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Experience gained in the commissioning of the normal conducting magnet interlock system (WIC) in TI8

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Abstract

This document describes the experience gained during the commissioning of the interlock system for normal conducting magnets in the SPS-LHC transfer line TI8. The procedures are detailed in a specific test procedure document, while this note concentrates on the experience gained when performing the installation and test sequences in TI8. It deals with difficulties and following improvements of the system as well as a proposal for future work and enhancements.

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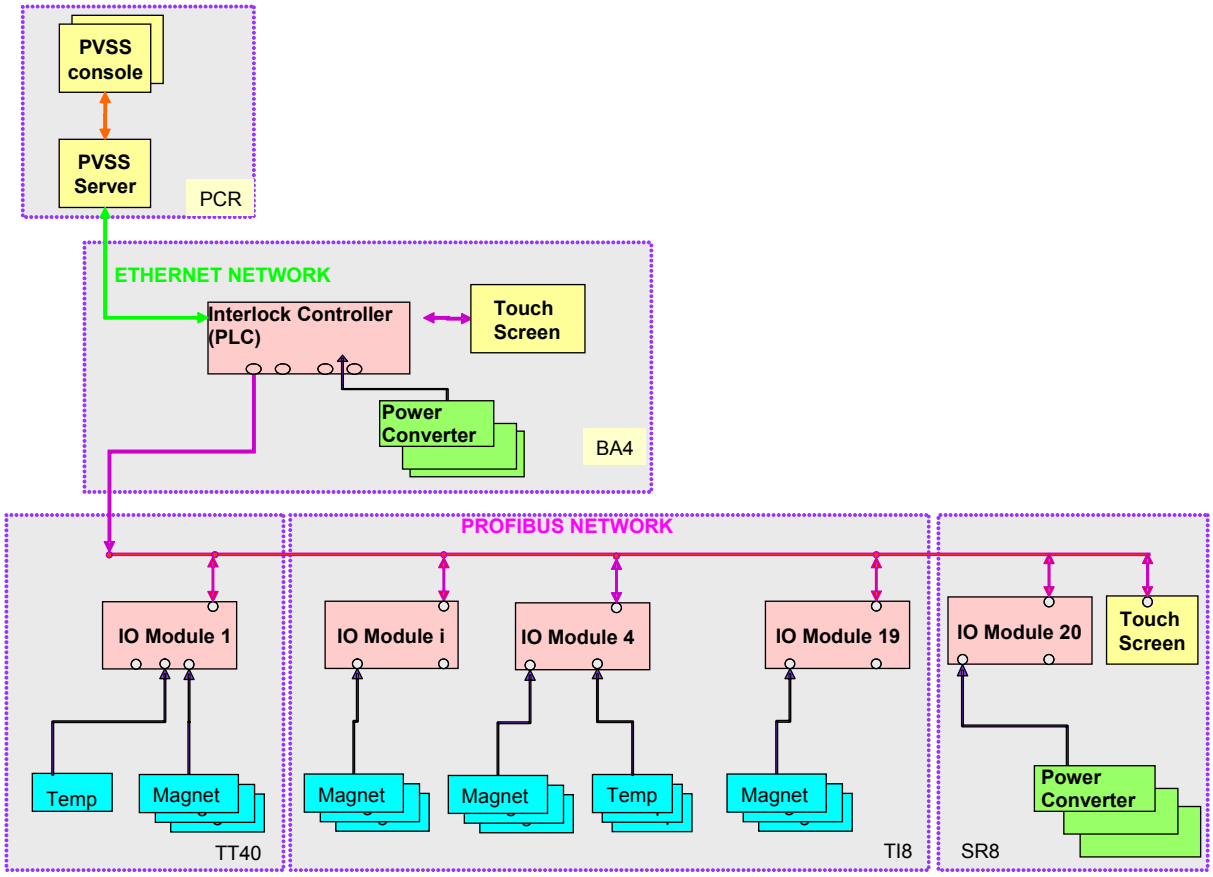
INTRODUCTION

After the independent qualification and electrical quality assurance of the normal conducting magnets in the TI8 transfer line, the normal conducting magnet interlocks system (in the following referred to as WIC, 'Warm Magnet Interlock System') has been installed and commissioned during this following commissioning phase. The detailed test procedures are described in the EDMS document 'Procedures for the commissioning of the normal conducting magnet interlock system in the SPS-LHC transfer line TI8'. This document outlines the experiences gained during installation and commissioning of the warm magnet interlock system in TI8. An overview on the systems concerned during this phase of installation and commissioning is shown in the following figure.



PURPOSE

The aim of this document is a documentation of the gained experience in order to facilitate following re-iterations of the commissioning in the transfer line TI8 and the coming commissioning of TI2. Due to the similarities in the interlock architecture between SPS-LHC transfer lines and the interlock system for normal

conducting magnets in the LHC, this document will help to identify possible failure modes and weak points of the system at an early stage.

EXPERIENCES DURING THE DIFFERENT COMMISSIONING STAGES

CONNECTIONS IN BETWEEN MAGNET AND THE WIC CRATE

- To verify the arrival of the magnet signal at the correct input of the remote I/O module, every cable is at first disconnected at the level of the magnet. For safety reasons this has to happen with all the power converters earthed and not switched on (mode consigné).
- Once a magnet is disconnected, the arrival of the over temperature signal to the correct Input can be confirmed, and the loss of the "Powering OK" signal of the corresponding power converter at the Output module (BA4 or SR8) is verified.
- Simultaneously the corresponding signals are verified at the supervision level in the PCR (PVSS application) and with the BA4 or SR8 touch panel.

It is important to verify every magnet, as during TI8 commissioning it has been found that some magnets in a circuit containing several magnets did not result in a powering abort of the corresponding power converter (MBIBV 87742, MQIF 87404 and MBI 81607). These magnets had to be added to the PLC program and this test sequence had to be repeated for the complete circuit.

