



USER MANUAL



- Double the output voltage by driving 2 high voltage amplifiers in bridge mode
- Switchable 50Ω /100kΩ input: buffer low-current signal sources to drive high-speed 50Ω amplifier inputs
- High speed: DC – 20MHz @ -3dB full power bandwidth
- $\pm 10V$ maximum output voltage

About this manual

This user manual is an integral part of the Falco Systems WMA-IB-HS phase inverter - buffer product. Please read it carefully and pay attention to the recommendations and instructions for safe use.

Operation of the phase inverter

The WMA-IB-HS is a low noise, high speed DC - 20MHz phase inverter - buffer designed to drive one or two high voltage amplifiers. It can be used:

- To drive two amplifiers in bridge mode by using both the buffered output and the inverting output, or
- As a high impedance buffer between a signal source and the amplifier

The input of the WMA-IB-HS is switchable to 100kΩ input impedance and to 50Ω:

- The 50Ω setting is used with 50Ω sources such as function- or arbitrary waveform generators, to ensure waveform

integrity even at high operating frequencies.

- The 100kΩ setting is used to buffer current limited signal sources such as typical computer controlled DAQ (data acquisition) cards.

Internal gain switching circuitry makes sure that the output signal amplitude does not change with the setting of the switch when the input impedance switch is toggled (when driven from a 50Ω source).

The outputs of the WMA-IB-HS can drive both high impedance and 50Ω high voltage amplifier inputs. The WMA-IB-HS can also be used as a high quality stand-alone phase inverter - buffer in a variety of other applications.

The WMA-IB-HS ships with a customized Mean Well GS25B28-P1J power supply. The power supply connector, 315mA fuse and on-off switch are on the rear panel of the WMA-IB-HS enclosure. A blue led indicates that the WMA-IB-HS is on.

The outputs are on the left of the front panel to accommodate neat cabling to high voltage amplifiers that typically have their inputs at the left side too.

Bridge mode

The WMA-IB-HS can be used to double the maximum output voltage driving a load, such as a piezo actuator, EO (electro-optical) modulator, or MEMS (electromechanical systems) device, among many others. This is achieved by driving two high voltage amplifiers both with the same signal, but with opposite polarity. The outputs of the amplifiers are connected in bridge mode. Fig. 1 shows the concept of the bridge mode circuit.

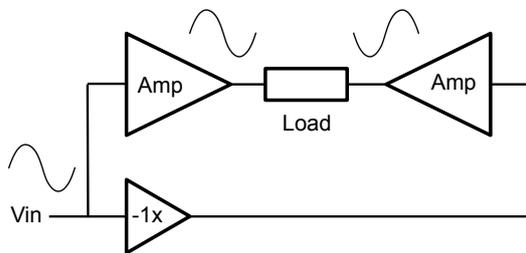


Figure 1. Doubling the maximal output voltage by using 'bridge mode'

The WMA-IB-HS inverts the signal and provides the signal for both amplifiers. The outputs of the two amplifiers are connected to the floating, ungrounded load. The WMA-IB-HS phase inverter - buffer amplifies 1x. If both amplifiers amplify e.g. 20x, the total output voltage across the load will be doubled in bridge mode, i.e. 40x in this case.



Figure 2. Connecting the high-speed phase inverter buffer and two amplifiers for bridge mode operation

Fig. 2 shows an actual setup with the high-speed phase inverter buffer connected to two high voltage amplifiers to drive them in bridge mode.

When two amplifiers are driven in bridge mode, the high voltage output signal with twice the amplitude of the individual high voltage amplifiers is available between the inner pins of the two high voltage amplifier BNC outputs and can be connected to the load (Fig 3). Make sure that the load is not grounded to the same ground as the amplifiers, as this would short-circuit one of the two high voltage amplifiers. This will not damage the amplifier (if it is short-circuit proof) but would reduce the output voltage available to that of a single amplifier only.

