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ISO 11451-3

Third edition
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Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy —

Part 3: On-board transmitter simulation

Véhicules routiers — Méthodes d'essai d'un véhicule soumis à des perturbations électriques par rayonnement d'énergie électromagnétique en bande étroite —

Partie 3: Simulation des émetteurs embarqués

Reference number
ISO 11451-3:2015(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

This third edition cancels and replaces the second edition (ISO 11451-3:2007), which has been technically revised.

ISO 11451 consists of the following parts, under the general title *Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy*:

— *Part 1: General principles and terminology*

— *Part 2: Off-vehicle radiation source*

— *Part 3: On-board transmitter simulation*

— *Part 4: Bulk current injection (BCI)*

Annexes A, B and C of of this part of ISO 11451 are for information only.

Introduction

In recent years, an increasing number of electronic devices for controlling, monitoring, and displaying a variety of functions have been introduced into vehicle designs. It is necessary to consider the electrical and electromagnetic environment in which these devices operate.

Electrical and radio frequency disturbances occur during the normal operation of many items of motor vehicle equipment. They are generated over a wide frequency range with various electrical characteristics and can be distributed to on-board electronic devices and systems by conduction, radiation, or both. Narrowband signals generated from sources on or off the vehicle can also be coupled into the electrical and electronic system, affecting the normal performance of electronic devices. Such sources of narrowband electromagnetic disturbances include mobile radios and broadcast transmitters.

The characteristics of the immunity of a vehicle to radiated disturbances have to be established. ISO 11451 provides various test methods for the evaluation of vehicle immunity characteristics (not all methods need be used to test a vehicle).

ISO 11451 is not intended as a product specification and cannot function as one. Therefore, no specific values for the test severity level are given.

Protection from potential disturbances needs to be considered in a total system validation, and this can be achieved using the various parts of ISO 11451.

NOTE Immunity measurements of complete vehicles are generally able to be carried out only by the vehicle manufacturer, owing to, for example, high costs of absorber-lined shielded enclosures, the desire to preserve the secrecy of prototypes, or a large number of different vehicle models. ISO 11452 specifies test methods for the analysis of component immunity, which are better suited for supplier use.

Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy —

Part 3:
On-board transmitter simulation

1 Scope

This part of ISO 11451 specifies methods for testing the immunity of passenger cars and commercial vehicles to electromagnetic disturbances from on-board transmitters connected to an external antenna and portable transmitters with integral antennas, regardless of the vehicle propulsion system (e.g. spark ignition engine, diesel engine, electric motor).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11451-1, *Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General principles and terminology*

ISO 11451-2, *Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 2: Off-vehicle radiation sources*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11451-1 and the following apply.

3.1
integral antenna
permanent fixed antenna which may be built-in, designed as an indispensable part of the portable transmitting device

4 Test conditions

The applicable frequency range of the test method is 1,8 MHz to 5,85 GHz.

The user of this part of ISO 11451 shall specify the test severity level or levels over the frequency bands. Typical on-board transmitter characteristics (frequency bands, power level and modulation) are given in Annex A.

NOTE Users of this part of ISO 11451 should be aware that Annex A is for information only and cannot be considered as an exhaustive description of various on-board transmitters available in all countries.

Standard test conditions are given in ISO 11451-1 for the following:

— test temperature;

— supply voltage;

— dwell time;

— test signal quality.

5 Test location

5.1 General

This test would typically be performed in an absorber lined shielded enclosure (ALSE). Where national regulations permit, the test can also be performed at an outdoor test site.

5.2 Absorber lined shielded enclosure (ALSE)

An absorber lined shielded enclosure with the characteristics specified in ISO 11451-2 is adequate for this test.

NOTE At frequencies where absorbers are not effective, the reflections in the chamber can affect the exposure of the vehicle.

5.3 Outdoor test site

Where national regulations permit the use of an outdoor test site, the outdoor test site should have an area with a radius of 10 m free from large metal structures or objects. When performing outdoor test-site tests, care shall be taken to ensure that harmonic suppression regulations are met.

6 Test instrumentation

6.1 General

The following test instrumentation is used:

— signal sources with internal or external modulation capability;

— power amplifier(s);

— power meter (or equivalent measuring instrument) to measure the forward and reverse power;

— field generating devices: antennas;

— field probes (for environmental monitoring).

6.2 Signal sources

6.2.1 Transmitters with antenna outside the vehicle

Signal sources for transmitters with antenna outside the vehicle can be

— simulated on-board transmitters: use of a signal generator and broadband power amplifier, and

— commercial on-board transmitters installed in vehicle capable of generating radio frequency (RF) power in their operational frequency ranges with specific output power.

NOTE When using simulated on-board transmitters, it is advisable to place an RF choke (ferrite or powdered iron toroid, depending on frequency) around the coaxial cable to the antenna, in order to reduce skin currents and more closely simulate a transmitter installed in the vehicle.

6.2.2 Transmitters with antenna inside the vehicle

Signal sources for transmitters with antenna inside the vehicle can be

— simulated portable transmitters: use of a metallic box with similar dimension to the portable transmitter and amplifier (if needed), and

— commercial portable transmitters with integral antennas.

6.3 RF power and field monitoring equipment

A power meter is required when using simulated on-board transmitters for measuring power to the antenna. Both forward power and reverse power shall be measured and recorded.

6.4 Antennas

6.4.1 Transmitters with antenna outside the vehicle

6.4.1.1 Simulated on-board transmitters

When an original equipment manufacturer (OEM) antenna is not installed on the vehicle, the antenna(s) described below shall be used.

— For frequency ranges lower than 30 MHz, loaded antennas shall be used. Loaded antennas employ lumped or distributed reactive components with a radiating element physically shorter than quarter wave at resonance.

— For frequency ranges higher than 30 MHz, e.g. for the very high frequency (VHF) and ultra-high frequency (UHF) bands, quarter wave antennas should be given preference over 5/8 wave antennas, since there are higher skin currents created by quarter wave antennas.

All antennas shall be tuned on the vehicle for minimum voltage standing wave ratio (VSWR, typically less than 2:1), unless otherwise specified in the test plan. As a minimum, the VSWR value shall be recorded with the antenna on the vehicle at the lower and upper band edge and at a middle frequency (see Annex B for guidance on influence of cable loss and VSWR).

When an OEM antenna is actually installed on the vehicle, this antenna shall be used for the test in the appropriate frequency range. In this case, the VSWR shall not be adjusted, but shall be recorded.

6.4.1.2 Commercial on-board transmitters

The vehicle OEM antenna shall be used for the test in the appropriate frequency range. In this case, the VSWR shall not be adjusted.

6.4.2 Transmitters with antenna inside the vehicle

6.4.2.1 Simulated portable transmitter

Unless otherwise specified the simulated portable transmitter antenna characteristics shall be a passive antenna as detailed in C.2. Examples of other antennas which can be used are defined in Annex C.

All antennas should have a minimum VSWR (typically less than 4:1), unless otherwise specified in the test plan. As a minimum, the VSWR value shall be recorded at the lower and upper band edge and at a middle frequency.

6.4.2.2 Commercial portable transmitters

When a commercial portable transmitter with integral antenna is used, its antenna shall be used for the test in the appropriate frequency range. In this case, the VSWR shall not be adjusted.

6.5 Stimulation and monitoring of the device under test

If remote stimulation and monitoring are required in the test plan, the vehicle shall be operated by actuators which have a minimum effect on the electromagnetic characteristics, e.g. plastic blocks on the push-buttons, pneumatic actuators with plastic tubes.

Connections to monitoring equipment can be accomplished by using fibre-optics or high resistance leads. Other types of leads can be used, but they require extreme care to minimize interactions. The orientation, length and location of such leads shall be carefully documented to ensure repeatability of test results.

Any electrical connection of monitoring equipment to the vehicle can cause malfunctions of the vehicle. Extreme care shall be taken to avoid such an effect.

7 Test set-up

7.1 Transmitters with antenna outside the vehicle

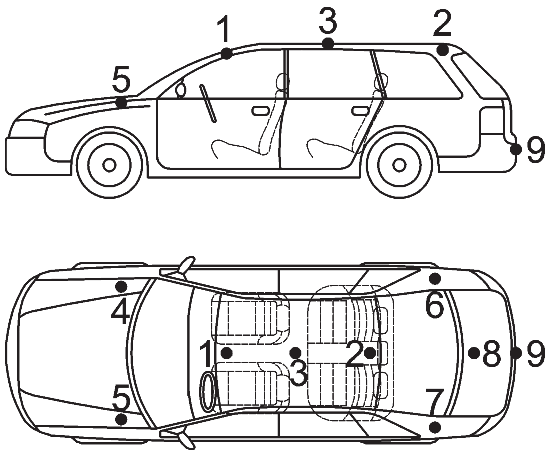
7.1.1 Simulated on-board transmitters

The test can be performed with test antenna(s) or with the vehicle's OEM antenna, as defined in 6.4.1.1.

When a test antenna is used, the location(s) of the transmitting antenna on the vehicle shall be defined in the test plan. If no specific location(s) are agreed between the users of this part of ISO 11451, the following location (s) are recommended, as illustrated in Figure 1:

— locations 1 (vehicle roof, front) and 2 (vehicle roof, rear) are the default locations for frequencies ≥30 MHz;

— location 9 (bumper) is the default location for frequencies <30 MHz.



Key

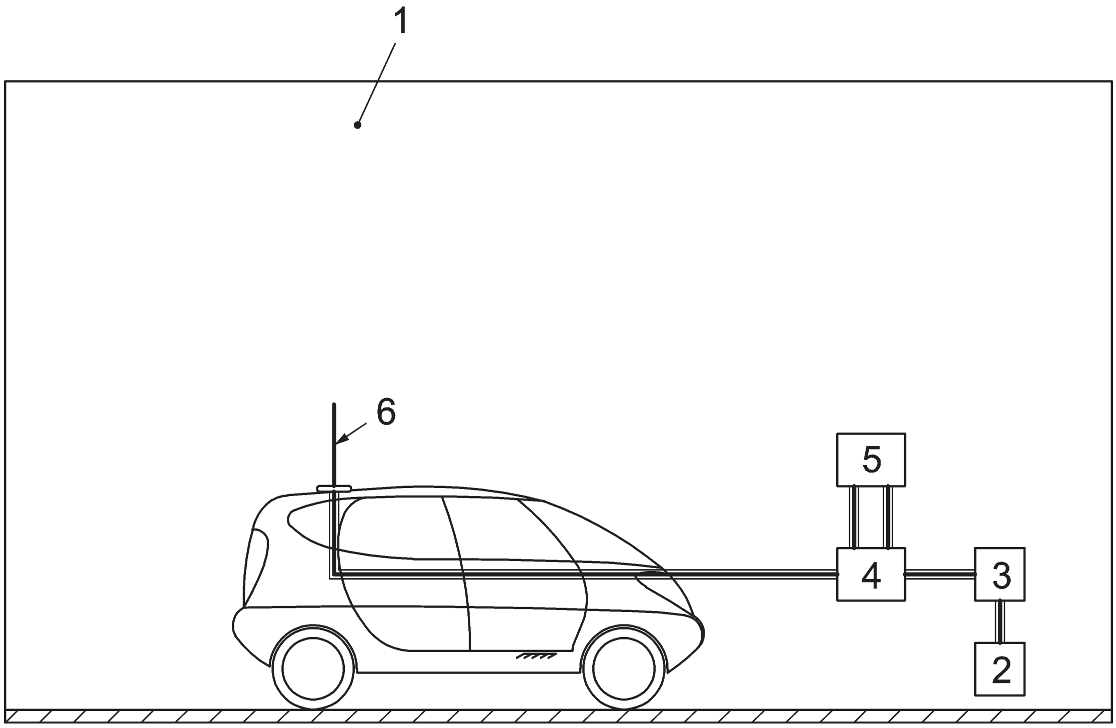
1	vehicle roof (front)	6	fender (rear, right)
2	vehicle roof (rear)	7	fender (rear, left)
3	vehicle roof (middle)	8	trunk lid (middle)
4	fender (front, right)	9	bumper (middle)
5	fender (front, left)		

Figure 1 — Recommended locations for antennas outside the vehicle

When the vehicle OEM antenna is used, it should be used as it is installed in the vehicle without any change of antenna characteristics (location, VSWR, etc.).

Examples of test set-up for simulated on-board transmitters are shown in Figure 2 (use of test antenna) and Figure 3 (use of vehicle OEM antenna).

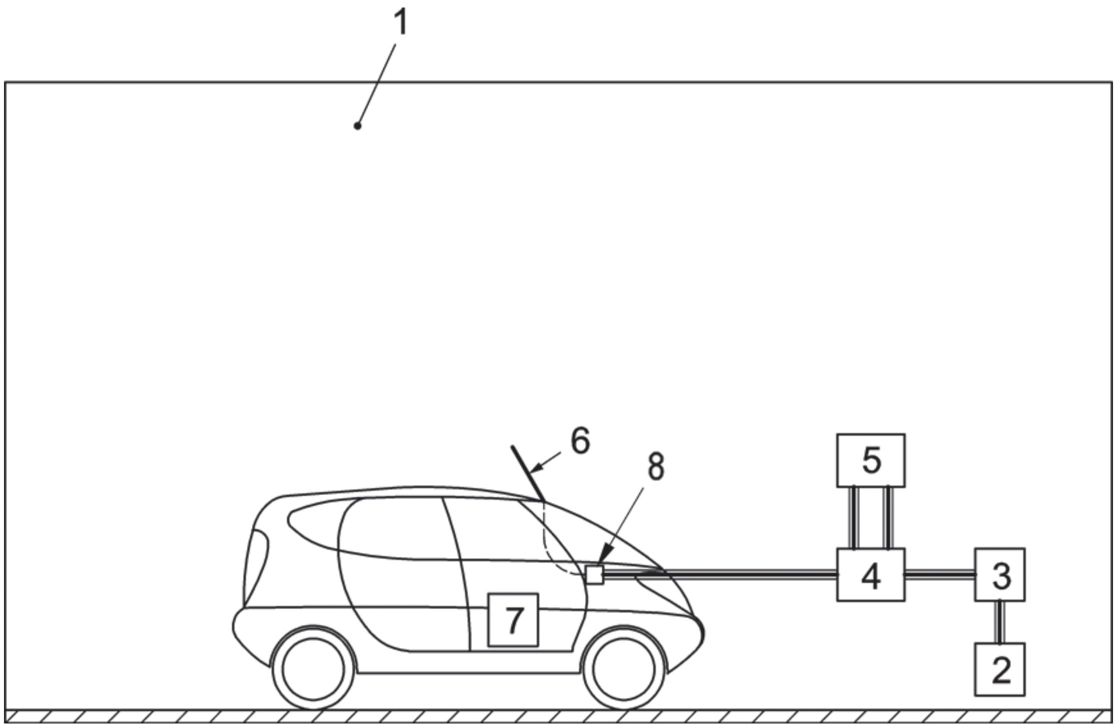
NOTE When the vehicle OEM antenna is used for multiple transmitters/receivers frequency, it is advisable not to use a simulated on-board transmitter (with “broadband” amplifier). The amplifier noise level can be sufficient to degrade some vehicle functions, like GPS satellite reception. The validation of such functions (relative to vehicle on-board-transmitter immunity) can only be performed with the vehicle OEM on-board transmitter. In this case, it might be necessary to operate the on-board vehicle transmitter in real conditions. This can be performed by using specific equipment, like a GSM base station simulator (see 7.1.2 and Figure 4).