The power converters for the magnets are located on both sides of the transfer line (BA4 and SR8), therefore the tunnel had to be walked through twice, firstly disconnecting only magnets powered from BA4 and secondly verifying magnets powered from SR8. Leaving aside the magnets that needed to be added to the PLC program, no major faults were experienced during this phase of commissioning. Specific Tests sheets as shown in Appendix#1 have been used to document the progressing tests during this commissioning phase.

CONNECTION IN BETWEEN POWER CONVERTERS AND THE WIC CRATE

During this second phase the power converters are in a state of operation, and although they are not supplying current, the magnet supplies are not earthed (power converters déconsignés).

- The tunnel has to be therefore reserved for interlock tests only. The tunnel is in the status "Magnet Patrol"
- Due to the increased risk, the test will require a team of two people in the tunnel. The cables at the level of the magnets are not accessible any more (due to the risk of current in the circuits)
- The interlock cables for the power converters are verified by disconnecting the magnet cables at the level of the WIC crate in the tunnel. As with the previous test sequence, cables connected to the power converters in BA4 are tested first, then secondly the converters held in SR8.
- Tests progress from crate to crate, and one of the magnets in each power converter circuit is disconnected. The loss of the "Powering OK" signal is tested at the level of the power converter, and confirmation that the according power converter has aborted its output. The change of state is

monitored at the same time at the supervision level in PCR. Each power converter is again tested this time with the removal of the "PC Permit" via the supervision software.

On completion of the test at the level of the crate, it is important to verify that the mechanical locking of each connector is secure, and no miscellaneous electrical faults due to bad contacts for example are present (one such fault has been found by the PVSS supervision application upon moving/touching a cable which showed to have a connector pin not correctly in place). Specific Tests sheets as shown in Appendix#1 have been used to document the progressing tests during this commissioning phase.

TEMPERATURE PROBES

A total of nine temperature probes (PT100) have been installed in the tunnel attached to the slave crates CIWRA 400285 (in TT40) and CIWRA 81644 (in TI8):

- CIWRA 400285: one temperature probe which informs us about the temperature inside the crate. This is convenient in order to know if the chassis architecture provides the proper ventilation conditions for normal operation of the slave crates.
- CIWRA 81644: eight temperature probes which inform about the temperature of the coil on different types of magnets: MBIAV 81553, MQIF 81600, MCIAH 81604, MBI 81620 (coil and yoke) as well as near the magnets, near the cables and at the concrete wall.

During the commissioning we have measured through the PVSS supervision system and the touch panels the temperature values, comparing them with a FLUKE temperature probe. The difference observed in some cases (MBI 81620 Yoke, MBIAV 81553, MQIF 81600, Near Magnets, Near Cables and Concrete Wall) was up to four degrees Celsius. We conclude that this is due to a bad factory calibration of the temperature probes.

A future application is the correlation of these temperature values with cooling and ventilation ones (tunnel air in and tunnel air out) in order to provide in a single fixed supervision screen all the values.

TIMING SYNCHRONISATION

The timing synchronization between all the systems involved is needed. The most common procedure is the use of the NTP protocol; however the Ethernet PLC CP (Communication Processor) installed in the WIC does not support it. The solution we have chosen is a home made NTP protocol implementation between the PLC and the PVSS systems. We have tested its operation during one week and the results showed a time difference of plus/minus one second between the PLC time and the PVSS console time.

Currently for our system the protocol has been proved to be sufficient, however in the future it would be desirable to use the SIEMENS CP IT series which supports NTP. This is important from the point of view of the correlation of data between the interlocks and the power converters team.

NETWORKING PROFIBUS AND ETHERNET

A cut on the PROFIBUS cable was discovered previous to the first commissioning stage, this was repaired and verified before commissioning commenced.

The operation of the remote I/O (PROFIBUS Slaves) and the PLC controller (PROFIBUS Master) when placed under certain fault conditions was tested during commissioning. The task was to test the fail safe operation of the remote I/O modules and the control software, in order to check the correct operation several scenarios have been considered and simulated:

- PROFIBUS cable cut: Disconnect the PROFIBUS cable on the output of a repeater located in a remote I/O crate, interrupting as such the PROFIBUS communication. The last crate in SR8 will fail safe and all the outputs to the power converters will automatically be switched off, this is due to the loss of communications with the CPU (PROFIBUS safe state). The PLC I/O module in BA4 will switch its outputs to the power converters off, this is done via the control software which detects the loss of communications.
- PROFIBUS connector failure: Remote I/O crate without repeater is disconnected from the network; therefore communication only with this module is lost. All the magnet inputs managed by this slave are lost, the according power converters in BA4 and SR8 are switched off by the WIC software. In any of the above cases, the system has been put into a safe state, namely switching off the power converters at the two extremities (BA4 and SR8).

At the Ethernet level, the Ethernet module of the PLC CPU has been set to STOP mode in order to simulate its failure. The result has been:

- The loss of communications from the PVSS supervision application due to the loss of the MODBUS over TCP/IP connection.
- The PLC continues operating normally without problems running the control software.

SLAVE CRATE RESETS

It is possible that due to radiation some slaves can present a malfunction. In order to rectify this situation a remote reset of the slave crates has been incorporated into the interlocks architecture. When a save crate has been found to be ‘Defective’ a reset is performed via the PVSS supervision system or via the touch panels. The slave reset disconnects the power supply to the slave crate remotely; this in turn switches off the power converters concerned by this crate, after a short time the power is restored and operation is resumed. During this phase of the commissioning we discovered a cabling problem from the output of crate CIWRA 87544. This has been repaired and no other abnormalities were discovered.

The remote reset of all the I/O crates were successfully tested both by the PVSS supervision systems and the local touch panels. Via the PVSS supervision tests performing multiple resets of several slaves were successfully completed. It is anticipated that a remote reset of the PLC CPU will be incorporated in to the WIC system.

POWERING FAILURES OF THE PLC AND SLAVE CRATE

Two further cases of failure were considered; a power failure to a remote I/O module (PROFIBUS Slave) and a power failure to the PLC controller (PROFIBUS master).

