868MHz HumPRO™ and HumPRC™ Series RF Transceiver PCB Layout Guide

Reference Guide RG-00111

Introduction

The HUM-868-PRO and HUM-868-PRC Series modules have been tested and found to be compliant with CE requirements for operation in the 863-870MHz band under the Radio Equipment Directive 2014/53/EU (RED). Linx has issued a Declaration of Conformity (DoC) for the HUM-868-PRO and HUM-868-PRC Series modules. The modules are designed with compliance in mind and have internal mechanisms to handle all of the strict frequency and timing requirements. Products seeking CE compliance should carefully consider the information provided in this document and consult an accredited CE test lab early in the design process. This guide includes details about the hardware and firmware configuration that was used during Linx CE testing. Some of the information included in this guide and in the Linx CE test report may be used to supplement the end product CE test report and Declaration of Conformity (DoC). This document addresses only radio testing (EMC/EMI). Safety testing is another important part of CE compliance but is outside the scope of this guide since safety testing must always be done on the end device as it will go to market.

Regulatory Standards Referenced

The modules were tested to the following standards in accordance with the regulations in the RED (Radio Equipment Directive 2014/53/EU)

European Standards

ETSI EN 300 220-1 V3.1.1	ETSI EN 301 489-1 V1.9.2
ETSI EN 300 220-2 V3.1.1	ETSI EN 301 489-3 V1.6.1

Test Procedures

EN 55022	EN 61000-4-4
EN 61000-3-2	EN 61000-4-5
EN 61000-3-3	EN, 61000-4-6
EN 61000-4-2	EN 61000-4-11
EN 61000-4-3	

Tested Modules

The HUM-868-PRC-CAS transceiver module was tested. This module uses the identical hardware and RF parameters as the HUM-868-PRO Series modules. The difference between the modules is the data content of the transmissions, which does not matter with regard to the CE testing. All of the test data and conditions contained in this document are applicable to both families.

Linx Testing Summary

The HUM-868-PRO and HUM-868-PRC Series transceiver modules use Adaptive Frequency Agility with periodic channel adaptivity and employ Polite Spectrum Access designed to operate in Band X (row 3) category shown in ETSI EN 300 220-2 V3.1.1, Annex C. To avoid confusion, it is important to communicate this classification distinction to the CE test lab since the transceivers have some features that may cause them to be misidentified as an FHSS device and be tested under requirements for a Band X row 1 device.

Operational Frequency Band		Maximum Effective Radiated Power	Channel access and occupation rules	Additional/other spectrum access parameters	Maximum occupied bandwidth	Other usage restriction	Notes	CEPT/ERC/REC 70-03 [i.1] implementation status
X	863 MHz to 870 MHz	25 mW e.r.p.	≤ 0,1 % duty cycle or polite spectrum access	≤ 1 % Duty Cycle if the band is limited to 865 MHz to 868 MHz	100 kHz for 47 or more channels	FHSS	Sub-bands for alarms [868,6 MHz to 868,7 MHz], [869,250 - 869,4 MHz], [869,650 MHz to 869,700 MHz] are excluded.	90 %
		25 mW e.r.p. Power density: -4,5 dBm/100 kHz. The power density can be increased to +6,2 dBm/100 kHz if the band of operation is limited to 865 MHz to 868 MHz. The power density can be increased to -0,8 dBm/100 kHz, if the band of operation is limited 865 MHz to 870 MHz.	≤ 0,1 % duty cycle or polite spectrum access	Duty cycle may be increased to 1 % if the band is limited to 865 MHz to 868 MHz and power limited to 10 mW e.r.p.	The whole band except for audio & video limited to 300 kHz and voice limited to 25 kHz		DSSS and any techniques other than FHSS Sub-bands [868,6 MHz to 868,7 MHz], [869,250 MHz to 869,4 MHz], [869,650 MHz to 869,700 MHz] for alarms are excluded.	90 %
		25 mW e.r.p.	≤ 0,1 % duty cycle or polite spectrum access		300 kHz except for voice limited to 25 kHz		Sub-bands [868,6 MHz to 868,7 MHz], [869,250 - 869,4 MHz], [869,650 MHz to 869,700 MHz] for alarms are excluded.	90 %

Figure 1: ETSI EN 300 220-2 V3.1.1 Annex C Band X (row 3)

Tests That are Not Applicable

The following tests are not applicable to the HUM-868-PRO and HUM-868-PRC transceivers.