Key

1 ALSE
2 RF signal generator (can be outside test facility)
3 power amplifier (can be outside test facility)
4 dual directional coupler (can be outside test facility)
5 power meter (can be outside test facility)
6 test antenna (positions defined in test plan)

Figure 2 — Example of test set-up for simulated on-board transmitter and test antenna



Key

1 ALSE

2 RF signal generator (can be outside test facility)

3 power amplifier (can be outside test facility)

4 dual directional coupler (can be outside test facility)

5 power meter (can be outside test facility)

6 vehicle OEM antenna

7 on-board transmitter (disconnected from vehicle antenna)

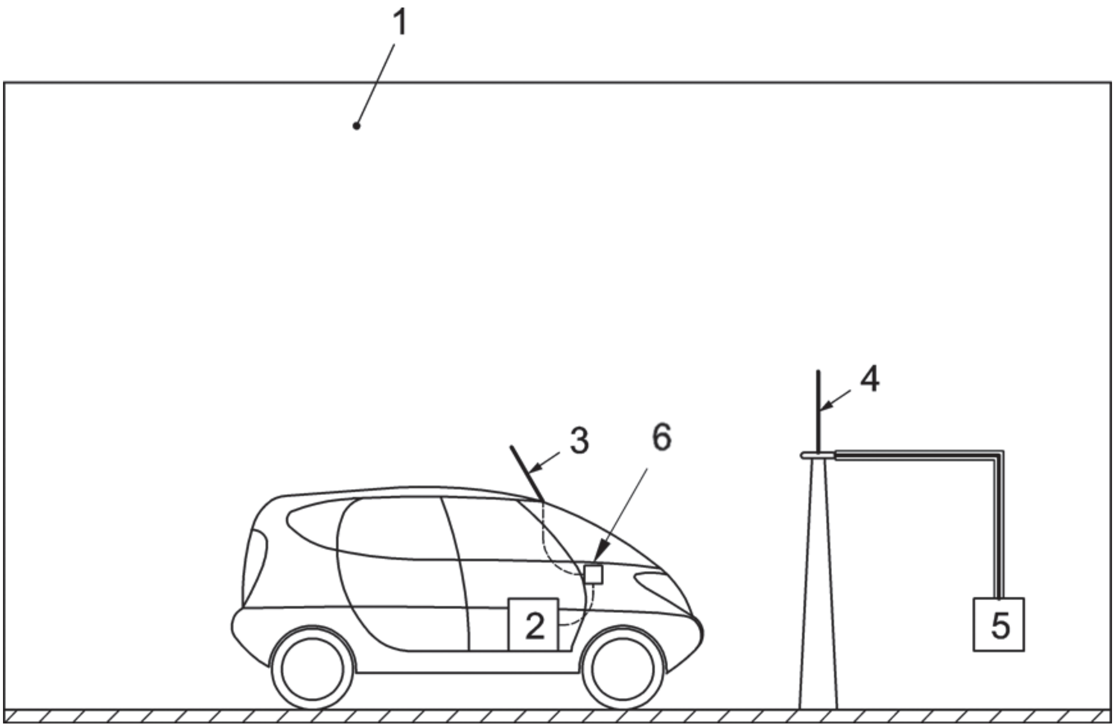
8 vehicle antenna cable connector

Figure 3 — Example of test set-up for simulated on-board transmitter and vehicle OEM antenna

7.1.2 Commercial on-board transmitters

The vehicle commercial on-board transmitter and OEM antenna should be used as it is installed in the vehicle, without any change of transmitter and antenna characteristics (location, VSWR, etc.).

An example of test set-up for commercial on-board transmitters is shown in Figure 4.



Key

1 ALSE

2 on-board transmitter (connected to vehicle antenna)

3 vehicle OEM antenna

4 antenna (when necessary)

5 base station simulator inside or outside test facility (when necessary)

6 vehicle antenna cable connector

Figure 4 — Example of test set-up for commercial on-board transmitter

7.2 Transmitters with antenna inside the vehicle

7.2.1 General

The location(s) of a simulated or commercial portable transmitter in the vehicle shall be defined in the test plan. If no specific location(s) are agreed between the users of this part of ISO 11451, the following location(s) are recommended:

— at the driver's head position (centred on the back of the seat at a height of 0,8 m from the seat cushion, with the seat in medium position), antenna in vertical polarization;

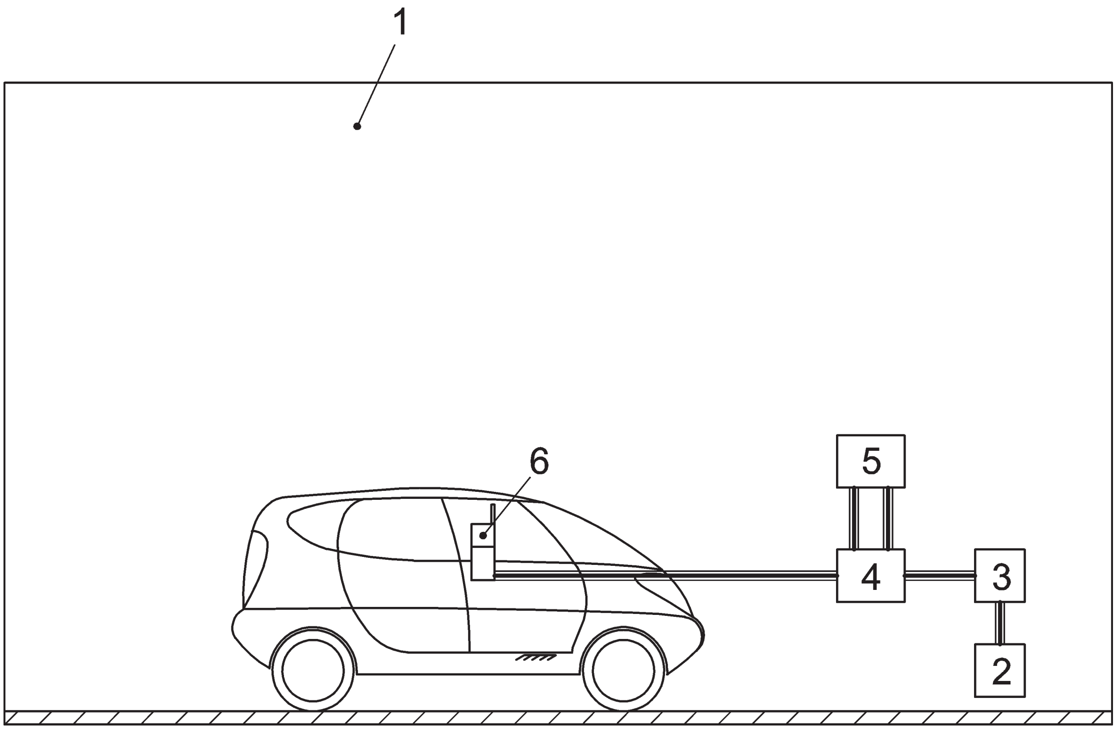
— at the passenger's head position (centred the back of the seat at a height of 0,8 m from the seat cushion, with the seat in medium position), antenna in vertical polarization;

— in specified places where a portable transmitter can be placed, i.e. between front seats, on the vehicle's centre console, storage compartments;

— at the rear passenger's head position (centred on the back of the seat at a height of 0,8 m from the seat cushion, with the seat in medium position), antenna in vertical polarization.

7.2.2 Simulated portable transmitters

An example of test set-up for simulated portable transmitters is shown in Figure 5.



Key

1 ALSE

2 RF signal generator (can be outside test facility)

3 power amplifier (can be outside test facility)

4 dual directional coupler (can be outside test facility)

5 power meter (can be outside test facility)

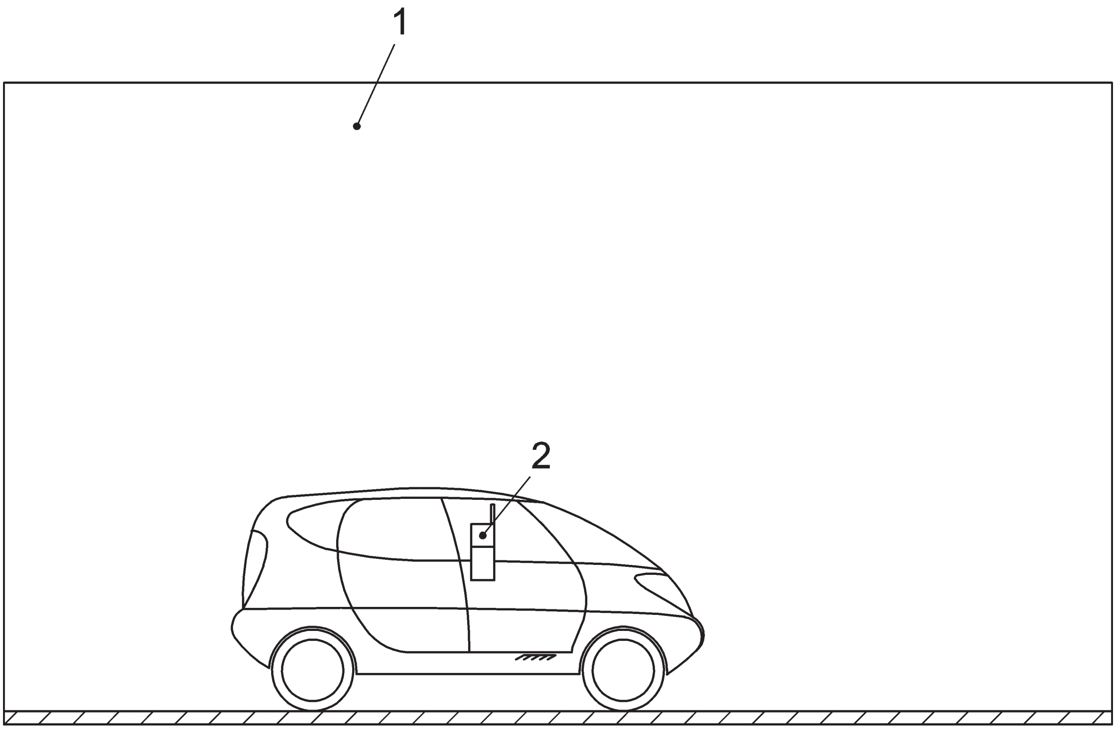
6 simulated portable transmitter (positions defined in test plan)

Figure 5 — Example of test set-up for simulated portable transmitters

7.2.3 Commercial portable transmitters

Examples of test set-up for commercial portable transmitters are shown in Figures 6 and 7 (use of base station simulator).

NOTE Certain RF systems (e.g. GSM phones) transmit with different RF power levels and frequencies. In such cases, the test might not necessarily be performed at the maximum RF power level. To control output power and frequency, either devices with modified software or base station simulators can be used.

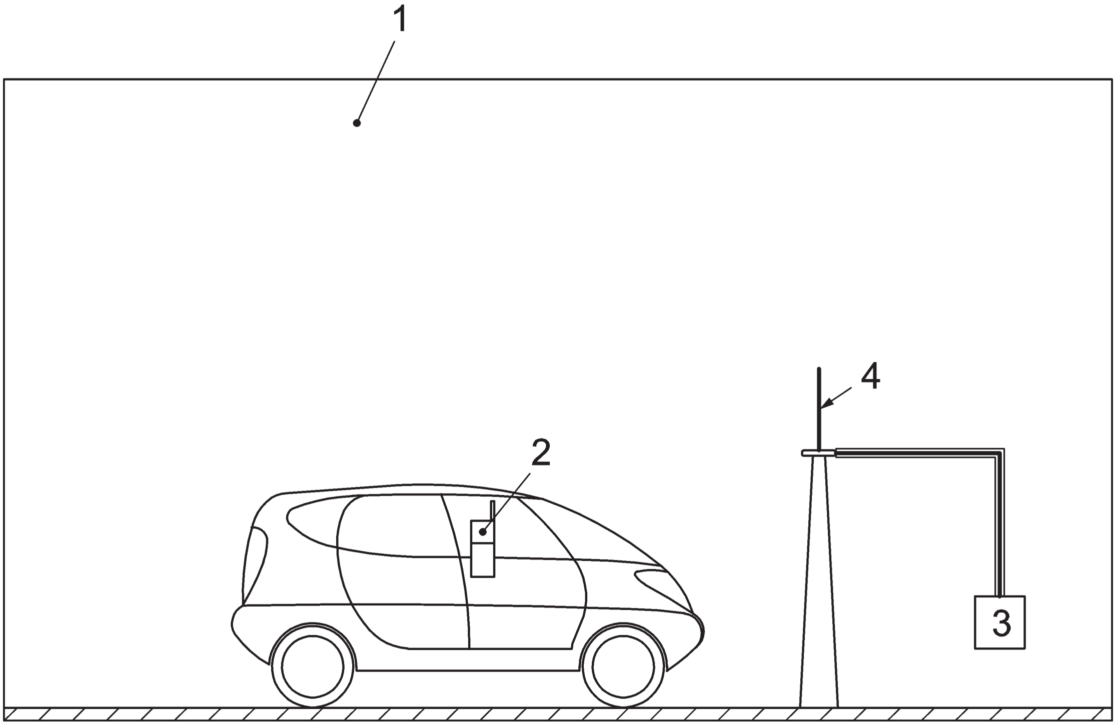


Key

1 ALSE

2 commercial portable transmitter (positions defined in test plan)

Figure 6 — Example of test set-up for commercial portable transmitters



Key

1 ALSE

2 commercial portable transmitter (positions defined in test plan)

3 base station simulator inside or outside test facility

4 antenna (when necessary)

Figure 7 — Example of test set-up for commercial portable transmitters and base station simulator

8 Test procedure

8.1 General

The general arrangement of vehicle, transmitter(s) and associated equipment represents a standardized test condition. Any deviations from the standard test configuration shall be agreed upon prior to testing and recorded in the test report.

The vehicle shall be made to operate under typical loading and operating conditions. These operating conditions shall be clearly defined in the test plan.

8.2 Test plan

Prior to performing the tests, a test plan shall be generated which shall include:

— test set-up;

— frequency range(s) and associated modulation(s);

— duration of transmission;

— antenna location and polarization;

— routing of the coaxial cable to the antenna in the vehicle (for simulated on-board transmitters);

— vehicle mode of operation;

- vehicle monitoring conditions;
- vehicle acceptance criteria;
- vehicle exposure methodology (simulated or commercial transmitter);
- simulated portable transmitter antenna or commercial transmitter antenna location;
- definition of test severity levels;
- maximum antenna VSWR value if necessary;
- test report content;
- any special instructions and changes from the standard test.

8.3 Test method

IMPORTANT — The appropriate guidelines (national regulation, ICNIRP [1][2] etc.) shall be followed for the protection of the test personnel.

8.3.1 Transmitters with antenna outside the vehicle

8.3.1.1 Simulated on-board transmitters

8.3.1.1.1 General

The vehicle, antenna(s) and associated equipment are installed as described in 7.1.1.

The test severity levels are defined in terms of root-mean-square (RMS) power measured for a continuous wave (CW) signal.

8.3.1.1.2 OEM antenna configuration

The reference parameter for the test is the forward power at the vehicle's antenna cable terminal.

For vehicles with an OEM antenna, the test shall at least be performed with this configuration even if tests are also performed with test antenna(s).

With the power amplifier output connected at the OEM antenna cable terminal, increase the forward power level until the predetermined level is achieved. For modulated signals, the peak conservation principle shall be applied as defined in ISO 11451-1. Perform the test at frequencies within the designed bandwidth of the OEM antenna (at least at the lower and upper band edge and at a middle frequency and at frequency steps not greater than those defined in ISO 11451-1).

Continue testing until all frequency bands, modulations, polarizations and antenna locations specified in the test plan are completed.

NOTE At test locations on the vehicle where system interactions are observed (changes/degradations in performance), the test can be repeated in a second step with commercial on-board transmitters transmitting with the maximum allowed power level, as defined in 8.3.1.2.

When required in the test plan, the immunity threshold shall be determined.

8.3.1.1.3 Test antenna configuration

The reference parameter for the test is the net power at the test antenna feed-point.

With the power amplifier output connected at the test antenna feed-point, increase the net power level until the predetermined level is achieved. For modulated signals, the peak conservation principle shall be applied as defined in ISO 11451-1. Perform the test at frequencies within the designed bandwidth of the test antenna (at least at the lower and upper band edge and at a middle frequency and at frequency steps not greater than those defined in ISO 11451-1). The use of more than one test antenna might be necessary to cover an entire frequency band.

Continue testing until all frequency bands, modulations, polarizations and antenna locations specified in the test plan are completed.

NOTE At test locations on the vehicle where system interactions are observed (changes/degradations in performance), the test can be repeated in a second step with commercial on-board transmitters transmitting with the maximum allowed power level, as defined in 8.3.1.2.