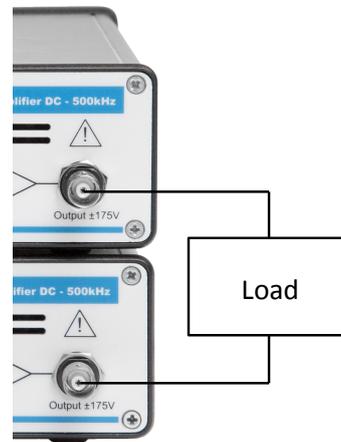


Figure 3. Connecting a load in bridge mode to two high voltage amplifiers

Connecting the load

The high speed phase inverter - buffer in combination with two Falco Systems high voltage amplifiers is capable of both very high speed and low noise performance. This performance can only be obtained with correct shielding of the cables connecting to the load and, if possible, shielding of the load itself. Solid BNC connectors and/or short, high quality BNC cables are recommended.

Some loads, such as certain EO-modulators, have a differential connector available, or two individual connectors, to drive them differentially (Fig. 4).

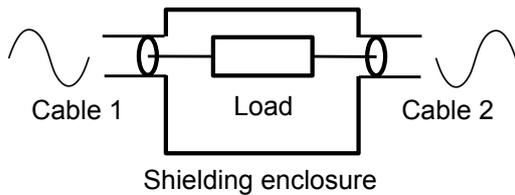


Figure 4. Shielded, differentially driven load for bridge mode operation

The housing of the modulator is connected to the shield of the cables this way, resulting in good interference rejection. This scheme is also the recommended one if the user has the possibility to design the connections of the load him/herself.

In situations where driving the load differentially with two connectors is impossible, e.g. because the load has only a single connector, both amplifier outputs have to be connected together at the load, as depicted in Fig. 5.

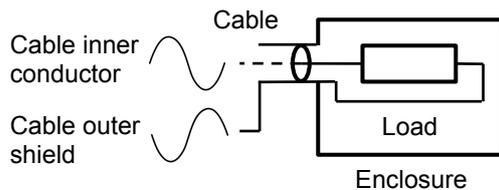


Figure 5. Driving a single-connector load in bridge mode

If one of the two connections of the connector is connected to the (conductive) housing of the load, check that:

- *the housing/outside of the load floats with respect to the ground of the amplifiers, i.e. it makes no contact with the electrical circuit to which the amplifiers belong, other than via the output cables, and*
- *the housing/outside of the load and the BNC connector itself cannot be touched, as it carries the full output voltage of one of the high voltage amplifiers. For this*

reason the sign  is present on the enclosure. The use of an insulated BNC connector is recommended.

To aid in connecting floating loads in bridge mode, Falco Systems offers a special 'bridge mode insulated tee-cable' (Fig. 6). This cable takes the two amplifier cables on BNC connectors, and has a third BNC connector, where the inner conductor of one input cable is connected

to the inner pin, and the inner conductor of the other cable to the outer ring, which is normally associated with the 0V shield. This functionality is very different from a normal BNC tee-adapter, which is only used to connect the inner conductor of a BNC cable to two cables, with all inner pins connected together.



Figure 6. A 'bridge mode' tee-cable for connecting the load is available from Falco Systems, and can be purchased on the website www.falco-systems.com

Required amplifier properties

The WMA-IB-HS phase inverter - buffer can be used with many high voltage amplifiers, and is not limited to driving amplifiers of the Falco Systems brand. Most amplifiers with an output current limiter are suitable, as the current limiter will ensure that the maximum power dissipation inside the amplifier will not be exceeded. When the setup is used with fast changing signals, the voltage and current transients at the amplifier outputs may be slightly different in bridge mode than when the load is grounded. For most amplifiers this will be no problem, but when in doubt, please contact the manufacturer of the high voltage amplifiers before using the amplifiers in bridge mode. Amplifiers without a current limiter will dissipate twice the normal power. The double voltage will be shared equally between the amplifiers in bridge mode, but the doubled voltage across the load will result in a doubled current, which flows through both amplifiers. Depending on the details of the setup, this higher dissipation may or may not be a problem. Again, when in doubt, please contact the manufacturer of the amplifiers before using the amplifiers in bridge mode.

