:
a) CET to perform the additional tests identified by NPCC (letter General Manager System Operation 15476/80/GM(SO)/NPCC/NRCC dated Nov 24, 2020). CET will prepare in a new test procedure "A7-Matiari-Lahore ±660kV HVDC Transmission Project Commissioning Tests-Additional Tests" and submit for NTDC/OE review and approval.
b) CET to successfully complete all additional tests at a suitable time prior to the end of the commissioning period and start of commercial operation.

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中国电力科学研究院有限公司 CHINA ELECTRIC POWER RESEARCH INSTITUTE

Approved RBJ RBJ Engineering Corporation 1-Feb-2021

报告编号：HXT2020-109

巴基斯坦默蒂亚里-拉合尔±660高压直流输电工程系统调试方案

（5）单极大功率系统调试方案

Matiari-Lahore ±660kV HVDC Transmission Project Commissioning Tests

(5) Monopole High Power System Tests Program

China Electric Power Research Institute

2021.01

Version	Date	Modification
…	…	…
4.0	29 Jan 2021	Updated according to OE recommendations about low voltage reactor

工作单位： 中国电力科学研究院有限公司

项目负责人： 班连庚，谢国平

报告编写人： 林少伯,周亦夫,谢国平,刘世成,庞广恒,雷霄

中国电力科学研究院有限公司

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内容摘要

巴基斯坦默蒂亚里-拉合尔高压直流输电工程单极大功率系统调试方案内容包括：极起/停，功率升降，手动分接头控制，大地/金属转换，热运行试验，特殊测量试验。其中详细列出了每个试验项目内容、步骤及验收标准等。

关键词：巴基斯坦默拉直流；单极大功率系统调试方案；系统调试

ABSTRACT

Monopole High Power System Tests Program for Pakistan Matiari-Lahore ±660kV HVDC Transmission Project includes pole start, power ramp, tap changer control, ground/metallic return transfer, heat run test and special measurements.

KEYWORDS: Pakistan Matiari-Lahore HVDC Project, Monopole High Power System Test Program, System Commissioning

Table of Contents

1 Preconditions

IMPORTANT: The pole power during the tests shall be up to 2200 MW, corresponding to 3333 A. The AC voltage at all the two converter stations including Matiari and LAHORE shall be 505-525kV before and during all tests. The frequency at all the converter stations shall be 49.5-50.5Hz.

Before starting of monopole high power tests, the following activities must have been completed:

- The low power monopolar tests
- Verify that the cooling equipment for converter transformers, smoothing reactor and thyristor valves are operating properly, with the correct switching of fans and pumps. Moreover, it must be checked that the redundant pumps, fans, and heat exchangers are available.
- The thyristor valve cooling pumps are running for more than 24 hours and all air bleeding valves are checked.
- There are four low voltage reactors available in Matiari and two LV reactors available in Lahore converter station.

Furthermore, the following pre-conditions apply for all tests defined in this procedure. If any particular pre-condition is necessary for a specific test, it will be added in the test description.

- The test leader from CEPRI and Owner must be appointed.
- All equipment tests and subsystem tests of equipment involved in this test must be completed.
- Low voltage tests completed
- AC-switchyard and associated protections and sequences, including breaker failure protection, tested
- Final trip test done on each area prior to deblocking.
- Verify list of remaining activities and make sure that the test can proceed.
- Verify list of temporary connections and make sure that the test can proceed.

- Verify Sequence of Events Recorder (SER) and make sure no relevant alarms are present and that all systems are operational.
- Prior to each test, select the relevant TFR points that will be recorded, stored, and used as test records.
- The switching sequence prepared by Owner is ready and the station (or all equipment involved in the test) is handed over for operation.

2 Pole 1 High Power Test, Normal Power Direction

2.1 Test Objective

The test objective is to check DC equipment performance during high power test.

2.2 Preconditions

（1）all low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[X] Normal Pow. Dir. [ ] Reversed Pow. Dir.

[X] With TCOM [ ] Without TCOM

[X] Power Control [ ] Current Control

[X] Joint Control [ ] Separate Control

[X] RPC Auto [ ] RPC Manual

[X] Q control [ ] U control

[X] Norm volt. [ ] Reduced volt.

[X] Ground Return [ ]Metallic Return

LAHORE:

[ ] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[X] Normal Pow. Dir. [ ] Reversed Pow. Dir.

[X] With TCOM [ ] Without TCOM

[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Norm volt.	[ ] Reduced volt.
[X] Ground Return	[ ]Metallic Return

2.3 Test Content and Procedure

2.3.1 Pole Start

（1） Before start of Heat Run Test, samples for DGA (Dissolved Gas Analysis) shall be taken from all converter transformers of the Pole at both stations.

（2） Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a '**Ready for Operation**' condition.

（3） Verify both stations in '**Ready for Operation**' condition.

（4） Switch RPC to **Q control** in both stations.

（5） Start pole 1 at minimum power in **Normal Power Direction**, **Ground Return Operation,** 200MW (303A), ramp rate 100MW/min.

（6） Record and save all data.

2.3.2 Power Ramp

（1） Verify both stations in '**Ready for Operation**' condition for pole2.

（2） Start pole2 at minimum power in Normal Power Direction, Ground Return Operation, 200MW (303A), ramp rate 100MW/min.

（3） Change pole1 and pole2 from pole power control to bipole power control.

（4） Ramp the bipole power up to 2000MW at 50MW/min rate in steps of 200MW with an interval of 2 min. The interval is to make sure the system is stable.