In either of these two cases the system has to be put into a safe state, namely switching off certain or all the power converters (BA4 and SR8). After the occurrence of a PLC or slave crate powering failure, the following system reactions have been guaranteed and successfully tested:

- Action: PLC CPU power loss. Reaction: All the outputs are put to a safe state and all the power converters are switched off.
- Action: Slave crate power loss. Reaction: The corresponding power converters which feed the magnets attached to that crate are switched off.

PLC CPU STOPS

We have tested the behaviour of our system in the case of a STOP of the CPU. We physically put the CPU in the STOP mode and observed that all the Power Converters were switched off, putting the system into a safe state. From the point of view of the PVSS supervision system, all communication with the PLC is lost and so no further information can be exchanged.

TESTS of SOFTWARE LINKS ON THE SUPERVISION LEVEL

The Warm magnet interlock controller receives and transmits some interlock signals via the supervision level: “PC Permit” and “Reset”.

Action	**Reaction required and verified**
● Enable “PC Permit” for PCs at BA4	Enable PCs to power magnets
● Enable “PC Permit” for PCs at SR8	Enable PCs to power magnets
● Disable “PC Permit” for PCs at BA4	Switch off signal to the correct PCs
● Disable “PC Permit” for PCs at SR8	Switch off signal to the correct PCs
● Remote reset of Slave Crates	Switch off the correct slave and the power converters which power the magnets attach to that crate
● Remote Reset of the WIC (Future operation)	Switch off the WIC, all power converters switched off
● Threshold changes of the temperature probes measurements	No action. It could be interesting to obtain a history of the overheated areas.

CONCLUSIONS

The tests were performed successfully, minor faults were found and rectified, no major faults were discovered.

The commissioning was completed in three phases:-

1. Test the whole system without the operation of the power converters, disconnect each magnet over temperature switch and confirm the correct input is affected and the correct power converter output has been removed.

Approximate time 4 days.

2. Test the whole system with the power converters in operation, disconnect one magnet in each crate for each power converter, and verify that the power converter switches its output off.

   Approximate time 2 days.

3. 1 additional day for supplementary tasks.

The Warm Magnet Interlocks for the transfer line TI8 have been successfully commissioned. No software or hardware modifications will be tolerated without prior notification of the responsible team AB/CO-IN.The interlock team remain responsible for the WIC system and will be present to support further tests and maintain full operation.

FUTURE WORK

The following improvements about security, safety and availability of our system are under study:

- Security: From anywhere at CERN, anybody could manipulate our PLC's (even reset them). A possible improvement is the use of the Siemens Scalance series.
- Safety: Our system could fail if the PLC CPU has a failure and at that moment any magnet overheats. This is quite difficult but the consideration of fault tolerant PLC architectures may reduce this probability.
- Availability: In our architecture, in the case of a PROFIBUS network failure, the whole system goes to a safe state but it cannot work anymore until fixing this problem. A possible solution is to duplicate the PROFIBUS network allowing each slave crate to be accessed by two independent PROFIBUS networks.

The above improvements will increase the dependability (guarantee of working) of our warm magnet interlocks architecture. However, considerations on financial resources have to be also considered.

The operation of the PVSS supervision has proved to be a success, however some improvements are anticipated:

- MODBUS protocol used for the communications between the WIC and the PVSS system. It works properly but has many limitations mainly due to the limited size of the data frame transmission, the speed (slow execution of the driver at the PLC side), the network load dependency (timeouts generation under increased load of the Ethernet network has been observed at the IT network but not at the Technical network) and the limited functionality (difficulty in the programming of communication protocols between PLC and PVSS). This advices the use of more powerful communication protocols such as S7 (Windows or Linux platforms) or OPC (only Windows platform). In the future it is planed to migrate to the S7 protocol as the standard communications protocol between SIEMENS PLC's and PVSS systems running under Linux OS.
- History buffer: This has been implemented and tested for the magnets overheating. However it needs some improvements mainly in terms of throughput (a maximum of ten records per second

were supported), efficiency (communications protocol with the PLC), and extension to Power Converters failures, Crates failures and Temperature probes overheating.

- NTP synchronization: our home made NTP protocol has worked properly achieving an accuracy of less than 1 second time difference between the PLC time and the PVSS time. However a more accurate one becomes necessary for the correlation of results with the power converters timing.
- Alive mechanism provision: If the PLC CPU stops working due to any CPU failure, an alive mechanism to inform the operator through the PVSS supervision is needed and has to be considered in the next future.
- Automatic configuration from a database system: our system has been configured through hardcode and possible changes imply many software modifications. This could be improved using a central database which stores the hardware configuration, and from it generate automatically the PLC code and the PVSS data points.
- General controls infrastructure integration: the integration of our application in the UNICOS framework and the LHC Logging, Alarm and Post-Mortem systems.

ACKNOWLEGEMENTS

We would like to express our gratitude to many people who have collaborated in this commissioning, especially to Rudiger Schmidt, Bruno Puccio, Jacky Brahy, Claude Dehavay, Herve Milcent, Philippe Gayet, Frederic Bernard and Yves Jacquemard.

Appendix #1

CIWRA
400285 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	400100	3401585A	E0.0	QTMD 400100	A12.3	
2	400107	3401587A	E0.1	MBHC 400107	A12.0	
3	400118	3401588A	E0.2	MBHC 400107	A12.0	
4	400129	3401589A	E0.3	MBHC 400107	A12.0	
5	400200	3401590A	E0.4	QTLF 400200	A12.4	
6	400293	3401591A	E0.5	MDSV 400293	A12.1	
7	400300	3401592A	E0.6	QTLD 400300	A12.5	
8	400309	3401593A	E0.7	MBHA 400309	A12.2	
9	400318	3401594A	E1.0	MBHA 400309	A12.2	
10	400326	3401595A	E1.1	MBHA 400309	A12.2	
11	400334	3401596A	E1.2	MBHA 400309	A12.2	
12	400400	3401597A	E1.3	QTLF 400400	A12.6	

