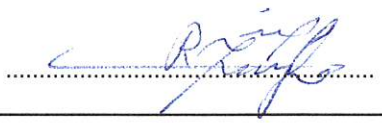
ANTENNA TEST REPORT **Antenna operating within the 2400.0 MHz - 2483.5 MHz band**	
Report Reference No	G0M-2209-1690-TFCAUT_V01
Testing Laboratory	Eurofins Product Service GmbH
Address	Storkower Str. 38c 15526 Reichenwalde Germany
Applicant	digades GmbH
Address	Äußere Weberstraße 20 02763 Zittau DE
Equipment under Test (EUT):	
Product Description	Head-up display for motorcycle helmets
Model(s)	TILSBERK Head-Up Display
Additional Model(s)	None
Brand Name(s)	TILSBERK Head-Up Display
Hardware Version(s)	HW3622
Software Version(s)	SW0201
FCC ID	QNFHUD

Testing:		
Test Lab Temperature	20 °C - 30 °C	
Test Lab Humidity	25 % - 55 %	
Date of receipt of test item	2022-12-19	
Report:		
Compiled by	Odai Qawasmeh	
Tested by (+ signature) (Responsible for Test)	Wilfried Treffke	
Approved by (+ signature) (Test Lab Engineer)	Radwan Jaafar	
Date of Issue	2023-02-21	
Total number of pages	28	
General Remarks:		
The test results presented in this report relate only to the object tested. **The results contained in this report reflect the results for this particular model and serial number. It is the responsibility of the manufacturer to ensure that all production models meet the intent of the requirements detailed within this report.** This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.		
Additional Comments:		

VERSION HISTORY

Version History			
Version	Issue Date	Remarks	Revised By
01	2023-02-21	Initial Release	

ABBREVIATIONS AND ACRONYMS

Acronyms	
Acronym	Description
EUT	Equipment Under Test
FCC	Federal Communications Commission
V_{NOM}	Nominal supply voltage

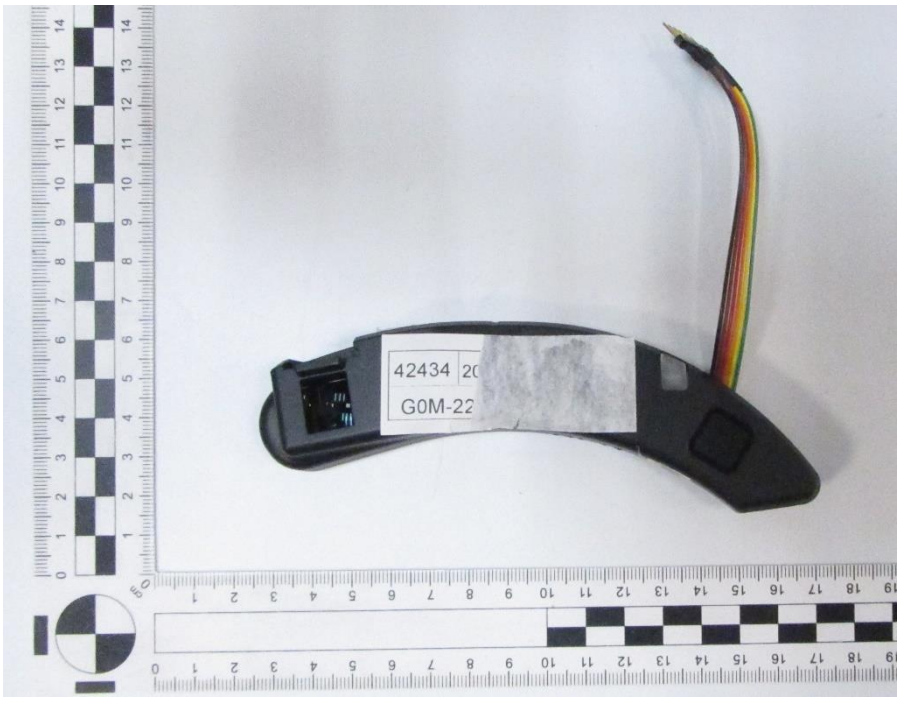
REPORT INDEX

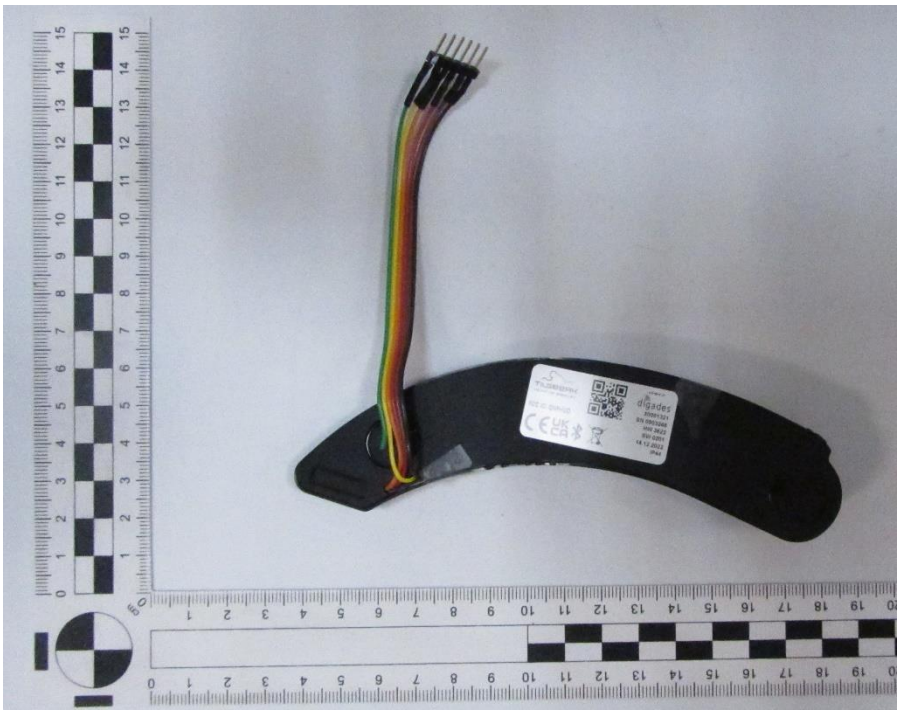
Eurofins Product Service GmbH
Storkower Str. 38c, D-15526 Reichenwalde, Germany

