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Validation of redundant UPS power distribution during HWC'17 : Test results

I. Romera (TE-MPE), V. Chareyre (EN-EL)


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Recall

- **Third campaign to validate the redundant UPS power distribution during the EYETS 2016-17 following a new commissioning procedure (EDMS 1773693)**
- **New procedure consists in provoking power cuts on General Services and UPS F4 networks to minimize the impact on sensitive equipment (UPS F3 validated by exclusion)**
- **Validation tests successfully carried out during the powering test campaign:**
 - 5th April => S78, S81
 - 10th April => S34, S45
 - 11th April => S56, S67
 - 19th April => S12, S23

CERN CH-1211 Geneva 23 Switzerland

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 LHC

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TEST PROCEDURE

VALIDATION OF REDUNDANT UPS POWER DISTRIBUTION FOR LHC EQUIPMENT SYSTEMS AFTER EYETS

ABSTRACT:

This document describes the global test of the redundant UPS power distribution which will be carried out prior to the powering test campaign after the EYETS. The objective of this test is to validate the correct powering of the critical users' equipment fed by UPS and to ensure that machine protection is not compromised even when losing a complete redundant power distribution network.

| PREPARED BY: | CHECKED BY: | APPROVED BY: |
|---------------------------------------|---|---|
| V. Chareyre EN-EL I. Romera TE-MPE | M. Bernardini, L. Bottura, J.P. Burnet, P. Chiggiato, D. Delikaris, R. Falch, K. Foraz, C. Gaignant, B. Goddard, E. Hatzigeorgi, M. Lamont, E. Jensen, R. Jones, H. De Maynard, M. Nonis, T. Otto, S. Roesler, R. Schmidt, L. Taviani, M. Tavel, J. Uythoven, J. Wenninger, M. Zerlauth | N. Bellegarde P. Collier J.M. Jimenez R. Losito A. Siemko |

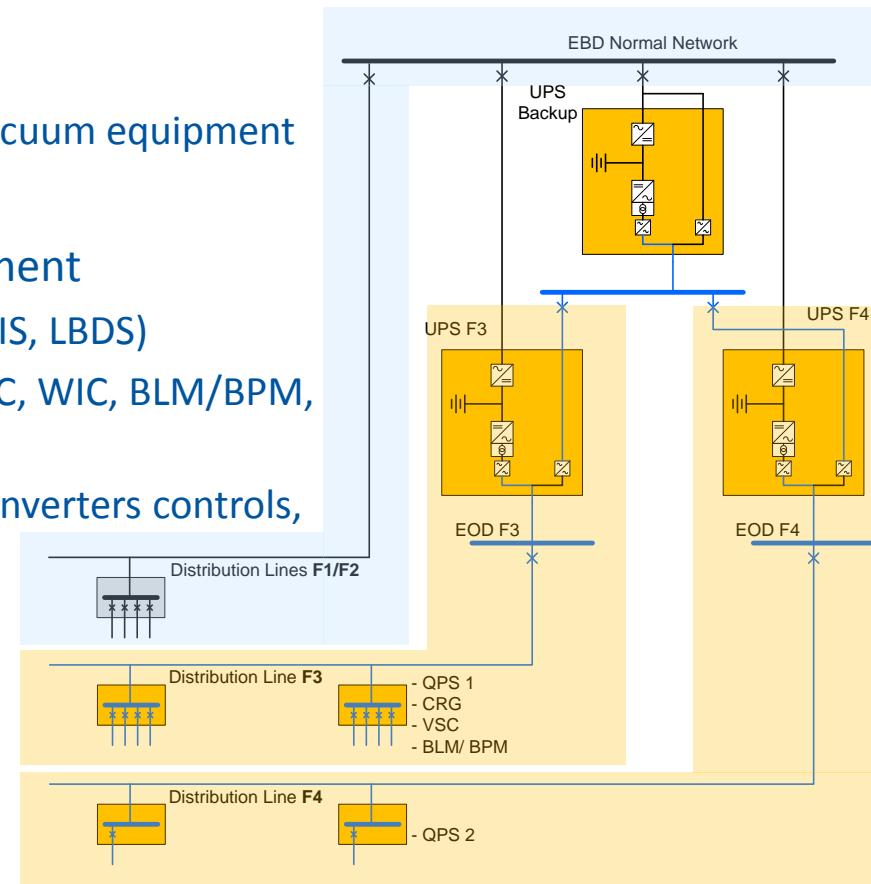
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Recall on power distribution networks