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CIWRA 80350	BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	80100	3401598A	E8.0	MQID 80100	A16.3	
2	80200	3402957A	E8.1	MQIF 80200	A16.4	
3	80300	3402958A	E8.2	MQID 80300	A16.5	
4	80407	3402960A	E8.4	MCICH 80407	A16.1	

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CIWRA
80350 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	80400	3402959A	E8.3	MQIF 87000	A0.0	
2	80500	3402961A	E8.5	MQID 87100	A0.1	
3	80600	3402964A	E8.6	MQIF 87000	A0.0	
4	80700	3402965A	E8.7	MQID 87100	A0.1	
5	80800	3402966A	E9.0	MQIF 87000	A0.0	
6	80900	3402967A	E9.1	MQID 87100	A0.1	
7	81000	3402968A	E9.2	MQIF 87000	A0.0	

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CIWRA
81240 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	81107	3402972A	E12.1	MBIAV 81107	A16.2	
2	81116	3402973A	E12.2	MBIAV 81107	A16.2	
3	81125	3402974A	E12.3	MBIAV 81107	A16.2	
4	81134	3402975A	E12.4	MBIAV 81107	A16.2	
5	81144	3402976A	E12.5	MBIAV 81107	A16.2	
6	81153	3402977A	E12.6	MBIAV 81107	A16.2	

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CIWRA
81240 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	81100	3402971A	E12.0	MQID 87100	A0.1	
2	81200	3402978A	E12.7	MQIF 87000	A0.0	
3	81300	3402979A	E13.0	MQID 87100	A0.1	
4	81400	3402980A	E13.1	MQIF 87000	A0.0	

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Location _____

CIWRA
81644 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	81507	3402984A	E16.1	MBIAV 81107	A16.2	
2	81516	3402985A	E16.2	MBIAV 81107	A16.2	
3	81525	3402986A	E16.3	MBIAV 81107	A16.2	
4	81534	3402987A	E16.4	MBIAV 81107	A16.2	
5	81544	3402988A	E16.5	MBIAV 81107	A16.2	
6	81553	3402989A	E16.6	MBIAV 81107	A16.2	
7	81607	3402991A	E17.0	MBI 81607	A12.7 & A16.0	
8	81620	3402992A	E17.1	MBI 81607	A12.7 & A16.0	
9	81634	3402993A	E17.2	MBI 81607	A12.7 & A16.0	
10	81648	3402994A	E17.3	MBI 81607	A12.7 & A16.0	
11	81707	3402996A	E17.5	MBI 81607	A12.7 & A16.0	
12	81720	3402997A	E17.6	MBI 81607	A12.7 & A16.0	
13	81807	3402999A	E18.0	MBI 81607	A12.7 & A16.0	
14	81820	3403000A	E18.1	MBI 81607	A12.7 & A16.0	
15	81834	3403001A	E18.2	MBI 81607	A12.7 & A16.0	
16	81848	3403002A	E18.3	MBI 81607	A12.7 & A16.0	

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CIWRA
81644 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	81500	3402993A	E16.0	MQID 87100	A0.1	
2	81600	3402990A	E16.7	MQID 87000	A0.0	
3	81700	3402995A	E17.4	MQID 87100	A0.1	
4	81800	3402998A	E17.7	MQID 87000	A0.0	

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Location _____

CIWRA
82044 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	81907	3403006A	E20.1	MBI 81607	A12.7 & A16.0	
2	81920	3403007A	E20.2	MBI 81607	A12.7 & A16.0	
3	81934	3403008A	E20.3	MBI 81607	A12.7 & A16.0	
4	81948	3403009A	E20.4	MBI 81607	A12.7 & A16.0	
5	82007	3403011A	E20.6	MBI 81607	A12.7 & A16.0	
6	82020	3403012A	E20.7	MBI 81607	A12.7 & A16.0	
7	82034	3403013A	E21.0	MBI 81607	A12.7 & A16.0	
8	82048	3403014A	E21.1	MBI 81607	A12.7 & A16.0	
9	82107	3403016A	E21.3	MBI 81607	A12.7 & A16.0	
10	82120	3403017A	E21.4	MBI 81607	A12.7 & A16.0	
11	82134	3403018A	E21.5	MBI 81607	A12.7 & A16.0	
12	82148	3403019A	E21.6	MBI 81607	A12.7 & A16.0	
13	82207	3403021A	E22.0	MBI 81607	A12.7 & A16.0	
14	82220	3403022A	E22.1	MBI 81607	A12.7 & A16.0	
15	82234	3403023A	E22.2	MBI 81607	A12.7 & A16.0	
16	82248	3403024A	E22.3	MBI 81607	A12.7 & A16.0	

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CIWRA
82044 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	81900	3403005A	E20.0	MQID 87100	A0.1	
2	82000	3403010A	E20.5	MQIF 87000	A0.0	
3	82100	3403015A	E21.2	MQID 87100	A0.1	
4	82200	3403020A	E21.7	MQIF 87000	A0.0	

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CIWRA
82444 BA4

Test	Magnet Position	Cable number	PLC Input	Power Converter	PLC Output	Comments
1	82307	3403028A	E24.1	MBI 81607	A12.7 & A16.0	
2	82320	3403029A	E24.2	MBI 81607	A12.7 & A16.0	
3	82334	3403030A	E24.3	MBI 81607	A12.7 & A16.0	
4	82348	3403031A	E24.4	MBI 81607	A12.7 & A16.0	
5	82407	3403033A	E24.6	MBI 81607	A12.7 & A16.0	
6	82420	3403034A	E24.7	MBI 81607	A12.7 & A16.0	
7	82434	3403035A	E25.0	MBI 81607	A12.7 & A16.0	
8	82448	3403036A	E25.1	MBI 81607	A12.7 & A16.0	
9	82507	3403038A	E25.3	MBI 81607	A12.7 & A16.0	
10	82520	3403039A	E25.4	MBI 81607	A12.7 & A16.0	
11	82534	3403010A	E25.5	MBI 81607	A12.7 & A16.0	
12	82548	3403041A	E25.6	MBI 81607	A12.7 & A16.0	
13	82607	3403043A	E26.0	MBI 81607	A12.7 & A16.0	
14	82620	3403044A	E26.1	MBI 81607	A12.7 & A16.0	
15	82634	3403045A	E26.2	MBI 81607	A12.7 & A16.0	
16	82648	3403046A	E26.3	MBI 81607	A12.7 & A16.0	