Buffer mode

Although primarily intended for driving high voltage amplifiers in bridge mode, the WMA-IB-HS can also be used as a stand-alone buffer to connect low power signal sources to equipment with a 50Ω input impedance. Please note that computer-controlled setups with DAQ (data acquisition) cards often are not able to drive a 50Ω high voltage amplifier input directly. This is caused by the very limited current capability of the outputs of typical DAQ cards, which is insufficient to drive a 50Ω input.

An example is driving the input of a Falco Systems WMA-300 high-speed high voltage amplifier from a DAQ card. This will result in a highly distorted and clipped signal coming out of the DAQ card at higher output voltages.

The solution is to use a WMA-IB-HS as the buffer between the low current signal source and the 50Ω equipment (Fig. 7).

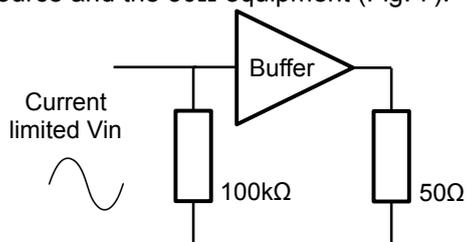


Figure 7. Using the WMA-IB-HS as a buffer with a high input impedance to drive a 50Ω impedance

The input of the WMA-IB-HS is set to the high impedance 100kΩ setting not to load the signal source unduly, and its 'buffered out' will drive 50Ω equipment without any problems. If the signal coming from the source is fast-changing, such as a square wave or high frequency sine wave, then mount the WMA-IB-HS very close to the signal source. This is done to prevent reflections in the non-50Ω connection between the signal source and the WMA-IB-HS buffer input.

50Ω: preserving signal amplitude

The WMA-IB-HS is equipped with both a 50Ω and a 100kΩ input. A typical 50Ω source such as a function or arbitrary waveform generator has a 50Ω output and will form a 1:2 voltage divider with the 50Ω input resistance of the WMA-IB-HS. To prevent the loss in signal amplitude due to

this voltage divider, the WMA-IB-HS amplifies the signal at its input by a factor 2 when the input is switched to the 50Ω setting. The factor 2 ensures that the signal at the output has the same amplitude when driven from a 50Ω source, irrespective of whether the input is set to 50Ω or 100kΩ.

If the signal source has a very low output resistance and drives the 50Ω input, the voltage gain is 2x, because the 1:2 voltage divider is absent. When the WMA-IB-HS drives a high impedance load such as an amplifier input, the voltage at the output will be the same as the voltage at the input. If the output drives a 50Ω input, the voltage divider consisting of the 50Ω output resistance of the WMA-IB-HS and the 50Ω input of the amplifier will divide the signal available at the high voltage amplifier input by a factor 2. This is just what a 50Ω signal source such as a function generator would do. Fig. 8 illustrates the gain of the WMA-IB-HS for different situations.

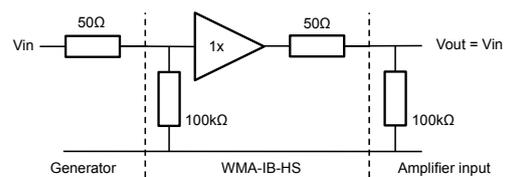


Figure 8a. 50Ω generator, 100kΩ input, high impedance load; $V_{out} = V_{in}$

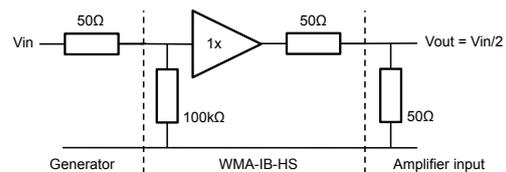


Figure 8b. 50Ω generator, 100kΩ input, 50Ω load; $V_{out} = V_{in}/2$ (this also happens without the WMA-IB-HS present, with only the amplifier input loading the generator)