1 Equipment (Test Item) Under Test

Description	Head-up display for motorcycle helmets	
Model	TILSBERK Head-Up Display	
Additional Model(s)	None	
Brand Name(s)	TILSBERK Head-Up Display	
Serial Number(s)	0003246	
Test Sample Id(s)	42434	
Hardware Version(s)	HW3622	
Software Version(s)	SW0201	
FCC ID	QNFHUD	
Equipment type	End Product	
Radio type	Transceiver	
Assigned frequency bands	2400.0 MHz - 2483.5 MHz	
Radio technology	Bluetooth LE 5.0	
Modulation	GFSK	
Number of antenna ports	1	
Antenna	Type	Integrated
	Model	PCB Antenna
	Manufacturer	digades GmbH
	Gain	0.89 dBi (by measurement)
Supply Voltage	V_{NOM}	5 VDC
Operating Temperature	T_{NOM}	25 °C
AC/DC-Adaptor	None	
Manufacturer	digades GmbH Äußere Weberstraße 20 02763 Zittau DE	

1.1 Photos – Equipment External

EUT Top View


EUT Bottom View


EUT Front View


EUT Back View


EUT Side View


EUT Side View

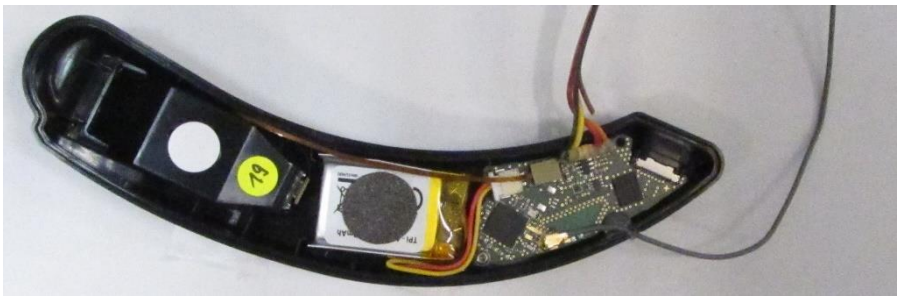

EUT label

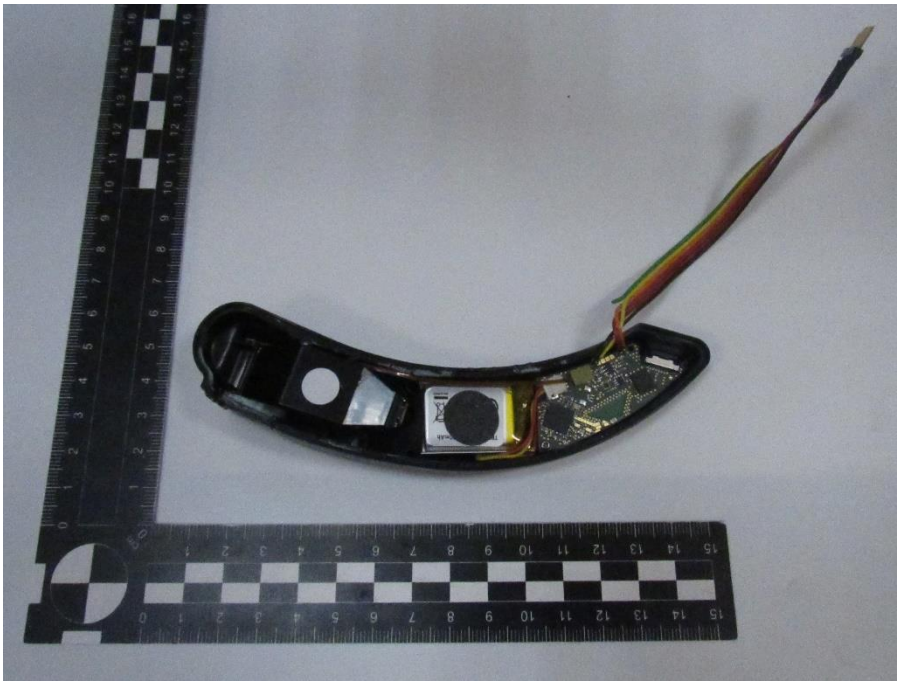

EUT PRINT TILSBERK

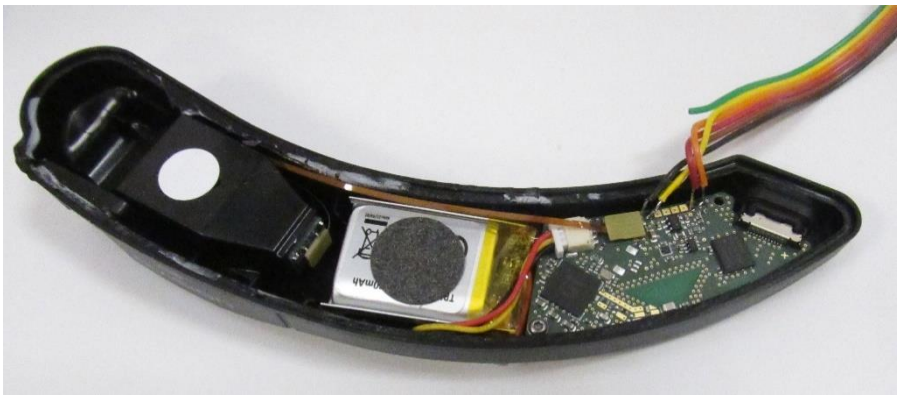

EUT conducted sample

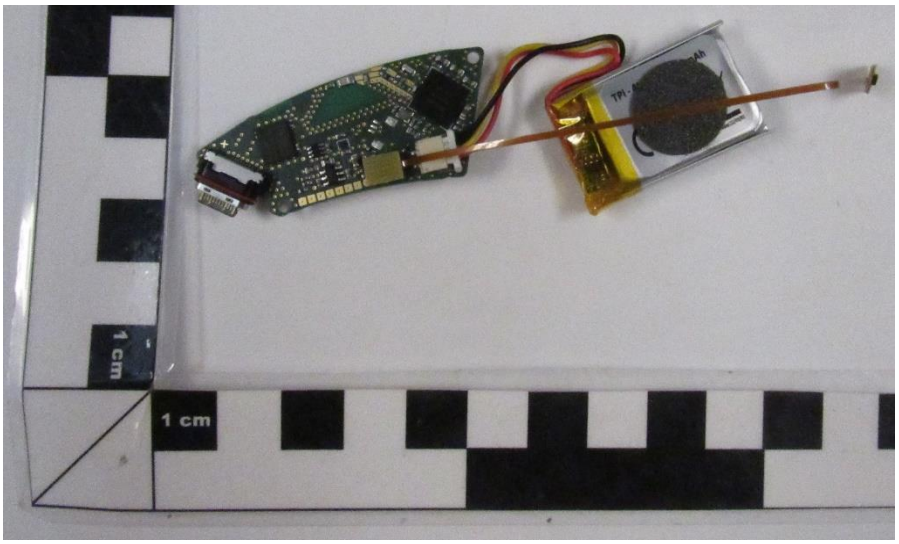

1.2 Photos – Equipment Internal

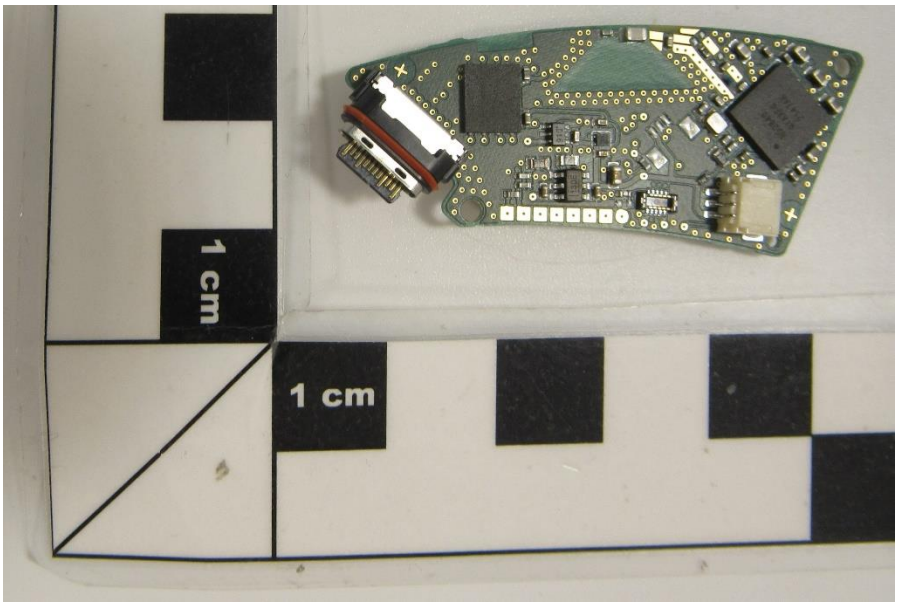
EUT opened (conducted Sample)


EUT opened (conducted Sample, zoomed)


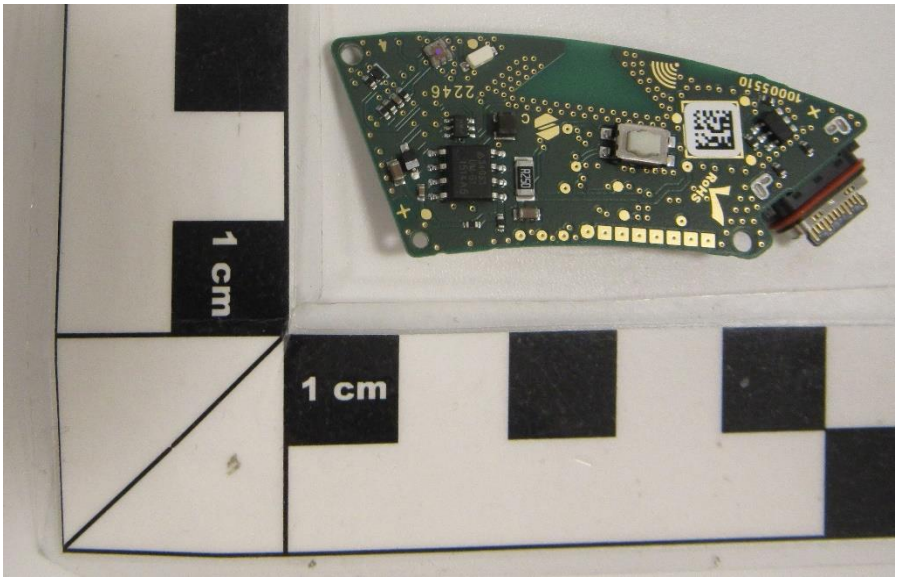
EUT opened (radiated Sample)


EUT opened (radiated Sample, zoomed)