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CIWRA
82444 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	82300	3403027A	E24.0	MQID 87100	A0.1	
2	82400	3403032A	E24.5	MQIF 87000	A0.0	
3	82500	3403037A	E25.2	MQID 87100	A0.1	
4	82600	3403042A	E25.7	MQIF 87000	A0.0	

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Location _____

CIWRA
82844 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	82707	3403050A	E28.1	MBI 81607	A12.7 & A16.0	
2	82720	3403051A	E28.2	MBI 81607	A12.7 & A16.0	
3	82734	3403052A	E28.3	MBI 81607	A12.7 & A16.0	
4	82748	3403053A	E28.4	MBI 81607	A12.7 & A16.0	
5	82807	3403055A	E28.6	MBI 81607	A12.7 & A16.0	
6	82820	3403056A	E28.7	MBI 81607	A12.7 & A16.0	
7	82834	3403057A	E29.0	MBI 81607	A12.7 & A16.0	
8	82848	3403058A	E29.1	MBI 81607	A12.7 & A16.0	
9	82907	3403060A	E29.3	MBI 81607	A12.7 & A16.0	
10	82920	3403061A	E29.4	MBI 81607	A12.7 & A16.0	
11	82934	3403062A	E29.5	MBI 81607	A12.7 & A16.0	
12	82948	3403063A	E29.6	MBI 81607	A12.7 & A16.0	
13	83007	3403065A	E30.0	MBI 81607	A12.7 & A16.0	
14	83020	3403066A	E30.1	MBI 81607	A12.7 & A16.0	
15	83034	3403067A	E30.2	MBI 81607	A12.7 & A16.0	
16	83048	3403068A	E30.3	MBI 81607	A12.7 & A16.0	

Completed By _____

Location _____

CIWRA
82844 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	82700	3403049A	E28.0	MQID 87100	A0.1	
2	82800	3403054A	E28.5	MQIF 87000	A0.0	
3	82900	3403059A	E29.2	MQID 87100	A0.1	
4	83000	3403064A	E29.7	MQIF 87000	A0.0	

Completed By _____

Location _____

CIWRA
83244 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	83107	3403072A	E32.1	MBI 81607	A12.7 & A16.0	
2	83120	3403073A	E32.2	MBI 81607	A12.7 & A16.0	
3	83134	34030704A	E32.3	MBI 81607	A12.7 & A16.0	
4	83148	34030705A	E32.4	MBI 81607	A12.7 & A16.0	
5	83207	3403077A	E32.6	MBI 81607	A12.7 & A16.0	
6	83220	3403078A	E32.7	MBI 81607	A12.7 & A16.0	
7	83234	3403079A	E33.0	MBI 81607	A12.7 & A16.0	
8	83248	3403080A	E33.1	MBI 81607	A12.7 & A16.0	
9	83307	3403082A	E33.3	MBI 81607	A12.7 & A16.0	
10	83320	3403083A	E33.4	MBI 81607	A12.7 & A16.0	
11	83334	3403084A	E33.5	MBI 81607	A12.7 & A16.0	
12	83348	3403085A	E33.6	MBI 81607	A12.7 & A16.0	
13	83407	3403087A	E34.0	MBI 81607	A12.7 & A16.0	
14	83420	3403088A	E34.1	MBI 81607	A12.7 & A16.0	
15	83434	3403089A	E34.2	MBI 81607	A12.7 & A16.0	
16	83448	3403090A	E34.3	MBI 81607	A12.7 & A16.0	

Completed By _____

Location _____

CIWRA
83244 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	83100	3403071A	E32.0	MQID 87100	A0.1	
2	83200	3403076A	E32.5	MQIF 87000	A0.0	
3	83300	3403081A	E33.2	MQID 87100	A0.1	
4	83400	3403086A	E33.7	MQIF 87000	A0.0	

Completed By _____

Location _____

CIWRA
83644 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	83507	3403094A	E36.1	MBI 81607	A12.7 & A16.0	
2	83520	3403095A	E36.2	MBI 81607	A12.7 & A16.0	
3	83534	3403096A	E36.3	MBI 81607	A12.7 & A16.0	
4	83548	3403097A	E36.4	MBI 81607	A12.7 & A16.0	
5	83607	3403099A	E36.6	MBI 81607	A12.7 & A16.0	
6	83620	3403100A	E36.7	MBI 81607	A12.7 & A16.0	
7	83634	3403101A	E37.0	MBI 81607	A12.7 & A16.0	
8	83648	3403102A	E37.1	MBI 81607	A12.7 & A16.0	
9	83707	3403104A	E37.3	MBI 81607	A12.7 & A16.0	
10	83720	3403105A	E37.4	MBI 81607	A12.7 & A16.0	
11	83734	3403106A	E37.5	MBI 81607	A12.7 & A16.0	
12	83748	3403107A	E37.6	MBI 81607	A12.7 & A16.0	
13	83807	3403109A	E38.0	MBI 81607	A12.7 & A16.0	
14	83820	3403110A	E38.1	MBI 81607	A12.7 & A16.0	
15	83834	3403111A	E38.2	MBI 81607	A12.7 & A16.0	
16	83848	3403112A	E38.3	MBI 81607	A12.7 & A16.0	

Completed By _____

Location _____

CIWRA
83644 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	83500	3403081A	E36.0	MQID 87100	A0.1	
2	83600	3403098A	E36.5	MQIF 87000	A0.0	
3	83700	3403103A	E37.2	MQID 87100	A0.1	
4	83800	3403108A	E37.7	MQIF 87000	A0.0	

