UHF Dual Band Line Amplifier

Product Description and User's Manual

Product Part No. 55-227901

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About This Manual

This Product Manual provides the following information:

- Description of the Amplifier
- Procedures for setup, configuration and checking the proper operation of the Amplifier
- Maintenance and troubleshooting procedures

Users

This Product Manual is intended for experienced technicians and engineers. It is assumed that the customers installing, operating, and maintaining Axell Wireless Amplifiers are familiar with the basic functionality of Amplifiers.

Notice

Disclaimer of Liability

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Safety to Personnel

- Before installing or replacing any of the equipment, the entire manual should be read and understood.
- *This equipment is to be installed only in a restricted access location.*
- Throughout this manual, there are "Caution" warnings. "Caution" calls attention to a procedure or practice, which, if ignored, may result in injury or damage to the system, system component or even the user. Do not perform any procedure preceded by a "Caution" until the described conditions are fully understood and met.

> **CAUTION!** This notice calls attention to a procedure or practice that, if ignored, may result in personal injury or in damage to the system or system component. Do not perform any procedure preceded by a "Caution" until described conditions are fully understood and met.

Compliance with FCC

Part 90 Signal Boosters	THIS IS A 90.219 CLASS B DEVICE

WARNING. This is **NOT** a **CONSUMER** device. It is designated for installation by **FCC LICENSEES** and **QUALIFIED INSTALLERS**. You **MUST** have an **FCC LICENSE** or express consent of an FCC Licensee to operate this device. You **MUST** register Class B signal boosters (as defined in 47 CFR 90.219) online at **www.fcc.gov/signal-boosters/registration**. Unauthorized use may result in significant forfeiture penalties, including penalties in excess of $ 100,000 for each continuing violation.

FCC Part 15

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

If not installed and used in accordance with the instructions, this equipment generates, uses and can radiate radio frequency energy. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to RF reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
Ensure that the input levels to the Line Amplifier are correct and that the equipment gain is not excessive.
Isolate or Relocate the Server Radiating antenna cable.
Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

Unauthorized Changes to Equipment

Changes or Modifications not expressly approved by the manufacturer responsible for compliance could void the user's authority to operate the equipment

FCC RF Exposure Limits

This unit complies with FCC RF exposure limits for an uncontrolled environment. This equipment can only be installed in in-building or tunnel applications and must be used as a line driver amplifier to drive radiating cable systems. There are no antennas used for the radiation, Radiating cables have a low level of coupling and as such the RF exposure is extremely low. As a precaution it is recommended that the radiating cable is operated at a minimum distance of 10 cm between the cable radiator and any person's body.

Radiating Antenna Installation

CAUTION! This Equipment is designed as an in-line Radiating Cable booster and must not be used as a Class B Off-Air repeater.

Installation of a radiating cable antenna must comply with the FCC RF exposure requirements. The radiating cable used for this transmitter must be mounted on permanent structures.
The FCC regulations mandate that the EIRP of type B signal boosters should not exceed 5W.
The radiating cable associated with In-Line Boosters has a high attenuation of coupling and as such a negative gain. The Line Amplifier has a maximum amplifier P1dB of +26.5dBm (0.44w), the radiating cable is typically -50dB radiating loss and therefore the ERP will always be below the 5W limit.

Equation (1) - Max SERVICE antenna gain

Not Applicable – Radiating cable fed equipment.

Equation (2) - Max DONOR antenna gain

Not Applicable – Radiating cable fed equipment

Compliance with FCC deployment rule regarding the radiation of noise

Good engineering practice must be used in regard to the signal booster's noise radiation. Thus, the gain of the signal booster should be set so that the EIRP of the output noise from the signal booster should not exceed the level of -43 dBm in 10 kHz measurement bandwidth.
In the event that the noise level measured exceeds the aforementioned value, the signal booster gain should be decreased accordingly.
In general, the ERP of noise on a spectrum more than 1 MHz outside of the pass band should not exceed -70 dBm in a 10 kHz measurement bandwidth.
The WMATA Line Amplifier (55-227901) signal booster has a noise level of below -90 dBm in 10 kHz measurement at 1 MHz spectrum outside the passband of the signal booster and an *in-band* noise level of -60 dBm (worst case) in a 10 kHz bandwidth.

Conclusion:
Good engineering practice requires that in general when the out of band noise measured at the service antenna input is more than -70 dBm per 10 kHz measurement bandwidth, an external band pass filter should be added to attenuate the out of band noise level. However, in this application using radiating cables, No further filtering will be required because of the cable coupling attenuation.

General Safety Warnings Concerning Use of This System

Always observe standard safety precautions during installation, operation and maintenance of this product. Only a qualified and authorized personnel should carry out adjustment, maintenance or repairs to the components of this equipment.

NOTE: Please refer to Axell Wireless for additional information and for requests for notifications to authorities.

 Caution labels!	Throughout this manual, there are "Caution" warnings. "Caution" calls attention to a procedure or practice, which, if ignored, may result in injury or damage to the system, system component or even the user. Do not perform any procedure preceded by a "Caution" until the described conditions are fully understood and met.
 Danger: Electrical Shock	This equipment can either be installed indoors or outdoors. When installed outdoors - wet conditions increase the potential for receiving an electric shock when installing or using electrically powered equipment. To prevent electrical shock when installing or modifying the system power wiring, disconnect the wiring at the power source before working with un insulated wires or terminals.
 Caution: RF Exposure	RF radiation, (especially at UHF frequencies) arising from transmitter outputs connected to AWL's equipment, must be considered a safety hazard. This condition might only occur in the event of cable disconnection, or because a 'spare' output has been left un-terminated. Either of these conditions would impair the system's efficiency. No investigation should be carried out until all RF power sources have been removed. This would always be a wise precaution, despite the severe mismatch between the impedance of an N type connector at 50Ω, and that of free space at 377Ω, which would severely compromise the efficient radiation of RF power. Radio frequency burns could also be a hazard, if any RF power carrying components were to be carelessly touched! Where the equipment is used near power lines or in association with temporary masts not having lightning protection, the use of a safety earth connected to the case-earthing bolt is strongly advised.
 Caution: Safety to personnel.	Before installing or replacing any of the equipment, the entire manual should be read and understood. The user needs to supply the appropriate AC or DC power to the Line Amplifier. Incorrect power settings can damage the Line Amplifier and may cause injury to the user. Please be aware that the equipment may, during certain conditions become very warm and can cause minor injuries if handled without any protection, such as gloves
 Caution: Safety to equipment	When installing, replacing or using this product, observe all safety precautions during handling and operation. Failure to comply with the following general safety precautions and with specific precautions described elsewhere in this manual violates the safety standards of the design, manufacture, and intended use of this product. Axell Wireless assumes no liability for the customer's failure to comply with these precautions. This entire manual should be read and understood before operating or maintaining the Line Amplifier.
 Warning: Restricted Access Location	Access to the Axell unit installation location is restricted to SERVICE PERSONNEL and to USERS who have been instructed on the restrictions and the required precautions to be taken.
 Attention: Electrostatic Sensitivity	Observe electrostatic precautionary procedures. ESD = Electrostatic Discharge Sensitive Device. Semiconductor transmitters and receivers provide highly reliable performance when operated in conformity with their intended design. However, a semiconductor may be damaged by an electrostatic discharge inadvertently imposed by careless handling. Static electricity can be conducted to the semiconductor chip from the centre pin of the RF input connector, and through the AC connector pins. When unpacking and otherwise handling the Line Amplifier, follow ESD precautionary procedures including use of grounded wrist straps, grounded workbench surfaces, and grounded floor mats.