（5） When Ramp bipole power from 400MW to 600MW at 999MW/min ramp speed.

（6） Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（7） Initiate in pole 1 a manual switchover from SC/PCPA to SC/PCPB and from SC/PCPB to SC/PCPA while ramp is in progress at both stations.

（8） Verify:

1） The reference is fulfilled after ramping in both stations at each power level.

2） Stable operation at each power level.

3） The RPC in both stations connects the appropriate number of filters and shunt banks in line with the technical specification during the ramping process.

（9） In Matiari CS, push the button “ESOF” to block pole2.

（10） Verify:

4） DC Power of Pole2 is transferred to pole1 sucessfully.

5） Pole 1 keeps steady operation at 2000MW.

（11） Perform Heat Run Test and Special Measurements See comments to heat run test as described in section 3.2.1 to 3.2.7 below.

（12） Initiate a manual switchover from SC/PCPA to SC/PCPB and from SC/PCPB to SC/PCPA while DC power is 2000MW at both stations.

（13） After the Heat Run Test and Special Measurements completed, Perform as Manual Tap Changer Step and Ground/Metallic Return Transfer described in section 2.3.3-2.3.4 at the power level 2000MW.

（14） Trigger TFR manually to Pole 1 DC side Analogue signal check in controls and Protection, and check the overlap.

（15） Ramp the power down to 200MW at 50MW/min rate in steps of 200MW with an interval of 2 min. The interval is to make sure the system is stable.

（16） When Ramp power from 800MW to 600MW at 999MW/min ramp speed.

（17） Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（18） Initiate a manual switchover from SC/PCPA to SC/PCPB and from SC/PCPB to SC/PCPA while ramp is in progress at both stations.

（19） Initiate manual changeover of valve cooling system main pumps during ramp at both stations.

（20） Verify:

1) the ramping process is smooth and continuous without transient changes in the power transmission.

2) the references are fulfilled after the ramping is completed.

（21） Stop the pole.

（22） Record and save test data.

2.3.3 Tap Changer Control, Manual Tap Changer Step

Notes: This test would be accomplished in parallel with 2.3.2.

Matiari:

（1） Set tap changer control in **MANUAL CONTROL** mode and decrease one steps for decreasing U_{di0}.

（2） Verify increased firing angle and maintained transmitted current.

（3） Set the tap changer control back to **AUTO CONTROL** mode.

（4） Verify that:

1） The tap changer would automatically return to original position if the AC voltage remained unchanged.

2） Firing angle back within control limits.

3） Maintained transmitted current.

LAHORE:

（5） Set tap changer control in **MANUAL CONTROL** mode and decrease one steps for decreasing Udi0.

（6） Verify:

1） Decreased DC voltage

2） Maintained gamma (γ) in LAHORE.

3） Decreased tap position in Matiari to maintain firing angle within control limits.

4） Maintained transmitted current.

（7） Set the tap changer control back to **AUTO CONTROL** mode.

（8） Verify that:

1） The tap changer would automatically return to original position if the AC voltage is unchanged.

2） Firing angle back within control limits.

3） DC voltage back to nominal value.

4） The tap position in Matiari is increased to maintain firing angle within control limits.

5） Maintained transmitted current.

（9） Record and save test data.

2.3.4 Ground/Metallic Return Transfer

Notes: This test would be accomplished in parallel with 2.3.2.

（1） Verify that both stations are in the '**Ready For Ground Return Operation**' condition (in software as well as by visual inspection).

Matiari:

（2） Order **TRANSFER TO METALLIC RETURN**.

（3） Verify:

1) Correct sequential operation of switches and breakers.

2) Correct operation of **MRTB)**in Matiari (The operation of the breaker should be observed visually carefully in order to interrupt the sequence in case of maloperation).

3) No disturbance in power transfer.

4) Check the correctness whether all related switches and breakers in Matiari and LAHORE are correctly operated in line with the technical specification.

（4） Order **TRANSFER TO GROUND RETURN.**

（5） Verify:

1） Correct sequential operation of switches and breakers.

2） No disturbance in power transfer.

3） Correct operation of **GRTS** in Matiari (The operation of the switch should be observed visually carefully in order to interrupt the sequence in case of maloperation).

4） Check the correctness whether all related switches and breakers in Matiari and LAHORE are correctly operated in line with the technical specification.

（6） Record and save all data.

3 Pole 1 Heat Run Test and Special Measurements

3.1 Preconditions

The test objective is to carry on heat run test and special measurement during high power test.

3.2 Preconditions

（1）all low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[X] Normal Pow. Dir. [ ] Reversed Pow. Dir.

[X] With TCOM [ ] Without TCOM

[X] Power Control [ ] Current Control

[X] Joint Control [ ] Separate Control

[X] RPC Auto [ ] RPC Manual

[X] Q control [ ] U control

[X] Norm volt. [ ] Reduced volt.

[X] Ground Return [ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[X] Normal Pow. Dir. [ ] Reversed Pow. Dir.

[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Norm volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

3.3 Test Content and Procedure

3.3.1 Pole 1 Run at 1.00 p.u. in Monopole without Redundant Cooling

Notes: The procedure (1) - (5) would be accomplished in parallel with 2.2.2-2.2.4.

（1） Before start of Heat Run Test, samples for DGA (Dissolved Gas Analysis) shall be taken from all Pole converter transformers at both stations.

（2） Switch RPC to **Q control** in both stations.

（3） Start the pole at minimum power in **Normal Direction**, **ground return operation,** 200MW (303A), ramp rate 50MW/min.