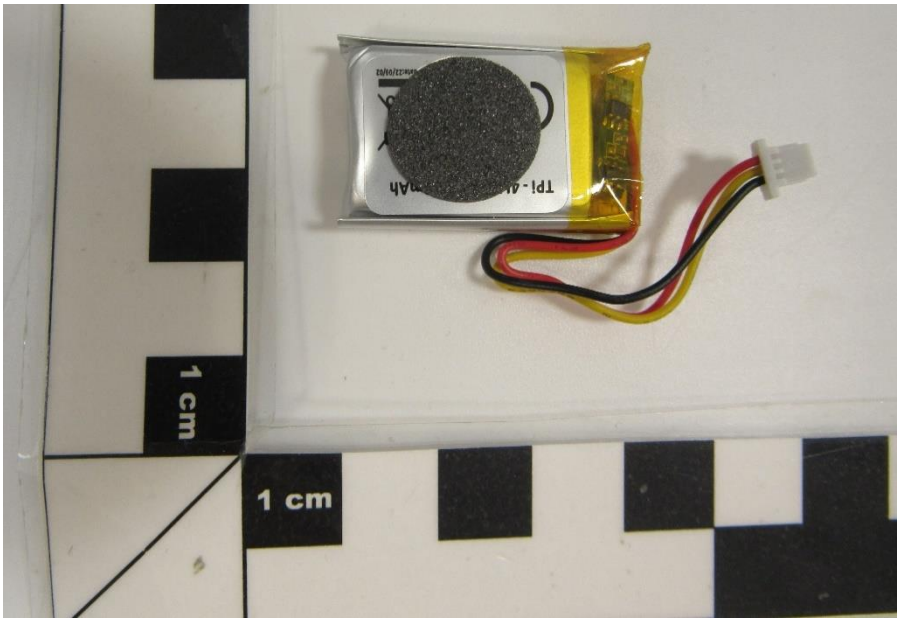
EUT outside of enclosure


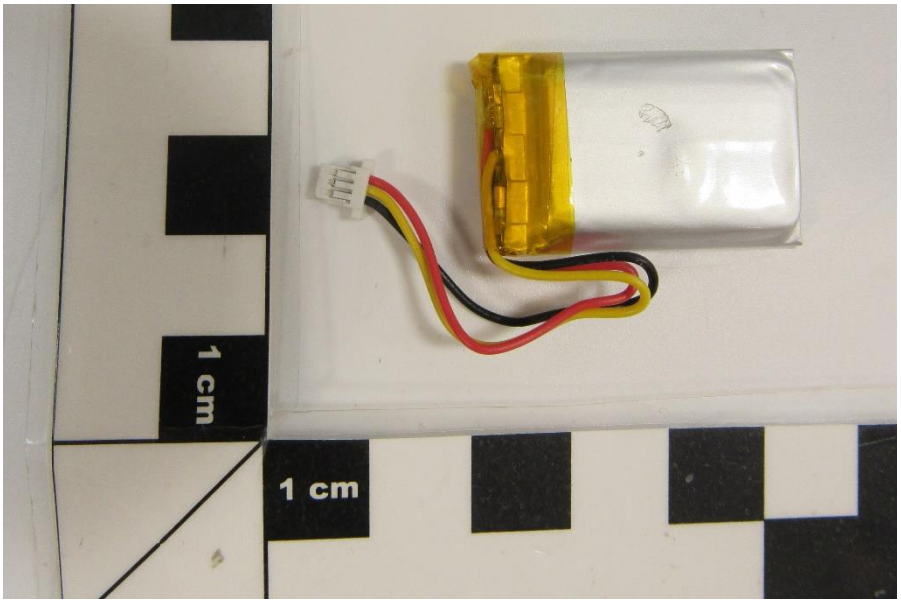
PCB Top View


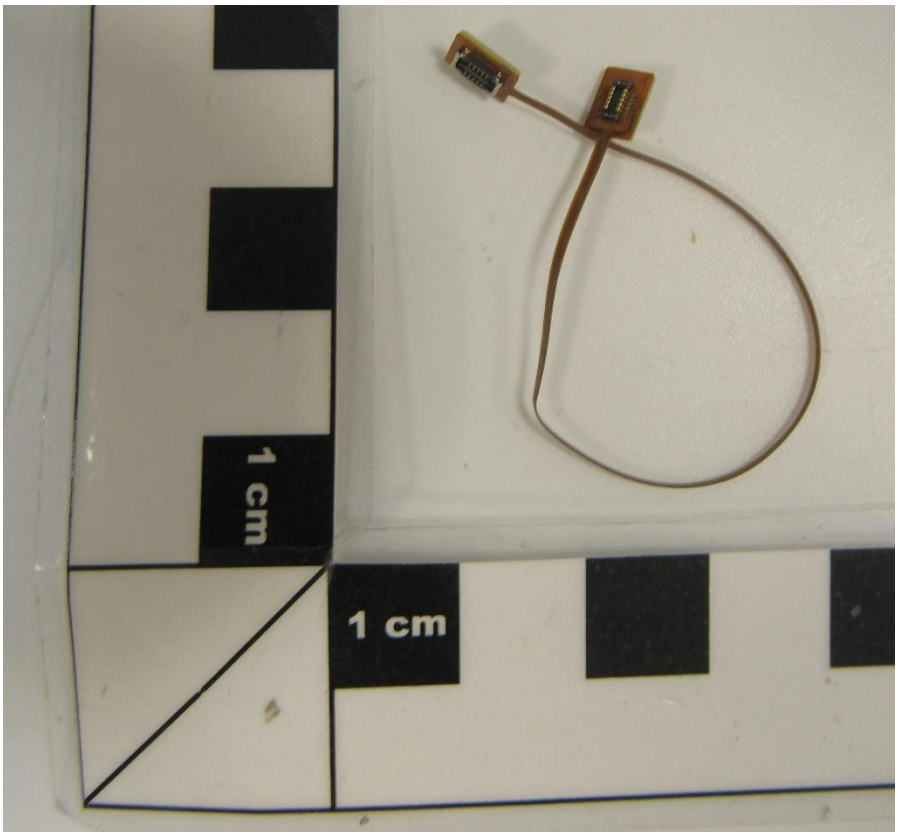
PCB Bottom View



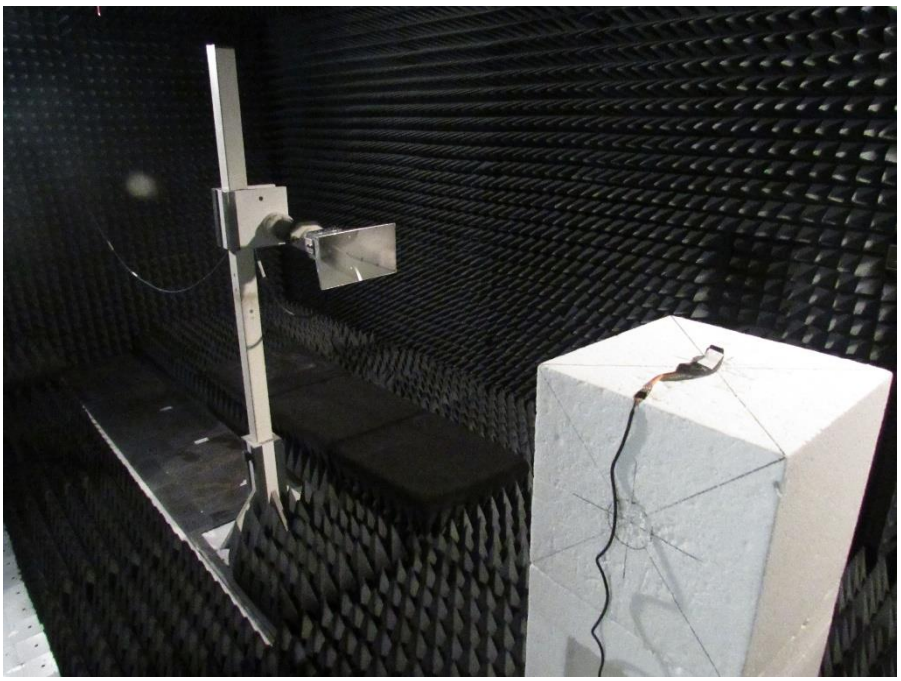
EUT Battery Top View

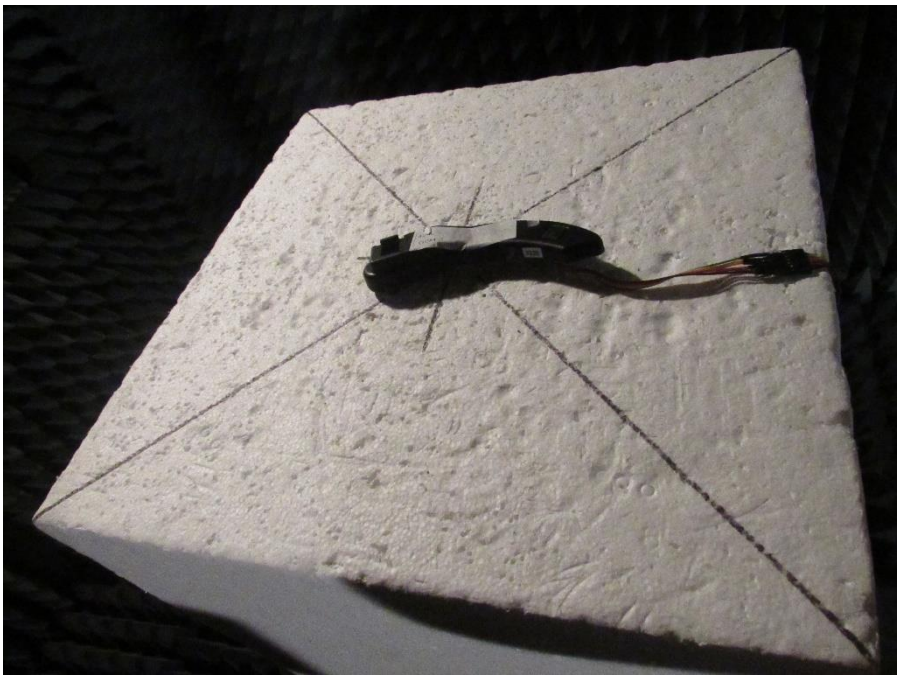


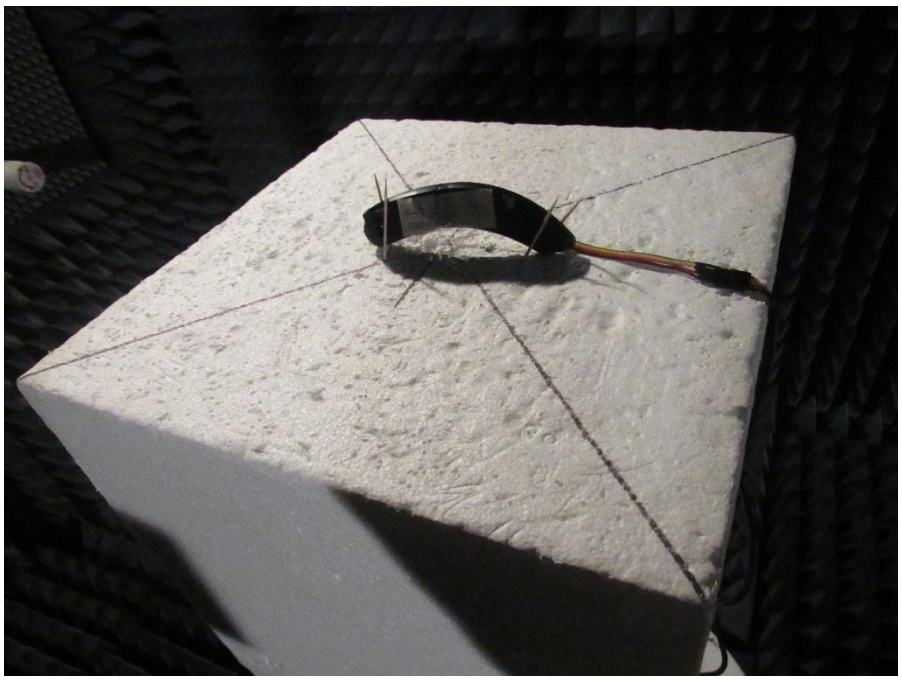
EUT Battery Bottom View


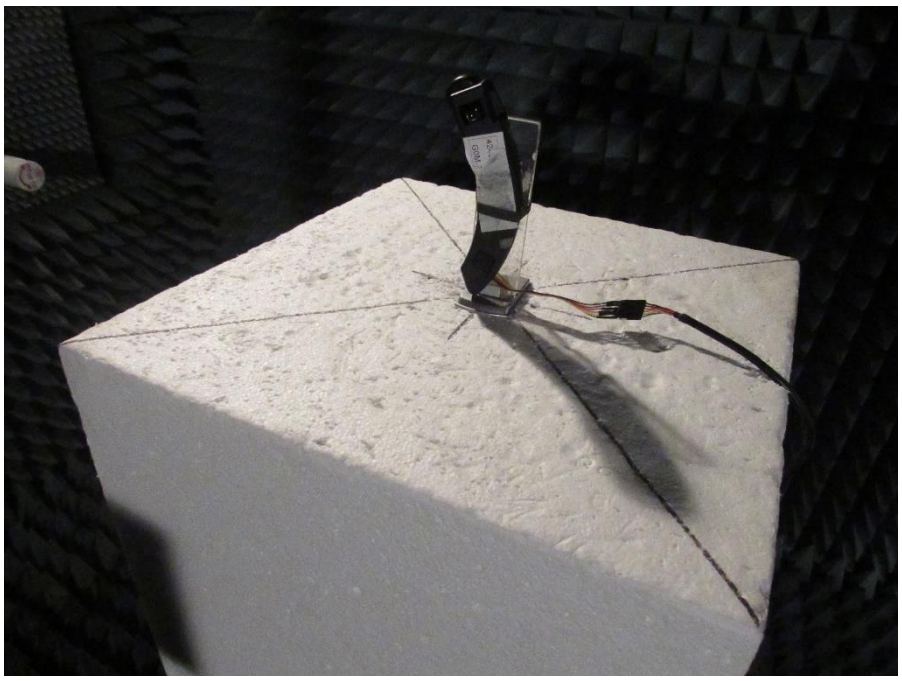
Flexible PCB cable


1.3 Photos Test Setup

Setup for measurement of antenna pattern


EUT horizontal 1


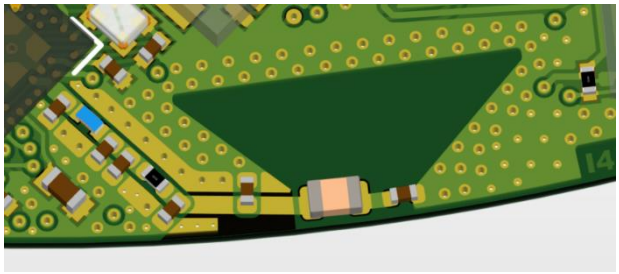
EUT horizontal


EUT vertical


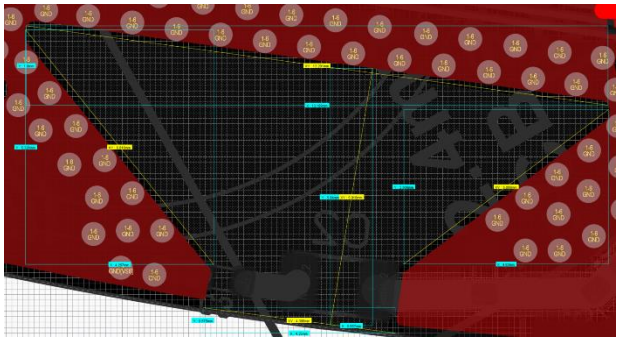
1.4 Mechanical Properties

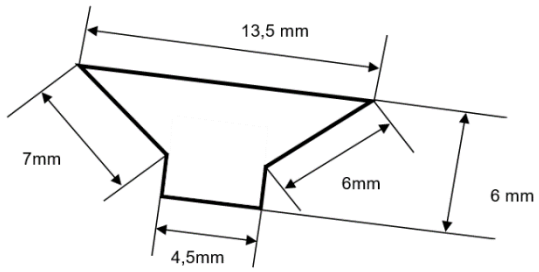
Material	Copper on the PCB
Connector	no / Connections on the PCB
Cable Length	none
Cable Type	none
Operation Temperature	-40°C to 130°C

3D model view:



Dimensions:





Construction of the circuit board (antenna):

#	Name	Material	Type	Thickness	Weight	Dk	Df
	Top Solder	SM-001-1	Solder Mask	0.035mm		4	
	Top Surface Finish	Tin	Surface Finish	0.025mm			
1	Top Layer	CF-003	Signal	0.018mm	1/2oz		
	PP1_2x106	PP-012	Prepreg	0.096mm		4	
2	Inner1	CF-003	Signal	0.018mm	1/2oz		
	Core1_2116	Core-009	Core	0.1016mm		4.5	
3	Inner2	CF-003	Signal	0.018mm	1/2oz		