- (Simplified) electrical distribution in LHC tunnel
 - **General services, no backup**
 - For all users
 - Including non-critical cryogenics and vacuum equipment
 - **F3 UPS network for all critical equipment**
 - Redundant machine protection (QPS, BIS, LBDS)
 - Non-redundant machine protection (PIC, WIC, BLM/BPM, Collimators, etc.)
 - Cryogenics/Vacuum controls, Power Converters controls, EE, World-FIP, etc.
 - IT star-points, GSM, etc.
 - **F4 UPS network for redundant machine protection**
 - QPS, BIS, LBDS



UPS layout in RE alcoves and LHC odd points

Test results: LBDS

- **Fully redundant system** powered by two redundant power distribution paths (i.e. F3 and F4)
- Non-conformities found in HWC'15 and HWC'16 were fixed immediately after the tests
- During HWC'17 => **Everything ok for all sub-systems with an impact on machine protection** (MKD, MKB, TSU, CIBUs, IPOC....)

| Sector | UPS area | Position | HWC'15 | HWC'16 | HWC'17 |
|--------|-----------|----------|---|--|--------|
| 56 | UA63/US65 | LBDS1 | System not armed. Test not conclusive | OK | OK |
| 56 | US65 | LBDS1 | OK | FEC "cfc-ua63-mkdtspm" used for monitoring with the two redundant power supplies on the same UPS | OK |
| 67 | UA67/US65 | LBDS2 | 2 re-trigger crates connected to the same UPS | OK | OK |
| 67 | UA67/US65 | LBDS2 | TSU-IPOC system only connected to one UPS | OK | OK |

- **Dedicated tests were done for the LBDS by provoking power cuts of UPS F3 and F4**, as new procedure only foresees validation of UPS F3 by exclusion
- Collateral effects => Some power supplies did not survive the power outage and had to be replaced

Test results: QPS (1/2)

- **Fully redundant equipment** powered by two redundant UPS networks (F3 and F4)
- Issues revealed during the two first campaigns were fixed after the tests
- During this campaign **4 new non-conformities were revealed**
- 3 types of issues were discovered:
 - **REAL:** Non-conformity related to UPS power distribution (EN-EL or system internal)
 - **COLLATERAL:** Non-conformity originated as a consequence of the test itself
 - **NONE:** Non-conformity revealed by the test but not related to UPS distribution (i.e. typically a system that was switched off before the test)

| Sector | Position | Description | Fault type | Crosscheck | HWC'17 |
|--------|----------|---|------------|---|---------|
| S12 | B10R1 | nQPS - Lost communication during F4 cut, both power packs powered from F4 | REAL | Three pins bent in power connector | Cleared |
| S45 | B19L5 | Lost power during F4 cut | REAL | Faulty cable between power pack and DQLPU-S | Cleared |
| S67 | MQ.31R6 | Powered from F3 instead of F4 | REAL | Reconnected to F4 | Cleared |
| S81 | B16R8 | nQPS – Lost power during F4 cut | REAL | Reconnected to F4 | Cleared |

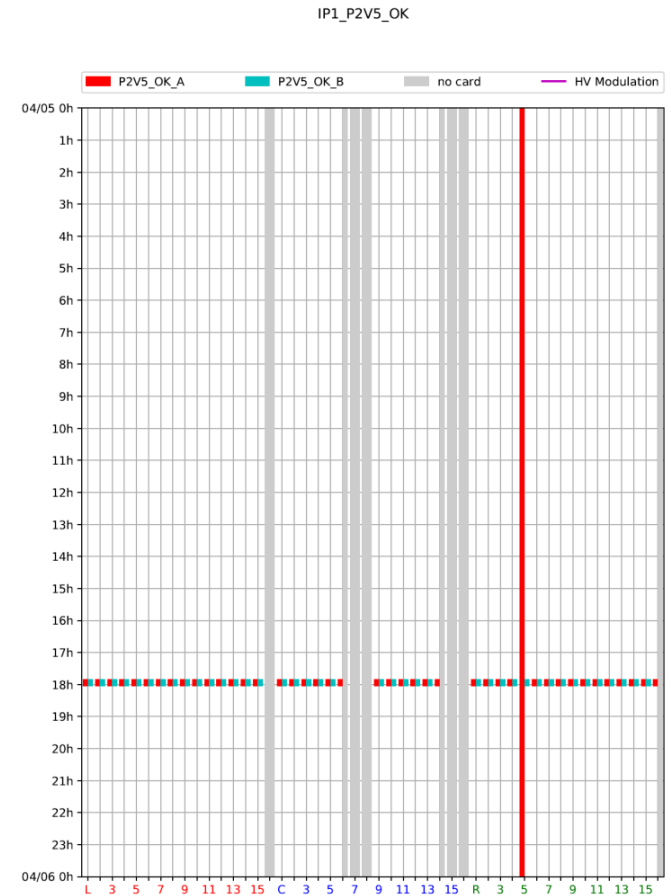
Test results: QPS (2/2)