Completed By _____

Location _____

CIWRA
84044 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	83907	3403116A	E40.1	MBI 81607	A12.7 & A16.0	
2	83920	3403117A	E40.2	MBI 81607	A12.7 & A16.0	
3	83934	3403118A	E40.3	MBI 81607	A12.7 & A16.0	
4	83948	3403119A	E40.4	MBI 81607	A12.7 & A16.0	
5	84007	3403121A	E40.6	MBI 81607	A12.7 & A16.0	
6	84020	340312A	E40.7	MBI 81607	A12.7 & A16.0	
7	84034	3403123A	E41.0	MBI 81607	A12.7 & A16.0	
8	84048	3403124A	E41.1	MBI 81607	A12.7 & A16.0	
9	84107	3403126A	E41.3	MBI 81607	A12.7 & A16.0	
10	84120	3403127A	E41.4	MBI 81607	A12.7 & A16.0	
11	84134	3403128A	E41.5	MBI 81607	A12.7 & A16.0	
12	84148	3403129A	E41.6	MBI 81607	A12.7 & A16.0	
13	84207	3403131A	E42.0	MBI 81607	A12.7 & A16.0	
14	84220	3403132A	E42.1	MBI 81607	A12.7 & A16.0	
15	84234	3403133A	E42.2	MBI 81607	A12.7 & A16.0	
16	84248	3403134A	E42.3	MBI 81607	A12.7 & A16.0	

Completed By _____

Location _____

CIWRA
84044 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	83900	3403115A	E40.0	MQID 87100	A0.1	
2	84000	3403120A	E40.5	MQIF 87000	A0.0	
3	84100	3443125A	E41.2	MQID 87100	A0.1	
4	84200	3403130A	E41.7	MQIF 87000	A0.0	

Completed By _____

Location _____

CIWRA
84444 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	84307	3403138A	E44.1	MBI 81607	A12.7 & A16.0	
2	84320	3403139A	E44.2	MBI 81607	A12.7 & A16.0	
3	84334	3403140A	E44.3	MBI 81607	A12.7 & A16.0	
4	84348	3403141A	E44.4	MBI 81607	A12.7 & A16.0	
5	84407	3403143A	E44.6	MBI 81607	A12.7 & A16.0	
6	84420	3403144A	E44.7	MBI 81607	A12.7 & A16.0	
7	84434	3403145A	E45.0	MBI 81607	A12.7 & A16.0	
8	84448	3403146A	E45.1	MBI 81607	A12.7 & A16.0	
9	84507	3403148A	E45.3	MBI 81607	A12.7 & A16.0	
10	84520	3403149A	E45.4	MBI 81607	A12.7 & A16.0	
11	84534	3403150A	E45.5	MBI 81607	A12.7 & A16.0	
12	84548	3403151A	E45.6	MBI 81607	A12.7 & A16.0	
13	84607	3403153A	E46.0	MBI 81607	A12.7 & A16.0	
14	84620	3403154A	E46.1	MBI 81607	A12.7 & A16.0	
15	84634	3403155A	E46.2	MBI 81607	A12.7 & A16.0	
16	84648	3403156A	E46.3	MBI 81607	A12.7 & A16.0	

Completed By _____

Location _____

CIWRA
84444 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	84300	3403137A	E44.0	MQID 87100	A0.1	
2	84400	3403142A	E44.5	MQIF 87000	A0.0	
3	84500	3403147A	E45.2	MQID 87100	A0.1	
4	84600	3403152A	E45.7	MQIF 87000	A0.0	

Completed By _____

Location _____

CIWRA
84844 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	84707	3403160A	E48.1	MBI 81607	A12.7 & A16.0	
2	84720	3403161A	E48.2	MBI 81607	A12.7 & A16.0	
3	84734	3403162A	E48.3	MBI 81607	A12.7 & A16.0	
4	84748	3403163A	E48.4	MBI 81607	A12.7 & A16.0	
5	84807	3403165A	E48.6	MBI 81607	A12.7 & A16.0	
6	84820	3403166A	E48.7	MBI 81607	A12.7 & A16.0	
7	84834	3403167A	E49.0	MBI 81607	A12.7 & A16.0	
8	84848	3403168A	E49.1	MBI 81607	A12.7 & A16.0	
9	84907	3401730A	E49.3	MBI 81607	A12.7 & A16.0	
10	84920	3401731A	E49.4	MBI 81607	A12.7 & A16.0	
11	84934	3401732A	E49.5	MBI 81607	A12.7 & A16.0	
12	84948	3401733A	E49.6	MBI 81607	A12.7 & A16.0	
13	85007	3401735A	E50.0	MBI 81607	A12.7 & A16.0	
14	85020	3401736A	E50.1	MBI 81607	A12.7 & A16.0	
15	85034	3401737A	E50.2	MBI 81607	A12.7 & A16.0	
16	85048	3401738A	E50.3	MBI 81607	A12.7 & A16.0	

Completed By _____

Location _____

CIWRA
84844 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	84700	3403159A	E48.0	MQID 87100	A0.1	
2	84800	3403164A	E48.5	MQIF 87000	A0.0	
3	84900	3403169A	E49.2	MQID 87100	A0.1	
4	85000	3403174A	E49.7	MQIF 87000	A0.0	

Completed By _____

Location _____

CIWRA
85244 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	85107	3403182A	E52.1	MBI 81607	A12.7 & A16.0	
2	85120	3403183A	E52.2	MBI 81607	A12.7 & A16.0	
3	85134	3403184A	E52.3	MBI 81607	A12.7 & A16.0	
4	85148	3403185A	E52.4	MBI 81607	A12.7 & A16.0	
5	85207	3403187A	E52.6	MBI 81607	A12.7 & A16.0	
6	85220	3403188A	E52.7	MBI 81607	A12.7 & A16.0	
7	85234	3403189A	E53.0	MBI 81607	A12.7 & A16.0	
8	85248	3403190A	E53.1	MBI 81607	A12.7 & A16.0	
9	85307	3403192A	E53.3	MBI 81607	A12.7 & A16.0	
10	85320	3403193A	E53.4	MBI 81607	A12.7 & A16.0	
11	85334	3403194A	E53.5	MBI 81607	A12.7 & A16.0	
12	85348	3403195A	E53.6	MBI 81607	A12.7 & A16.0	
13	85407	3403197A	E54.0	MBI 81607	A12.7 & A16.0	
14	85420	3403198A	E54.1	MBI 81607	A12.7 & A16.0	
15	85434	3403199A	E54.2	MBI 81607	A12.7 & A16.0	
16	85448	3403200A	E54.3	MBI 81607	A12.7 & A16.0	