	PP2_2x2116	PP-023	Prepreg	0.22mm		4.5	
4	Inner3	CF-003	Signal	0.018mm	1/2oz		
	Core2_2116	Core-009	Core	0.1016mm		4.5	
5	Inner4	CF-003	Signal	0.018mm	1/2oz		
	PP3_2x106	PP-012	Prepreg	0.096mm		4	
6	Bottom Layer	CF-003	Signal	0.018mm	1/2oz		
	Bottom Surface...	Tin	Surface Finish	0.025mm			
	Bottom Solder	SM-001-1	Solder Mask	0.035mm		4	

1.5 Support Equipment

Product Type	Device	Manufacturer	Model	Comment
AE	Notebook	Lenovo	-	-
CBL	USB to UART	-	-	-
SFT	nRF Connect Desktop	Nordic	-	for configuring test modes
Description:				
AE	Auxiliary Equipment			
SIM	Simulator			
CBL	Connecting Cable			
SFT	Software			
Comment:				

1.6 Test Modes

Mode	Description
GFSK 1 Mbit/s	Mode = Transmit Modulation = GFSK Spreading = None Packet Type = PRBS9 Packet Length = 193 Bytes Duty cycle = 87.7% Power = +4 dBm (Software Setting)
Comment:	

1.7 Test Frequencies

Designator	Mode	Channel	Frequency [MHz]
F1	Tx	39	2480

2 Test Conditions and Results

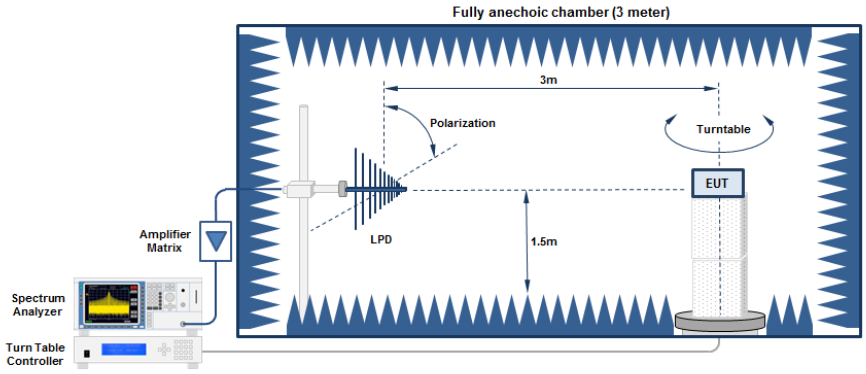
2.1 Test Conditions and Results – Antenna pattern

2.1.1 Information

Test Information	
Operator	Wilfried Treffke
Date	2023-02-02

2.1.2 Setup

Test Setup



2.1.3 Equipment

Test Software			
Description	Manufacturer	Name	Version