| Sector | Position | Description | Fault type | Crosscheck | HWC'17 |
|--------|------------------|---|------------|-----------------------------|---------|
| S23 | B11R2 | nQPS – DS board partially lost during F4 cut | COLLATERAL | Power pack damaged | Cleared |
| | MQ.13R2 | Heater fired during F4 cut, DQQDL board damaged | COLLATERAL | DQQDL changed | Cleared |
| | RQ5.R2 | Heaters latched, probably not reset after IST | NONE | Not related to UPS powering | Cleared |
| | B31L3 | nQPS – DS kept loop open after repowering | COLLATERAL | Power pack damaged | Cleared |
| S34 | MQ.25L4 | Syco - Switch mode power supply damaged during test | COLLATERAL | Confirmed | Cleared |
| | B9R4 | HDS not charged | NONE | Not related to UPS | Cleared |
| S45 | MQ.25R4 | Heater fired during F4 cut | NONE | DQQDL not correctly plugged | Cleared |
| S56 | RQ4.R5 RQ5.R5 | Communication lost during F4 cut | COLLATERAL | TRACO power supply damaged | Cleared |
| | MQ.20R5 | Syco – Switch mode power supply damaged during test | COLLATERAL | Confirmed | Cleared |
| | MQ.22R5 | Syco - Switch mode power supply damaged during test | COLLATERAL | Confirmed | Cleared |
| S81 | RQX.L1 | Heaters discharged during F4 cut | COLLATERAL | TRACO power supply damaged | Cleared |

Test results: Beam instrumentation (1/2)

■ BLM

- BLM acquisition systems are **powered by a single UPS power distribution network** (i.e. UPS F3)
- None of the BLM acquisition cards has switched off during the UPS validation, i.e. **no non-conformity observed**
- Despite not all cards were fully operational and few cards had still issues, **BLM team could reliably extract the needed information** (i.e. by checking HV, 2.5V and ± 5 V power supplies)
- To be noted that BLM team highly appreciate the **new procedure as reduces significantly the validation time, avoids having to restore the boards and increases the life-time of electronics**



Report showing the status of one of the 2.5V power supplies in the BLM-R crate in IP1

Test results: Beam instrumentation (2/2)

■ BPM

- Front-end electronics powered by a **single UPS distribution network (F3)**
- Located in the tunnel under the dipole and quadrupole magnets and in UA, UJ and RRs alcoves
- **Tests were not closely followed due to other task with higher priority...**

| Sector | UPS area | Position | HWC'15 | HWC'16 | HWC'17 |
|--------|----------|------------|--|------------------------------|--------|
| 23 | UA27 | BYPMs | Test not conclusive, data missing | Ok : cut 7/03 11h43 | Ok? |
| | UJ33 | BYPM.B10L3 | Remained powered during all the test | Ok : cut 7/03 18h00 | Ok? |
| 34 | UJ33 | BYPM.B10R3 | Remained powered during all the test | Ok : cut 7/03 18h00 | Ok? |
| | | BY01=UJ33 | Remained powered during all the test | Ok : cut 7/03 18h00 | Ok? |
| 67 | US65 | BYPM.10R6 | Remained powered upon UPS F3 power cut | Ok : cut 8/03 11h28 | Ok? |
| 78 | RE78 | BYPLMs | Test not conclusive, data missing from 12 to 34R7 | Data missing Fesa token lost | Ok? |
| | UA83 | BY03=UA83 | Remained powered during all the test | Ok : cut 03/03 11h30 | Ok? |
| 81 | US85 | BYPM.8R8 | Powered from UPS F4 network, Reconnected to F3 by EN-EL | Ok | Ok? |
| | RE88 | BYPM.12R8 | Remained powered during all the test. New UPS F3 socket installed by EN-EL | Ok | Ok? |
| | RE12 | BYPLM.20L1 | Remained powered during all the test | Ok : cut 03/03 16h37 | Ok? |