（4） Ramp the power up to 2000MW at 50MW/min rate in steps of 200MW, with an interval of 2 min with stable operation in between each 200MW increase:

（5） Keep the pole in operation for 4 hours at 1.0 p.u. The following verifications should be carried during this period.

1) Verify that the measured currents and voltages at DC and AC side are correct.

2) Read and record valve cooling water temperature inlet and outlet (local and/or remote indications) continuously, until reasonable stable temperature is reached (temperatures should be stable within approximately 15 minutes).

3) Read and record temperature of coil winding and hot spot in converter transformer and smoothing reactor every 30 minutes (local

and/or remote indications) until reasonable stable temperature is reached (temperatures should be stable within approximately 3 hours).

4) Read and record AC-side individual harmonics, D_n, total harmonic distortion, THD, Telephone Harmonic Form Factor, THFF, in Matiari and LAHORE.

5) Read and record DC-side harmonics and Ieq in Matiari andLAHORE.

6) Perform special measurements as described in below section 3.3.3-3.3.7.

7) **The Power Loss in Station** should be measured by subtracting the DC power from the power flowing into the converter transformer.

（6） Record and save all data.

（7） Keep pole running at 1.0 p.u. and proceed to the next item.

3.3.2 Pole 1 Run at 1.1 p.u. in Monopole with Redundant Cooling

（1） Verify the pole 1 running at 1.0p.u. in metallic transfer return.

（2） Ramp the power up to 2200MW at 50MW/min rate in steps of 200MW, with an interval of 2 min with stable operation in between each 200MW increase:

（3） Keep the pole 1 in operation for 2 hours at 1.1 p.u. The following verifications should be carried during this period.

1) Verify that the reference is fulfilled after the ramping is completed.

2) Verify that the measured currents and voltages at DC and AC side are correct.

3) Read and record valve cooling water temperature inlet and outlet (local and/or remote indications) continuously, until reasonable stable temperature is reached (temperatures should be stable within approximately 15 minutes).

4) Read and record temperature of coil winding and hot spot in converter transformer and smoothing reactor every 30 minutes (local and/or remote indications) until reasonable stable temperature is reached

5) Read and record AC-side individual harmonics, Dn, total harmonic distortion, THD, Telephone Harmonic Form Factor, THFF, in Matiari and LAHORE.

6) Read and record DC-side harmonics and Ieq in Matiari and LAHORE.

7) Perform special measurements as described in below section 3.3.3-3.3.7.

8) **The Power Loss in Station** should be measured by subtracting the DC power from the power flowing into the converter transformer.

（4） Ramp the power down to 2000MW (3030A), at 50MW/min

（5） Record and save all data.

3.3.3 Radio Interference Measurements

To check if the radio and television interference generated by the HVDC plant is within the specified limit at the specified locations.

（1） Choose 1 or 2 test places inside the converter stations and about 450m away outside the converter station and carry out the measurement of the interference frequency spectrum.

（2） To measure the frequency spectrum characteristics of radio interference under the outlet line of the ±660 kV valve hall and at 20 m from the outlet line inside the converter station.

（3） Record and save all data.

3.3.4 Audible Noise Check

To check if the audible noise level, generated by the HVDC plant, is within the specified limits at specified locations.

（1） Measurement of Audible noise near the convertor transformer in the converter station.

（2） Measurement of Audible noise along the boundary line outside the converter station.

（3） Measurement of Audible noise in front of the houses near the converter

station, if there are houses.

（4） Record and save all data.

3.3.5 Station Service Power Losses

The aim of this test is to determine the losses of the auxiliary supply under load and no-load conditions. According to the study report, only the critical and essential loads of the equipment supplied are included.

（1） In status **Ready for Operation**, the loads on the 400V power level are measured within one scheduled time period (for example 5 times measurements in one hour). The measurement results are averaged to get values, which are equivalent losses to the no-load or fixed losses.

（2） Verify that these measured loss values should be within limited value specified by technical specification.

（3） When the pole 1 is in operation at 1.0 p.u. or 1.1 p.u., the loads on the 400V power level are measured within one scheduled time period (for example 5 times measurements in one hour). The measurement results are averaged to get values.

（4） Record and save all data.

3.3.6 Temperature Measurement With IR-Camera Equipment

（1） Verify by use of IR-camera that the temperature of busbars, clamps conductors, equipment, etc. are acceptable in DC-yard, AC-yard, and valve hall.

（2） Record and save all data.

3.3.7 Ground Electrode Test

This test is to be carried out together with Heat Run Test, and it shall be conducted in both electrode sites simultaneously.

（1） Measure the electrode resistance by measuring the neutral bus voltage and the electrode current.

（2） Measure step and touch potentials at the electrode sites.

（3） Measure the various cable current of the electrode.

（4） Measure the temperature rise in the electrode conductor and the soil in the electrode site.

（5） Record all measurements mentioned above.

（6） Verify:

1) The current distribution within the various parts cables of the electrode shall be within the design limits.

2) Step and touch potentials must be within safe limits

3) The electrode conductor temperature shall be within the design limits.

（7） Record and save all data.

4 Pole 2 High Power Test, Normal Power Direction

4.1 Test Objective

The test objective is to check DC equipment performance during high power test.

4.2 Preconditions

（1）all low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[ ] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[X] Normal Pow. Dir. [ ] Reversed Pow. Dir.

[X] With TCOM [ ] Without TCOM

[X] Power Control [ ] Current Control

[X] Joint Control [ ] Separate Control

[X] RPC Auto [ ] RPC Manual

[X] Q control [ ] U control

[X] Norm volt. [ ] Reduced volt.