Antenna pattern software	Eurofins Product Service GmbH	Eurofins Antenna Pattern	1.9

Test Equipment					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Anechoic chamber	Frankonia	AC 4	EF00200	---	---
Spectrum analyzer	R&S	FSU26	EF01407	2022-07	2023-07
Antenna	Schwarzbeck	BBHA 9120D	EF00019	2020-11	2023-11

2.1.4 Procedure

Test Procedure

1. EUT is placed on a non conducting support at the center of a turn table 1.5 m above the ground
2. EUT set to the test mode here the highest conducted output power has been measured
3. The receiver is set to peak detection with max hold
4. The EUT is rotated through 360° in horizontal plane
5. The measurement procedure is repeated for all possible EUT positions.

2.1.5 Results

Test Result – EUT horizontal			
Channel [MHz]	Antenna polarization	Max. rad. Power [dBm e.i.r.p]	Max. antenna gain [dBi]
2480	vertical	0.56	-4.21
2480	horizontal	5	0.23

Test Result – EUT horizontal 1			
Channel [MHz]	Antenna polarization	Max. rad. Power [dBm e.i.r.p]	Max. antenna gain [dBi]
2480	vertical	-6.99	-11.76
2480	horizontal	5.66	0.89

Test Result – EUT vertical			
Channel [MHz]	Antenna polarization	Max. rad. Power [dBm e.i.r.p]	Max. antenna gain [dBi]
2480	vertical	5.54	0.77
2480	horizontal	-3.98	-8.75