Tests That are Not Applicable		
Description	**Results**	**Notes**
Duty Cycle	Not Applicable	This test was not performed because the EUT uses polite spectrum access.
Maximum e.r.p. spectral density	Not Applicable	This test was not performed because the EUT meets the requirements of Annex C, Band X(row 3) of ETSI EN 300 220-2 V3.1.1
Adjacent Channel Power	Not Applicable	This test was not required because the EUT has an OCW that is greater than 25 kHz.
Adaptive Power Control	Not Applicable	This test is not required because the EUT does not operate in Band AA of ETSI EN 300 220-2 V3.1.1, Annex C
Short term behavior	Not Applicable	This test was not performed because the EUT is not in the bands Y, Z, AA, AB, AC or AD of ETSI EN 300 220-2 V3.1.1, Annex C.
FHSS Equipment	Not Applicable	This test was not performed because the EUT meets the requirements of Band X(row 3) of ETSI EN 300 220-2 V3.1.1, Annex C and is not declared as an FHSS system.

Figure 2: Tests That are Not Applicable

Executed Tests

The following tests were performed on the the HUM-868-PRO and HUM-868-PRC transceivers at an accredited CE test lab in accordance with all applicable test procedures.

Executed Tests		
Description	**Results**	**Notes**
Operating Frequency	Pass	The EUT complies with clause 5.1.2 of ETSI EN 300 220-1 V3.1.1 as required by ETSI EN 300 220-2 V3.1.1.
Unwanted emissions in the spurious domain	Pass	The EUT complies with the limits of clause 5.9.2 of ETSI EN 300 220-1 V3.1.1 as required by ETSI EN 300 220-2 V3.1.1
Effective Radiated Power	Pass	The EUT complies with the ERP limits of Band X, Annex C for FHSS of ETSI EN 300 220-1 V3.1.1 as required by ETSI EN 300 220-2 V3.1.1
Occupied Bandwidth	Pass	The EUT complies with the limits of clause 5.6.2 of ETSI EN 300 220-1 V3.1.1 and Annex C, Band X of ETSI EN 300 200-2 V3.1.1
Tx Out of Band Emissions	Pass	The EUT complies with the limits of clause 5.8.2 of ETSI EN 300 220-1 V3.1.1 as required by ETSI EN 300 220-2 V3.1.1
Transient Power	Pass	The EUT complies with the limits of clause 5.10.2 of ETSI EN 300 220-1 V3.1.1 as required by ETSI EN 300 220-2 V3.1.1
Tx behavior under Low Voltage Conditions	Pass	The EUT complies with the limits of clause 5.12.2 of ETSI EN 300 220-1 V3.1.1 as required by ETSI EN 300 220-2 V3.1.1
RX sensitivity	Pass	The EUT complies with the limits of clause 5.14.2 of ETSI EN 300 220-1 V3.1.1 as required by ETSI EN 300 220-2 V3.1.1
Blocking	Pass	The EUT complies with the limits of clause 5.14.2 of ETSI EN 300 220-1 V3.1.1 as required by ETSI EN 300 220-2 V3.1.1
Clear Channel Assessment Method	Pass	The EUT complies with the limits of clause 5.21.2.2 of ETSI EN 300 220-1 V3.1.1 as required by ETSI EN 300 220-2 V3.1.1
Polite spectrum access timing parameters	Pass	The EUT complies with the limits of clause 5.21.3.2 of ETSI EN 300 220-1 V3.1.1 as required by ETSI EN 300 220-2 V3.1.1
Adaptive Frequency Agility	Pass	This test complies with clause 5.21.4 of ETSI EN 300 220-1 V3.1.1 as required by ETSI EN 300 220-2 V3.1.1. The use of AFA has been declared by the manufacturer.
Direct ESD, Air Discharge, +/-2.0 kV, +/-4.0 kV, and +/-8.0 kV (insulated surfaces)	Pass	Complies with the relevant requirements of ETSI EN 301 489-1 V1.9.2 and ETSI EN 301 489-3 V1.6.1. The EUT would not accept any air discharges to any insulated surfaces.
Indirect ESD, +/-2.0 kV and +/-4.0 kV (HCP and VCP)	Pass	Complies with the relevant requirements of ETSI EN 301 489-1 V1.9.2 and ETSI EN 301 489-3 V1.6.1. The unit operates within the specifications.
Radiated RF Electromagnetic Field Test, 80 MHz to 1 GHz, and 1400 MHz to 2700 MHz, 3 V/m with an 80% amplitude modulated 1 kHz sine wave	Pass	Complies with the relevant requirements of ETSI EN 301 489-1 V1.9.2 and ETSI EN 301 489-3 V1.6.1. The unit operates within the specifications.