[ ] Ground Return [X] Metallic Return

LAHORE:

[X] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[X] Normal Pow. Dir. [ ] Reversed Pow. Dir.

[X] With TCOM [ ] Without TCOM

[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Norm volt.	[ ] Reduced volt.
[ ] Ground Return	[X] Metallic Return

4.3 Test Content and Procedure

4.3.1 Pole Start

（1） Before start of Heat Run Test, samples for DGA (Dissolved Gas Analysis) shall be taken from all converter transformers in the pole at both stations.

（2） Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a '**Ready for Operation**' condition.

（3） Verify both stations in '**Ready for Operation**' condition.

（4） According the actual situation and test requirement, verify the DC configuration is METALLIC RETURN(MR).

（5） Switch RPC to **Q control** in both stations.

（6） Start the pole at minimum power in **Normal Power Direction**, **Metallic Return Operation,** 200MW (303A), ramp rate 100MW/min.

（7） Record and save all data.

4.3.2 Power Ramp

（1） Ramp the power up to 2000MW at 50MW/min rate in steps of 200MW with an interval of 2 min. The interval is to make sure the system is stable.

（2） When Ramp power from 400MW to 600MW at 999MW/min ramp speed.

（3） Initiate a manual switchover from SC/PCPA to SC/PCPB and from SC/PCPB to SC/PCPA while ramp is in progress at both stations.

（4） Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（5） Verify:

1） The reference is fulfilled after ramping in both stations at each power level.

2） Stable operation at each power level.

3） The RPC in both stations connects the appropriate number of filters and shunt banks in line with the technical specification during the ramping process.

（6） Perform Heat Run Test and Special Measurements as described in section 5.2.1-5.2.6.

（7） Initiate a manual switchover from SC/PCPA to SC/PCPB and from SC/PCPB to SC/PCPA while the DC power is 2000MW at both stations.

（8） After the Heat Run Test and Special Measurements completed, Perform as Manual Tap Changer Step and Ground/Metallic Return Transfer described in section 4.3.3-4.3.4 at the power level 2000MW.

（9） Trigger TFR manually to Pole 1 DC side Analogue signal check in controls and Protection, and check the overlap.

（10） When we finish the heat run and special measurement test, the available AC filters will be switch in/off one by one.

（11） Ramp the power down to 200MW at 50MW/min rate in steps of 200MW with an interval of 2 min. The interval is to make sure the system is stable.

（12） When Ramp power from 800MW to 600MW at 999MW/min ramp speed.

（13） Initiate a manual switchover from SC/PCPA to SC/PCPB and from SC/PCPB to SC/PCPA while ramp is in progress at both stations.

（14） Initiate manual changeover of valve cooling system main pumps during ramp at both stations.

（15） Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

（16） Verify:

3) the ramping process is smooth and continuous without transient changes in the power transmission.

4) the references are fulfilled after the ramping is completed.

（17） Stop the pole.

（18） Record and save test data

4.3.3 Tap Changer Control, Manual Tap Changer Step

Notes: This test would be accomplished in parallel with 4.3.2.

Matiari:

（1） Set tap changer control in MANUAL CONTROL mode and decrease one steps for decreasing Udi0.

（2） Verify increased firing angle and maintained transmitted current.

（3） Set the tap changer control back to **AUTO CONTROL** mode.

（4） Verify that:

1） The tap changer would automatically return to original position if the AC voltage remained unchanged.

2） Firing angle back within control limits.

3） Maintained transmitted current.

LAHORE:

（5） Set tap changer control in **MANUAL CONTROL** mode and decrease one steps for decreasing Udi0.

（6） Verify:

5） Decreased DC voltage

6） Maintained gamma (γ) in LAHORE.

7） Decreased tap position in Matiari to maintain firing angle within control limits.

8） Maintained transmitted current.

（7） Set the tap changer control back to **AUTO CONTROL** mode.

（8） Verify that:

6） The tap changer would automatically return to original position if the AC voltage is unchanged.

7） Firing angle back within control limits.

8） DC voltage back to nominal value.

9） The tap position in Matiari is increased to maintain firing angle within control limits.

10） Maintained transmitted current.

（9） Record and save test data

5 Pole 2 Heat Run Test and Special Measurements

5.1 Preconditions

The test objective is to carry on heat run test and special measurement during high power test.

5.2 Preconditions

（1）all low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[ ] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[X] Normal Pow. Dir. [ ] Reversed Pow. Dir.

[X] With TCOM [ ] Without TCOM

[X] Power Control [ ] Current Control

[X] Joint Control [ ] Separate Control

[X] RPC Auto [ ] RPC Manual

[X] Q control [ ] U control

[X] Norm volt. [ ] Reduced volt.

[ ] Ground Return [X] Metallic Return

LAHORE:

[X] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[X] Normal Pow. Dir. [ ] Reversed Pow. Dir.

[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Norm volt.	[ ] Reduced volt.
[ ] Ground Return	[X] Metallic Return

5.3 Test Content and Procedure

5.3.1 Pole 2 Run at 1.00 p.u. in Monopole without Redundant Cooling

Notes: The procedure (1) - (5) would be accomplished in parallel with 4.3.2-4.3.4.

（1） Before start of Heat Run Test, samples for DGA (Dissolved Gas Analysis) shall be taken from converter transformers.

（2） Switch RPC to **Q control** in both stations.

（3） Start the pole at minimum power in **Normal Direction**, **metallic return operation,** 200MW (303A), ramp rate 50MW/min.