ANNEX A Antenna patterns

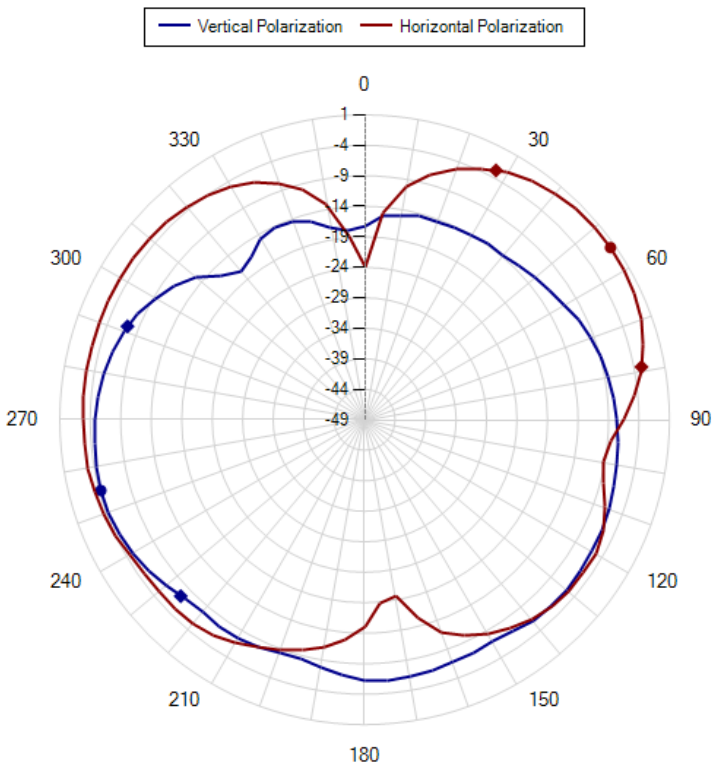
Antenna Pattern

Project Number:	G0M-2209-1690
Product:	Head-up display for motorcycle helmets
Model:	TILSBERK Head-Up Display
EUT Position:	horizontal
EUT Antenna:	integrated
Operating Conditions:	Tnom / Vnom
Operating Frequency:	2480 MHz
Detector:	Peak
RBW:	1 MHz
VBW:	3 MHz
Sweep Time:	7 ms
Conducted Power:	4.77 dBm
Operator:	Mr. Treffke
Date:	2023-02-02

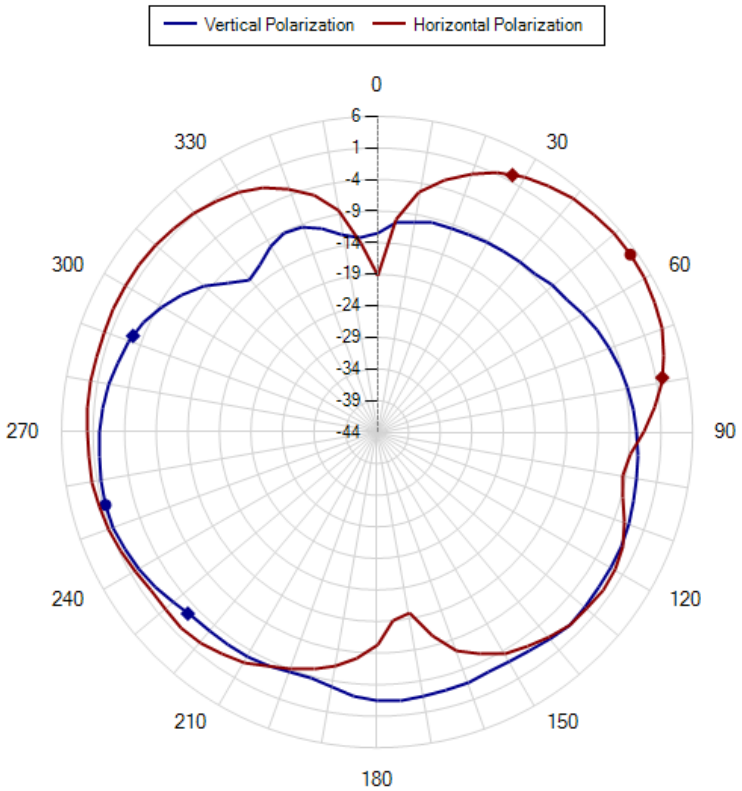
Result Summary

Antenna Polarization	Turn table Angle [°]	Max. rad. power [dBm e.i.r.p.]	Max. antenna gain [dBi]
Vertical	255	0.56	-4.21
Horizontal	55	5	0.23

Antenna Gain [dBi]



Radiated Power [dBm e.i.r.p.]



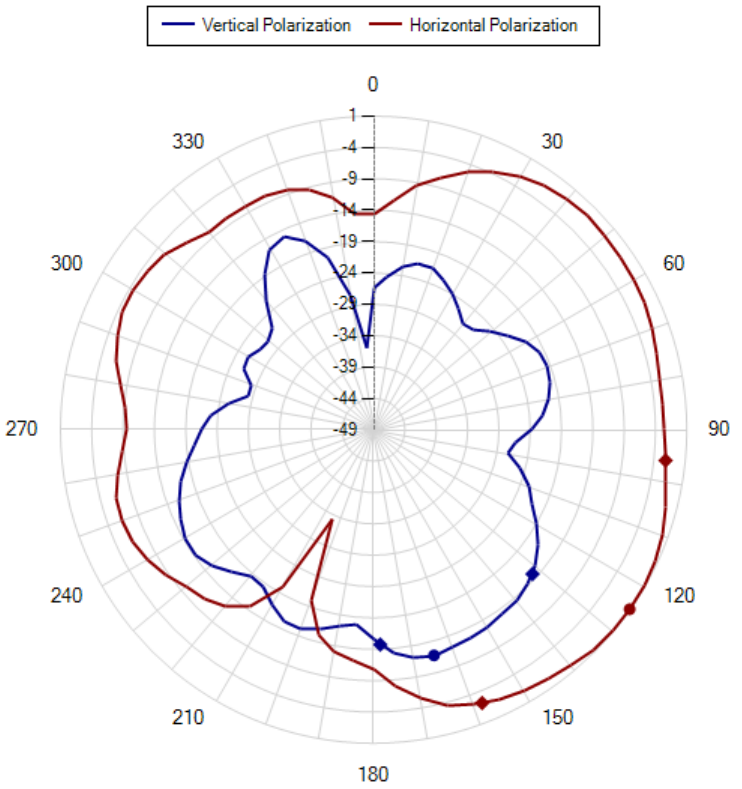
Antenna Pattern

Project Number:	G0M-2209-1690
Product:	Head-up display for motorcycle helmets
Model:	TILSBERK Head-Up Display
EUT Position:	horizontal 1
EUT Antenna:	integrated
Operating Conditions:	Tnom / Vnom
Operating Frequency:	2480 MHz
Detector:	Peak
RBW:	1 MHz
VBW:	3 MHz
Sweep Time:	7 ms
Conducted Power:	4.77 dBm
Operator:	Mr. Treffke
Date:	2023-02-02

