2. OVERVIEW/SYSTEM DESCRIPTION

The AFL Channel Selective Cell Enhancer is a 2-way on-band repeater. Various models are available to cover frequency bands from 50MHz to 3000MHz. Its main sphere of applications is in urban areas where the topology is such that shadows occur in the propagation pattern (for example within large buildings, conference centres and tunnels, etc.,)

The Channel Selective Cell Enhancer is a 2-port device for direct connection to two antennas, usually a highly directional Yagi or similar aligned towards the base (donor) site and an omni-directional antenna to cover the mobiles. The frequency bands that are passed by the Cell Enhancer are set as per the specific customer requirements.

AFL manufacture a wide range of Cell Enhancers, configured for each customer's specific requirements. Two basic physical variants are available, a rack mounted version to fit in a standard 19" rack and an environmentally sealed wall mounted version which requires no further enclosure.

The rack-mounted version is usually supplied in 3 units, a power supply unit and 2 RF units (one containing each path). Each shelf/tray unit containing active modules has a ‘D.C. on’ indicator on the front panel and the PSU also has an ‘A.C. on’ indicator.

The wall-mounted version is supplied in a single environmentally-protected case. Handles are provided for carrying the unit and the door is fitted with locks. A supply isolator switch is fitted inside the unit and there are ‘.DC. on’ and ‘Alarm on’ indicators on the outside of the door.

3.1 Description

The system consists of separate modules mounted within a lockable, environmentally protected enclosure. It is designed to amplify twelve bi-directional channels (six uplink, six downlink) of mobile signals operating in the VHF waveband. All twelve channel selective modules are configurable for any frequency (within the channel modules' designed range) set by the DIP switches on the channel control modules – see section 4.8 for channel frequency calculation examples. Alarms are provided for each amplifier and channel selective module which are wired as a volt-free, relay isolated summary loop, terminating at pins 1 & 2 in the external connector. The 'normal' condition is that each active device 'holds' a local relay closed, (so if power fails, the alarms become active) making a fail-safe system.

3.2 Electrical Specification

PARAMETER		SPECIFICATION
Frequency range:		167.0-172MHz (Downlink)
		162.0-165MHz (Uplink)
Channel module frequencies:		Unspecified
Bandwidth:		3MHz uplink 5MHz downlink
Channel ripple:		<±1.5dB
Gain:		>95dB
Gain Adjustment:		0 - 30dB (in 2dB steps)
Spurious noise (in-band 30kHz):		<-13dBm (U/L & D/L)
Uplink Power:		>10.0Watts
Downlink Power:		>40.0Watts
DownlinkO/P power/channel:		+24dBm
UplinkO/P power/channel:		+18dBm
Channel module gain:		30dB
Channel module ALC:		-15.5dBm (downlink)
		-14dBm (uplink)
PA 1 dB compression point:		+44dBm (downlink)
		+38dBm (uplink)
PA IP3:		+56dBm (downlink)
		+50dBm (uplink)
Noise Figure:		<6dB
VSWR:		better than 1.5:1
RF Connectors:		N type, female
Input supply power:		110 or 230V ac
Temperature range:	operational:	-10°C to +60°C
	storage:	-40°C to +70°C
Alarms Fitted: (volt-free contacts/TTL)		1 Amplifiers
		2 Channel modules

3.3 Mechanical Specification

Case Size:	Height:	**800**mm
	Width:	**600**mm
	Depth:	**250**mm
(excluding heatsinks, connectors, handles and feet)		
Fixings:		**4** holes on **630**(w) x **640**(h)mm
Weight:		**80**kg (approximately)
RF Connectors:		**N type female**
Environmental Protection:		**IP65** with door closed and ports terminated
Finish:	Case:	To **RAL 7035**
	Heatsinks:	**Matt black**
	Handles:	**Black technopolymer**
Temperature Range:	operational:	**-20**°C to +**60**°C
	storage:	**-40**°C to +**70**°C
Supply cord:		Unit supplied with 3-pin IP68 connector for customer interface with AC input.