（4） Ramp the power up to 2000MW at 50MW/min rate in steps of 200MW, with an interval of 2 min with stable operation in between each 200MW increase:

（5） Keep the pole in operation for 4 hours at 1.0 p.u. The following verifications should be carried during this period.

8) Verify that the reference is fulfilled after the ramping is completed.

9) Verify that the measured currents and voltages at DC and AC side are correct.

10) Read and record valve cooling water temperature inlet and outlet (local and/or remote indications) continuously, until reasonable stable temperature is reached.

11) Read and record temperature of coil winding and hot spot in converter transformer and smoothing reactor every 30 minutes (local and/or remote indications) until reasonable stable temperature is reached.

12) Read and record AC-side individual harmonics, D_n, total harmonic distortion, THD, Telephone Harmonic Form Factor, THFF, in Matiari and LAHORE.

13) Read and record DC-side harmonics and Ieq in Matiari andLAHORE.

14) Perform special measurements as described in below section 5.3.3-5.3.6.

15) **The Power Loss in Station** should be measured by subtracting the DC power from the power flowing into the converter transformer.

（6） Record and save all data.

（7） Keep pole running at 1.0 p.u. and proceed to the next item.

5.3.2 Pole 2 Run at 1.1 p.u. in Monopole with Redundant Cooling

（1） Verify the pole 2 running at 1.0p.u. in metallic transfer return.

（2） Ramp the power up to 2200MW at 50MW/min rate in steps of 200MW, with an interval of 2 min with stable operation in between each 200MW increase:

（3） Keep the pole 2 in operation for 2 hours at 1.1 p.u. The following verifications should be carried during this period.

9) Verify that the reference is fulfilled after the ramping is completed.

10) Verify that the measured currents and voltages at DC and AC side are correct.

11) Read and record valve cooling water temperature inlet and outlet (local and/or remote indications) continuously, until reasonable stable temperature is reached (temperatures should be stable within approximately 15 minutes).

12) Read and record temperature of coil winding and hot spot in converter transformer and smoothing reactor every 30 minutes (local

and/or remote indications) until reasonable stable temperature is reached (temperatures should be stable within approximately 3 hours).

13) Read and record AC-side individual harmonics, Dn, total harmonic distortion, THD, Telephone Harmonic Form Factor, THFF, in Matiari and LAHORE.

14) Read and record DC-side harmonics and Ieq in Matiari and LAHORE.

15) Perform special measurements as described in below section 5.3.3-5.3.6.

16) **The Power Loss in Station** should be measured by subtracting the DC power from the power flowing into the converter transformer.

（4） Ramp the power down to 2000MW (3030A), at 50MW/min

（5） Record and save all data.

5.3.3 Radio Interference Measurements

To check if the radio and television interference generated by the HVDC plant is within the specified limit at the specified locations.

（1） Choose 1 or 2 test places inside the converter stations and about 450m away outside the converter station and carry out the measurement of the interference frequency spectrum.

（2） To measure the frequency spectrum characteristics of radio interference under the outlet line of the ±660 kV valve hall and at 20 m from the outlet line inside the converter station.

（3） Record and save all data.

5.3.4 Audible Noise Check

To check if the audible noise level, generated by the HVDC plant, is within the specified limits at specified locations.

（1） Measurement of Audible noise near the convertor transformer in the converter station.

（2） Measurement of Audible noise along the boundary line outside the converter

station.

（3） Measurement of Audible noise in front of the houses near the converter station, if there are houses.

（4） Record and save all data.

5.3.5 Station Service Power Losses

The aim of this test is to determine the losses of the auxiliary supply under load and no-load conditions. According to the study report, only the critical and essential loads of the equipment supplied are included.

（1） In status **Ready for Operation**, the loads on the 400V power level are measured within one scheduled time period (for example 5 times measurements in one hour). The measurement results are averaged to get values.

（2） Verify that these measured loss values should be within limited value specified by technical specification.

（3） When the pole 2 is in operation at 1.0 p.u. or 1.1 p.u., the loads on the 400V power level are measured within one scheduled time period (for example 5 times measurements in one hour). The measurement results are averaged to get values, which are equivalent losses to the no-load or fixed losses.

（4） Record and save all data.

5.3.6 Temperature Measurement With IR-Camera Equipment

（1） Verify by use of IR-camera that the temperature of busbars, clamps conductors, equipment, etc. are acceptable in DC-yard, AC-yard, and valve hall.

（2） Record and save all data.

6 Pole1 High Power Test, Reversed Power Direction (Optional)

2.1 Test Objective

The test objective is to check AC system response during high power test under reversed power direction.

2.2 Preconditions

（1）all low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[ ] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[ ] Normal Pow. Dir. [X] Reversed Pow. Dir.

[X] With TCOM [ ] Without TCOM

[X] Power Control [ ] Current Control

[X] Joint Control [ ] Separate Control

[X] RPC Auto [ ] RPC Manual

[X] Q control [ ] U control

[X] Norm volt. [ ] Reduced volt.

[X] Ground Return [ ] Metallic Return

LAHORE:

[X] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[ ] Normal Pow. Dir. [X] Reversed Pow. Dir.

[X] With TCOM [ ] Without TCOM

[X] Power Control [ ] Current Control

[X] Joint Control [ ] Separate Control

[X] RPC Auto [ ] RPC Manual

[X] Q control [ ] U control

[X] Norm volt. [ ] Reduced volt.

[X] Ground Return [ ] Metallic Return

6.3 Test Content and Procedure

6.3.1 Pole Start

（1） Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a 'Ready for Operation' condition.