Figure 3: Executed Tests

Tests That Were Not Performed

The following tests were not performed on the transceiver modules because of the hardware configuration that was used (battery powered hand held device). Some of these tests may be applicable to the final end product depending on the type of end device, the power source, or other factors. Consult an accredited CE test lab to see if any of these tests need to be performed on the end device.

Tests That Were Not Performed		
Description	**Results**	**Notes**
Radiated emissions from the enclosure of ancillary equipment measured on a stand alone basis	Not Tested	This test was not performed because the EUT has no ancillary equipment.
DC power input / output ports (per section 8.3 of ETSI EN 301 489-1 V1.9.2)	Not Tested	This test was not performed because the EUT operates on battery power only, has no DC input cables, and is a portable equipment.
AC main power input / output ports (per section 8.4 of ETSI EN 301 489-1 V1.9.2)	Not Tested	This test was not performed because the EUT operates on battery power only and is portable equipment.
Telecommunication Ports (per section 8.7 of ETSI EN 301 489-1 V1.9.2)	Not Tested	This test was not performed because the EUT has no telecommunication ports.
Harmonic current emissions (AC mains input port)	Not Tested	This test was not performed because the EUT operates on battery power only and is portable equipment.
Voltage fluctuations and flicker (AC mains input port)	Not Tested	This test was not performed because the EUT operates on battery power only and is portable equipment.
Direct ESD, Contact Discharge, +/-2.0 kV and +/-4.0 kV (conducted surfaces)	Not Tested	This test was not performed because the EUT contained no metallic or conductive surfaces.
Fast Transients, Common Mode, +/-0.5 kV on signal and DC ports, +/-1.0 kV on AC ports	Not Tested	This test was not performed because the EUT operates on battery power only, has no cables, and is portable equipment.
Surges +/-0.5 kV, +/-1.0 kV and +/-2.0 kV Line to Ground, +/-0.5 kV and +/-1.0 kV Line to Line on the AC ports	Not Tested	This test was not performed because the EUT operates only on battery power and is portable equipment.
Radio Frequency, Common Mode, 150 kHz to 80 MHz, 3 V/m with an 80% amplitude modulated 1 kHz sine wave	Not Tested	"This test was not performed because the EUT operates on battery power only, has no cables, and is portable equipment."
Transients and surges in the vehicular environment	Not Tested	This test was not performed because the EUT is not intended for vehicular use.
Voltage Dips and Interruptions 30% reduction for 10 mS, 60% reduction for 100 mS, 100% reduction for 5 sec	Not Tested	This test was not performed because the EUT operates only on battery power.

Figure 4: Tests That Were Not Performed

Full Linx CE Test Report

The Linx CE test report for the HUM-868-PRO and HUM-868-PRC transceivers is available in its entirety upon request.