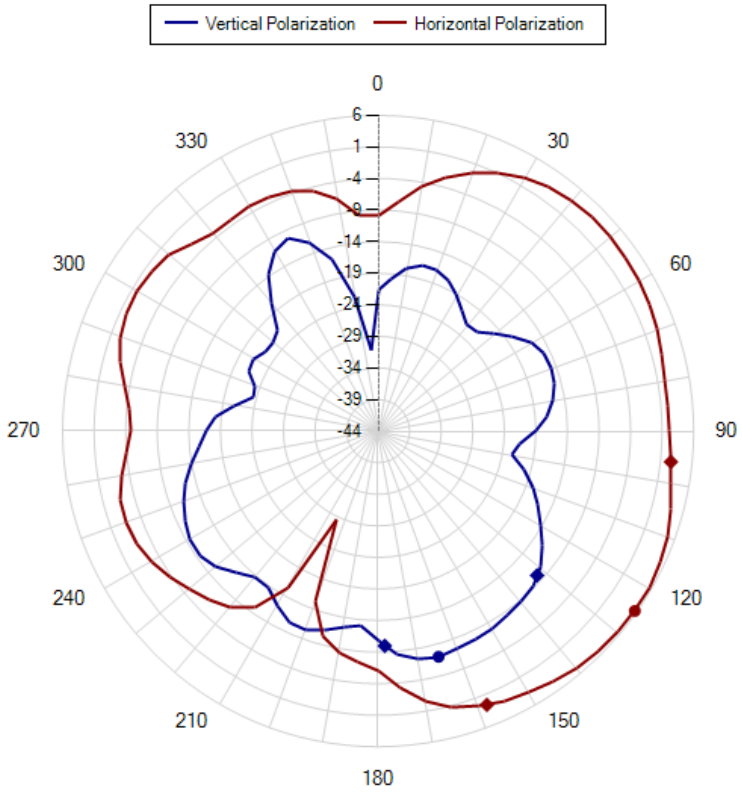
Result Summary

Antenna Polarization	Turn table Angle [°]	Max. rad. power [dBm e.i.r.p.]	Max. antenna gain [dBi]
Vertical	165	-6.99	-11.76
Horizontal	125	5.66	0.89

Antenna Gain [dBi]



Radiated Power [dBm e.i.r.p.]



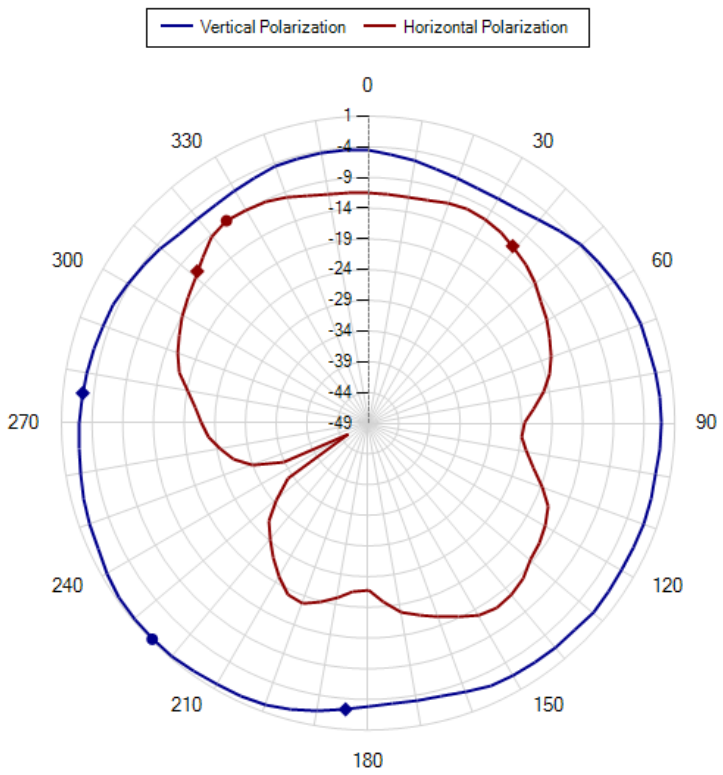
Antenna Pattern

Project Number:	G0M-2209-1690
Product:	Head-up display for motorcycle helmets
Model:	TILSBERK Head-Up Display
EUT Position:	vertical
EUT Antenna:	integrated
Operating Conditions:	Tnom / Vnom
Operating Frequency:	2480 MHz
Detector:	Peak
RBW:	1 MHz
VBW:	3 MHz
Sweep Time:	7 ms
Conducted Power:	4.77 dBm
Operator:	Mr. Treffke
Date:	2023-02-02

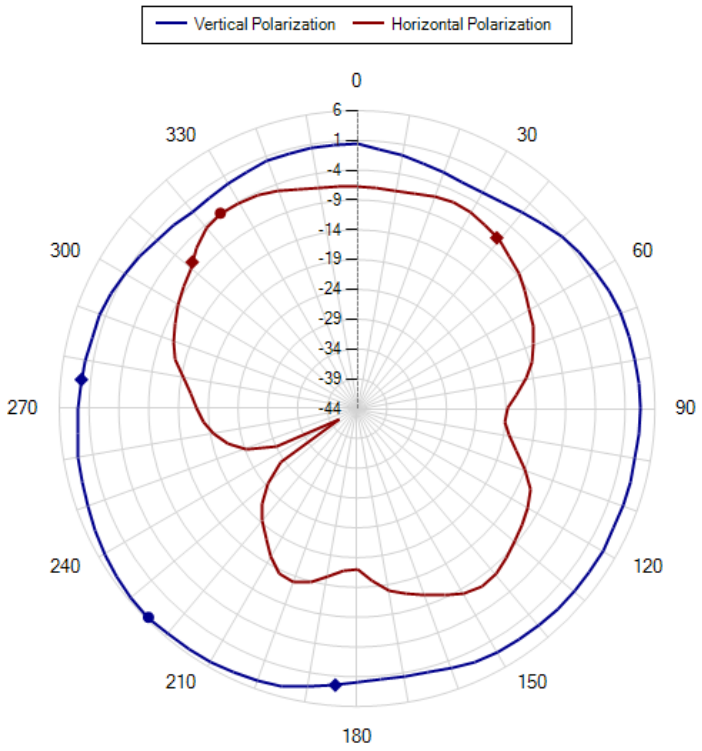
Result Summary

Antenna Polarization	Turn table Angle [°]	Max. rad. power [dBm e.i.r.p.]	Max. antenna gain [dBi]
Vertical	225	5.54	0.77
Horizontal	325	-3.98	-8.75

Antenna Gain [dBi]



Radiated Power [dBm e.i.r.p.]



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