（2） Verify both stations in '**Ready for Operation**' condition.

（3） According the actual situation and test requirement, verify the DC configuration is GROUND RETURN(GR).

（4） Switch RPC to **Q control** in both stations.

（5） Start the pole at minimum power in **Reversed Power Direction**, GROUND RETURN(GR)**,** 200MW (303A), ramp rate 100MW/min.

（6） Record and save all data.

6.3.2 Power Ramp

（1） Ramp the power up to 1000MW at 50MW/min rate in steps of 200MW with an interval of 2 min. The interval is to make sure the system is stable.

（2） Verify:

1） The reference is fulfilled after ramping in both stations at each power level.

2） Stable operation at each power level.

3） The RPC in both stations connects the appropriate number of filters and shunt banks in line with the technical specification during the ramping process.

（3） Ramp the power down to 200MW at 50MW/min rate in steps of 200MW with an interval of 2 min. The interval is to make sure the system is stable.

（4） Verify:

5) the ramping process is smooth and continuous without transient changes in the power transmission.

6) the references are fulfilled after the ramping is completed.

（5） Stop the pole.

（6） Record and save test data.

7 Safety measures and special points for the station tests

7.1 For HVDC system

（1） All personnel who take part in the test shall follow all the safety regulations for the electrical works strictly.

（2） In the station a qualified engineer should be appointed as a test leader from the Owner, who shall be a coordinator with CEPRI commissioning engineers.

（3） In the station, qualified technicians from the Owner, the assembly companies or the manufacture companies with mobile phone have to be appointed to watch the equipment in AC yard, in DC yard and in valve hall separately when a test proceeds. They ought to report immediately to the test leader as they find any abnormality or fault of the equipment.

（4） No person except observers as in 3 above is allowed to enter into the test area without permission .

（5） All the high voltage area shall be isolated with closed fence and a notice board with ‘HV DANGER!’ should be put on it.

（6） In the station, an emergent maintenance team with mobile phone shall be ready for any repair or inspection work when needed.

（7） Only the personnel with the test identity are allowed to enter the test area.

（8） The qualified operators are only allowed to carry out the operation under NPCC direction.

（9） All the operations shall be done strictly according to the Operation Instructions.

（10） The temporary test wiring and maintenance of main circuit equipment in site and control & protection cubicles should be proceeded and corresponding safety measures should be carried out by the qualified personnel under the supervision of qualified specialists.

（11） The test wiring to control or protection cubicles shall be demonstrated and supervised by qualified specialists.

7.2 For AC system

All the regulations and safety measures for the AC system operation have to be followed strictly.

8 Annex

HVDC--High Voltage Direct Current

DC-- Direct Current

AC--Alternative Current

CEPRI--China Electric Power Research Institute

TFR --Transient Fault Recorder

PCP--Pole Control & Protection

SCM--SCADA and Monitoring

SC--Station Control

RPC--Reactive Power Control

DGA-- Dissolved Gas Analysis

IR Camera -- Infrared Camera

Dn--Individual Harmonics

THD-- Total Harmonic Distortion

THFF--Telephone Harmonic Form Factor

IEQ-- Equivalent Interference Current

MRTB-- Metallic Return Transfer Breaker

GRTS-- Ground Return Transfer switch

NBGS-- Neutral Bus Ground Switch

OE notes that approval of this test procedure is conditional on the following:
a) CET to perform the additional tests identified by NPCC (letter General Manager System Operation 15476/80/GM(SO)/NPCC/NRCC dated Nov 24, 2020). CET will prepare in a new test procedure "A7-Matiari-Lahore ±660kV HVDC Transmission Project Commissioning Tests-Additional Tests" and submit for NTDC/OE review and approval.
b) CET to successfully complete all additional tests at a suitable time prior to the end of the commissioning period and start of commercial operation.

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中国电力科学研究院有限公司

Approved RBJ Engineering Corporation 1-Feb-2021

报告编号：HXT2020-108

巴基斯坦默蒂亚里-拉合尔±660高压直流输电工程系统调试方案

（6）双极大功率系统调试方案

Matiari-Lahore ±660kV HVDC Transmission Project Commissioning Tests

(6) Bipole High Power System Tests Program

China Electric Power Research Institute

2021.01

Version	Date	Modification
…	…	…
4.0	29 Jan 2021	Updated according to OE recommendations about low voltage reactor

工作单位： 中国电力科学研究院有限公司

项目负责人： 班连庚，谢国平

报告编写人： 林少伯,周亦夫,谢国平,刘世成,庞广恒,雷霄

中国电力科学研究院有限公司

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内容摘要

巴基斯坦默蒂亚里-拉合尔高压直流输电工程双极大功率系统调试方案内容包括：极起/停，双极功率升降，手动分接头控制，大地/金属转换，热运行试验，特殊测量试验。其中详细列出了每个试验项目内容、步骤及验收标准等。

关键词：巴基斯坦默拉直流；双极大功率系统调试方案；系统调试

ABSTRACT

Bipole High Power System Tests Program for Pakistan Matiari-Lahore ±660kV HVDC Transmission Project includes pole start, bipole power ramp, tap changer control, ground/metallic return transfer, heat run test and special measurements.

KEYWORDS: Pakistan Matiari-Lahore HVDC Project, Bipole High Power System Test Program, System Commissioning

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1 Preconditions

IMPORTANT: The pole power during the tests shall be up to 2000 MW, corresponding to 3030 A. The AC voltage at all the both converter stations including Matiari and LAHORE shall be 505-525kV before and during all tests. The frequency at all the both converter stations shall be 49.5-50.5Hz.