4. SUB-UNIT MODULES

4.1 3 Port Tx Hybrid Couplers (05-000103 & 05-000104)

4.1.1 Description

The transmitter hybrid couplers provide isolation from unwanted reflected frequencies to/from the leaky feeder antennas. They are 4 port devices with the one unused port terminated internally with a 50 Ω dummy load. The '104' version has higher power capability due to an attached heatsink.

Being passive devices, the hybrid couplers should be maintenance free over their entire lifetime and have an extremely high MTBF figure. It is not recommended that the top cover be removed or any of the internal components needlessly touched, since the original factory alignment/tuning would be extremely hard to reproduce in a 'field' environment.

4.1.2 Technical Specification

PARAMETER	SPECIFICATION
Frequency Range:	140-170 MHz
Bandwidth:	±10% of f_o
Insertion Loss:	3.2dB
Impedance:	50Ω
V.S.W.R:	1.2:1
Input to input isolation:	>20dB
Connectors:	Type N Standard
Dimensions:	140 x 120 x 35mm
Power rating:	25Watts (05-000103)
	100W (05-000104)
Weight:	0.5kg

4.2 ¼Watt 0- -30dB Switched Attenuator (10-000703)

4.2.1 General Application

In many practical applications for Cell Enhancers etc., the gain in each path is found to be excessive. Therefore, provision is made within the unit for the setting of attenuation in each path, to reduce the gain.

4.2.2 Switched Attenuators

The AFL switched attenuators are available in two different types; 0 – 30dB in 2 dB steps (as in this case), or 0 – 15dB in 1 dB steps. The attenuation is simply set using the four miniature toggle switches on the top of each unit. Each switch is clearly marked with the attenuation it provides, and the total attenuation in line is the sum of the values switched in. They are designed to maintain an accurate 50Ω impedance over their operating frequency at both input and output.

4.3 VHF/UHF Low Noise Amplifier (11-006002)

4.3.1 Description

The 21dB gain low noise amplifier used is a double stage solid-state low-noise amplifier. Class A circuitry is used throughout the unit to ensure excellent linearity over a very wide dynamic range. The two active devices are very moderately rated to provide a long, trouble-free working life. There are no adjustments on this amplifier, and in the unlikely event of failure then the entire amplifier should be replaced. The amplifier features a dedicated, in-built alarm monitoring system based on class A DC biasing levels whose output is a volts-free relay contact pair that may be integrated into an existing system via the 9-way D-type interface.

4.3.2 Technical Specification

PARAMETER		SPECIFICATION
Frequency range:		70 – 500MHz
Bandwidth:		<430MHz
Gain:		21dB (typical)
1dB Compression Point:		+20dB (typical)
3rd order intercept:		+33dB (typical)
Input return loss:		>14dB
Output return loss:		>20dB
VSWR:		Better than 1.5:1
Noise figure:		<2.7dB
Connectors:		SMA female
Supply:		230 - 260mA @ 10 to 24V DC
Size:		88 x 50 x 34mm (ex. connectors)
Temperature range:	operational:	-10°C to +60°C
	storage:	-20°C to +70°C
Weight:		0.26kg

4.3.3 LNA 'D' Connector Pin-out details

Connector pin	Signal
1	+Ve input (10-24V)
2	GND
3	Alarm RelayO/P bad
4	Alarm Relay common
5	Alarm Relay good
6	No connection
7	TTL voltage set
8	TTL alarm/0V (good)
9	O/C good/0V bad

4.4 10Watt Power Amplifier (12-002001)

4.4.1 Description

The power amplifier fitted to this unit is a multi-stage, solid state power amplifier. Class A circuitry is employed throughout the device to ensure excellent linearity over a wide dynamic frequency range. All the semi-conductor devices are very conservatively rated to ensure low device junction temperatures and a long, trouble free working lifetime.

The power amplifier should require no maintenance over its operating life. Under no circumstances should the cover be removed or the side adjustments disturbed unless it is certain that the amplifier has failed; since it is critically aligned during manufacture and any re-alignment will require extensive test equipment.