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1. Antenna Specifications and Installation Criteria

WARNING!!!

- This Dual Band Line Amplifier is specifically designed for in-line radiating cable operation and must not be directly connected to an off air radiating antenna.
- The installer is held accountable for implementing the rules required for deployment.
- Good engineering practice must be used to avoid interference.
- Output power should be reduced to solve any IMD interference issues.

This chapter provides information on the donor source feed and server output radiating infrastructure associated with the Line Amplifier equipment.

1.1. Base (Donor) Input

The Base (Donor) input is normally provided from the attenuated end of an existing radiating cable of from an in-line coupler used to coupler off a sample of the main line signal for downlink amplification. In the uplink direction a low level signal is fed back into the donor cable for retransmission to the base station equipment. The output signal of the Line Amplifier is not transmitted to air.

1.1.1. Required Input Information

You will require the following information:

- Number of carriers
- Carrier Power
- Length and type of radiating coaxial cable connecting the Donor system to the Line Amplifier and the attenuation.

1.2. Service Antenna Requirements

WARNING!!!

a. The installer is held accountable for implementing the rules required for deployment.
b. Good engineering practice must be used to avoid interference.
c. Output power should be reduced to solve any IMD interference issues"

This product is designed as a Line Amplifier repeater to extend the signal coverage distance of a radiating cable system and must not be used as an off air repeater.

1.2.1. Required Radiating Antenna Information

The following antenna requirements, specifications and site considerations should be met:

- Service area type and size
- Radiating Cable Coupling factor and longitudinal Attenuation
- Distance from Mobile

Mobile Signal = Line Amplifier Output – cable attenuation dB/100ft – cable coupling dB – distance correction.
e.g. Typical 7/8" cable = loss 0.7dB / 100' with Coupling Loss 80dB @ 6'

Thus for an 800' cable with +10dBm input we have:
+10 – (0.7*8) – 80 = -75.6dBm radiated signal from the cable at 6' distance.

1.3. RF Cabling Requirements

- For all coaxial connections to/from the Line Amplifier - high performance, flexible, low loss 50Ω coaxial communications cable.
- All cables shall be weather-resistant type.
- Make sure that cable and connector are compatible. Using cables and connectors from the same manufacturer is helpful.
- All connectors must be clean and dry
- Waterproof all outdoor connections using silicone, vulcanizable tape or other suitable substance as moisture and dust can impair RF characteristics.
- Make sure enough room has been allocated for the bending radius of the cable. RF cables must not be kinked, cut or damaged in any way
- Use jumper cable for easy installation. The RF Coaxial cable can be substituted at each end with a jumper cable.

2. Pre-Installation Requirements

2.1. Safety Guidelines

Before installing the Line Amplifier, review the following safety information:

- Follow all local safety regulations when installing the Line Amplifier.
- Only qualified personnel are authorized to install and maintain the Line Amplifier.
- Ground the Line Amplifier with the grounding bolt located on the underside of the Line Amplifier
- Do not use the grounding bolt to connect external devices.
- Follow Electro-Static Discharge (ESD) precautions.

2.2. Selecting a Location

Select a location that will take into account the following criteria:

- Relative location of Radiating cable system and access
- Cooling and airflow
- Wall compatibility
- Access to the equipment for installation or maintenance

2.2.1. Cooling and Airflow

- Install the Line Amplifier in a shielded, ventilated, and easy-to-reach area.
- The Line Amplifier is convection cooled so airflow and alternation should be possible.
- Verify that ambient temperature of the environment does not exceed 50°C (122°F)

2.2.2. Wall Compatibility

- Check the suitability of the wall on which the Line Amplifier is to be mounted.
- The Line Amplifier wall mount brackets assembly should be fixed to a solid wall (these include brickwork, block work, and concrete.);
- (Due to the weight of the Line Amplifier, it is NOT recommended to fix to a hollow wall).

2.2.3. Access to the Line Amplifier

- **Plan connection cable clearances -** the RF and power connections located on the underside of the Line Amplifier will need at least 12” vertical clearance below the Line Amplifier to enable the connections to be made. The minimum bend radius for RF cables must not be less than the recommendations made by the cable manufacturer. Plan the cable runs and ensure adequate space is available.
- **Allow for door opening** - ensure that there is sufficient space at the front of the Line Amplifier to allow the door to be fully opened and for maintenance engineers to get access to the unit with test equipment such as a spectrum analyser.
- **Allow space around the Line Amplifier -** verify that there is a minimum of a 50 cm (20”) radius of space around the Line Amplifier, enabling easy access to the Line Amplifier for maintenance and on-site inspection. Allow an additional 50 cm of space in front of the Line Amplifier when the door is fully open.

3. WMATA Dual Band UHF Line Amplifier 55-227901

3.1. Equipment Overview

WMATA Dual Band UHF Line Amplifier 55-227901 is a Bi-directional Line Amplifier designed for Radiating Cable signal extension. The equipment consists of four signal paths (2 downlink and 2 uplink) to provide dual band operation.

The two Downlink bands are: 489.5 MHz – 491.0 MHz & 496.0 MHz – 496.9 MHz.

The two Uplink bands are: 492.5 MHz – 494.0 MHz & 499.0 MHz – 499.9 MHz.

The equipment provides 17dB to 47dB of gain, via a number of amplifiers in each direction. An ALC system is fitted to each amplifier path to provide Automatic Level Control to prevent signal overload and interference. High selectivity band pass duplexers are used on both the downlink and uplink paths to provide isolation between the interleaved frequency bands.

The equipment is built into a wall-mounted, environmentally protected NEMA lockable steel case, the RF ports and connectors are also NEMA rated to ensure a weatherproof product. A supply isolator switch is fitted inside the unit and there are Power On and Alarm indicators on the outside of the door.