Before starting of high power bipolar transmission tests the following activities must have been completed:

- The low power monopolar tests
- Verify that the cooling equipment for converter transformers, smoothing reactor and thyristor valves are operating properly, with the correct switching of fans and pumps. Moreover, it must be checked that the redundant pumps, fans, and heat exchangers are available.
- The thyristor valve cooling pumps are running for more than 24 hours and all air bleeding valves are checked.
- There are four low voltage reactors available in Matiari and and two LV reactors available in Lahore converter station.

Furthermore, the following pre-conditions apply for all tests defined in this procedure. If any particular pre-condition is necessary for a specific test, it will be added in the test description.

- The test leader from CEPRI and Owner must be appointed.
- All equipment tests and subsystem tests of equipment involved in this test must be completed.
- Low voltage tests completed
- AC-switchyard and associated protections and sequences, including breaker failure protection, tested
- Final trip test done on each area prior to deblocking.
- Verify list of remaining activities and make sure that the test can proceed.
- Verify list of temporary connections and make sure that the test can proceed.

- Verify Sequence of Events Recorder (SER) and make sure no relevant alarms are present and that all systems are operational.
- Prior to each test, select the relevant TFR points that will be recorded, stored, and used as test records.
- The switching sequence prepared by Owner is ready and the station (or all equipment involved in the test) is handed over for operation.

2 Bipole Rated Load Operation, Normal Power Direction

2.1 Test Objective

The test objective is to carry on heat run test and special measurement during high power test.

2.2 Preconditions

（1）all low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[X] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[X] Normal Pow. Dir. [ ] Reversed Pow. Dir.

[X] With TCOM [ ] Without TCOM

[X] Power Control [ ] Current Control

[X] Joint Control [ ] Separate Control

[X] RPC Auto [ ] RPC Manual

[X] Q control [ ] U control

[X] Norm volt. [ ] Reduced volt.

[X] Ground Return [ ] Metallic Return

LAHORE:

[ ] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[X] Normal Pow. Dir. [ ] Reversed Pow. Dir.

[X] With TCOM [ ] Without TCOM

[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Norm volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

2.3 Test Content and Procedure

2.3.1 Bipole Power Ramping

（1） Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a '**Ready for Operation**' condition.

（2） Verify both stations in '**Ready for Operation**' condition.

（3） Start the bipole at minimum bipole power in **Normal Direction** in Matiari, 400MW (303A), ramp rate 50MW/min.

（4） Verify steady performance indicators and stable operation at minimum power.

（5） Ramp the power up to 4000MW at 100MW/min rate in steps of 400MW, with an interval of 2 min with stable operation in between each 400MW increase:

（6） Verify:

1）The reference is fulfilled after ramping in both stations at each power level.

2）Stable operation at each power level.

3）The RPC in both stations connects the appropriate number of filters and shunt banks in line with the technical specification during the ramping process.

（7） Ramp the power down to 400MW at 50MW/min rate in steps of 400MW, with an interval of 2 minutes with stable operation in between each 400MW increase:

（8） Initiate a manual switchover from SC/PCPA to SC/PCPB and from SC/PCPB to SC/PCPA while ramp is in progress at both poles in both stations..

（9） Verify:

1) the ramping process is smooth and continuous without transient changes in the power transmitted.

2) the references in both stations are fulfilled after the ramping is completed.

（10） Stop the bipole

（11） Record and save test data

2.3.2 Heat Run Test at 1.00 p.u.

Notes：

（1） Keep the pole in operation for 2 hours at 1.0 p.u. The following verifications should be carried during this period:

（2） Perform the tests or measurements below:

1) Verify in both stations that the reference is fulfilled after the ramping is completed.

2) Verify correct measured current and voltage at DC and AC side.

3) Read valve cooling water temperature inlet and outlet (local and remote indications) continuously, until reasonable stable temperature is reached.

4) Read temperature of coil winding and hot spot in converter transformer and smoothing reactor every 30 minutes (local and/or remote indications) until reasonable stable temperature is reached.

5) Read AC-side individual harmonics, D_n, total harmonic distortion, D_{eff}, Telephone Harmonic Form Factor, THFF, in Matiari and LAHORE.

6) Read DC-side harmonics and Ieq in Matiari and LAHORE.

（3） Perform the tests or measurements below:

1) Verify main circuit parameters: firing angles, extinct angles, AC and DC currents and voltages.

2) Read temperatures of valve cooling water, transformer and reactor, and verify the stable operation.

3) Perform special measurements as described in below section 2.3.3-2.3.6.

4) **The Power Loss in Station** should be measured by subtracting the DC power from the power flowing into the converter transformer.

（4） Record and save all data.

2.3.3 Radio Interference Measurements

To check if the radio and television interference generated by the HVDC plant is within the specified limit at the specified locations.

（1） Choose 1 or 2 test places inside the converter stations and about 450m away outside the converter station and carry out the measurement of the interference frequency spectrum.

（2） To measure the frequency spectrum characteristics of radio interference under the outlet line of the ±660 kV valve hall and at 20 m from the outlet line inside the converter station.

（3） Record and save all data.

2.3.4 Audible Noise Check

To check if the audible noise level, generated by the HVDC plant, is within the specified limits at specified locations.

（1） Measurement of Audible noise near the convertor transformer in the converter station.

（2） Measurement of Audible noise along the boundary line outside the converter station.

（3） Measurement of Audible noise in front of the houses near the converter station, if there are houses.