4.4.2 Technical Specification

PARAMETER		SPECIFICATION
Frequency range:		100 - 250MHz (tuned to spec.)
Bandwidth:		20MHz (typical, tuned to spec.)
Maximum RF output:		>10Watts
Gain:		>50dB
1dB compression point:		+40dBm
3rd order intercept point:		+50dBm
VSWR:		better than 1.5:1
Connectors:		SMA female
Supply:		2.5Amps @ 24V DC
Weight:		1kg (excluding heatsink)
Temperature range:	operational:	-10°C to +60°C
	storage:	-20°C to +70°C

4.5 20Watt Power Amplifier (12-003601)

4.5.1 Description

The 20Watt power amplifier fitted to this unit is a multi-stage, solid state power amplifier. Class A circuitry is employed throughout the device to ensure excellent linearity over a wide dynamic frequency range. All the semi-conductor devices are very conservatively rated to ensure low device junction temperatures and a long, trouble free working lifetime.

The power amplifier should require no maintenance over its operating life. Under no circumstances should the cover be removed or the side adjustments disturbed unless it is certain that the amplifier has failed; since it is critically aligned during manufacture and any re-alignment will require extensive test equipment.

4.5.2 Technical Specification

PARAMETER		SPECIFICATION
Frequency Range:		88 - 108MHz
Bandwidth:		20MHz (typical, tuned to spec.)
Maximum Output Power:		>20W
Gain:		44dB
1dB Compression Point:		<+43dBm
3rd Order Intercept Point:		<+54dBm
VSWR:		better than 1.45:1
Connectors:		SMA female
Supply:		4.8A @ 24V DC
Temperature range:	operational:	-10°C to +60°C
	storage:	-20°C to +70°C
Size:		276 x 78 x 40mm (case only)
Weight:		1.5 kg (excluding heatsink)

4.6 DC/DC Converter, 24V in, 12V 8A out (13-003011)

4.6.1 Description

The DC/DC converter fitted is an O.E.M high power PCB unit with an 8 amp @ 12V output capability. The regulator exists within this unit because of the need to supply 12V DC to the channel modules; if the unit is being supplied with power by the external 24V DC rail, there would be only be 24V in the system and the channel modules would have no power. The circuit is basically an O.E.M semiconductor regulator (one side of which has a heatsink mounting plate, usually bolted to the casing of a Cell Enhancer) and smoothing components built onto a printed circuit board with screw block terminations.
Note: no circuit diagram of this O.E.M. regulator is available. This unit should not be repaired, only replaced.

4.6.2 Technical Specification

PARAMETER		SPECIFICATION
Input Voltage Range:		18-28V DC
Output Voltage:		12V±0.5V
Max. Current Load:		8.0Amps
Temperature range:	operation :	-10°C to +60°C
	storage:	-20°C to +70°C
Size(PCB):		190 x 63mm
Weight (Loaded PCB):		291gms

4.7 Channel Control Module (17-002101)

4.7.1 Description

The purpose of the channel control modules is to change the channel selective module frequencies by means of a series of D.I.P switch banks, each switch corresponding to a different 'frequency bit'.

4.7.2 Technical Specification

Below shows the pin assignments for each switch on a channel control module.

IDC PIN	25-way Connector	Function
1	13	Freq. bit 1 (12.5kHz)
2	25	Freq. bit 2 (25kHz)
3	12	Freq. bit 3 (50kHz)
4	24	Freq. bit 4 (100kHz)
5	11	Freq. bit 5 (200kHz)
6	23	Freq. bit 6 (400kHz)
7	10	Freq. bit 7 (800kHz)
8	22	Freq. bit 8 (1.6MHz)
9	9	Freq. bit 9 (3.2MHz)
10	21	Freq. bit 10 (6.4MHz)
11	8	Freq. bit 11 (12.8MHz)
12	20	Freq. bit 12 (25.6MHz)
13	7	Freq. bit 13 (51.2MHz)
14	19	Freq. bit 14 (102.4MHz)
15	6	Freq. bit 15 (204.8MHz)
16	18	Freq. bit 16 (409.6MHz)
17	5	Module alarm
18	17	N/C
19	4	
20	16	
21	3	
22	15	+5V
23	2	0V
24	14	Switched 12V
25	1	0V
26	---	---

4.7.3 VHF/ UHF Programming Procedure

Check that the required frequency falls within the operational frequency limits of the Cell Enhancer.