Hardware Configuration

For CE testing, the HUM-868-PRC-CAS transceiver module was designed into a simple battery-powered hand held transmitter product that is representative of a typical application. Products that match the hardware layout and PCB layer stack that was used in this testing may be able to use some of the results from the Linx CE test report as supplementary test data in the end product CE test report, reducing time and costs for the end product's compliance testing.

RF Trace Dimensions

The RF signal is routed on the PCB between Pin 19 on the module and the antenna pad using a 50 ohm microstrip structure. The copper thicknesses, dimensions of the copper features, PCB substrate materials, and PCB layer stackup all play an important role in maintaining a good 50 ohm RF path that will ensure optimal performance. The following RF Trace dimensions were used on the test units.

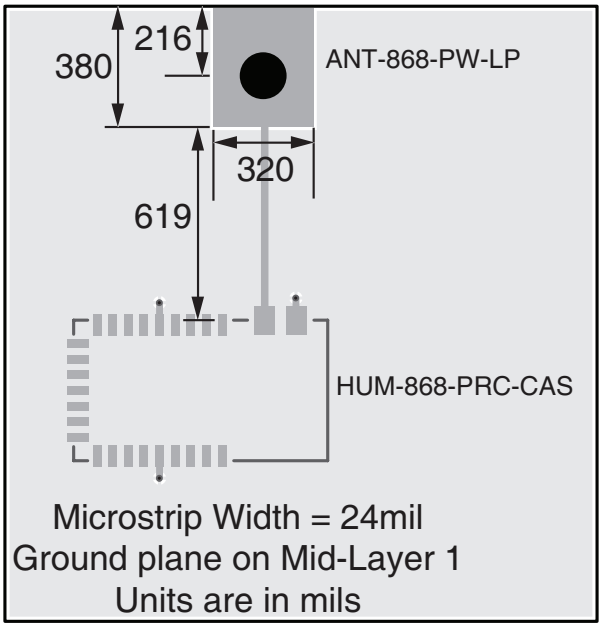
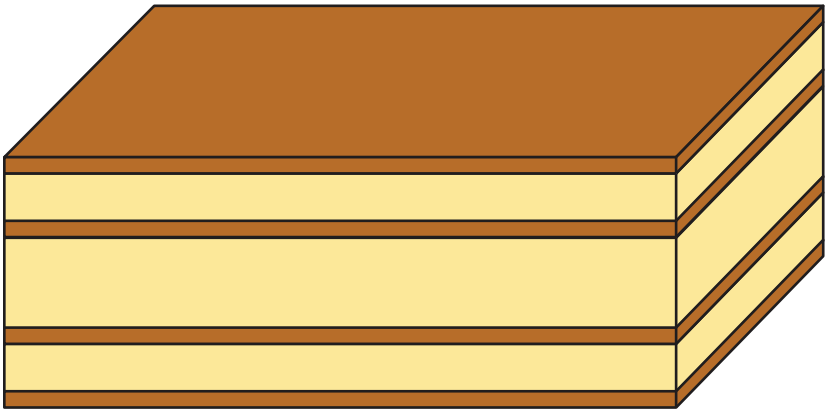


Figure 5: HUM-868-PRC-CAS PCB Layout for CE Testing

PCB Stackup

The following PCB Stackup was used for the test units. Note the copper layer thicknesses, substrate thicknesses, and substrate dielectric constant value.



Layer Name	Thickness	Material
Top Layer	1.4mil	Copper
Dielectric 1	14.0mil	FR-4 (Er = 4.6)
Mid-Layer 1	1.4mil	Copper
Dielectric 2	28.0mil	FR-4 (Er = 4.6)
Mid-Layer 2	1.4mil	Copper
Dielectric 3	14.0mil	FR-4 (Er = 4.6)
Bottom Layer	1.4mil	Copper

Figure 6: HUM-868-PRC-CAS PCB Layer Stack

Tested Antenna

The following antenna was used for the test units.