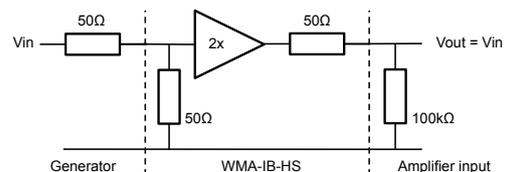


Figure 8c. 50Ω generator, 50Ω input, high impedance load; $V_{out} = V_{in}$

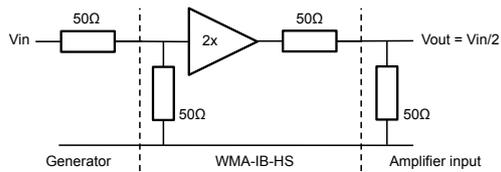


Figure 8d. 50Ω generator, 50Ω input, 50Ω load; $V_{out} = V_{in}/2$

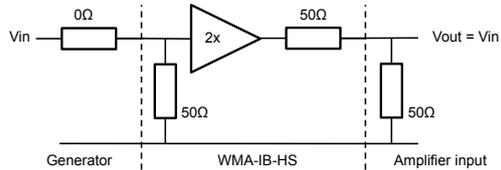


Figure 8e. 0Ω generator, 50Ω input, 50Ω load; $V_{out} = V_{in}$

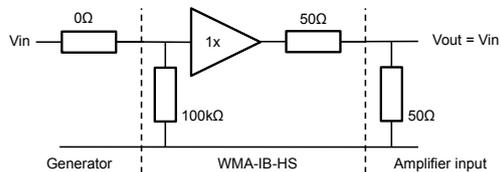


Figure 8f. 0Ω generator, $100k\Omega$ input, high impedance load; $V_{out} = V_{in}$

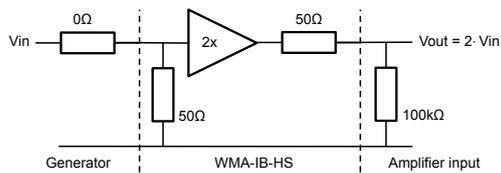


Figure 8g. 0Ω generator, 50Ω input, high impedance load; $V_{out} = 2 \cdot V_{in}$

Figure 8. The gain structure of the WMA-IB-HS under different conditions

More information about 50Ω systems can be found online in the Falco Systems application note "High voltage amplifiers and the ubiquitous 50 Ohm: caveats and benefits" at:

www.falco-systems.com/applications.html

Recommendations and safety

Recommendations:

- Heed the advice in the 'connecting the load' section of the manual. In short: do not short circuit one of the amplifiers by grounding the load, and make sure the voltage-carrying parts of the load cannot be touched during operation.

- Never apply more than $+10V$ (or less than $-10V$) to the phase inverter/buffer input to prevent damage.

- The phase inverter/buffer cannot be damaged by a short-circuit condition or capacitive loading, but avoid:

- Connecting a charged capacitor to the input or output.

- Connecting a highly inductive load to the output (such as a coil).

- Do not connect anything to the phase inverter - buffer that can act as an antenna.

- This product should only be cleaned with a soft, slightly moist cloth. Disconnect the phase inverter/buffer from the power supply and all equipment before cleaning.

Safety:

- The WMA-IB-HS high speed phase inverter - buffer is only suitable for indoor use in a class II environment (domestic, light industrial).

- Only use the power supply adapter supplied by Falco Systems: Mean Well GS25B28-P1J, 100-240V~ 50/60Hz in, 28V 25W DC out, with custom MiniDIN connector.

- Only replace fuses with the correct type: 5x20mm 315mA 230V fuse on the rear panel.

- This product cannot be powered by non-sinusoidal mains power generators.