For each channel required, subtract the synthesiser offset from the required operating frequency and record the resulting local oscillator frequency.

Divide each local oscillator frequency by the channel spacing and check that the result is an integer (i.e.: no remainder).

If the synthesiser division ratio is not an integer value, check the required operational frequency and repeat the calculation checking for mistakes.

Convert the required local oscillator frequency to synthesiser programming switch state patterns according to the following table.

Switch number	Synthesiser offset added when switch in UP position
1	+12.5kHz
2	+25kHz
3	+50kHz
4	+100kHz
5	+200kHz
6	+400kHz
7	+800kHz
8	+1.6MHz
9	+3.2MHz
10	+6.4MHz
11	+12.8MHz
12	+25.6MHz
13	+51.2MHz
14	+102.4MHz
15	+204.8MHz
16	+409.6MHz

4.7.4 VHF/ UHF Programming Example

Frequency required: 465.5MHz

Channel spacing: 12.5kHz

Synthesiser offset: 21.4MHz

The Local Oscillator frequency is therefore: 465.4 – 21.4 = 444.0 MHz

Dividing the LO frequency
by the channel spacing of: 0.0125MHz:

$$\frac{444.0}{0.0125} = 35520$$

This is an integer value, therefore it is OK to proceed.

Local Oscillator Frequency of: 444.0 MHz	Switch settings															
	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0

Switch setting: 0 = switch DOWN (on, frequency ignored)
1 = switch UP (off, frequency added)

4.8 Channel Selective Module (17-009106)

4.8.1 Description

The channel selectivity module is employed when the Cell Enhancer requirement dictates that very narrow bandwidths (single operating channels), must be selected from within the operating passband. One channel selectivity module is required for each channel.

The Channel Selectivity Module is an Up/Down frequency converter that mixes the incoming channel frequency with a synthesised local oscillator, so that it is down-converted to an Intermediate Frequency (IF) in the upper HF range. An eight pole crystal filter in the IF amplifier provides the required selectivity to define the operating passband of the Cell Enhancer to a single PMR channel. The same local oscillator then converts the selected IF signal back to the channel frequency.

Selectivity is obtained from a fixed bandwidth block filter operating at an intermediate frequency (IF) in the low VHF range. This filter may be internal to the channel selectivity module (Crystal or SAW filter) or an externally mounted bandpass filter, (LC or Helical Resonator). Various IF bandwidths can therefore be accommodated. A synthesized Local Oscillator is employed in conjunction with high performance frequency mixers, to translate between the signal frequency and IF.

The operating frequency of each channel selectivity module is set by the programming of channel selectivity module frequencies and is achieved digitally, via hard wired links, banks of DIP switches, or via an onboard RS232 control module, providing the ability to remotely set channel frequencies.

Automatic Level Control (ALC) is provided within each channel selectivity module such that the output level is held constant for high level input signals. This feature prevents saturation of the output mixer and of the associated amplifiers.

Alarms within the module inhibit the channel if the synthesised frequency is not locked. The synthesiser will not usually go out of lock unless a frequency far out of band is programmed.

The channel selectivity module is extremely complex and, with the exception of channel frequency programming within the design bandwidth, it cannot be adjusted or repaired without extensive laboratory facilities and the necessary specialised personnel. If a fault is suspected with any channel selectivity module it should be tested by substitution and the complete, suspect module should then be returned to AFL for investigation.

Operators note: None of the channel modules is frequency pre-programmed, they must all be set using the method described in section 4.8.

4.9 24V Relay Board (20-001602)

4.9.1 Description

The General Purpose Relay Board allows the inversion of signals and the isolation of circuits. It is equipped with two dual pole change-over relays RL1 and RL2, with completely isolated wiring, accessed via screw terminals.
Both relays are provided with polarity protection diodes and diodes for suppressing the transients caused by "flywheel effect" which can destroy switching transistors or induce spikes on neighbouring circuits. It's common use is to amalgamate all the alarm signals into one, volts-free relay contact pair for the main alarm system.
Note that the board is available for different voltages (12 or 24V) depending on the type of relays fitted at RL1 and RL2.