Completed By _____

Location _____

CIWRA
85244 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	85100	3403181A	E52.0	MQID 87100	A0.1	
2	85200	3403186A	E52.5	MQIF 87000	A0.0	
3	85300	3403191A	E53.2	MQID 87100	A0.1	
4	85400	3403196A	E53.7	MQIF 87000	A0.0	

Completed By _____

Location _____

CIWRA
85644 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	85507	3403204A	E56.1	MBI 81607	A12.7 & A16.0	
2	85520	3403205A	E56.2	MBI 81607	A12.7 & A16.0	
3	85534	3403206A	E56.3	MBI 81607	A12.7 & A16.0	
4	85548	3403207A	E56.4	MBI 81607	A12.7 & A16.0	
5	85607	3403209A	E56.6	MBI 81607	A12.7 & A16.0	
6	85620	3403210A	E56.7	MBI 81607	A12.7 & A16.0	
7	85634	3403211A	E57.0	MBI 81607	A12.7 & A16.0	
8	85648	3403212A	E57.1	MBI 81607	A12.7 & A16.0	
9	85707	3403214A	E57.3	MBI 81607	A12.7 & A16.0	
10	85720	3403215A	E57.4	MBI 81607	A12.7 & A16.0	
11	85734	3403216A	E57.5	MBI 81607	A12.7 & A16.0	
12	85748	3403217A	E57.6	MBI 81607	A12.7 & A16.0	
13	85807	3403219A	E58.0	MBI 81607	A12.7 & A16.0	
14	85820	3403220A	E58.1	MBI 81607	A12.7 & A16.0	
15	85834	3403221A	E58.2	MBI 81607	A12.7 & A16.0	
16	85848	3403222A	E58.3	MBI 81607	A12.7 & A16.0	

Completed By _____

Location _____

CIWRA
85644 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	85500	3403203A	E56.0	MQID 87100	A0.1	
2	85600	3403208A	E56.5	MQIF 87000	A0.0	
3	85700	3403213A	E57.2	MQID 87100	A0.1	
4	85800	3403218A	E57.7	MQIF 87000	A0.0	

Completed By _____

Location _____

CIWRA
86044 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	85907	3403226A	E60.1	MBI 81607	A12.7 & A16.0	
2	85920	3403227A	E60.2	MBI 81607	A12.7 & A16.0	
3	85934	3403228A	E60.3	MBI 81607	A12.7 & A16.0	
4	85948	3403229A	E60.4	MBI 81607	A12.7 & A16.0	
5	86007	3403231A	E60.6	MBI 81607	A12.7 & A16.0	
6	86020	3403232A	E60.7	MBI 81607	A12.7 & A16.0	
7	86034	3403233A	E61.0	MBI 81607	A12.7 & A16.0	
8	86048	3403234A	E61.1	MBI 81607	A12.7 & A16.0	
9	86107	3403236A	E61.3	MBI 81607	A12.7 & A16.0	
10	86120	3403237A	E61.4	MBI 81607	A12.7 & A16.0	
11	86134	3403238A	E61.5	MBI 81607	A12.7 & A16.0	
12	86148	3403239A	E61.6	MBI 81607	A12.7 & A16.0	
13	86207	3403241A	E62.0	MBI 81607	A12.7 & A16.0	
14	86220	3403242A	E62.1	MBI 81607	A12.7 & A16.0	
15	86234	3403243A	E62.2	MBI 81607	A12.7 & A16.0	
16	86248	3403244A	E62.3	MBI 81607	A12.7 & A16.0	

Completed By _____

Location _____

CIWRA
86044 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	85900	3403225A	E60.0	MQID 87100	A0.1	
2	86000	3403230A	E60.5	MQIF 87000	A0.0	
3	86100	3403235A	E61.2	MQID 87100	A0.1	
4	86200	3403240A	E61.7	MQIF 87000	A0.0	

Completed By _____

Location _____

CIWRA
86444 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	86307	3403248A	E64.1	MBI 81607	A12.7 & A16.0	
2	86320	3403249A	E64.2	MBI 81607	A12.7 & A16.0	
3	86334	3403250A	E64.3	MBI 81607	A12.7 & A16.0	
4	86348	3403251A	E64.4	MBI 81607	A12.7 & A16.0	
5	86407	3403253A	E64.6	MBI 81607	A12.7 & A16.0	
6	86420	3403254A	E64.7	MBI 81607	A12.7 & A16.0	
7	86434	3403255A	E65.0	MBI 81607	A12.7 & A16.0	
8	86448	3403256A	E65.1	MBI 81607	A12.7 & A16.0	
9	86507	3403258A	E65.3	MBI 81607	A12.7 & A16.0	
10	86520	3403259A	E65.4	MBI 81607	A12.7 & A16.0	
11	86534	3403260A	E65.5	MBI 81607	A12.7 & A16.0	
12	86548	3403261A	E65.6	MBI 81607	A12.7 & A16.0	
13	86607	3403263A	E66.0	MBI 81607	A12.7 & A16.0	
14	86620	3403264A	E66.1	MBI 81607	A12.7 & A16.0	
15	86634	3403265A	E66.2	MBI 81607	A12.7 & A16.0	
16	86648	3403266A	E66.3	MBI 81607	A12.7 & A16.0	