Tested Antenna			
Linx Part Number	**Type**	**Gain**	**Impedance**
ANT-868-PW-LP	¼ Wave Whip	2.1dBi	50Ω

Hardware Variations

ETSI does not provide guidelines on what hardware changes can be made while still retaining validity of the testing that was done on the module. Rather, they require that the manufacturer of the end product declare that the end product conforms to all of the applicable rules, regardless of what testing was done on any indivicual subassembly or module. Changes made to the PCB layout, PCB layer stack or antenna may or may not be considered equivalent, depending on the type and magnitude of the change as well as considerations surrounding other components incorporated into the end product.

Consult an accredited CE compliance lab and discuss the applicability of equivalent hardware configurations and if any of the Linx CE test results can be used to supplement the end product's CE test report or DoC.

Firmware Configuration

There are two transceiver configuration settings that must not be changed from their default values in order to maintain CE compliance. The settings must not be configurable by the user in the end device.

ENCSMA – Carrier Sense Multiple Access

Volatile Address = 0x56
Non-Volatile Address = 0x0B
Default Value = 0x02

The default value of 0x02 enables Polite Spectrum Access and duty cycle limiting as required for CE compliance. This register must not be changed from its default value and must not be configurable by the user.

CRSSI - Carrier Sense Minimum RSSI

Volatile Address = NA
Non-Volatile Address = 0x3F
Default Value = 0xA4

This value is the minimum RSSI value that causes the module to determine that a channel is already in use. This register must not be changed from its default value and must not be configurable by the user.

Manufacturer Declarations

The following technical information may be used to fill out the manufacturer declarations document ETSI EN 300 220-2 V3.1.1 Annex D (application for testing).

In accordance with ETSI EN 300 220-2 clause 4, the following information is provided by the manufacturer.

a) The name of the manufacturer or his trademark

This is provided by the manufacturer of the end product.

b) The type equipment designation

This is provided by the manufacturer of the end product.

c) The application(s) of the equipment

This is provided by the manufacturer of the end product.

d) The operating frequency(ies)

HumPRO™ Series RF Channels				
863.05	864.45	865.85	867.25	868.65
863.15	864.55	865.95	867.35	868.75
863.25	864.65	866.05	867.45	868.85
863.35	864.75	866.15	867.55	868.95
863.45	864.85	866.25	867.65	869.05
863.55	864.95	866.35	867.75	869.15
863.65	865.05	866.45	867.85	869.25
863.75	865.15	866.55	867.95	869.35
863.85	865.25	866.65	868.05	869.45
863.95	865.35	866.75	868.15	869.55
864.05	865.45	866.85	868.25	869.65
864.15	865.55	866.95	868.35	869.75
864.25	865.65	867.05	868.45	869.85
864.35	865.75	867.15	868.55	869.95

e) The operational frequency band(s)

Band X row 3 (863MHz to 870MHz)

f) The operating channel(s) width(s)

48kHz

The operating channel is less than or equal to 25 kHz? ☐

g) Maximum radio-frequency power transmitted in the frequency band(s) in which the radio equipment operates

14.125mW

h) What is the spectrum access mechanism of the equipment?

☐ Duty Cycle
☑ Polite Spectrum Access

i) In case of polite spectrum access:

The CCA time implemented by the equipment is 5ms.
The minimal unit of deferral period is: 0.5ms.
The dead time T_{DIS} is 1.5ms.

j) Is the equipment battery powered?

☐Yes ☐No

This is provided by the manufacturer of the end product.

k) Is the equipment frequency agile?

☑Yes ☐No

l) Is the equipment declared as FHSS?

☐Yes ☑No

m) In case of FHSS equipment:

The declared hop channel bandwidth is …….kHz.
The number of non-overlapping channels or hopping positions separated by the declared hop channel
bandwidth is.....
The dwell time per channel is ….. ms.
The return time to a hop channel is ……. ms.
Is CCA implemented in the equipment? ☐Yes ☐No

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