4.9.2 Technical Specification

PARAMETER		SPECIFICATION
Operating voltage:		8 to 30V (floating earth)
Alarm Threshold:		Vcc - 1.20 volt ±15%
Alarm output relay contacts:		
Max. switch current:		1.0Amp
Max. switch volts:		120Vdc/60VA
Max. switch power:		24W/60VA
Min. switch load:		10.0µA/10.0mV
Relay isolation:		1.5kV
Mechanical life:		>2x10^7 operations
Relay approval:		BT type 56
Connector details:		Screw terminals
Temperature range	operational:	:-10°C to +55°C
	storage:	:-40°C to +70°C

4.10 Six-Way Splitter (93-100004)

4.10.1 Description

The wide range, low power, hybrid splitter/combiner provides the means to divide the signal into six before the channel modules & re-combine the six signals into one after processing.

Being passive devices, the receivers should be maintenance free over their entire lifetime and have an extremely high MTBF figure. It is not recommended that the top cover be removed should the unit be suspected of failure, replacement with a new unit is usually the most cost effective solution.

4.10.2 Technical Specification

PARAMETER		SPECIFICATION
Frequency Range:		50-500MHz
Rx/Rx Isolation:		>20dB
Typical Insertion Loss:		10.5 dB
VSWR:		1.3:1
Impedance:		50Ω
Output Connectors:		N Type
Input Connectors:		N Type / BNC
Temperature range	operation:	-10°C to +60°C
	storage:	-20°C to +70°C
Dimensions:		145 x 64 x 37mm (case only)

4.11 STPS12045TV 60A Dual Diode Assembly (94-100004)

4.11.1 Description

The purpose of these dual diode assemblies is to allow two (or more) DC voltage sources to be combined, so that the main 24 volt DC rail within the equipment is sourced from either the mains driven SMPU, or externally through an XLR connector on the rear panel. When the DC is sourced externally, the heavy-duty diodes prevent any reverse current from flowing back to their source or the alternative supply rail. Combining diodes such as these would also be used if the equipment is to be powered from external back-up batteries.

4.12 JWS100-12/A PSU (96-300051)

4.12.1 Description

The mains power supply unit used to power the channel selective modules is a switched-mode type capable of supplying 12V DC at 8.5Amps continuously, (the cell enhancer draws approximately 5.0Amps from this 12V supply under normal conditions).

No routine maintenance of the PSU is required. If a fault is suspected, then the output voltage from the power supply may be measured on its output terminals. This is typically set to 12.2V. The output voltage may be varied using the multi-turn adjustment potentiometer mounted close to the DC output terminals.

All the PSU's used in AFL Cell Enhancers are capable of operation from either 110 or 220V nominal AC supplies. The line voltage is sensed automatically, so no adjustment or link setting is needed by the operator.

4.12.2 Technical Specification

AC Input Supply:	
Voltage:	110 or 220V nominal
	90 to 132 or 180 to 264V (absolute limits)
Frequency:	47 to 63Hz
DC Output Supply:	
Voltage:	12V DC (nominal)
	10-14V (absolute limits)
Current:	8.5A

4.13 24V, 400W Power Supply Pack (96-300054)

4.13.1 Description

The main 24V power supply unit is a switched-mode type capable of supplying 24V DC at 17.0Amps continuously. Equipment of this type typically requires approximately 12.0 Amps at 24V DC, so the PSU will be used conservatively ensuring a long operational lifetime.

No routine maintenance of the PSU is required. If a fault is suspected, then the output voltage from the power supply may be measured on its output terminals. This is typically set to 24.5V using the multi-turn potentiometer mounted close to the DC output studs on the PSU PCB.

All the PSU's used in AFL Cell Enhancers are capable of operation from either 110 or 220V nominal AC supplies. The line voltage is sensed automatically, so no adjustment or link setting is needed by the operator.

4.13.2 Technical Specification

AC Input Supply	
Voltages:	110 or 220V nominal
	90 to 132 or 180 to 264V (absolute limits)
Frequency:	47 to 63Hz
DC Output Supply:	
Voltage:	24V DC (nominal)
	20 to 28V (absolute limits)
Maximum current:	17A