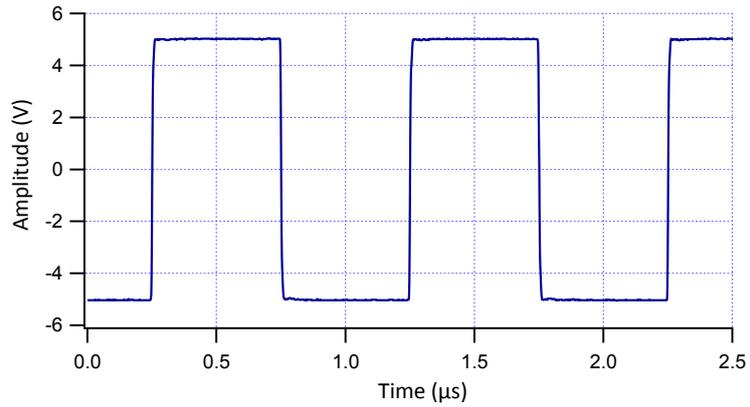
- Only replace a damaged power cord with an equivalent type: H03VVH2-F 2X 0,75 mm², with Euro to C7 equipment connector.

- The airflow to and from the WMA-IB-HS should not be blocked or impeded, to allow for adequate ventilation.

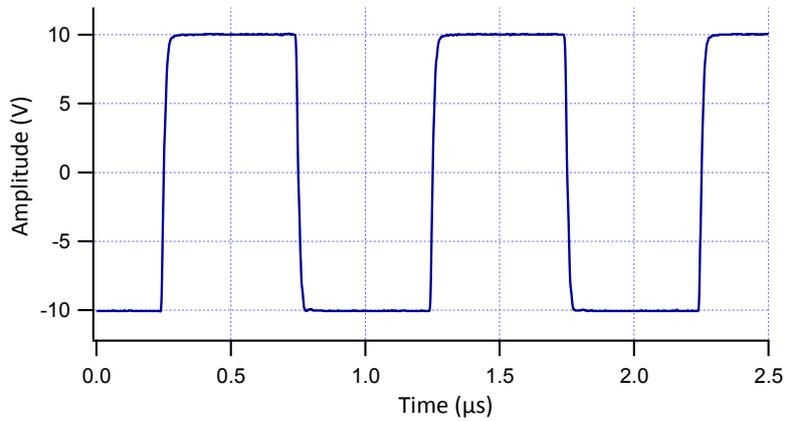
Transmitter mode

This high speed phase inverter - buffer can generate a significant amount of power at frequencies used for radio transmission and reception. It should not be used for telecommunication as described in the R&TTE directive 95/5/EC. Always use coaxial cables.

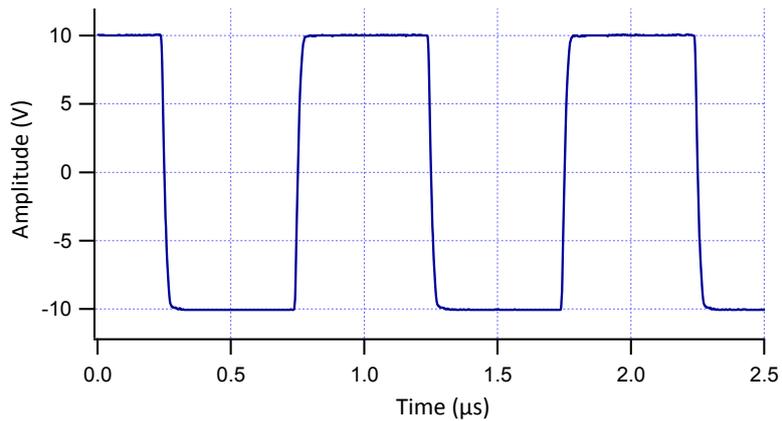
WMA-IB-HS phase inverter - buffer characteristics



9a. Input signal (divided by 2 due to the 50Ω loading of the 50Ω output of the generator by the 50Ω input of the WMA-IB-HS)



9b. Buffered output signal: signal amplitude is restored by the 2x gain of the WMA-IB-HS