When required in the test plan, the immunity threshold shall be determined.

8.3.1.2 Commercial on-board transmitters

The vehicle is installed in the test facility as described in 7.1.2.

The test shall be performed with unmodified commercial on-board transmitter characteristics (power, modulation, etc.) and the unmodified vehicle OEM antenna. Any exception to this practice shall be specified in the test plan.

NOTE In general, the commercial on-board transmitter power considered for this test is the commercially available/declared value of rated power.

Operate the commercial on-board transmitter connected to the OEM antenna in the configuration(s) indicated in the test plan, noting any anomalies.

Continue testing until all on-board transmitter(s) specified in the test plan are completed.

8.3.2 Transmitters with antenna inside the vehicle

8.3.2.1 Simulated portable transmitters

This method is performed in two phases:

— test level setting;

— test of the vehicle.

8.3.2.1.1 Test level setting

The adjustment of the net power level shall be performed in continuous wave (CW), with the simulated portable transmitter antenna placed at a minimum distance of 1 m from any part of the vehicle, from the ground plane and from the test enclosure, and 0,5 m from any absorber, until the predetermined level is achieved.

Record the net power level and the forward power level.

NOTE If a PEP (peak envelope power) meter is used, the modulated signal can be used during the power adjustment.

8.3.2.1.2 Vehicle test

There are two alternative ways, either of which can be used, to expose the vehicle after the test level setting phase.

a) Approach the simulated portable transmitter at the various positions indicated in the test plan without switching off the power of the simulated portable transmitter.

b) Switch off the power of the simulated portable transmitter, approach the simulated portable transmitter at the various positions indicated in the test plan, then switch on the power of the simulated portable transmitter.

The test on the vehicle shall be performed at the various positions indicated in the test plan, with CW and/or modulated signals indicated in Annex A.

The test on the vehicle shall be performed without any change in the forward power level recorded during the determination of the net power (test level setting).

For amplitude modulation (AM) and pulse modulation (PM) signals, the test on the vehicle shall be performed with power level adjustment, in order to fulfil the peak conservation principle given in ISO 11451-1. The power adjustments shall be performed in the same condition of simulated portable transmitter location as described for test level setting.

NOTE 1 Due to the position of the simulated portable transmitter antenna close to the vehicle, variation in transmitter net power can occur. If a variation of net power occurs, readjustment of net power is not required.

If manual positioning of the antenna is required while the RF power is switched on, then care shall be taken, according to ICNIRP Guidelines, to minimize the exposure of the operator to the generated field. It is recommended that a minimum distance of 0,5 m from the operator to the simulated portable transmitter be maintained in order to limit operator influence.

Perform the test at frequencies within the designed bandwidth of the test antenna (at least at the lower and upper band edge and at a middle frequency and at frequency steps not greater than those defined in ISO 11451-1).

Continue testing until all frequency bands, modulations, polarizations and simulated portable transmitter antenna locations specified in the test plan are completed.

NOTE 2 Because it is not practical to perform the test at every possible location of a portable transmitter inside the vehicle, the test can be performed as a first step for limited defined locations with power levels higher than the typical one given in Annex A.

NOTE 3 At test locations on the vehicle where system interactions are observed (changes/degradations in performance), the test can be repeated in a second step with commercial portable transmitters transmitting with the maximum allowed power level, as defined in 8.3.2.2.

8.3.2.2 Commercial portable transmitters

The vehicle and associated equipment are installed as described in 7.2.3.

The test shall be performed with unmodified commercial portable transmitter characteristics (power, modulation, antenna). Any exception to this practice shall be specified in the test plan.

NOTE In general, the commercial portable transmitter power considered for this test is the commercially available/declared value of rated power.

Operate the commercial portable transmitter in the configuration(s) indicated in the test plan, noting any anomalies.

Continue testing until all portable transmitter types and locations specified in the test plan have been tested.

8.4 Test report

As required by the test plan, a test report shall be submitted, detailing information regarding the test equipment, test site, test set-up, systems tested, frequencies, power levels, the antenna used, the portable or commercial transmitter used, VSWR values, system interactions, and any other information relevant to the test.

Annex A
(informative)

Typical characteristics of on-board transmitters

Examples of typical characteristics for vehicle on-board transmitters are given in Tables A.1 and A.2, and an explanation of terms used in these tables is given in Table A.3. These characteristics are for information only: frequency bands can be different from one region to another, and the use of power levels greater than those indicated can be expected.

For amplitude modulation (AM) and pulse modulation, powers are specified using the peak conservation principle (RMS power of a CW signal with same peak amplitude).

Table A.1 — Typical characteristics for transmitters with antenna outside vehicle

Transmitter designation	Frequency band MHz	Power W	Typical transmitter modulation	Test Modulation
short wave	1,8 to 30	100 (RMS)	Telegraphy, AM, SSB, FM	AM 1 kHz, 80 %
8 m	30 to 50	120 (RMS)	FM	CW
6 m	50 to 54	120 (RMS)	Telegraphy, AM, SSB, FM	AM 1 kHz, 80 %
4 m	68 to 87,5	120 (RMS)	FM	CW
2 m	144 to 148	120 (RMS)	Telegraphy, AM, SSB, FM	CW
70 cm	410 to 470	120 (RMS)	Telegraphy, AM, SSB, FM	CW
TETRA/TETRAPOL	380 to 390 410 to 420 450 to 460 806 to 825 870 to 876	20 (Peak)	TDMA/ FDMA, Tetra: π/4 DQPSK	PM 18 Hz, 50 % duty cycle
AMPS/GSM850	824 to 849	20 (Peak)	GMSK, PSK, DS	PM 217 Hz, 50 % duty cycle or PM 217 Hz, Ton = 577 µs t = 4 600 µs
GSM 900	876 to 915	20 (Peak) or 8 (Peak)	GMSK	PM 217 Hz, 50 % duty cycle or PM 217 Hz, Ton = 577 µs t = 4 600 µs
23 cm	1 200 to 1 300	25 (RMS.)	Telegraphy, AM, SSB, FM	CW
PCS, GSM1800/1900	1 710 to 1 785 1 850 to 1 910	2 (Peak) or 1 (Peak)	GMSK	PM 217 Hz, 50 % duty cycle or PM 217 Hz, Ton = 577 µs t = 4 600 µs
IMT-2000	1 885 to 2 025	1 (Peak)	QPSK	PM 1 600 Hz, 50 % duty cycle

Table A.1 *(continued)*

Transmitter designation	Frequency band MHz	Power W	Typical transmitter modulation	Test Modulation
LTE 800	832 to 862	4 (Peak)	QPSK	PM 1 000 Hz 10 % duty cycle
LTE 2600	2 500 to 2 620	4 (Peak)	QPSK	PM 1 000 Hz 10 % duty cycle

Table A.2 — Typical characteristics for transmitters with antenna inside vehicle

Transmitter designation	Frequency band MHz	Power W	Typical transmitter modulation	Test Modulation
10 m	26 to 30	10 (RMS)	Telegraphy, AM, SSB, FM	AM 1 kHz, 80 %
2 m	144 to 148	10 (RMS)	Telegraphy, AM, SSB, FM	CW
70 cm	410 to 470	10 (RMS)	Telegraphy, AM, SSB, FM	CW
TETRA/TETRAPOL	380 to 390 410 to 420 450 to 460 806 to 825 870 to 876	10 (Peak)	TDMA/ FDMA, Tetra: π/4 DQPSK	PM 18 Hz, 50 % duty cycle
AMPS/GSM850	824 to 849	10 (Peak)	GMSK, PSK, DS	PM 217 Hz, 50 % duty cycle or PM 217 Hz, Ton = 577 µs *t* = 4 600 µs
GSM900	876 to 915	16 (Peak) or 2 (Peak)	GMSK	PM 217 Hz, 50 % duty cycle or PM 217 Hz, Ton = 577 µs *t* = 4 600 µs
PDC	893 to 898 925 to 958 1 429 to 1 453	0,8 (Peak)	TDMA	PM 50 Hz 50 % duty cycle
PCS, GSM1800/1900	1 710 to 1 785 1 850 to 1 910	2 (Peak) or 1 (Peak)	GMSK	PM 217 Hz, 50 % duty cycle or PM 217 Hz, Ton = 577 µs *t* = 4 600 µs
IMT-2000	1 885 to 2 025	CW – 1 (RMS) PM – 1 (Peak)	QPSK	CW and PM 1 600 Hz, 50 % duty cycle
Bluetooth/WLAN	2 400 to 2 500	0,5 (Peak)	QPSK	PM 1 600 Hz, 50 % duty cycle
IEEE 802.11a	5 725 to 5 850	1(Peak)	QPSK	PM 1 600 Hz, 50 % duty cycle
LTE 800	832 to 862	4 (Peak)	QPSK	PM 1 000 Hz 10 % duty cycle
LTE 2600	2 500 to 2 620	4 (Peak)	QPSK	PM 1 000 Hz 10 % duty cycle

Table A.3 — Terms

Term (modulation/access system/name)	Definition	Example of use
AM	Amplitude Modulation	Broadcast
AMPS	Advanced Mobile Phone System	—
DECT	Digital Enhanced Cordless Telecommunications	—
DQPSK	Differential Quadrature Phase Shift Keying	Iridium Satellite Telephone
FDMA	Frequency Division Multiplex Access	—
FM	Frequency Modulation	Broadcast
GMSK	Gaussian Minimum Shift Keying	GSM
GSM 850	Global System of Mobile Phones 850 MHz Band	—
GSM 900	Global System of Mobile Phones 900 MHz Band	—
GSM 1800/1900	Global System of Mobile Phones 1800/1900 MHz Band	—
HAM	Term/Name for licensed Amateur Radio	HAM Radio Station
IEEE 802.11a	802.11 refers to a family of specifications developed by the IEEE for wireless LAN technology	WLAN
IMT-2000	International Mobile Telecommunications 2000	UMTS
LTE	Long Term Evolution network	4G mobile
PCS	Personal Communications Service	—
PDC	Personal Digital Cellular	—
PM	Pulse Modulation	PDC
PSK	Phase Shift Keying	CDMA
QPSK	Quadrature Phase Shift Keying	UMTS, W-LAN
SSB	Single Side Band	Military, HAM Radio
Telegraphy (CW)	Morse telegraphy/Coded Work	—
TDMA	Time Division Multiple Access	Tetra 25, DECT, GSM
TETRA	Terrestrial Trunked Radio	—
TETRAPOL	Terrestrial Trunked Radio Police	—
UMTS	Universal Mobile Telecommunication System	—
WLAN	Wireless Local Area Network	—
10 m/6 m/2 m/70 cm/23 cm	HAM Radio Band as wavelength	—

Annex B
(informative)

Guidance on tuning antennas on the vehicle for minimum voltage standing wave ratio (VSWR)

Where the test level is specified using net power, the required forward power at the coupler can be calculated based on knowledge of cable loss and measurement of VSWR at the coupler.

At the antenna, the ratio of reflected to forward power is related to VSWR as defined in Formula (B.1), and the ratio of net to forward power is related to VSWR as defined in Formula (B.2):

$$\frac{P_{\text{ant,REFL}}}{P_{\text{ant,FWD}}} = \left(\frac{k_{\text{VSWR,ant}} - 1}{k_{\text{VSWR,ant}} + 1}\right)^2 \tag{B.1}$$

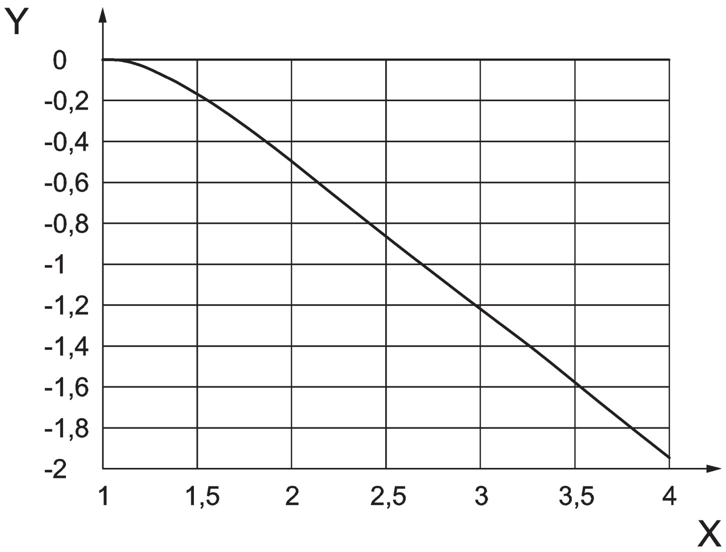
$$\frac{P_{\text{ant,NET}}}{P_{\text{ant,FWD}}} = 1 - \left(\frac{k_{\text{VSWR,ant}} - 1}{k_{\text{VSWR,ant}} + 1}\right)^2 \tag{B.2}$$

$$\Delta P = 10 \times \lg\left(\frac{P_{\text{ant,NET}}}{P_{\text{ant,FWD}}}\right) \tag{B.3}$$

where

$k_{\text{VSWR,ant}}$	is the voltage standing wave ratio at the antenna;
$P_{\text{ant,REFL}}$	is the reflected power at the antenna;
$P_{\text{ant,FWD}}$	is the forward power at the antenna;
$P_{\text{ant,NET}}$	is the net power at the antenna;
ΔP	is the difference between net power in dB and forward power in dB.

For a cable (transmission line) with 0 dB attenuation, ΔP as a function of VSWR is plotted in Figure B.1.



Key

X voltage standing wave ratio

Y ΔP (dB)

Figure B.1 — Relationship between ΔP and VSWR

The relationship between forward power at the coupler and net power at the antenna can be calculated. If the cable loss between power coupler and antenna is given by A, as defined in Formula (B.4):

$$A = \frac{P_{\text{ant,FWD}}}{P_{\text{meas,FWD}}} \tag{B.4}$$

the net power to the antenna, $P_{\text{ant,NET}}$, as defined in Formula (B.5), is:

$$P_{\text{ant,NET}} = \left(A \times P_{\text{meas,FWD}}\right) - \left(\frac{1}{A} \times P_{\text{meas,REFL}}\right) \tag{B.5}$$

where

$P_{\text{meas,FWD}}$ is the measured forward power;

$P_{\text{meas,REFL}}$ is the measured reflected power.

This can be expressed in terms of VSWR measured at the coupler, as defined in Formula (B.6):

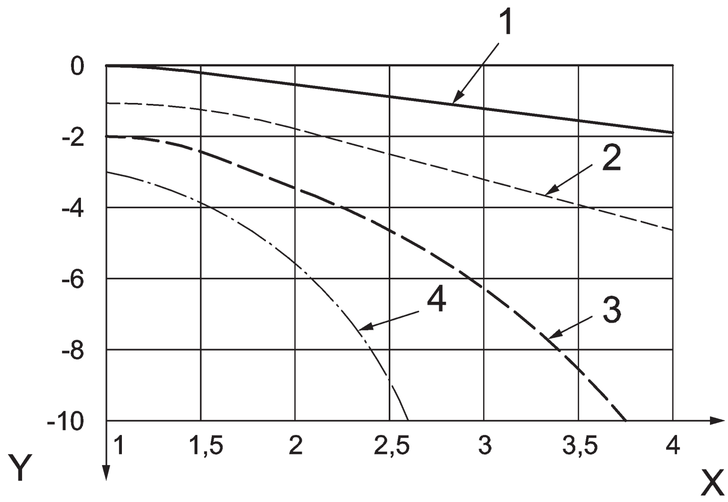
$$\frac{P_{\text{ant,NET}}}{P_{\text{meas,FWD}}} = A - \frac{1}{A} \times \left(\frac{k_{\text{VSWR,meas}} - 1}{k_{\text{meas,FWD}} + 1}\right)^2 \tag{B.6}$$

$$\Delta P' = 10 \times \lg\left(\frac{P_{\text{ant,NET}}}{P_{\text{meas,FWD}}}\right) \tag{B.7}$$

where

$k_{\text{VSWR,meas}}$is the measured voltage standing wave ratio.