Completed By _____

Location _____

CIWRA
86444 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	86300	3403247A	E64.0	MQID 87100	A0.1	
2	86400	3403252A	E64.5	MQIF 87000	A0.0	
3	86500	3403257A	E65.2	MQID 87100	A0.1	
4	86600	3403262A	E65.7	MQIF 87000	A0.0	

Completed By _____

Location _____

CIWRA
86844 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	86707	3403270A	E68.1	MBI 81607	A12.7 & A16.0	
2	86720	3403271A	E68.2	MBI 81607	A12.7 & A16.0	
3	86734	3403272A	E68.3	MBI 81607	A12.7 & A16.0	
4	86748	3403273A	E68.4	MBI 81607	A12.7 & A16.0	
5	86807	3403275A	E68.6	MBI 81607	A12.7 & A16.0	
6	86820	3403276A	E68.7	MBI 81607	A12.7 & A16.0	
7	86834	3403277A	E69.0	MBI 81607	A12.7 & A16.0	
8	86848	3403278A	E69.1	MBI 81607	A12.7 & A16.0	
9	86907	3403280A	E69.3	MBI 81607	A12.7 & A16.0	
10	86920	3403281A	E69.4	MBI 81607	A12.7 & A16.0	
11	86934	3403282A	E69.5	MBI 81607	A12.7 & A16.0	
12	86948	3403283A	E69.6	MBI 81607	A12.7 & A16.0	
13	87007	3403285A	E70.0	MBI 81607	A12.7 & A16.0	
14	87020	3403286A	E70.1	MBI 81607	A12.7 & A16.0	
15	87034	3403287A	E70.2	MBI 81607	A12.7 & A16.0	
16	87048	3403288A	E70.3	MBI 81607	A12.7 & A16.0	

Completed By _____

Location _____

CIWRA
86844 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	86700	3403269A	E68.0	MQID 87100	A0.1	
2	86800	3403274A	E68.5	MQIF 87000	A0.0	
3	86900	3403279A	E69.2	MQID 87100	A0.1	
4	87000	3403284A	E69.7	MQIF 87000	A0.0	

Completed By _____

Location _____

CIWRA
87244 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	87107	3403292A	E72.1	MBI 81607	A12.7 & A16.0	
2	87120	3403293A	E72.2	MBI 81607	A12.7 & A16.0	
3	87134	3403294A	E72.3	MBI 81607	A12.7 & A16.0	
4	87148	3403295A	E72.4	MBI 81607	A12.7 & A16.0	
5	87207	3403297A	E72.6	MBI 81607	A12.7 & A16.0	
6	87220	3403298A	E72.7	MBI 81607	A12.7 & A16.0	
7	87234	3403299A	E73.0	MBI 81607	A12.7 & A16.0	
8	87248	3403300A	E73.1	MBI 81607	A12.7 & A16.0	
9	87307	3403302A	E73.3	MBI 81607	A12.7 & A16.0	
10	87320	3403303A	E73.4	MBI 81607	A12.7 & A16.0	
11	87334	3403304A	E73.5	MBI 81607	A12.7 & A16.0	
12	87348	3403305A	E73.6	MBI 81607	A12.7 & A16.0	
13	87410	3403308A	E74.1	MBI 81607	A12.7 & A16.0	
14	87424	3403309A	E74.2	MBI 81607	A12.7 & A16.0	

Completed By _____

Location _____

CIWRA
87244 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	87100	3403291A	E72.0	MQID 87100	A0.1	
2	87200	3403296A	E72.5	MQIF 87200	A0.2	
3	87300	3403301A	E73.2	MQID 87300	A0.3	
4	87400	3403306A	E73.7	MQIF 87404	A0.4	
5	87404	3403307A	E74.0	MQIF 87404	A0.4	

Completed By _____

Location _____

CIWRA
87544 BA4

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	87507	3403313A	E76.1	MBI 81607	A12.7 & A16.0	
2	87520	3403314A	E76.2	MBI 81607	A12.7 & A16.0	
3	87534	3403315A	E76.3	MBI 81607	A12.7 & A16.0	
4	87548	3403316A	E76.4	MBI 81607	A12.7 & A16.0	

Completed By _____

Location _____

CIWRA
87544 SR8

Test	Magnet Position	Cable Number	PLC Input	Power Converter	PLC Output	Comments
1	87500	3403312A	E76.0	MQID 87500	A0.5	
2	87600	3403317A	E76.5	MQIF 87600	A0.6	
3	87700	3403318A	E76.6	MQID 87700	A0.7	
4	87715	3403319A	E76.7	MBIBV 87742	A1.0	
5	87722	3403320A	E77.0	MBIBV 87742	A1.0	
6	87728	3403321A	E77.1	MBIBV 87742	A1.0	
7	87735	3403322A	E77.2	MBIBV 87742	A1.0	
8	87742	3403323A	E77.3	MBIBV 87742	A1.0	
9	87800	3403324A	E77.4	MQIF 87800	A1.1	
10	87833	3403327A	E77.5	MBIAH 87833	A1.2	
11	87841	3403328A	E77.6	MBIAH 87833	A1.2	
12	87850	3403329A	E77.7	MBIAH 87833	A1.2	
13	87858	3403330A	E78.0	MBIAH 87833	A1.2	
14	87866	3403331A	E78.1	MBIAH 87833	A1.2	
15	87874	3403332A	E78.2	MBIAH 87833	A1.2	
16	87883	3403333A	E78.3	MBIAH 87833	A1.2	
17	87900	3403334A	E78.4	MQID 87900	A1.3	
18	88000	3403335A	E78.5	MQIF 88000	A1.4	
19	88100	3403336A	E78.6	MQID 88100	A1.5	
20	C6R8	3403337A	E78.7	MSIB	A1.6	
21	B6R8	3403338A	E79.0	MSIB	A1.6	
22	A6R8	3403339A	E79.1	MSIB	A1.6	
23	B6R8	3403340A	E79.2	MSIA	A1.6	
24	A6R8	3403341A	E79.3	MSIA	A1.6	

Completed By _____

Location _____