9c. Corresponding inverted output signal

Figure 9. 1MHz 20Vpp square wave output signal at the buffered and inverted outputs (50Ω input impedance setting, function generator with 50Ω output)

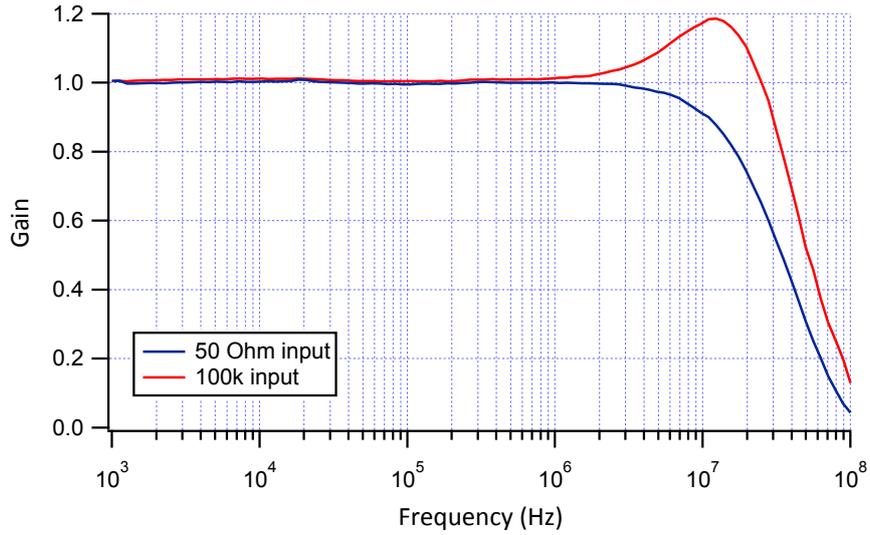
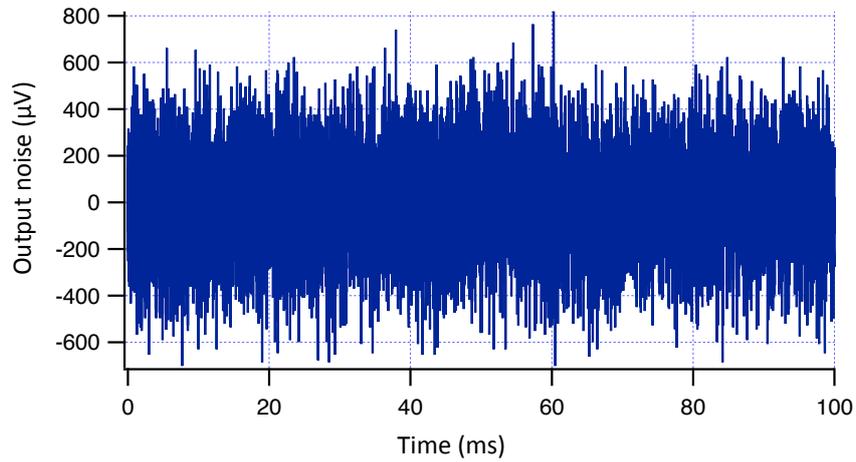
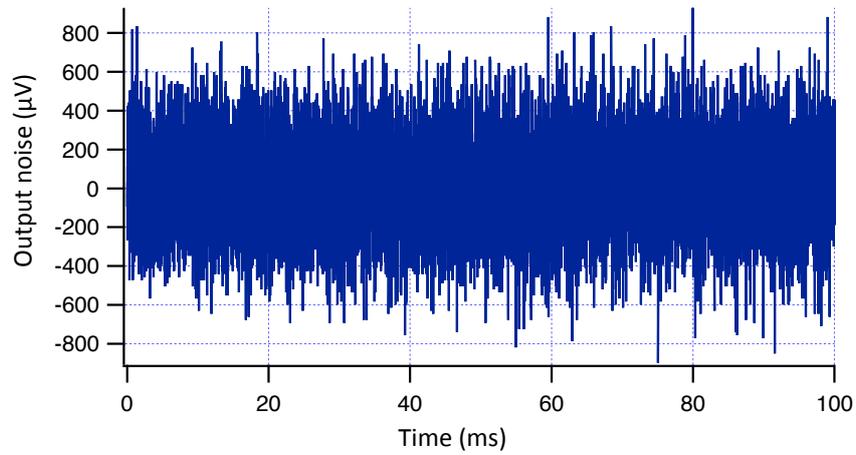