（4） Record and save all data.

2.3.5 Station Service Power Losses

The aim of this test is to determine the losses of the auxiliary supply under load and no-load conditions. According to the study report, only the critical and essential loads of the equipment supplied are included.

（1） In Ready for Operation status, the loads on the 400V power level are measured within one scheduled time period (for example 5 times measurements in one hour). The measurement results are averaged to get values, which are equivalent losses to the no-load or fixed losses.

（2） Verify that these measured loss values should be within limited value specified by technical specification.

（3） When the bipole is in operation at 1.0 p.u., the loads on the 400V power level are measured within one scheduled time perioed (for example 5 times measurements in one hour). The measurement results are averaged to get values.

（4） Record and save all data.

2.3.6 Temperature Measurement With IR-Camera Equipment

（1） Verify by use of IR-camera that the temperature of busbars, clamps conductors, equipment, etc. are acceptable in DC-yard, AC-yard, and valve hall.

（2） Record and save all data.

3 Bipole High Power Operation, Reversed Power Direction(Optional)

3.1 Test Objective

The test objective is to check the AC system response during high power test under reversed power direction.

3.2 Preconditions

（1）all low power tests have been finished.

（2）AC system precondition:

1) The 500kV bus voltage of two AC systems is about 505~525kV.

2）Both sides of AC system are capable to supply the power for the test.

（3）DC system precondition:

Matiari:

[ ] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[ ] Normal Pow. Dir. [X] Reversed Pow. Dir.

[X] With TCOM [ ] Without TCOM

[X] Power Control [ ] Current Control

[X] Joint Control [ ] Separate Control

[X] RPC Auto [ ] RPC Manual

[X] Q control [ ] U control

[X] Norm volt. [ ] Reduced volt.

[X] Ground Return [ ] Metallic Return

LAHORE:

[X] Master

[X] SC A Active [ ] SC B Active

[X] PCP A Active [ ] PCP B Active

[ ] Normal Pow. Dir.	[X] Reversed Pow. Dir.
[X] With TCOM	[ ] Without TCOM
[X] Power Control	[ ] Current Control
[X] Joint Control	[ ] Separate Control
[X] RPC Auto	[ ] RPC Manual
[X] Q control	[ ] U control
[X] Norm volt.	[ ] Reduced volt.
[X] Ground Return	[ ] Metallic Return

3.3 Test Content and Procedure

3.3.1 Bipole Power Ramping

（1） Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a '**Ready for Operation**' condition.

（2） Verify both stations in '**Ready for Operation**' condition.

（3） Start the bipole at minimum bipole power in **Reversed Direction** in Lahore, 400MW (303A), ramp rate 100MW/min.

（4） Verify steady performance indicators and stable operation at minimum power.

（12） Ramp the power up to 2000MW at 50MW/min rate in steps of 400MW, with an interval of 2 min with stable operation in between each 400MW increase:

（13） Verify:

1）The reference is fulfilled after ramping in both stations at each power level.

2）Stable operation at each power level.

3）The RPC in both stations connects the appropriate number of filters and shunt banks in line with the technical specification during the ramping process.

（14） Ramp the power down to 400MW at 50MW/min rate in steps of 400MW, with an interval of 2 minutes with stable operation in between each 400MW increase:

（15） Initiate a manual switchover from SC/PCPA to SC/PCPB and from SC/PCPB to SC/PCPA in both poles at both stations while ramp is in progress.

（16） Verify:

1) the ramping process is smooth and continuous without transient changes in the power transmitted.

2) the references in both stations are fulfilled after the ramping is completed.

（17） Stop the pole

（18） Record and save test data

4 Safety measures and special points for the station tests

4.1 For HVDC system

（1） All personnel who take part in the test shall follow all the safety regulations for the electrical works strictly.

（2） In the station a qualified engineer should be appointed as a test leader from the Owner, who shall be a coordinator with CEPRI commissioning engineers.

（3） In the station, qualified technicians from the Owner, the assembly companies or the manufacture companies with mobile phone have to be appointed to watch the equipment in AC yard, in DC yard and in valve hall separately when a test proceeds. They ought to report immediately to the test leader as they find any abnormality or fault of the equipment.

（4） No person can enter into the test area without permission.

（5） All the high voltage area shall be isolated with closed fence and a notice board with ‘HV DANGER!’ should be put on it.

（6） In the station, an emergent maintenance team with mobile phone shall be ready for any repair or inspection work when needed.

（7） Only the personnel with the test identity are allowed to enter the test area.

（8） The qualified operators are only allowed to carry out the operation.

（9） All the operations shall be done strictly according to the Operation Instructions.

（10） The temporary test wiring and maintenance of main circuit equipment in site and control & protection cubicles should be proceeded and corresponding safety measures should be carried out by the qualified personnel under the supervision of qualified specialists.

（11） The test wiring to control or protection cubicles shall be demonstrated and supervised by qualified specialists.

4.2 For AC system

All the regulations and safety measures for the AC system operation have to be followed strictly.

5 Annex

HVDC--High Voltage Direct Current

DC--Direct Current

AC--Alternative Current

CEPRI--China Electric Power Research Institute

TFR --Transient Fault Recorder

PCP--Pole Control & Protection

SCM--SCADA and Monitoring

SC --Station Control

RPC--Reactive Power Control

DGA-- Dissolved Gas Analysis

IR Camera -- Infrared Camera

Dn --Individual Harmonics

THD--Total Harmonic Distortion

THFF--Telephone Harmonic Form Factor

IEQ-- Equivalent Interference Current