The equation results for cable loss values of 0 dB, 1 dB, 2 dB, and 3 dB are shown in Figure B.2.



Key

X voltage standing wave ratio

Y $\Delta P'$ (dB)

1 A (dB) = 0

2 A (dB) = 1

3 A (dB) = 2

4 A (dB) = 3

Figure B.2 — Relationship between Δ*P*′ and VSWR

If VSWR and cable loss are low, then antenna net power can be approximated by measured forward power, multiplied by the cable attenuation factor, as defined in Formula (B.8):

$$P_{\text{ant,NET}} \approx A \times P_{\text{meas,FWD}} \tag{B.8}$$

However, for high VSWR or cable loss, the nonlinear interactions described above shall be taken into consideration to determine the net power delivered to the antenna.

Annex C
(informative)

Examples of simulated portable transmitter antennas

C.1 Introduction

This annex provides details of the miniature broadband antenna with examples of other simulated portable transmitter antennas which can be used to perform the tests described in this part of ISO 11451.

— Miniature Broadband antenna

— Sleeve antennas

— Monopole antennas

All dimensions in the figures included in Annex C are in millimetres.

C.2 Miniature broadband antenna

C.2.1 General

The small broadband antenna acts comparable to a symmetrical broadband dipole antenna. In contrast to an ordinary dipole antenna the radiating elements have been designed especially for wide bandwidth, close distance to the EUT and good field uniformity. Due to the wide frequency coverage a significant reduction of testing time can be achieved. The geometrical characteristics of the miniature broadband antenna for simulated portable transmitters are indicated in Figure C.2.

C.2.2 Typical characteristics

— Input impedance: 50 Ohms

— Balun transformation ratio: 1:1

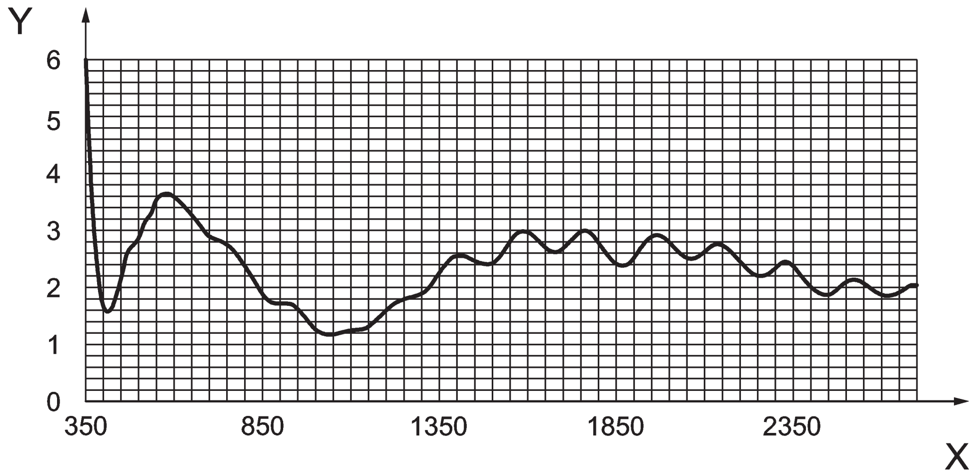
— Frequency range: 360 MHz to 2 700 MHz

— Radiating element dimensions: 240 mm × 109 mm

— Maximum Power input 20 W

— Connector: Type N-female

— VSWR characteristic (see Figure C.1)

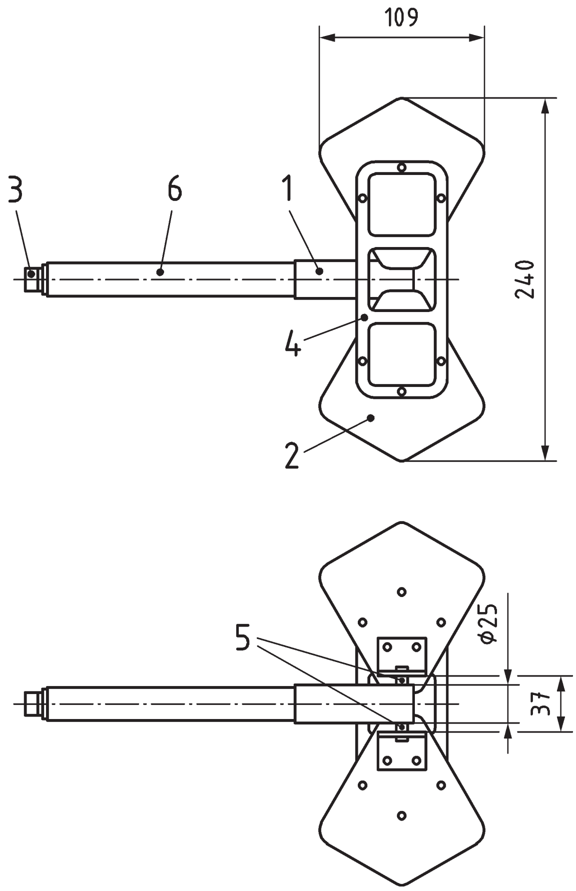


Key

X frequency in MHz

Y voltage standing wave ratio

Figure C.1 — Typical VSWR characteristics



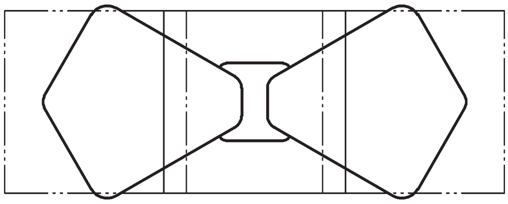
Key

1 broadband low loss balun 1:1
2 flat antenna elements
3 N-female connector
4 element fixture and spacing frame (5 mm, non metallic)
5 symmetrical terminals, M4
6 22 mm tube for handling or fixture

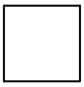
Figure C.2 — Construction details of broadband antenna

C.2.3 Electric fields generated by the antenna

Test antenna has three 100 mm × 100 mm test zones where field uniformity is better than ±3 dB. In frequency range of 360 MHz to 480 MHz E field is concentrated under the elements of the antenna and moves to the centre after 800 MHz. Test antenna, as shown in Figure C.3 has three 100 mm × 100 mm test zones.



Key

 100 mm × 100 mm uniform test zones; E field for 800 ≤ *f* ≤ 2 700 MHz and uniform H field for 360 ≤ *f* ≤ 2 700 MHz

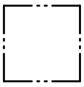
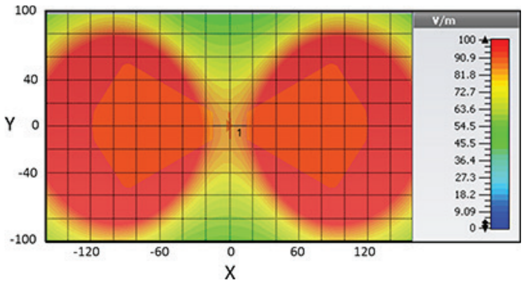
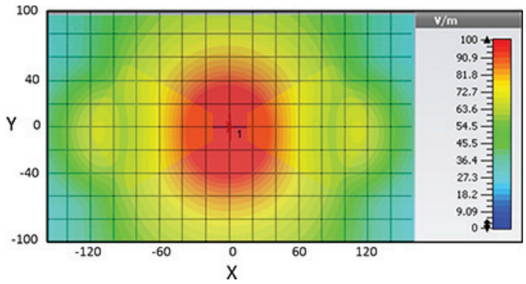
 100 mm × 100 mm uniform test zones; E field for 360 ≤ *f* ≤ 480 MHz

Figure C.3 — Field uniformity zones

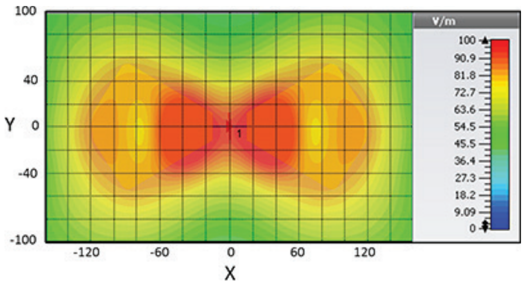
Figures C.4 and C.5 show field distribution and peak amplitudes respectively in volts per metre (V/m) and in ampere per metre (A/m) for a 1 W net input at a 50 mm distance from the antenna elements. The greenest areas (the mid-grey areas toward the grid edges when viewed in monochrome) show a field degradation of greater than 6 dB from the maximum field.



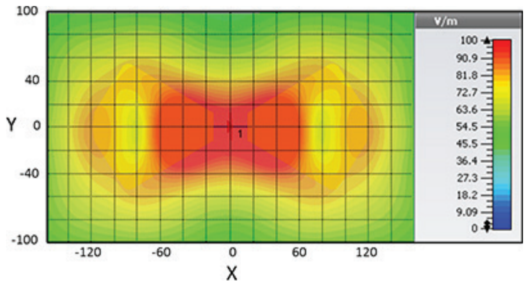
400 MHz; 1 W net input;
average E field strength: 100 V/m



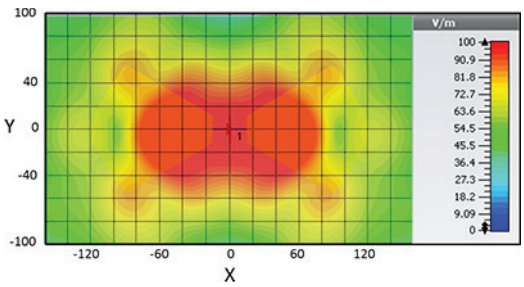
900 MHz; 1 W net input;
average E field strength: 67 V/m



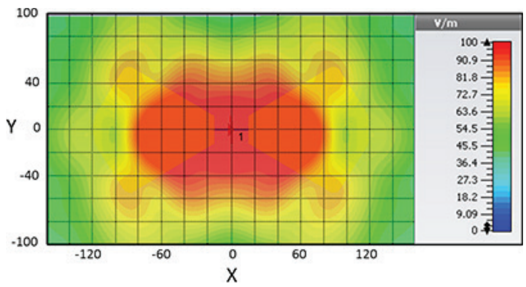
1 800 MHz; 1 W net input;
average E field strength: 84 V/m



2 000 MHz; 1 W net input;
average E field strength: 89 V/m



2 450 MHz; 1 W net input;
average E field strength: 114 V/m



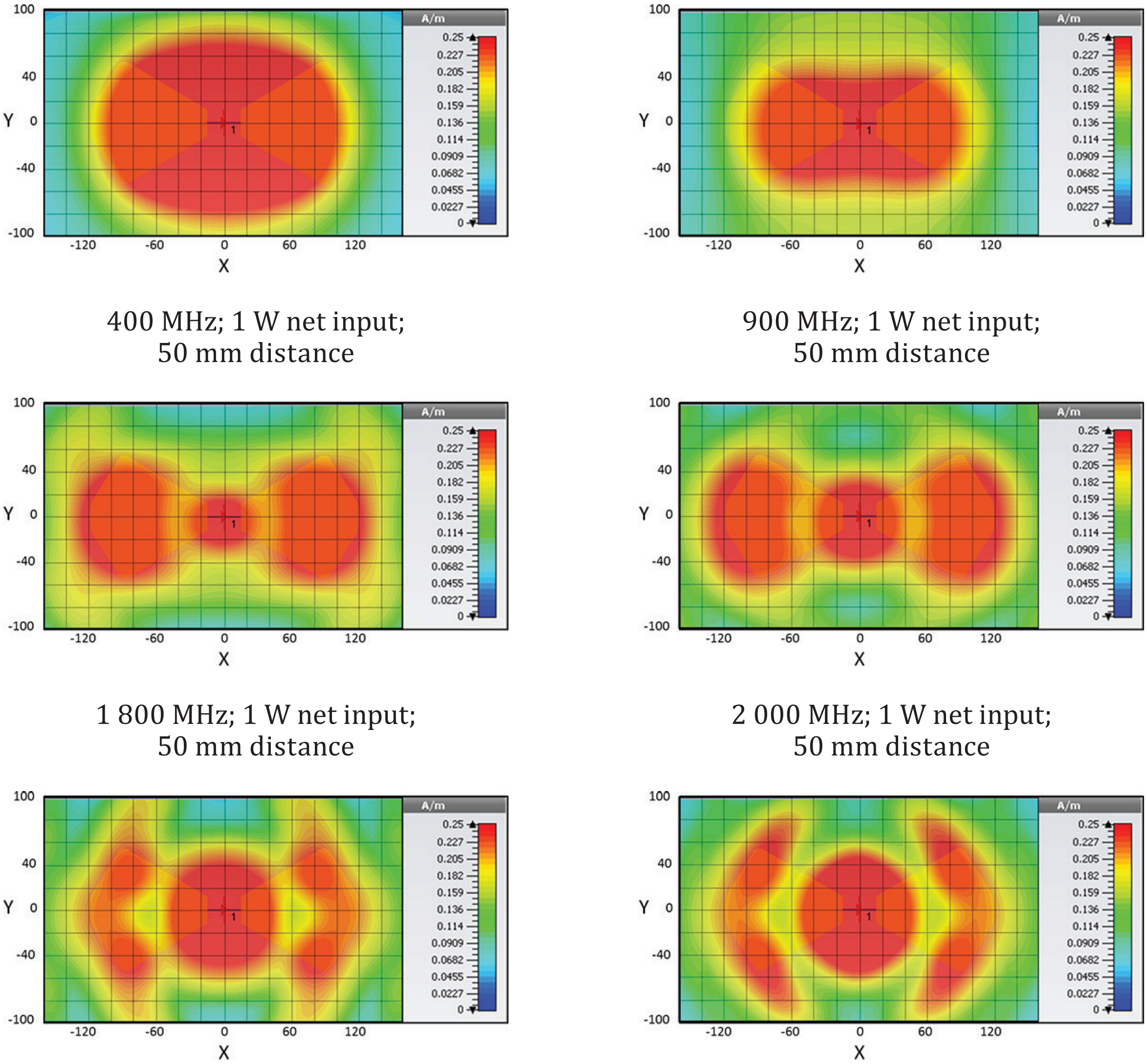
2 600 MHz; 1 W net input;
average E field strength: 137 V/m

Key

X mm

Y mm

Figure C.4 — E field pattern for the broadband antenna



400 MHz; 1 W net input;
50 mm distance

900 MHz; 1 W net input;
50 mm distance

1 800 MHz; 1 W net input;
50 mm distance

2 000 MHz; 1 W net input;
50 mm distance

2 450 MHz; 1 W net input;
50 mm distance

2 600 MHz; 1 W net input;
50 mm distance

Key

X mm

Y mm

Figure C.5 — H field (A/m) pattern for the broadband antenna

C.3 Sleeve antenna

C.3.1 General

Examples of sleeve antenna configuration for simulated portable transmitters are given in Figure C.6. Explanation of antenna and sleeve length of each frequency band is given in Table C.1. These characteristics are for information only.

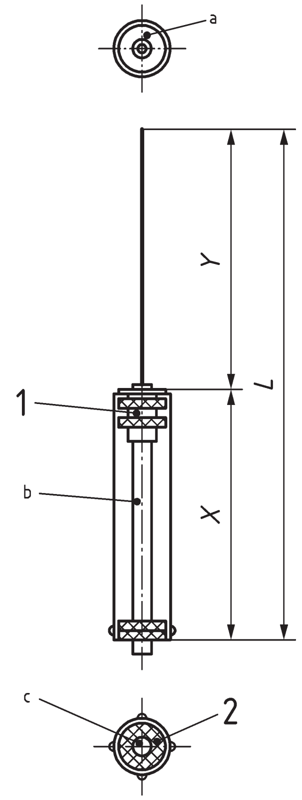
C.3.2 Typical characteristics

- Input impedance: 50 Ω
- Permissible power: 30 W
- Connector: Type BNC
- Gain: 2,15 dB ± 1 dB
- VSWR: <2:1

C.3.3 Antenna Configuration

The antennas are designed as typical 1/4 λ sleeve antennas. Each band antenna utilizes a 3D-2V cable, a BNC connector, a brass rod as antenna element and a steel pipe as sleeve element. For keeping a constant cross section along the sleeve and cable, a cable fixing plastic screw and 4 polycarbonate screws could be applied at the bottom of sleeve element.