Test results: Collimation

- **Collimator controls are powered by single UPS F3 power distribution network**, except in point 7 where there is a UPS in TZ76 exclusively dedicated to the collimation
- During this campaign => **All collimator control systems remained power during the tests**
- **TZ76 and USC55 areas were not concerned** by the power cuts during the test campaign

| Location | Racks | UPS test | HWC'16 | HWC'17 |
|----------|---------------------------------|-------------------------------|-----------------------------------|----------------------|
| US15 | TYCFL01 to 03 | 03/03/2016 | All systems switched off at 17H20 | Ok, remained powered |
| | | 07/03/2016 | All systems switched off at 16H56 | Ok, remained powered |
| UA23 | TYCFL01 to 03, TYTDI01, TYCDD01 | 07/03/2016 | All systems switched off at 11H25 | Ok, remained powered |
| UA27 | TYCFL01 | 07/03/2016 | All systems switched off at 11H46 | Ok, remained powered |
| UJ33 | TYCOL01 to 10 | 02/03/2016 | All systems switched off at 15H37 | Ok, remained powered |
| | | 07/03/2016 | All systems switched off at 17H56 | Ok, remained powered |
| USC55 | TYCFL01 to 03 | Area not concerned | | |
| US65 | TYCFL01 | 08/03/2016 | All systems switched off at 11H39 | Ok, remained powered |
| TZ76 | TYCHL14 to 48 | Not concerned (dedicated UPS) | | |
| UA83 | TYCFL01 | 03/03/2016 | All systems switched off at 11H47 | Ok, remained powered |
| UA87 | TYCFL01 to 03, TYTDI01 | 03/03/2016 | All systems switched off at 11H00 | Ok, remained powered |

Test results: Machine Interlocks

▪ Beam Interlock System - BIS

- Fully redundant equipment powered by two redundant UPS distribution networks
- Non-conformities revealed during the first campaign were fixed in 2015
- No non-conformities revealed this year

| Sector | UPS area | Position | HWC'15 | HWC'16 | HWC'17 |
|--------|----------|----------|--|--------|--------|
| 34 | UA43 | CYCIB01 | Faulty WIENER power supply powered by UPS F3 | OK | OK |
| 67 | TZ76 | CYCIB01 | Both WIENER power supplies powered by UPS F4 | OK | OK |

- To be noted that some CIBUs are not redundantly powered (i.e. installed in users' rack) and lost power during the test

▪ Magnet Interlock Systems – PIC and WIC

- Magnet interlocks are powered by a single UPS (i.e. F3)
- Two non-critical non-conformities revealed during the first campaign
- Systems relocated in the TZ76 and UL557 during LS1 were powered by UPS F4

| Sector | UPS area | Position | HWC'15 | HWC'16 | HWC'17 |
|--------|----------|----------|--|--------------|--------------|
| 56 | UL557 | CYCIP01 | Rack powered by UPS F4 instead of UPS F3 | NON CRITICAL | NON CRITICAL |
| 67 | TZ76 | CYCIP01 | Rack powered by UPS F4 instead of UPS F3 | NON CRITICAL | NON CRITICAL |