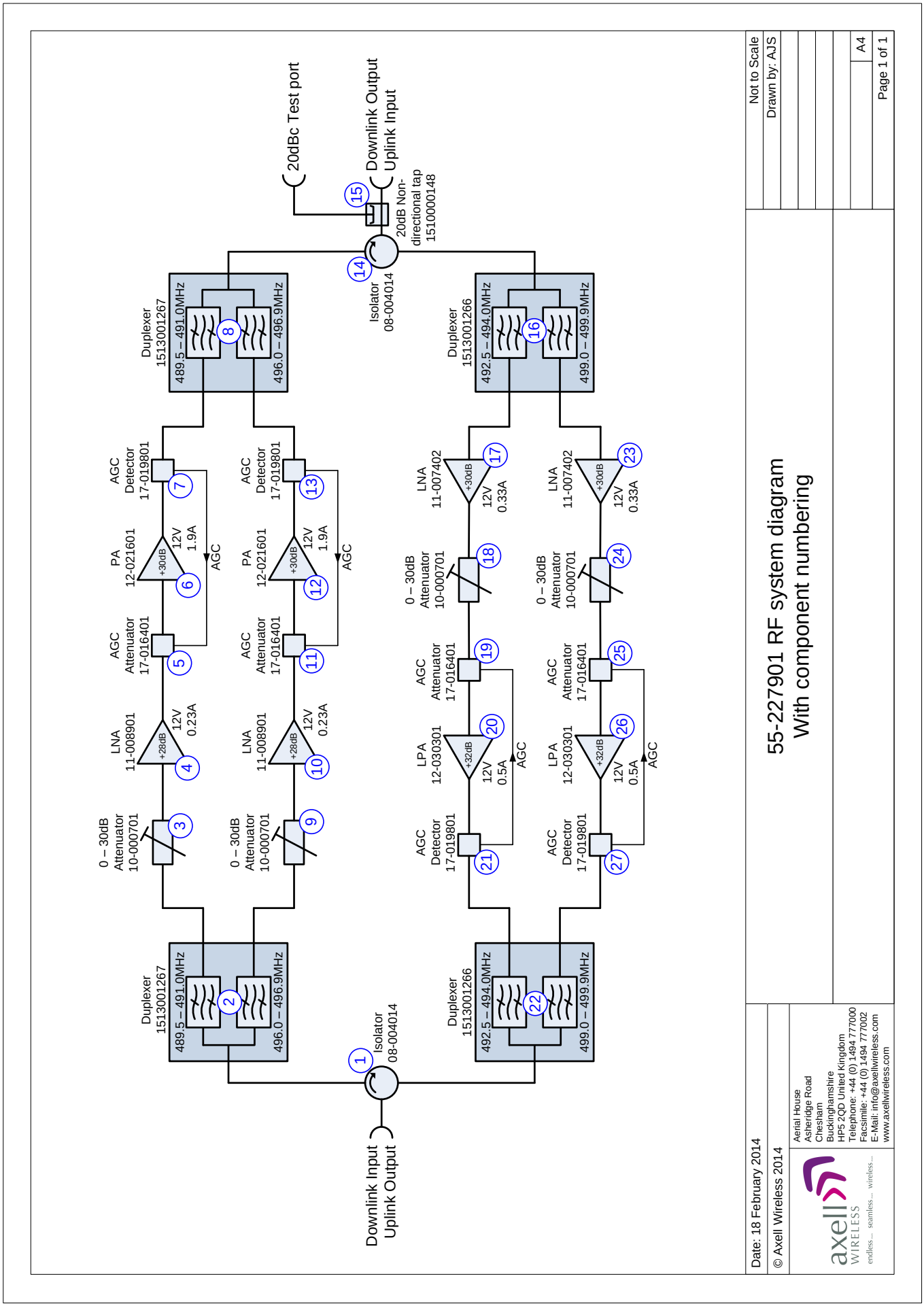
3.2. Theory of operation

Please refer to system Diagram para 3.3 which identify the component positions thus (x).

The downlink input signal from the proceeding base station feeding radiating cable enters the donor input port and is fed to a circulator (1) which directs the transmission into the downlink duplexer (2). The downlink duplexer filters the signal to provide 2 downlink outputs to the amplifier chains. Each amplifier chain consists of a similar line up of components. The filtered downlink is fed via an adjustable attenuator (3 or 9) and into a low noise amplifier (4 or 10) which provides 28dB gain. The amplified signal is then fed via a diode attenuator module (5 or 11) which forms part of the ALC feedback control loop. The ALC attenuator then feeds the signal into an output amplifier (6 or 12) which provides 30dB gain but is restricted to 0.4W output power. The downlink signal then passes through the ALC detector (7 or 13), the ALC detector ensures that should the output power level become equal to or exceed the 0.4W threshold, a control voltage is fed back to the ALC attenuator to reduce the input drive level to prevent overload of the output amplifier. Following the detector the two downlink paths are recombined in the output duplexer (8) before passing through the server port circulator (14) and the 20dB signal monitor tapper (15) and out to the server radiating cable.

The uplink input signal from the mobile feeding radiating cable enters the server input port and is fed via a 20dB signal monitor tapper (15) to a circulator (14) which directs the transmission into the uplink duplexer (16). The uplink duplexer filters the signal to provide 2 uplink outputs to the amplifier chains. Each amplifier chain consists of a similar line up of components. The filtered uplink is fed via a low noise amplifier (17 or 23) which provides 30dB gain and into an adjustable attenuator (18 or 24). The signal is then fed via a diode attenuator module (19 or 25) which forms part of the ALC feedback control loop. The ALC attenuator then feeds the signal into an output amplifier (20 or 26) which provides 32dB gain being restricted to 0.1W output power. The uplink signal then passes through the ALC detector (21 or 27), the ALC detector ensures that should the output power level become equal to or exceed the 0.1W threshold, a control voltage is fed back to the ALC attenuator to reduce the input drive level to prevent overload of the output amplifier. Following the detector the two downlink paths are recombined in the output duplexer (8) before passing through the donor port circulator (1) and out to the base station fed radiating cable.