- L mm = X mm + Y mm = $\lambda/2 \times 0{,}95$
- X: Y = 55: 45 (Based on the configuration samples)
- λ [mm]: Wavelength of centre frequency
- Fractional shortening: 95 %
- Sleeve outer diameter: 20 mm (equivalent to S45RP)
- Antenna diameter: 2 mm (brass rod)
- Sleeve inner diameter: 18,5 mm (equivalent to S45RP)
- Connector: BNC (UG-625/U, BNC-P-3)
- Cable: 3D-2V



Key

1 BNC connector

2 polycarbonate screw: M3

a tightening with a 14,9 mm diameter nut

b cable

c cable-fixing plastic screw - material: nylon MC - outer diameter: 13 mm - inner diameter: 6 mm – thickness: 6 mm - screw hole: M3

Figure C.6 — Example of 1/4 λ sleeve antenna configuration

NOTE The surfaces of the antenna element and sleeve are recommended to be of a rust-resistant metallic material (e.g. Ni).

Table C.1 — Example of antenna and sleeve element length for each band

Transmitter	**Frequency band** (MHz)	**Centre Frequency** (MHz)	**X** (mm) **Antenna element length** **Tolerance: X** ±5(%)	**Y** (mm) **Sleeve length** **Tolerance:** Y ± 5(%)
TETRA/ TETRAPOL	380 - 390	395	198 ± 9	162 ± 8
	410 - 420	415	189 ± 9	155 ± 8
	450 - 460	455	172 ± 8	141 ± 7
	806 - 876	841	93 ± 5	76 ± 4
70cm	420 - 450	435	180 ± 9	147 ± 7
AMPS/GSM850	824 - 849	836,5	94 ± 5	77 ± 4
NOTE Antenna element and sleeve length could be tuned to attain the specific VSWR.				

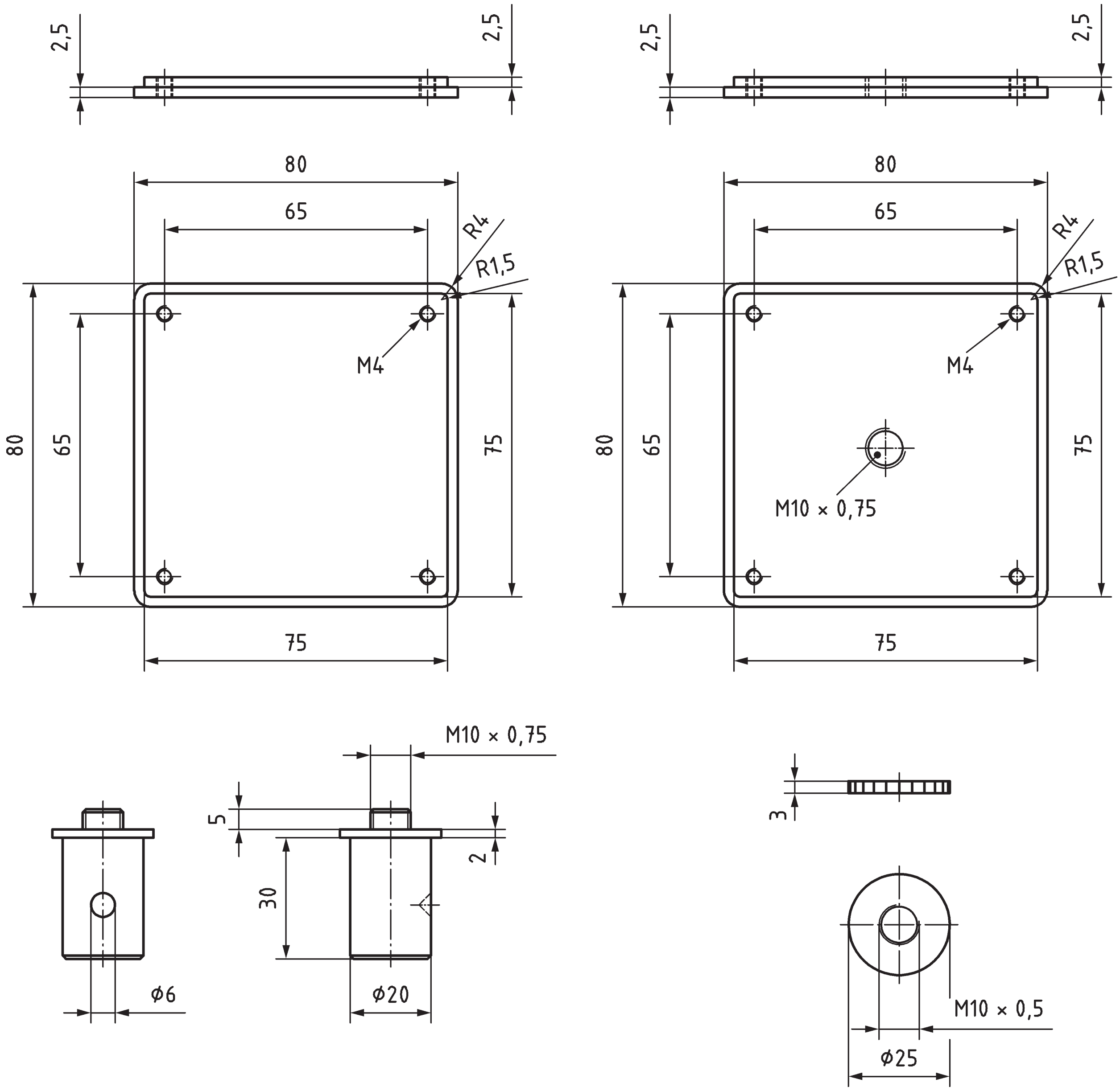
Table C.1 *(continued)*

Transmitter	Frequency band (MHz)	Centre Frequency (MHz)	**X** (mm) Antenna element length Tolerance: X ±5(%)	**Y** (mm) Sleeve length Tolerance: Y ± 5(%)
GSM900/PDC	876 - 915	895,5	88 ± 4	72 ± 4
PDC	925 - 958	941,5	83 ± 4	68 ± 3
PDC	1 440 – 1 453	1 446,5	54 ± 3	44 ± 2
PCS/GSM1800/1900	1 710 – 1 910	1 810	43 ± 2	35 ± 2
NOTE Antenna element and sleeve length could be tuned to attain the specific VSWR.				

C.4 Monopole antenna

C.4.1 General

The antenna is integrated into a PVC casing fitted with a PMMA [poly(methyl methacrylate)] window for the sighting of the antenna inside. This casing is also equipped with an SMA-type bulkhead and a mechanical connector into which a handle is fitted to hold the antenna at a distance. The construction characteristics common to all such antennas of this casing are shown in Figures C.7 and C.8.



Key

1 male support for antenna mast

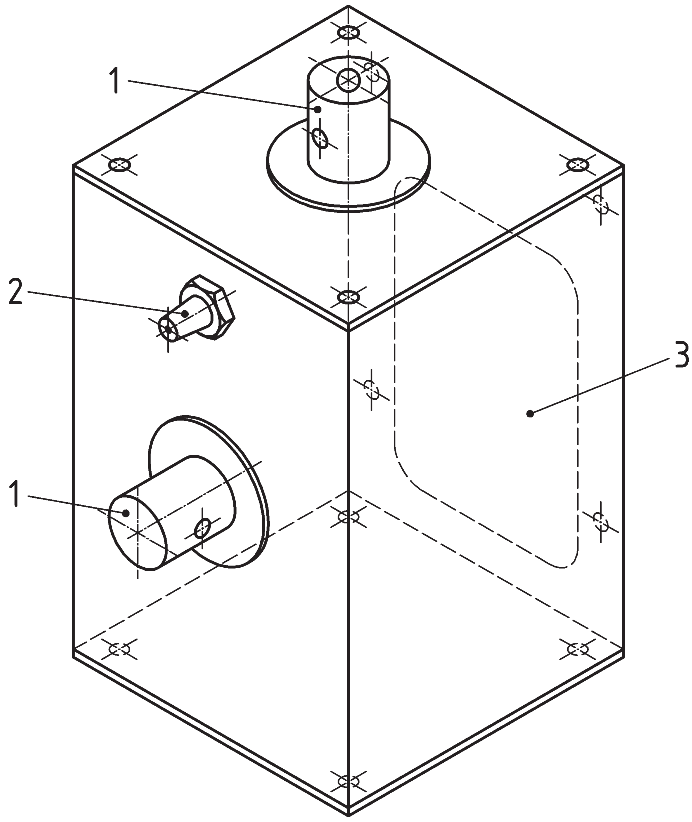
2 coaxial connector

3 Altuglas[a] window (built into housing)

[a] Altuglas® is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

Figure C.7 — Common casing construction characteristics — General

Dimensions in millimetres



NOTE The use of this casing in performing tests with the antenna positioned at 50 mm from the DUT also requires the use of a 10 mm shim. In order to avoid using the shim, the casings can be manufactured with an outside dimension of 100 mm instead of 80 mm.

Figure C.8 — Common casing construction characteristics — Details

C.5 Antenna for 890 MHz to 915 MHz frequency band

C.5.1 Typical characteristics

— Antenna bandwidth: 890 MHz to 915 MHz (min)

— Input impedance: 50 Ω

— Permissible power: 20 W

— Connector: Type-SMA

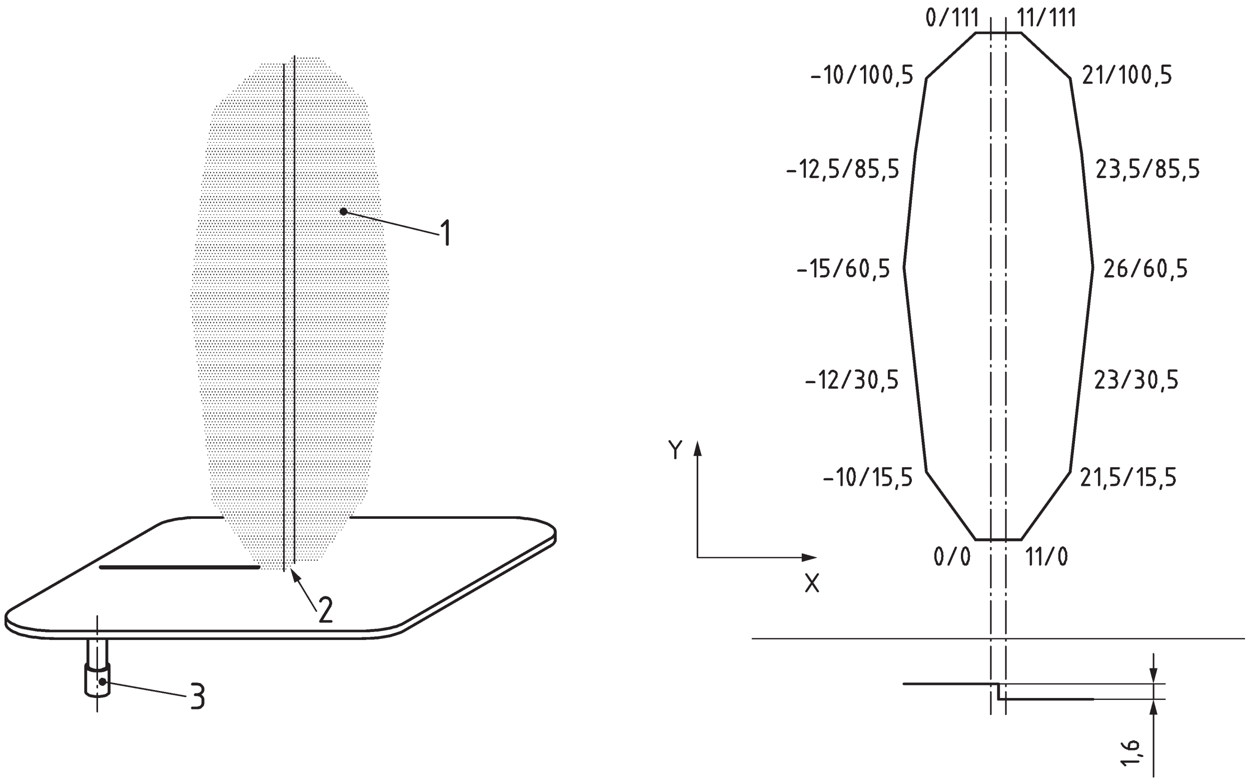
— Gain: Typically 0,5 dB ± 0,5 dB

— VSWR < 2:1 over the entire band

C.5.2 Antenna construction and integration into casing

The antenna is produced from a type-FR4 printed circuit and supplied in its centre by a microstrip line. The radiating element consists of a single pole in the shape of a leaf placed vertically in relation to the ground plane. The geometrical characteristics of the assembly are indicated in Figures C.9a and C.9b.

The construction details of the casing are indicated in Figure C.9c.



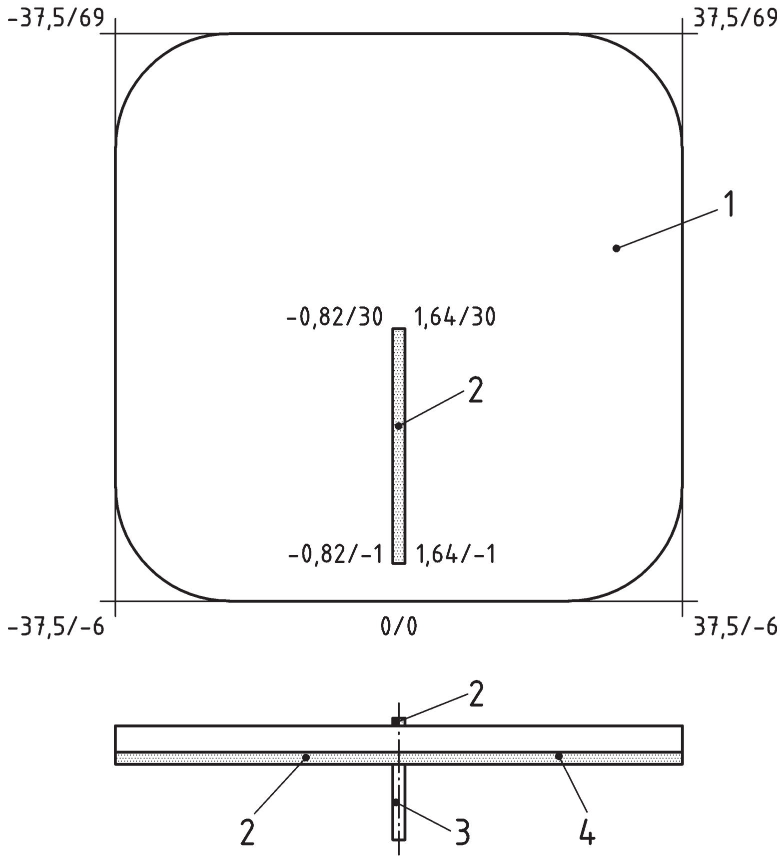
Key

1 aerial element

2 brazing

3 RG 402 + SMA female connector

Figure C.9a — Antenna geometrical characteristics — General



Key

1 card dimension 75/75 mm

2 copper (Cu)