Test results: WorldFIP and Timing

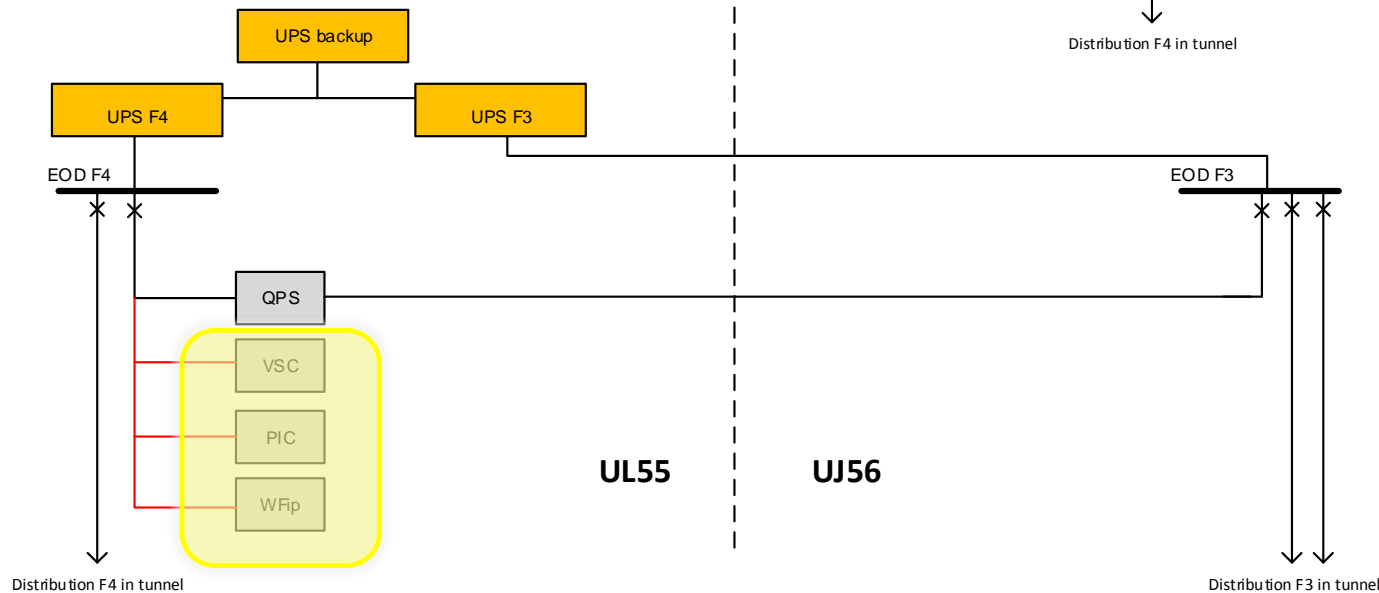
- **FIP and Timing infrastructure is powered by single UPS line (i.e. UPS F3)** and used for controls and diagnostics of some main clients: Power Converters, QPS and Cryogenics
- **A non-conformity persists** during this test campaign which can impact diagnostics in case of losing redundant UPS power path (F4)

| UPS Area | Clients affected | HWC'16 | HWC'17 |
|---------------------|------------------|---|------------------------------------|
| TZ76 / RR73 / RR77 | EPC/QPS/ Cryo | Agents lost communication with F4 power cuts Repeaters in CYFRE01 in TZ76 powered by F4 | OK, fixed during EYETS before test |
| UJ56 | EPC | FipDiag powered by F4 | NON CRITICAL, just diagnostics |
| UL557 / RR53 / RR77 | Cryo | Agents lost communication with F4 power cuts Repeaters in CYFRE01 in UL557 powered by F4 | OK, fixed during EYETS before test |

- Installation of redundant **WorldFIP powering was not considered as mandatory** by user clients and not endorsed by the LMC due to considerable cost (see J. Palluel at LMC 216th)

Singularities in UL55 and TZ76

- UPSs and users racks moved during LS1 due to radiation issues (R2E project)
- F3 switchboard left in UJ56 and UJ76 because tunnel distribution remained unchanged
- Racks in UL55 and TZ76 connected to F4 switchboard installed in the same zone while they should be connected to F3 network



Before LS1

After LS1

Conclusions

- **New procedure was highly appreciated by most of UPS users** as simplifies the validation of Machine Protection Systems and reduces collateral effects
- **Impact on cryogenics is reduced compared to the old procedure** (e.g. redundant 24V DC power supplies only partly switched off) and recovery time estimated to 3-4 hours for powering tests / 1.5 days for final physics configuration (2nd option chosen this year).
- **Less and less non-conformities revealed during the 3rd campaign**
- Non-negligible effort to prepare the new test campaign and impact on powering tests

=> MPP to review the necessity of repeating these tests on a yearly basis

=> MPP to decide what to do with singularities affecting powering of MPS in UL55 and TZ76

Thanks for your attention