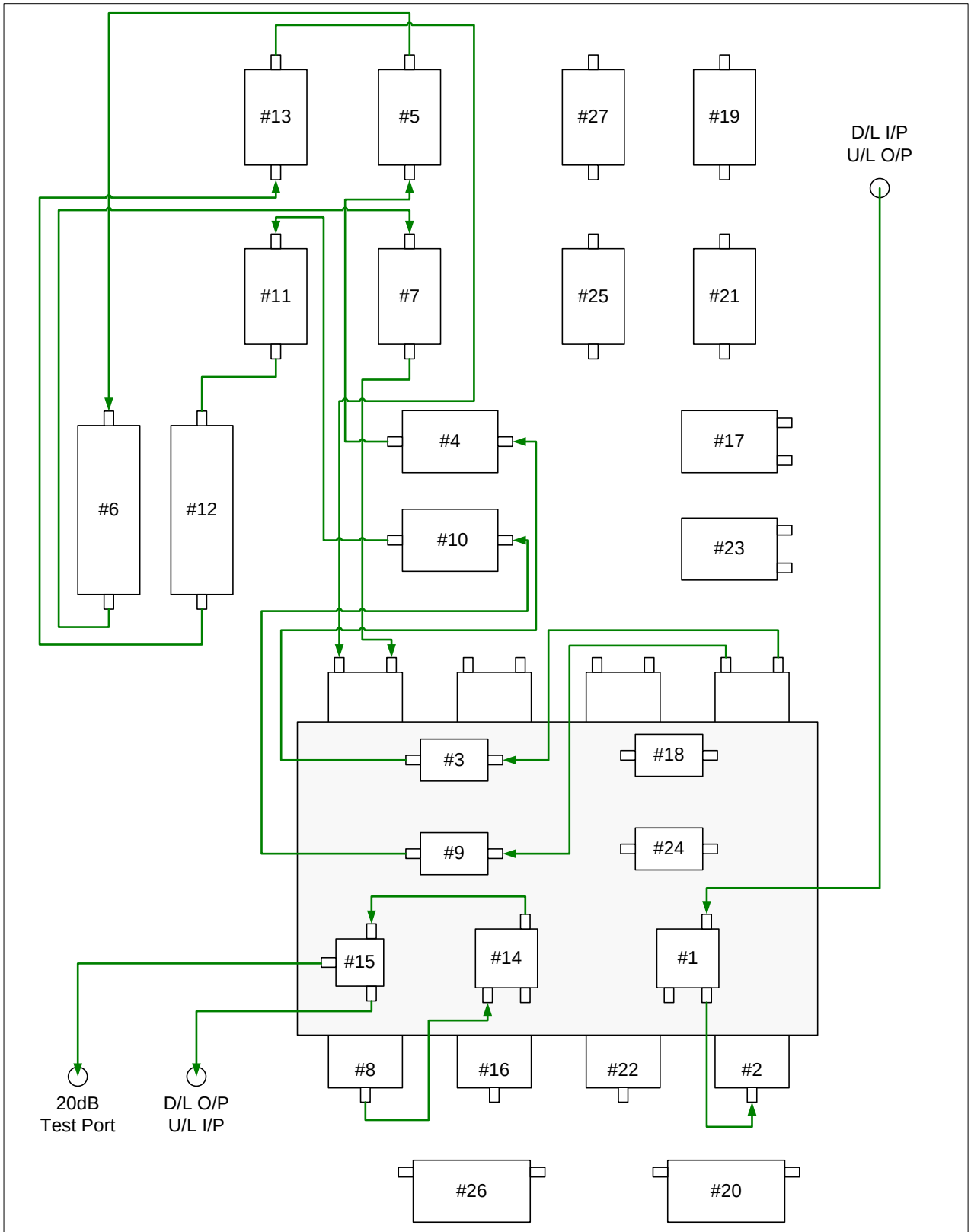
3.3. System Diagram



3.4. Table of Components by Position Number

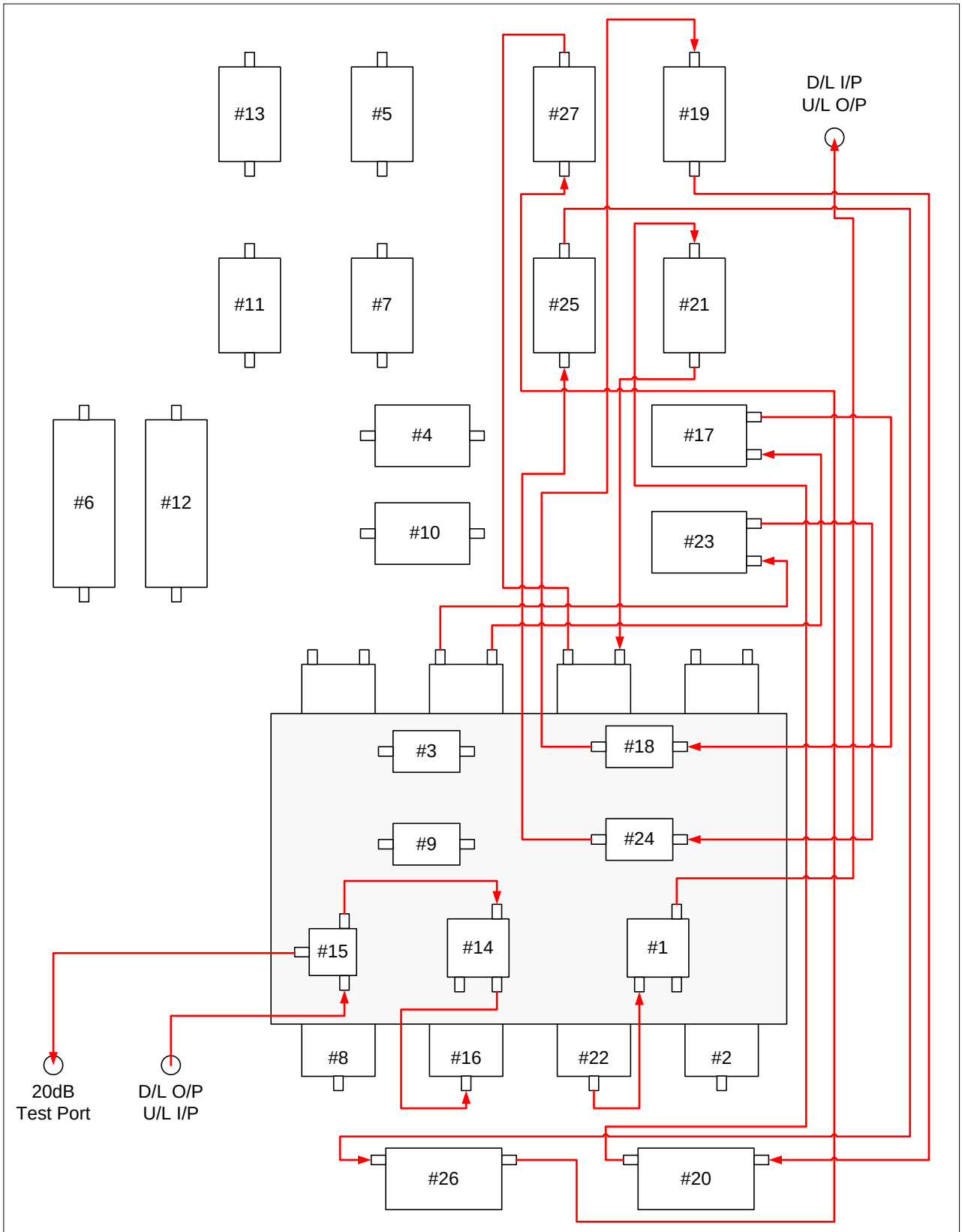
Component position number	Component description	Component part number
1	“Base” port Isolator	08-004014
2	“Base” Downlink Duplexer	1513001267
3	489.5 MHz - 491.0MHz D/L path Variable Switched Attenuator 0-30dB	10-000701
4	489.5 MHz - 491.0MHz D/L path Low Noise Amplifier 28dB Gain	11-008901
5	489.5 MHz - 491.0MHz D/L path AGC Attenuator Module	17-016401
6	489.5 MHz - 491.0MHz D/L path Power Amplifier 20dB Gain	12-021601
7	489.5 MHz - 491.0MHz D/L path AGC Detector Module	17-019801
8	“Mobile” Downlink Duplexer	1513001267
9	496.0 MHz - 496.9MHz D/L path Variable Switched Attenuator 0-30dB	10-000701
10	496.0 MHz - 496.9MHz D/L path Low Noise Amplifier 28dB Gain	11-008901
11	496.0 MHz - 496.9MHz D/L path AGC Attenuator Module	17-016401
12	496.0 MHz - 496.9MHz D/L path Power Amplifier 20dB Gain	12-021601
13	496.0 MHz - 496.9MHz D/L path AGC Detector Module	17-019801
14	“Mobile” port Isolator	08-004014
15	Power Tapper 20dB	1510000148
16	“Mobile” Uplink Duplexer	1513001266
17	492.5 MHz - 494.0MHz U/L path Low Noise Amplifier 30dB Gain	11-007402
18	492.5 MHz - 494.0MHz U/L path Variable Switched Attenuator 0-30dB	10-000701
19	492.5 MHz - 494.0MHz U/L path AGC Attenuator Module	17-016401
20	492.5 MHz - 494.0MHz U/L path Low Power Amplifier 33dB Gain	12-030301
21	492.5 MHz - 494.0MHz U/L path AGC Detector Module	17-019801
22	“Base” Uplink Duplexer	1513001266
23	499.0 MHz - 499.9MHz U/L path Low Noise Amplifier 30dB Gain	11-007402
24	499.0 MHz - 499.9MHz U/L path Variable Switched Attenuator 0-30dB	10-000701
25	499.0 MHz - 499.9MHz U/L path AGC Attenuator Module	17-016401
26	499.0 MHz - 499.9MHz U/L path Low Power Amplifier 33dB Gain	12-030301
27	499.0 MHz - 499.9MHz U/L path AGC Detector Module	17-019801

3.5. Exploded schematic showing Downlink RF path and components



Date: 18 February 2014	55-227901 Exploded schematic showing Downlink RF path and components	Not to Scale
© AWL 2014		Drawn by: AJS
Aerial House Asheridge Road Chesham Buckinghamshire HP5 2QD United Kingdom Telephone: +44 (0) 1494 777000 Facsimile: +44 (0) 1494 777002 E-Mail: info@axellwireless.com www.axellwireless.com		Issue: 1
		Size: A4
		Page 1 of 1