3 RG 402 + SMA female

4 FR4 1,6 mm/35 µm Cu - ground plane on lower side

Figure C.9b — Antenna geometrical characteristics — Details

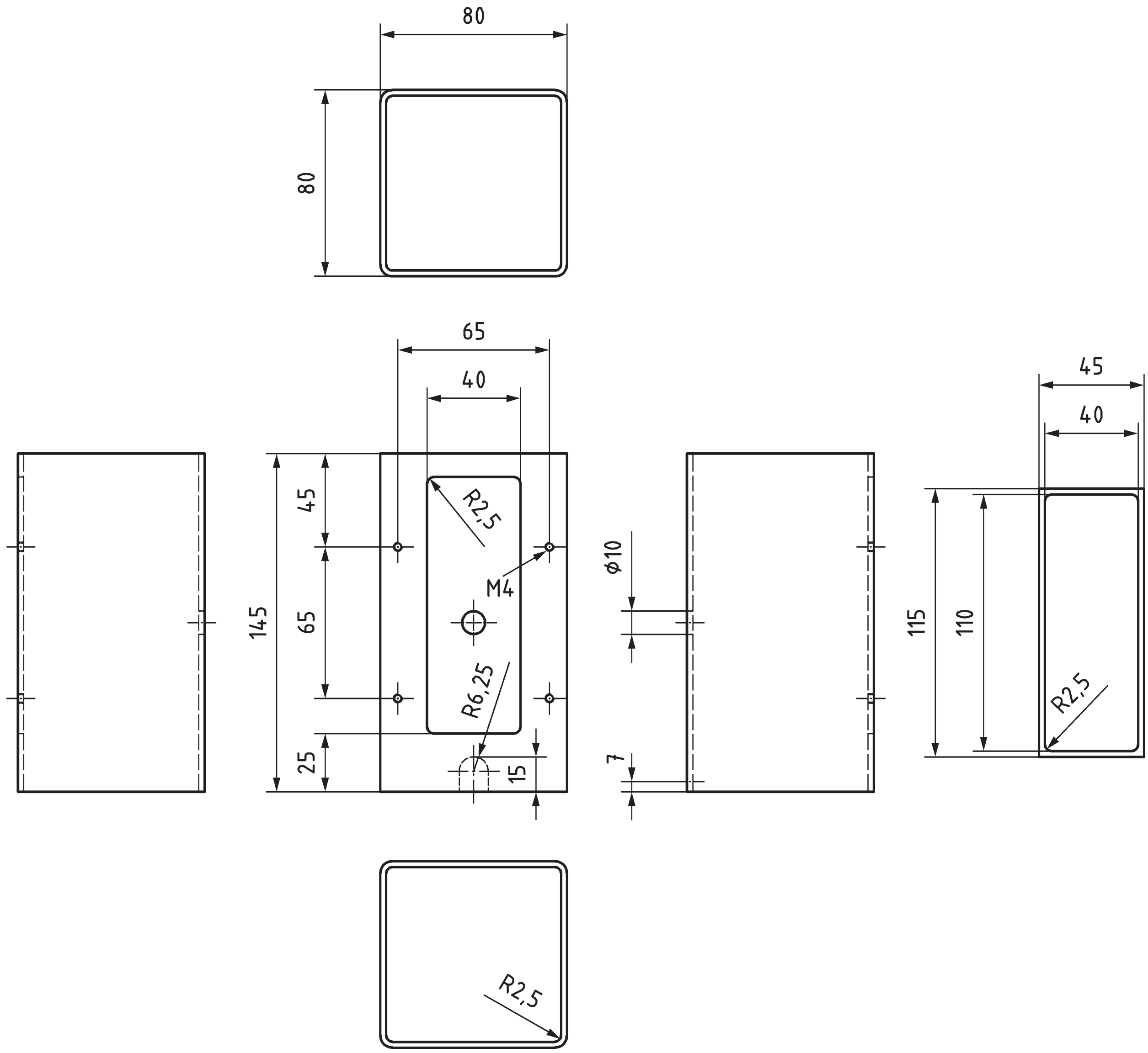


Figure C.9c — Casing construction — Details

C.6 Antenna for 1 710 MHz to 1 785 MHz frequency band

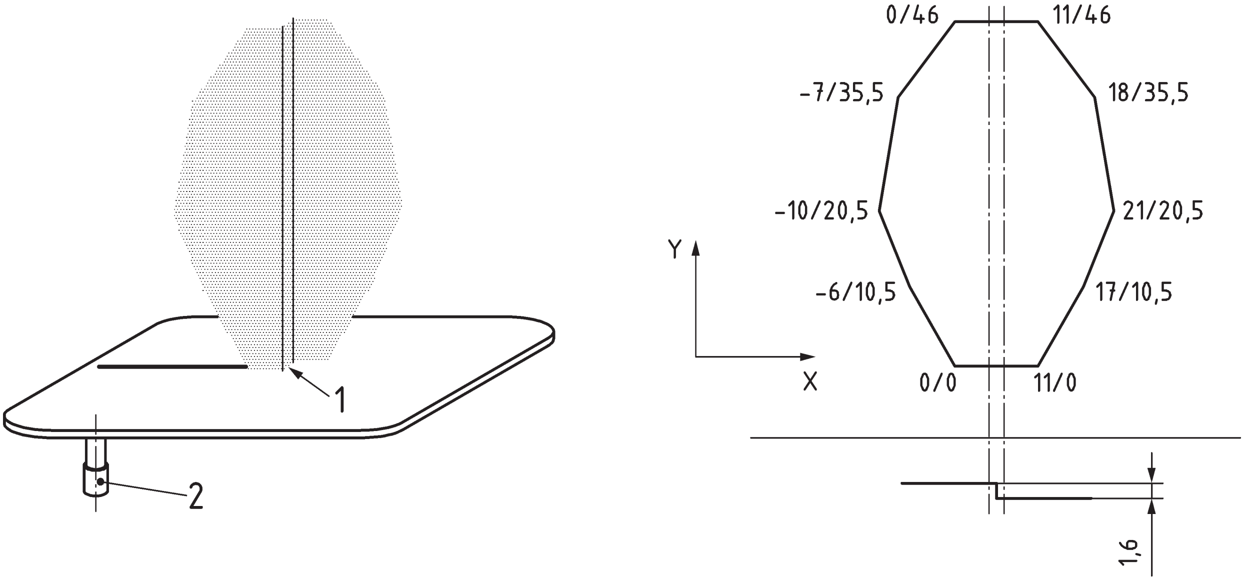
C.6.1 Typical characteristics

- Antenna bandwidth: 1 710 MHz to 2 025 MHz (min)
- Input impedance: 50 Ω
- Permissible power: 20 W
- Connector: Type-SMA
- Gain: Typically 0 dB ± 1 dB
- VSWR < 2:1 over the entire band.

C.6.2 Antenna construction and integration into casing

The antenna is produced from a type-FR4 printed circuit and supplied in its centre by a microstrip line. The radiating element consists of a single pole in the shape of a leaf placed vertically in relation to the ground plane. The geometrical characteristics of the assembly are indicated in Figure C.10a and C.10b.

The construction details of the casing are indicated in Figure C.10c.

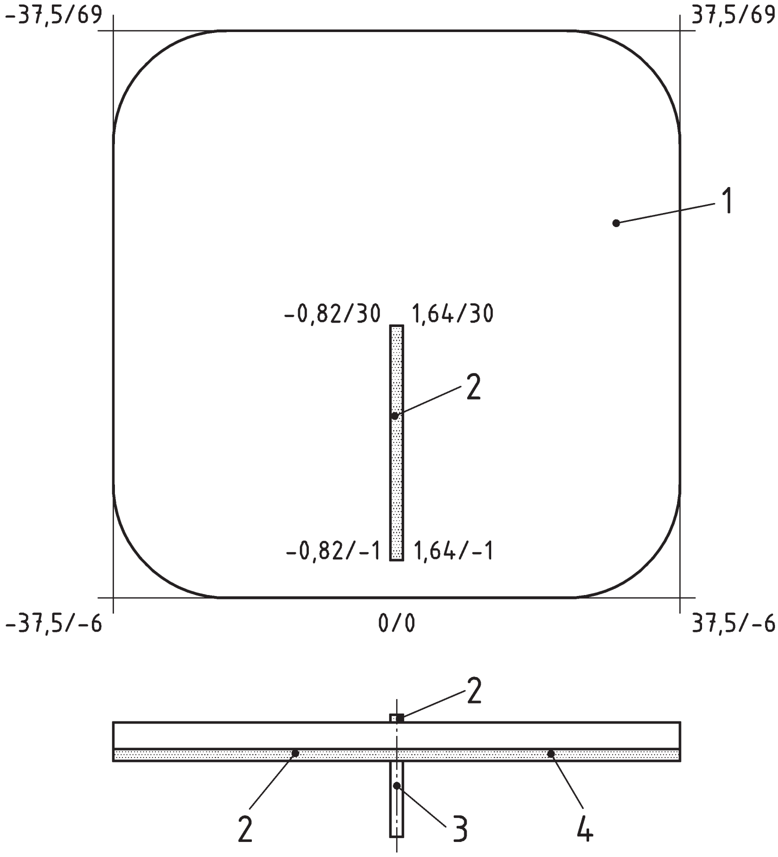


Key

1 Brazing

2 RG 402 + SMA female connector

Figure C.10a — Antenna geometrical characteristics — General



Key

1 card dimension 75/75 mm

2 copper (Cu)

3 RG 402 + SMA female

4 FR4 1,6 mm/35 µm Cu - ground plane on lower side

Figure C.10b — Antenna geometrical characteristics — Details

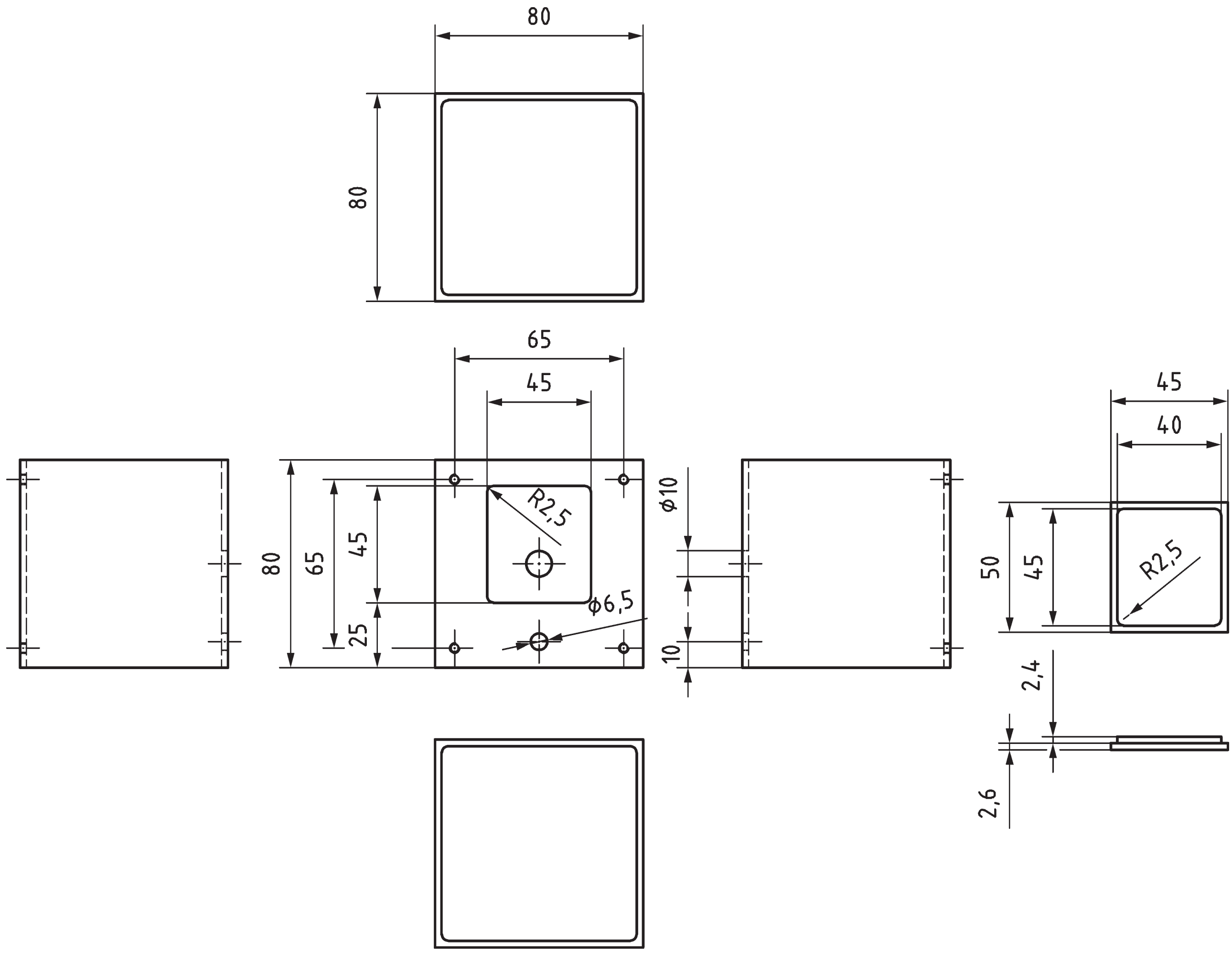


Figure C.10c — Casing construction — Details

C.7 Antenna for 2 402 MHz to 2 480 MHz frequency band

C.7.1 Typical characteristics

— Antenna bandwidth: 2 402 MHz to 2 480 MHz (min.)

— Input impedance: 50 Ω

— Permissible power: 20 W

— Connector: Type-SMA

— Gain: Typically

— 0 dB ± 0,5 dB at 2 402 MHz

— −1 dB ± 0,5 dB at 2 420 MHz

— −2 dB ± 0,5 dB at 2 440 MHz

— −3 dB ± 0,5 dB at 2 460 MHz

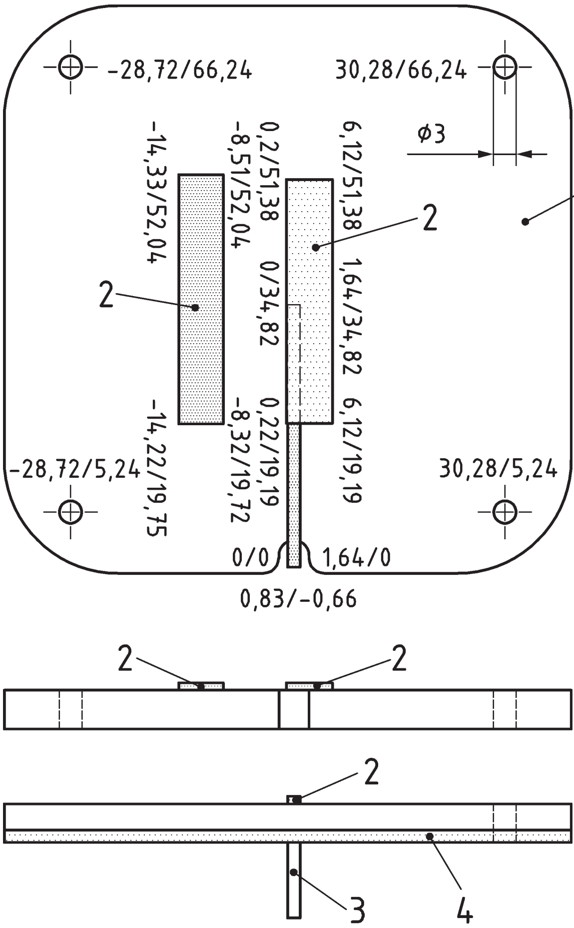
— −5 dB ± 0,5 dB at 2 480 MHz

— VSWR < 2:1 over the entire band.

C.7.2 Antenna construction and integration into casing

The antenna is produced from a type-FR4 printed circuit and supplied in its centre by a microstrip line. The radiating element consists of a printed dipole coupled with an interference dipole parallel to the first one. The geometrical characteristics of the assembly are indicated in Figure C.11a.

The construction details of the casing are indicated in Figure C.11b.