Figure 10. Bandwidth at 3Vpp into a 50Ω load with the input switched to 50Ω and 100kΩ input impedance (the 100kΩ response depends on type of source and input cable properties)



11a. Noise at the buffered output



11b. Noise at the inverted output

Figure 11. Output noise (AC coupled) with a 50Ω shielded BNC dummy load on the input, with the input switched to 50Ω impedance

Technical specifications

Input: 50Ω or 100kΩ input impedance, switchable, ±10V max input voltage

Output: 50Ω output impedance, ±10V max out in a high impedance load, ±5V max out in a 50Ω load

Gain: buffered out: +1x, inverted out: -1x, independent of the input impedance switch setting. Gain changes automatically

Bandwidth DC – 20MHz @-3dB typical at either output, when input and outputs are used with 50Ω equipment

Noise and offset: buffered out: ~125μVrms noise, Inverted out: ~160μVrms noise (all values typical, in DC – 100MHz measurement bandwidth); typical offset of both outputs ~0.9mV with 50Ω input setting, ~3.3mV with 100kΩ setting

Delay time: input to buffered out: 12 ns typical, buffered out to inverted out: 9 ns typical

Operating temperature: 15 – 30°C

Storage temperature: 0 – 60°C

Relative humidity: 30 – 70% non-condensing

Maximum usage height: 2000m

Dimensions and weight: 190x106x40mm, 0.4 kg

Power: 28V DC, 200mA maximum, with 315mA 5x20mm 230V fuse and on/off switch on rear panel. Use the power supply adapter supplied by Falco Systems only: Mean Well GS25B28-P1J, 100-240V~ 50/60Hz in, 28V 0.75A DC out, 25W, with custom MiniDIN connector

Country of origin: The Netherlands

Specifications may be subject to change

Harmonized standards

This product complies with the following standards:

Safety: EN61010-1

EMC: EN61326

FCC: 47 CFR 15

The  mark is present on the WMA-IB-HS to indicate compliance of this equipment with the European Union safety and EMC regulations, while the  mark has been added to indicate compliance with the United States FCC regulations.

WEEE and RoHS

Do not dispose of the WMA-IB-HS phase inverter – buffer as standard waste, but bring it to a WEEE electronic waste collection point. This is indicated by the



sign on the WMA-IB-HS. The WMA-IB-HS has been built in compliance with the RoHS directive.

Warranty

Falco Systems products are guaranteed against malfunction due to defects in materials or workmanship for a period of 1 year from the date of shipment.

If a malfunction occurs during this period, the product will be repaired or replaced without charge. The product will be returned to the customer prepaid.

The warranty does not apply to:

- Exterior finish or appearance
- Malfunction resulting from use or operation of the product in other ways than specified in the user manual
- Malfunctioning due to misuse or abuse of the product
- Malfunctioning occurring after changes or repairs have been made by anyone other than Falco Systems.

To obtain warranty service, the customer has to inform Falco Systems first via info@falco-systems.com to receive further instructions.

Falco Systems will not be liable for any consequential damages, including, without limitation, devices or equipment connected to the product, injury to persons or property or loss of use. See for more details the Falco Systems Standard Terms and Conditions of Sale, which can also be obtained via info@falco-systems.com.

User manual version

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Falco Systems

Falco Systems

Remisestraat 1

2225 TH Katwijk aan Zee

The Netherlands

Tel. +31 (0)6 21840996

Fax. +31 (0)20 2031445

Email: info@falco-systems.com

www.falco-systems.com