3.6. Exploded schematic showing Uplink RF path and components



Date: 18 February 2014	55-227901 Exploded schematic showing Uplink RF path and components	Not to Scale
© AWL 2014		Drawn by: AJS
Aerial House Asheridge Road Chesham Buckinghamshire HP5 2QD United Kingdom Telephone: +44 (0) 1494 777000 Facsimile: +44 (0) 1494 777002 E-Mail: info@axellwireless.com www.axellwireless.com		Issue: 1
		Size: A4
		Page 1 of 1

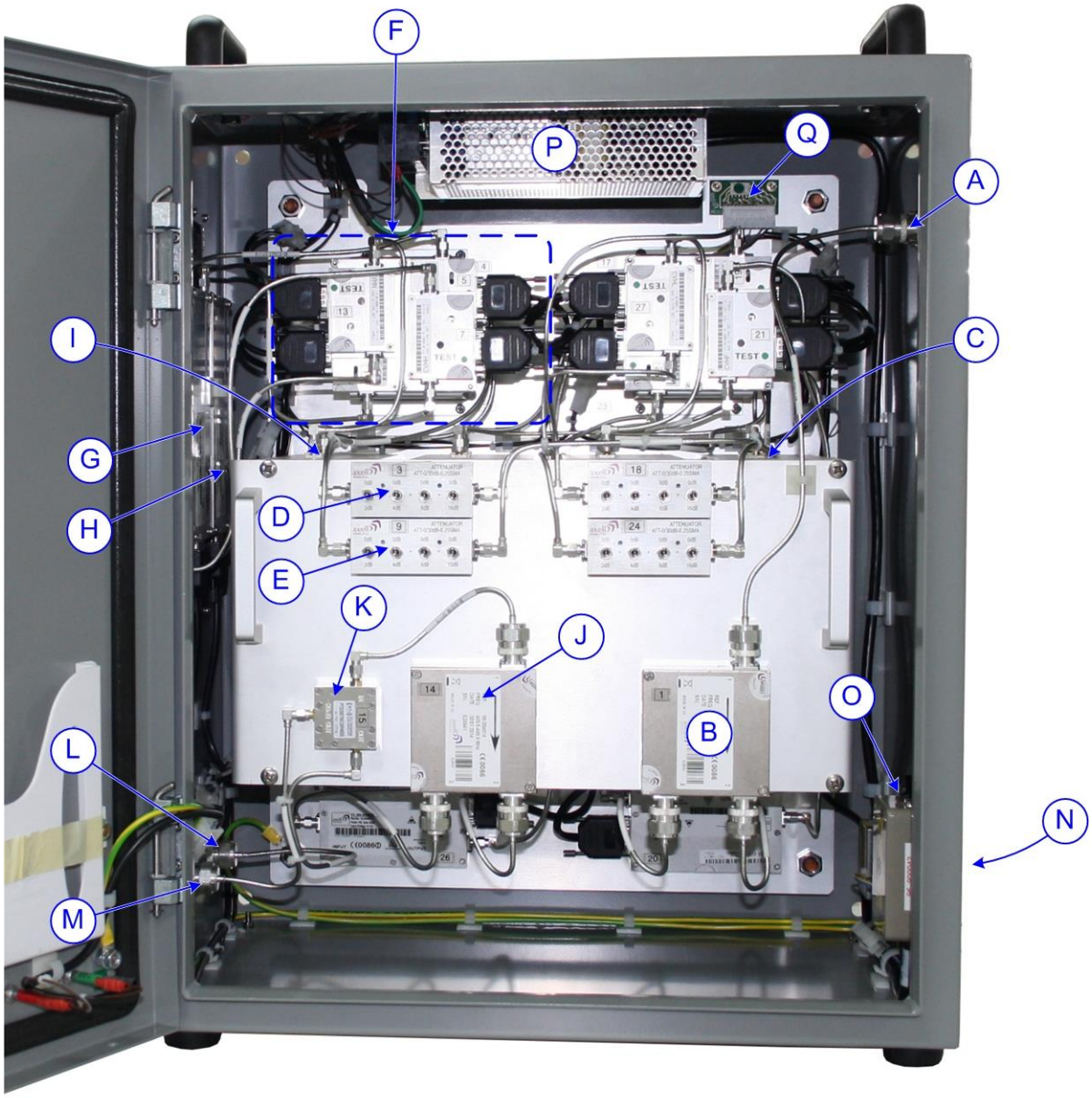
3.7. Front View

A	Green LED “POWER ON” illuminated during normal operating conditions
B	Red LED “ALARM” illuminated during alarm conditions
C	Door locks
D	Lifting handles
E	FCC Compliance label

3.8. Side Views

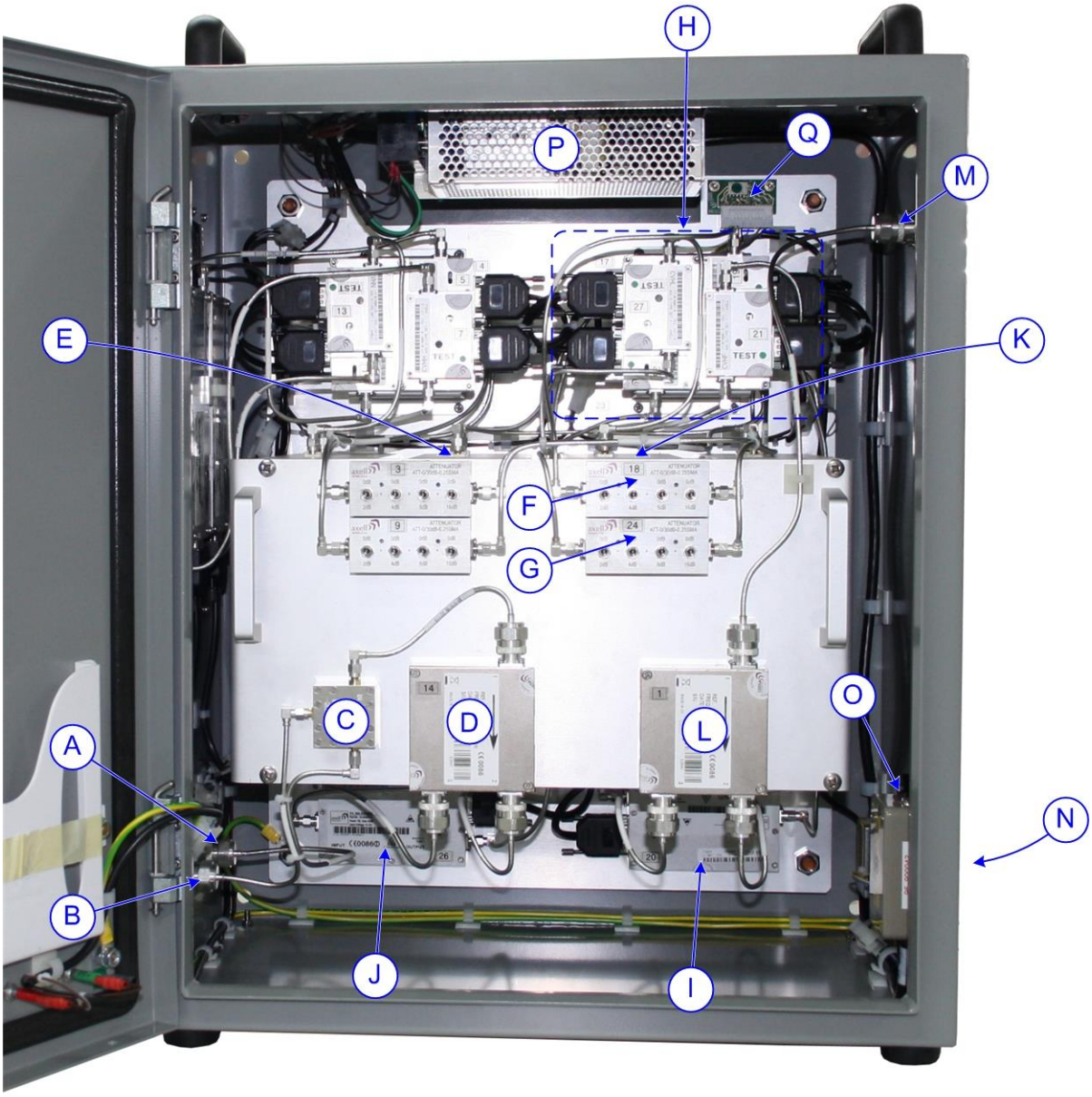
A	Common RF port D/L I/P and U/L O/P, “Base” port
B	Common RF port D/L O/P and U/L I/P, “Mobile” port
C	20dB test/monitor port
D	3 Pole panel plug, AC Input
E	6 Pole panel plug, Alarm Output
F	Grounding connection
G	Position of wall mount brackets (not fitted at time of photography)