Key

1 card dimension 75/75 mm

2 copper (Cu)

3 RG 402 + SMA female

4 FR4 1,6 mm/35 µm Cu - ground plane on lower side

Figure C.11a — Antenna geometrical characteristics

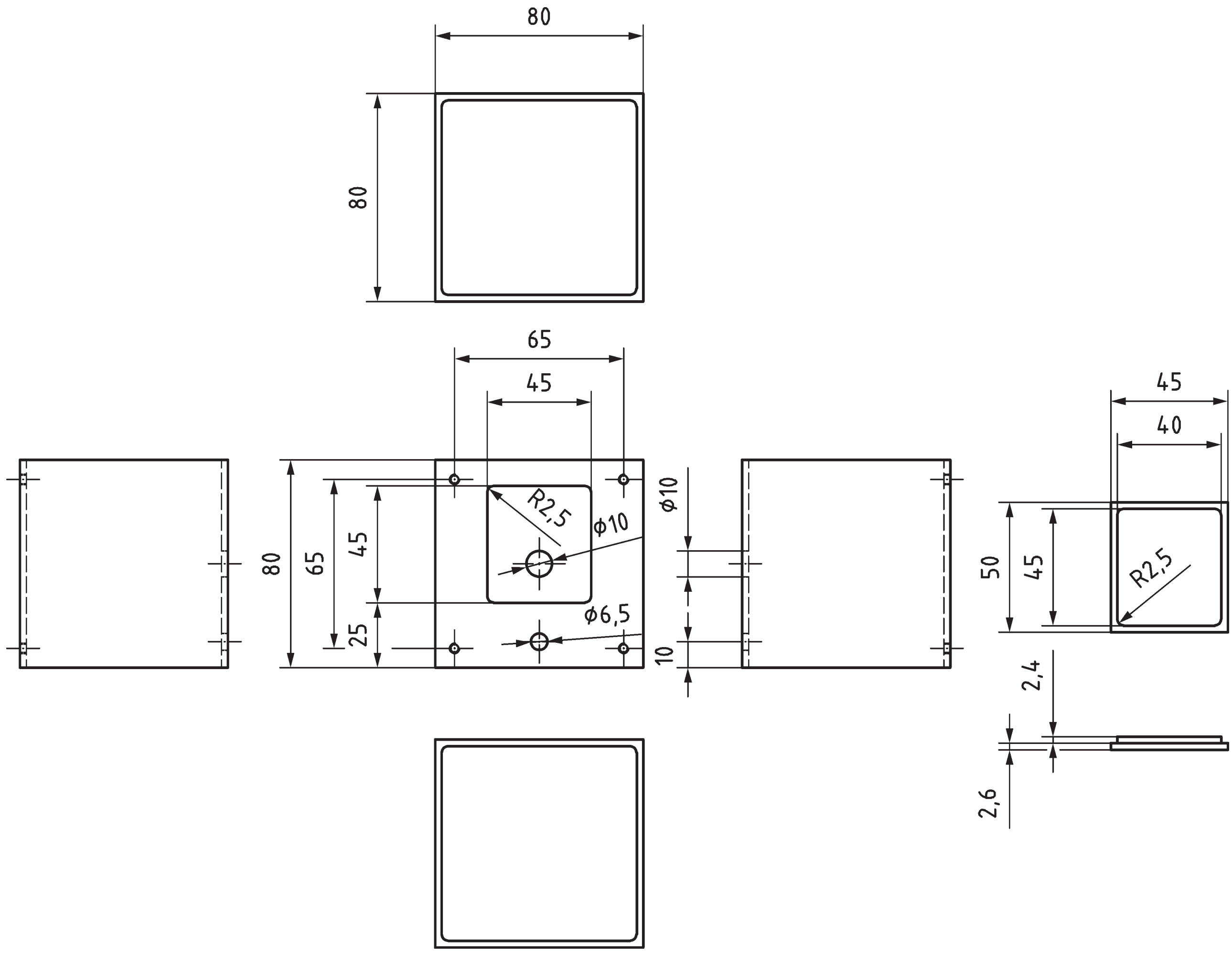


Figure C.11b — Casing construction — Details

C.8 Antenna for 26,96 MHz to 27,4 MHz frequency band

C.8.1 Typical characteristics

— Antenna bandwidth: 26,96 MHz to 27,4 MHz (min.)

— Input impedance: 50 Ω

— Permissible power: 50 W

— Connector: Type-SMA

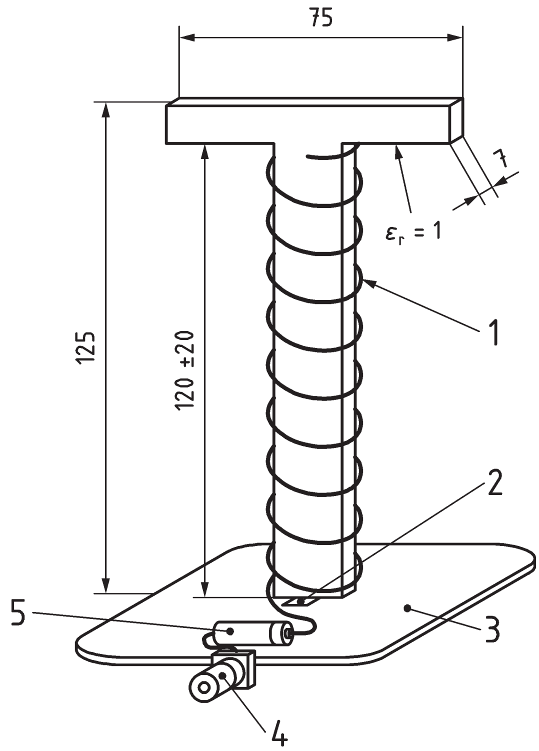
— Gain: Typically 0,5 dB ± 0,5 dB

— VSWR < 2:1 over the entire band

C.8.2 Antenna construction and integration into casing

The antenna is produced from a type-FR4 printed circuit and supplied in its centre by a microstrip line. The radiating element consists of a single pole at the bottom of which is placed a serial helicoidal coil as described in Figure C.12a.

The construction details of the casing are indicated in Figure C.12b and C.12c.



Key

1 coated copper wire - diameter 1 mm/710 mm (diameter of the winding, number of turns: 9 ± 0,5)

2 copper patch - dimension 5/5 mm

3 FR4 1,6 mm/35 µm Cu - ground plane on lower side - dimension 74/74 mm

4 BNC connector (EMERSON ref: VBM511–1502)

5 adjustable coil 20W (4 – 10 µH)

Figure C.12a — Antenna geometrical characteristics

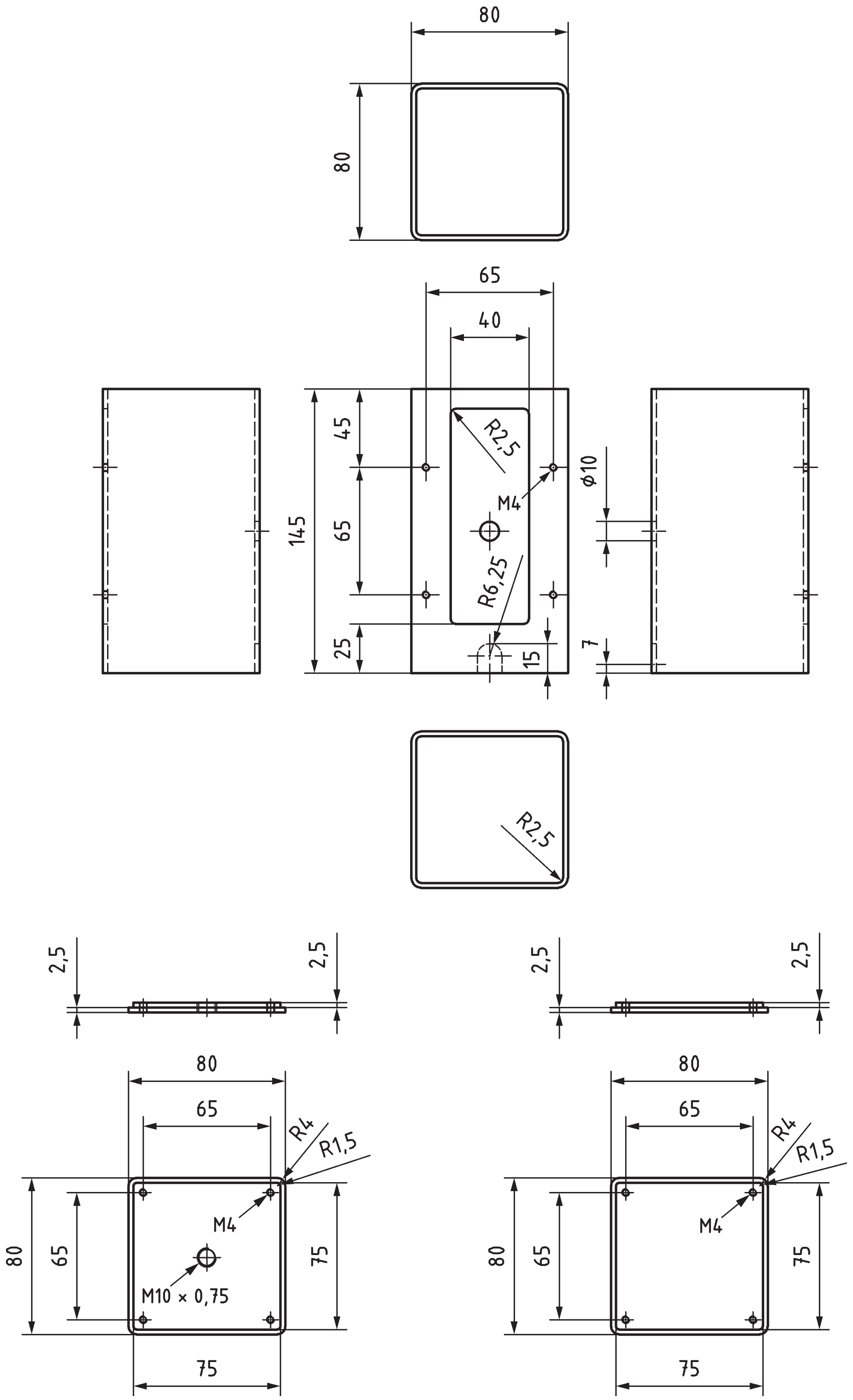


Figure C.12b — Casing construction — Details

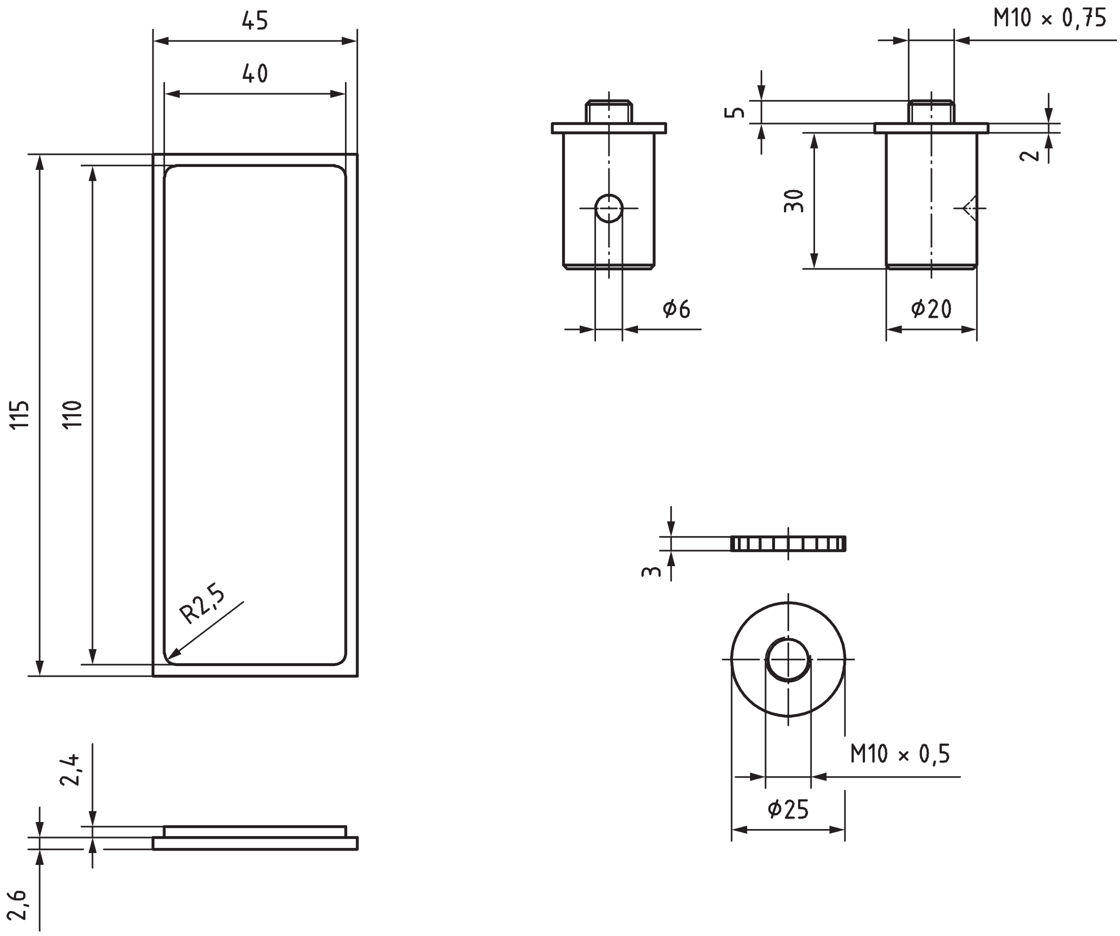


Figure C.12c — Casing construction — Details (continued)

C.9 Antenna for 144 MHz to 148 MHz frequency band

C.9.1 Typical characteristics

— Antenna bandwidth: 144 MHz to 148 MHz (min.)

— Input impedance: 50 Ω

— Permissible power: 50 W

— Connector: Type BNC

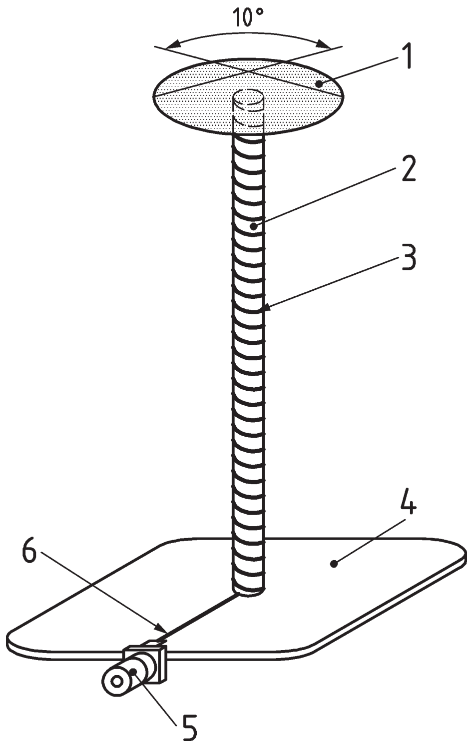
— Gain: Typically −13,5 dB ± 1 dB

— VSWR < 2,1:1 over the entire band

C.9.2 Antenna construction and integration into casing

The antenna is produced from a type-FR4 printed circuit and supplied in its centre by a microstrip line. The radiating element consists of a helicoidal single pole at the top of which is placed a perpendicular metallic cylinder as described in Figure C.13a.

The construction details of the casing are indicated in Figures C.13b and C.13c.