3.9. Interior Picture - Downlink Path



A	Common RF port D/L I/P and U/L O/P, “Base” port
B	“Base” port Isolator
C	“Base” port Downlink Duplexer - position of, behind panel
D	489.5 MHz - 491.0MHz Downlink path Variable Attenuator
E	496.0 MHz - 496.9MHz Downlink path Variable Attenuator
F	Downlink paths Low Noise Amplifiers and AGC Detector and Attenuator Modules
G	489.5 MHz - 491.0MHz Downlink path Power Amplifier
H	496.0 MHz - 496.9MHz Downlink path Power Amplifier
I	“Mobile” port Downlink Duplexer - position of, behind panel
J	“Mobile” port Isolator
K	20dB Non-directional Tap
L	Common RF port D/L O/P and U/L I/P, “Mobile” port
M	20dB test/monitor port
N	Position of AC input and Alarm output
O	AC trip switch (96-300042)
P	PSU module (96-300052)
Q	12V Relay PCB Assembly (80-008909)

3.10. Interior Picture - Uplink Path

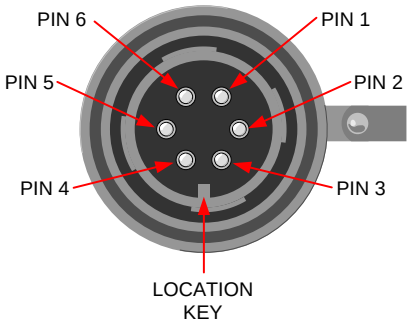


A	Common RF port U/L I/P and D/L O/P, “Mobile” port
B	20dB test/monitor port
C	20dB Non-directional Tap
D	“Mobile” port Isolator
E	“Mobile” port Uplink Duplexer - position of, behind panel
F	492.5 MHz - 494.0MHz Uplink path Variable Attenuator
G	499.0 MHz - 499.9MHz Uplink path Variable Attenuator
H	Uplink paths Low Noise Amplifiers and AGC Detector and Attenuator Modules
I	492.5 MHz - 494.0MHz Uplink path Low Power Amplifier
J	499.0 MHz - 499.9MHz Uplink path Low Power Amplifier
K	“Base” port Uplink Duplexer - position of, behind panel
L	“Base” port Isolator
M	Common RF port U/L O/P and D/L I/P, “Base” port
N	Position of AC input and Alarm output
O	AC trip switch (96-300042)
P	PSU module (96-300052)
Q	12V Relay PCB Assembly (80-008909)

3.11. Specification

Parameter		Specification
Downlink		
Frequency Range Band 1		489.5 – 491.0MHz
Frequency Range Band 2		496.0 – 496.9MHz
Maximum Gain		47dB
Gain Adjustment (manual adjustment)		0 – 30dB in 2dB steps
Output Test Port		20dBc
Maximum RF Output Power		+26dBm (AGC limit for FCC)
In-Band Spurious Noise (30kHz B/W)		< -30dBm
Uplink		
Frequency Range Band 1		492.5 – 494.0MHz
Frequency Range Band 2		499.0 – 499.9MHz
Maximum Gain		47dB
Gain Adjustment (manual adjustment)		0 – 30dB in 1dB steps
Maximum RF Output Power		+20dBm (AGC limit for FCC)
Noise Figure		6dB
In-Band Spurious Noise (30kHz B/W)		< -30dBm
General		
Case Size H x W x D		26.5” x 22.25” x 13”
Case Material		Steel
Case Finish		ANSI-61 Powder Coat
AC Supply Voltage		110V
RF Connectors		N type female
Alarms Fitted[(1)]		Summary Alarm Output Volt free dry contact
Temperature Range	operation	-4°F to +140°F
	storage	-40°F to +158°F
Humidity		95% RHNC

[(1)] Volt free dry contact, Alarm connector pins 1 & 2
Closed = Good, Open = Alarm



4. Installation – General Notes

4.1. General Remarks

When this equipment is initially commissioned, please keep a record of the initial set-up parameters, this will help both the installation personnel and Axell Wireless should these figures be needed for future reference or diagnosis.

The procedure for installing and commissioning an Axell Wall Mount Line Amplifier is generally as follows:

1) Secure the Line Amplifier in the chosen wall position.

2) Fix the antenna and connect its cables to the Amplifier antenna ports.

3) Connect a suitable mains or battery power supply to the Amplifier

4) Calculate the attenuation settings required for the uplink and the downlink paths, and set the attenuators as described elsewhere in this document.

5) Switch the equipment mains on with the small switch located inside the Amplifier on the lower right hand side of the case.

6) If Input RF is available, then make test calls via the Amplifier to ensure correct operation, if possible monitoring the signal levels during these calls to ensure that the uplink and downlink RF levels are as anticipated.

4.2. Electrical Connections

It is recommended that the electrical mains connection is made by a qualified electrician, who must be satisfied that the supply will be the correct voltage and of sufficient capacity.

All electrical and RF connections should be completed and checked prior to power being applied for the first time.

Ensure that connections are kept clean and are fully tightened.

4.3. RF Connections

Care must be taken to ensure that the correct connections are made with particular attention made to the base station TX/RX ports. In the event that the base transmitter is connected to the RX output of the equipment, damage to the equipment will be done if the base station transmitter is then keyed.

4.3.1. Termination of Unused Ports

In the event that any RF ports are unused (available for future expansion) these ports must be kept terminated with the load terminations supplied by Axell for that purpose
Ensure that connections are kept clean and are fully tightened.

4.4. Commissioning

Once all connections are made the equipment is ready for commissioning.

To commission the system the test equipment detailed in Section 5.2. will be required.
Using the system diagrams and the end-to-end test specification (supplied with the equipment), the equipment should be tested to ensure correct operation. Typical RF levels that are not listed in the end-to-end specification, such as input levels to the fibre transmitters are detailed in the maintenance section of this manual.

On initial power up the system alarm indicators on the front door of the equipment should be checked. A green LED on the front door of the unit illuminates to indicate that the power supply is connected to the unit

In the event that any part of the system does not function correctly as expected, check all connections to ensure that they are to the correct port, that the interconnecting cables are not faulty and that they are tightened. The majority of commissioning difficulties arise from problems with the interconnecting cables and connectors.

4.5. RF Installation & Gain Calculations

1. Ensure that the in-line amplifier gain is set to minimum. Measure the signal level from the donor feeding cable and coupler to ascertain the RF input level and gain required.

   Note: Ensure that the number of potential carriers is known for the operating band.

2. The equipment gain is set by setting the variable switched attenuators in each path (uplink and downlink) refer to the photographs and layout drawings for the exact attenuator locations). Note that the uplink (mobile to base) and downlink (base to mobile) path gains are set independently. This allows the paths to have different gains if required to set the correct output power levels.

3. It is recommended that the gains are set such that the Downlink channel output levels from the equipment are typically +10dBm per channel

   (Input level + Gain = Output level).

5. Maintenance

5.1. Fault Finding

5.1.1. Quick Fault Checklist

All Axell equipment is individually tested to specification prior to despatch. Failure of this type of equipment is not common. Experience has shown that a large number of fault conditions relating to tunnel installations result from simple causes often occurring as result of transportation, unpacking and installation. Below are listed some common problems which have resulted in poor performance or an indicated non-functioning of the equipment.

- Mains power not connected or not switched on.
- External connectors not fitted or incorrectly fitted.
- Internal connectors becoming loose due to transport vibration.
- Wiring becoming detached as a result of heavy handling.
- Input signals not present due to faults in the preceding feeder system.
- Base transmissions not present due to fault at the base station.
- Modems fitted with incorrect software configuration.

5.1.2 Fault Isolation

In the event that the performance of the system is suspect, a methodical and logical approach to the problem will reveal the cause of the difficulty. The System consists of modules fitted in a wall mounted, environmentally protected enclosure.

Transmissions from the main base stations are passed through the system to the mobile radio equipment; this could be a handheld radio or a transceiver in a vehicle. This path is referred to as the downlink. The return signal path from the mobile radio equipment to the base station is referred to as the uplink.

The first operation is to check the alarms of each of the active units and determine that the power supplies to the equipment are connected and active.

If an amplifier is suspect, check the DC power supply to the unit. If no other fault is apparent use a spectrum analyser to measure the incoming signal level at the input and then after reconnecting the amplifier input, measure the output level. Consult with the system diagram to determine the expected gain and compare result.

In the event that there are no alarms on and all units appear to be functioning it will be necessary to test the system in a systematic manner to confirm correct operation.

5.1.3. Downlink

Confirm that there is a signal at the expected frequency and RF level from the proceeding cable. If this is not present then the fault may lay outside the system.

If a signal is not received at the output it will be necessary to follow the downlink path through the system to find a point at which the signal is lost. The expected downlink output for the given input can be found in the end-to-end test specification.

5.1.4. Uplink

Testing the uplink involves a similar procedure to the downlink except that the frequencies used are those transmitted by the mobile equipment.

5.1.5. Checking service

Following the repair of any part of the system it is recommended that a full end-to-end test is carried out in accordance with the test specification and that the coverage is checked by survey.
It is important to bear in mind that the system includes a radiating cable network and base stations that may be faulty or may have been damaged.

5.1.6. Fault repair

Once a faulty component has been identified, a decision must be made on the appropriate course to carry out a repair. A competent engineer can quickly remedy typical faults such as faulty connections or cables. The exceptions to this are cable assemblies connecting band pass filter assemblies that are manufactured to critical lengths to maintain a 50-ohm system.

Care should be taken when replacing cables or connectors to ensure that items are of the correct specification. The repair of component modules such as amplifiers and band pass filters will not usually be possible in the field, as they frequently require specialist knowledge and test equipment to ensure correct operation. It is recommended that items of this type are replaced with a spare unit and the faulty unit returned to Axell Wireless for repair.

5.1.7. Service Support

Advice and assistance with maintaining and servicing this system are available by contacting Axell Wireless Ltd., see Contact Information.

NOTE

Individual modules are not intended to be repaired on site and attempts at repair will invalidate active warranties. Company policy is that individual modules should be repaired by replacement. Axell Wireless Ltd. maintains a level of stock of most modules which can usually be despatched at short notice to support this policy.

5.2. Tools & Test Equipment

The minimum tools and test equipment needed to successfully service this Axell Wireless product are as follows:-

Spectrum analyser	100kHz to 2GHz (Dynamic range = 90dB).
Signal Generator	30MHz to 2GHz (-120dBm to 0dBm o/p level).
Attenuator	20dB, 10W, DC-2GHz, (N male – N female).
Test Antenna	Yagi or dipole for operating frequency.
Digital multi-meter	Universal Volt-Ohm-Amp meter.
Test cable x 2	N male – N male, 2M long RG214.
Test cable x 2	SMA male – N male, 1m long RG223.
Hand tools	Philips #1&2 tip screwdriver. 3mm flat bladed screwdriver. SMA spanner and torque setter.

5.3. Care of Modules

5.3.1. General Comments

Many of the active modules contain semiconductor devices utilising MOS technology, which can be damaged by electrostatic discharge. Correct handling of such modules is mandatory to ensure their long-term reliability.

To prevent damage to a module, it must be withdrawn and inserted with care. The module may have connectors on its underside, which might not be visible to the service operative.

5.3.2. LNA Replacement (general procedure)

The following *general* instructions should be followed to remove a module:

1) Remove power to the unit
2) Remove all visible connectors (RF, DC & alarm)
3) Release module retaining screws.
4) Slowly but firmly, pull the module straight out of its position. Take care not to twist/turn the module during withdrawal. (When the module is loose, care may be needed, as there may be concealed connections underneath).

5.3.3. Module Replacement (general procedure)

1) Carefully align the module into its location then slowly push the module directly straight into its position, taking care not to twist/turn it during insertion.
2) Reconnect all connectors, RF, alarm, power etc., (concealed connectors may have to be connected first).
3) Replace retaining screws (if any).
4) Double-check all connections before applying power.

5.3.4. Power Amplifier Replacement (general procedure)

1) Remove power to the unit. (Switch off at mains/battery, or remove DC in connector)

2) Remove alarm wires from alarm screw terminal block or disconnect multi-way alarm connector.

3) Carefully disconnect the RF input and output coaxial connectors (usually SMA)

If alarm board removal is not required, go to step 5.

4) There is (usually) a plate attached to the alarm board which fixes it to the amplifier, remove its retaining screws and the alarm board can be withdrawn from the amplifier in its entirety. On certain types of amplifier the alarm board is <u>not</u> mounted on a dedicated mounting plate; in this case it will have to firstly be removed by unscrewing it from the mounting pillars, in most cases, the pillars will not have to be removed before lifting the amplifier.

5) If the amplifier to be removed has a heatsink attached, there may be several different ways it can have been assembled. The most commonly used method, is screws through the front of the heatsink to threaded screw holes (or nuts and bolts), into the amplifier within the main case. If the heatsink is mounted on the rear of the main case (e.g., against a wall in the case of wall mounted enclosures), then the fixing method for the heatsink will be from within the case, (otherwise the enclosure would have to be removed from the wall in order to remove the heatsink).

When the heatsink has been removed, the amplifier may be unscrewed from the main casing by its four corner fixings and gently withdrawn.

Fitting a new power amplifier module will be the exact reverse of the above.

Note: Do not forget to apply fresh heatsink compound to the heatsink/main case joint and also between the amplifier and the main case.

5.3.5. Low Power Amplifier Replacement (general procedure)

- Disconnect the mains power supply and disconnect the 24V dc supply connector for the LPA.
- Disconnect the RF input and output cables from the LPA.
- Disconnect the alarm connector.
- Remove the LPA module by removing the four retaining screws, replace with a new LPA module and secure it with the screws.
- Connect the RF cables to the LPA input and output connectors.
- Reconnect the DC supply connector and turn the mains switch on.

Note: Tighten SMA connectors using only a dedicated SMA torque spanner. If SMA connectors are over-tightened, irreparable damage will occur. Do not use adjustable pliers to loosen/tighten SMA connectors.

Also take care not to drop or knock the module as this can damage (or misalign in the case of tuned passive modules) sensitive internal components. Always store the modules in an environmentally friendly location

5.3.6. Module Transportation:

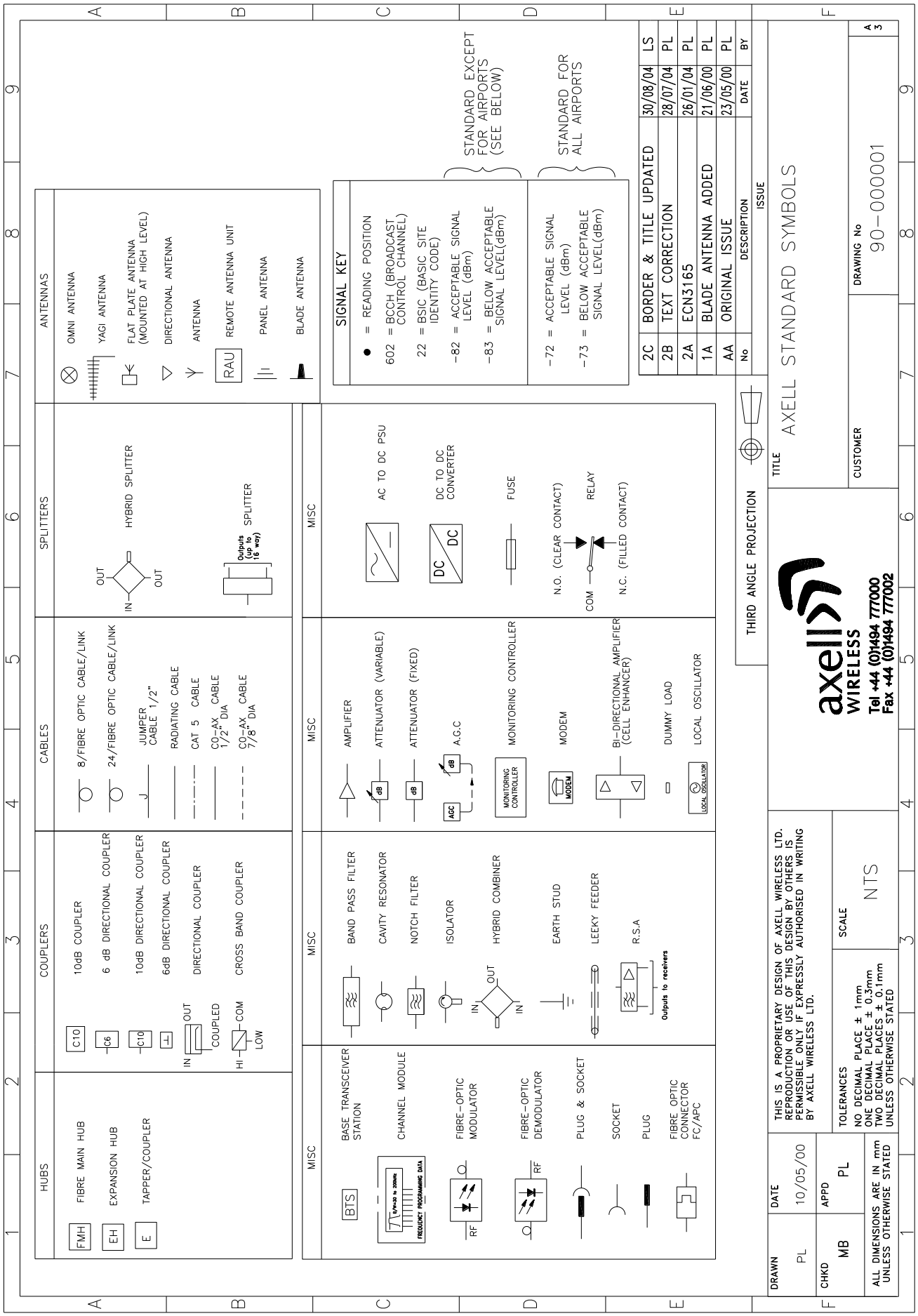
To maintain the operation, performance and reliability of any module it must be stored and transported correctly. Any module not installed in a whole system must be kept in an anti-static bag or container. These bags or containers are normally identified by being pink or black, and are often marked with an ESD label. Any module sent back to Axell Wireless for investigation/repair must be so protected. Please contact the Axell Wireless Network Services Support Desk before returning a module.

Appendix A

A.1. Glossary of Terms used in this document

Repeater or Cell Enhancer	A Radio Frequency (RF) amplifier which can simultaneously amplify and re-broadcast Mobile Station (MS) and Base Transceiver Station (BTS) signals.
Band Selective Repeater	A Repeater designed for operation on a range of channels within a specified frequency band.
Channel Selective Repeater	A Repeater, designed for operation on specified channel(s) within a specified frequency band. Channel frequencies may be factory set or on-site programmable.
AC	Alternating Current
AEM	Axell Element Manager (Network control and monitoring software)
AGC	Automatic Gain Control
BBU	Battery Backup Unit
BDA	Bi-directional Amplifier
BTS	Base Transceiver Station (Base Station)
B/W	Bandwidth
C/NR	Carrier-to-Noise Ratio
Critical Harness	A coaxial cable harness with components of a critical length used to minimise phase discrepancies when joining signal paths of differing frequencies.
DAS	Distributed Antenna System
DC	Direct Current
Downlink (D/L)	Signals transmitted from the BTS to the Mobiles
DSP	Digital Signal Processing
F/O	Fibre Optic
GND	Ground
ID	Identification (Number)
I/P	Input
LCX	Leaky Coaxial Cable (Leaky Feeder).
LED	Light Emitting Diode
LNA	Low Noise Amplifier
LPA	Low Power Amplifier
Mobile(s)	Hand-portable or other “Mobile” RF Transceiver equipment
MOU	Master Optical Unit
MTBF	Mean Time Between Failures
N/A	Not Applicable
N/C (of Relays)	Normally Closed
N/O (of Relays)	Normally Open
OFR	On Frequency Repeater
OIP3	Output Third Order Intercept Point
O/P	Output
P1dB	1dB Compression Point
PA	Power Amplifier
RF	Radio Frequency
RHNC	Relative Humidity, Non Condensing
RMC	Repeater Maintenance Console (a GUI based Repeater management application)
RSA	Receiver/Splitter Amplifier
RX	Receiver (Received)
SDR	Software-Defined Radio
S/N	Serial Number
TX	Transmitter (Transmitted)
Uplink (U/L)	Signals transmitted from the Mobiles to the BTS
UPS	Uninterruptible Power Supply
VSWR	Voltage Standing Wave Ratio
WDM	Wave division multiplex
Date Format	Date Format used in this document is dd/mm/yyyy

A.2. Key to Drawing Symbols used in this document



A.3. Document Amendment Record

Issue No.	Date	Incorporated by	Section Amended	Reason for new issue
1	10/01/2014	AJS		Draft
2	18/02/2014	AJS		Issue
3	17/06/2014	AJS		FCC compliance changes