Key

1 brass cone diameter 50 mm - thickness 0,1 mm

2 PVC cylinder - ε_r = 3,3 – diameter 10 mm - length 127 mm

3 coated copper wire - diameter 1 mm/900 mm - number of turns: 29

4 FR4 1,6 mm/35 µm Cu - ground plane on lower side - dimension 74/74 mm

5 BNC connector (EMERSON ref: VBM511–1502)

6 microstrip line 35/2/0,8 mm

Figure C.13a — Antenna geometrical characteristics

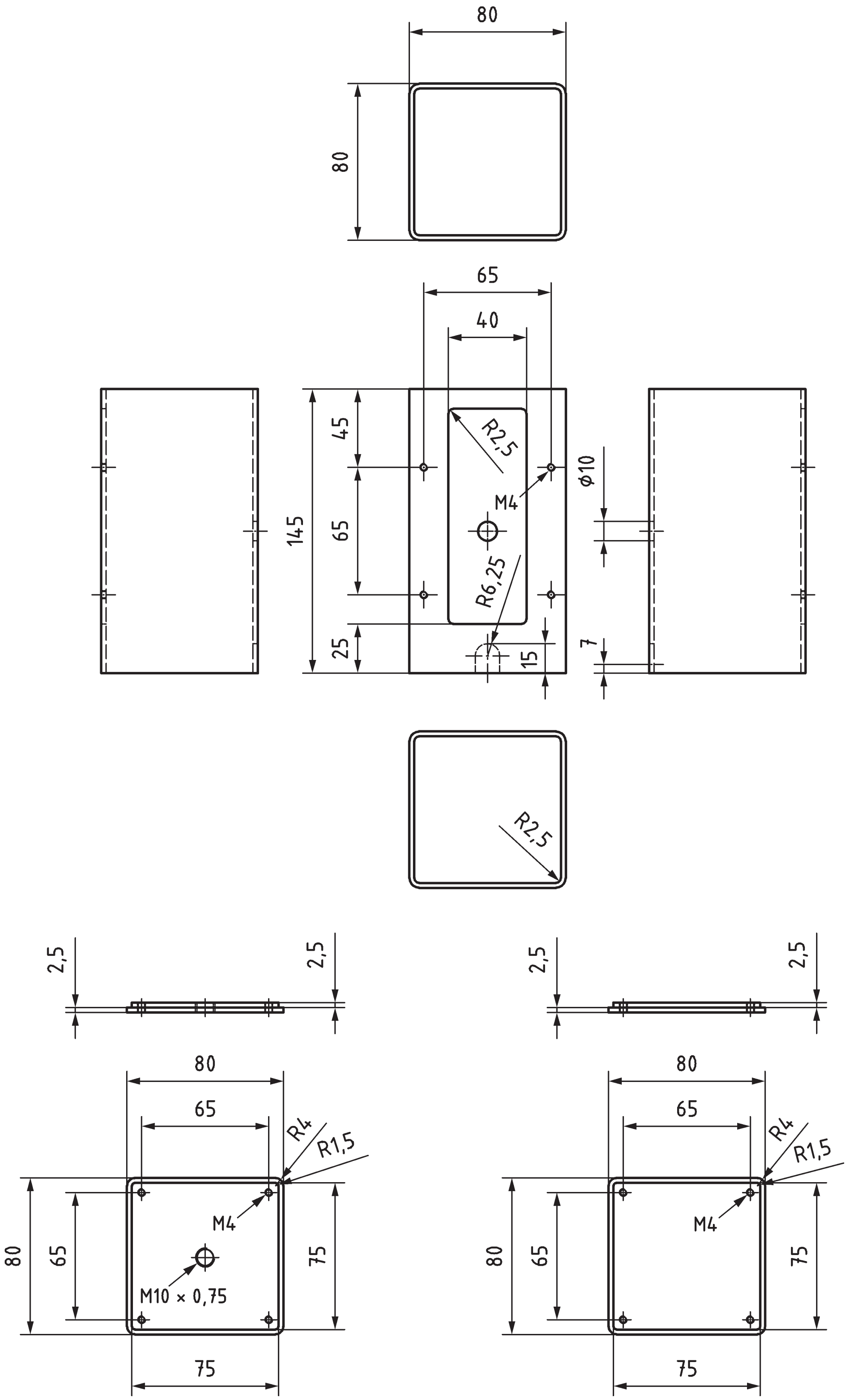


Figure C.13b — Casing construction — Details

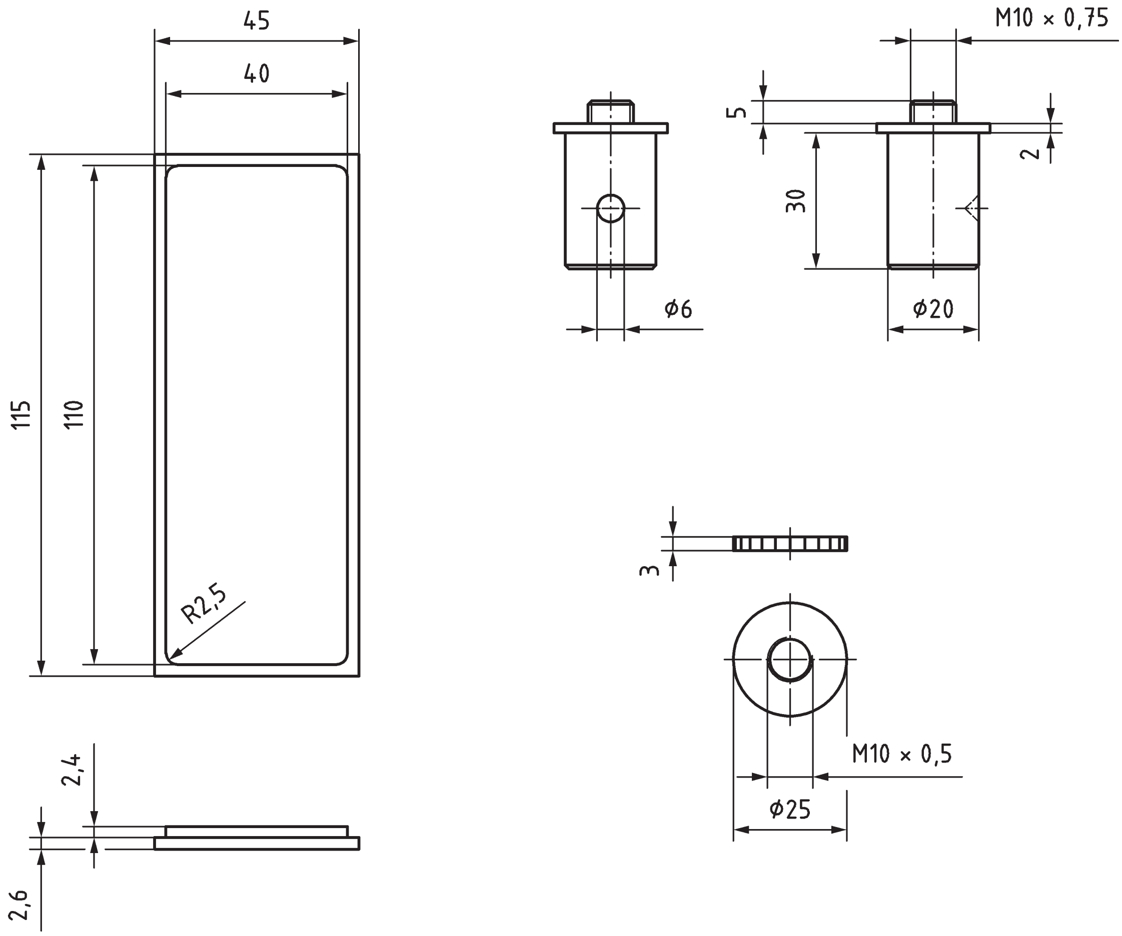


Figure C.13c — Casing construction — Details (continued)

C.10 Antenna for 168 MHz to 173 MHz frequency band

C.10.1 Typical characteristics

— Antenna bandwidth: 169,8 MHz to 173 MHz (min.)

— Input impedance: 50 Ω

— Permissible power: 50 W

— Connector: Type BNC

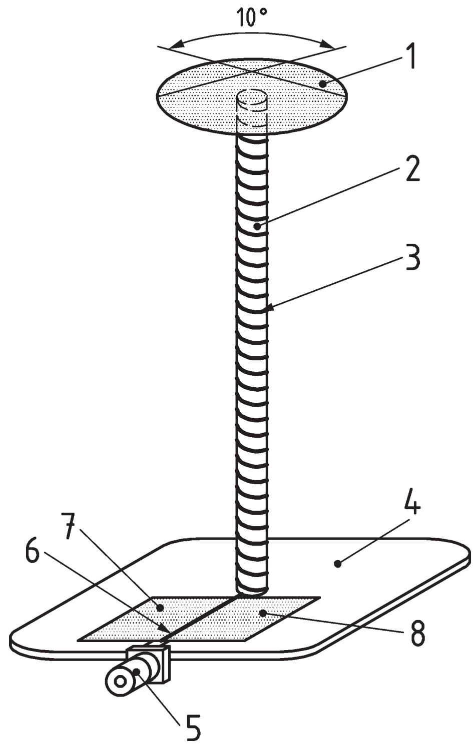
— Gain: Typically −16 dB ± 1 dB

— VSWR < 2,6:1 over the entire band

C.10.2 Antenna construction and integration into casing

The antenna is produced from a type-FR4 printed circuit and supplied in its centre by a microstrip line. The radiating element consists of a helicoidal single pole at the top of which is placed a perpendicular metallic cylinder as described in Figure C.14a.

The construction details of the casing are indicated in Figures C.14b and C.14c.



Key

1 brass cone diameter 50 mm - thickness 0,1 mm

2 PVC cylinder - ε_r = 3,3 - diameter 10 mm – length 127 mm

3 coated copper wire – diameter 1 mm/900 mm - number of turns: 29

4 FR4 1,6 mm/35 µm Cu - ground plane on lower side - dimensions 74/74 mm

5 BNC connector (EMERSON ref: VBM511–1502)

6 microstrip line 35/2/0,8 mm

7 C1 = 15 to 25 pF

8 C2 = 15 to 25 pF

Figure C.14a — Antenna geometrical characteristics

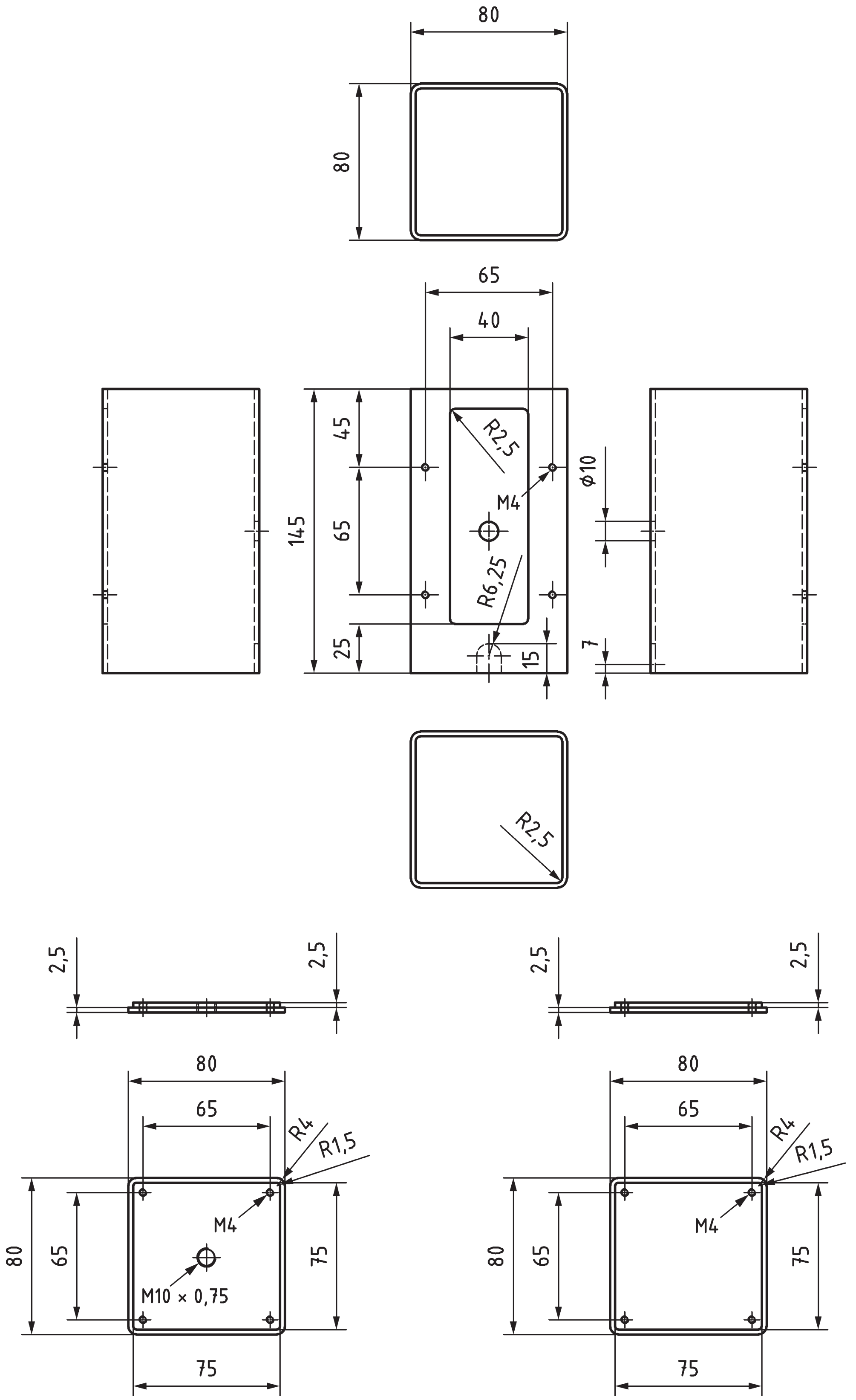


Figure C.14b — Casing construction — Details

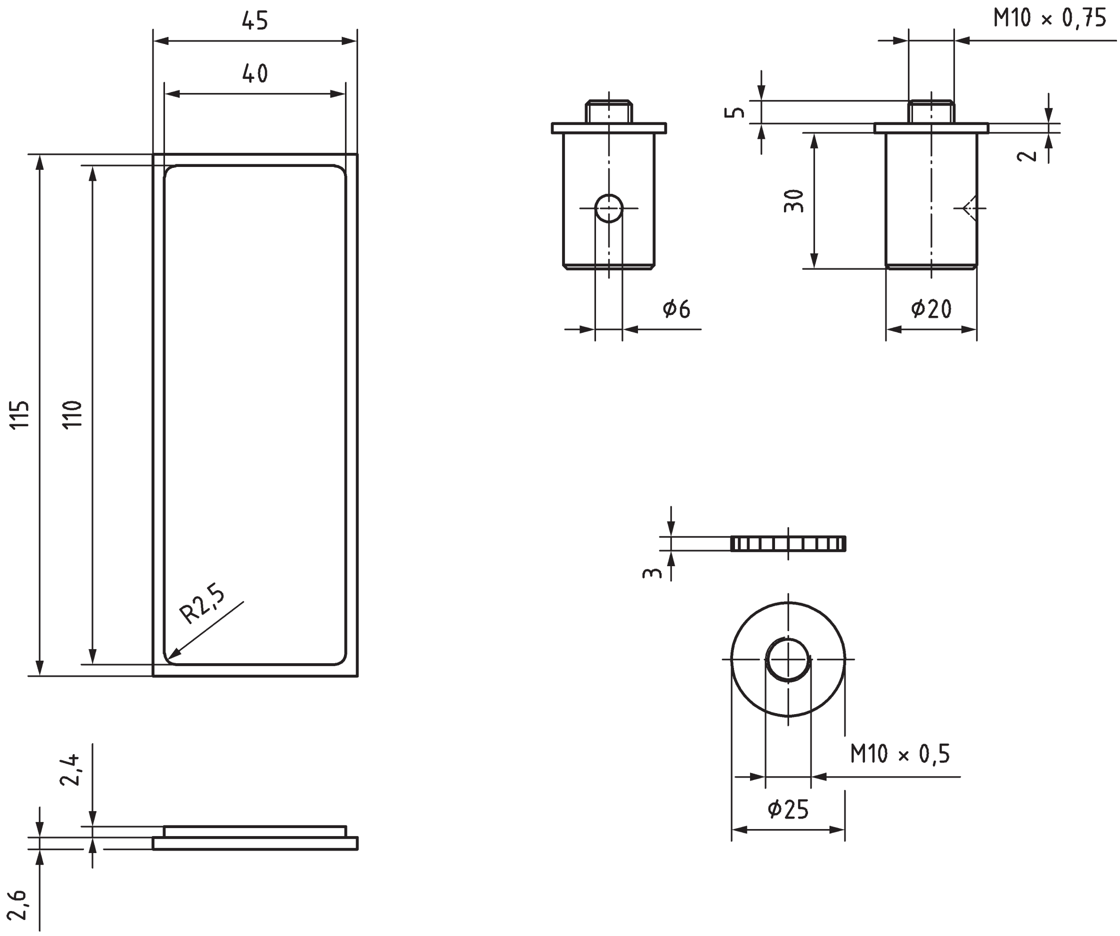


Figure C.14c — Casing construction — Details (continued)

C.11 Antenna for 380 MHz to 430 MHz frequency band

C.11.1 Typical characteristics

— Antenna bandwidth: 380 MHz to 430 MHz (min.)

— Input impedance: 50 Ω

— Permissible power: 50 W

— Connector: Type BNC

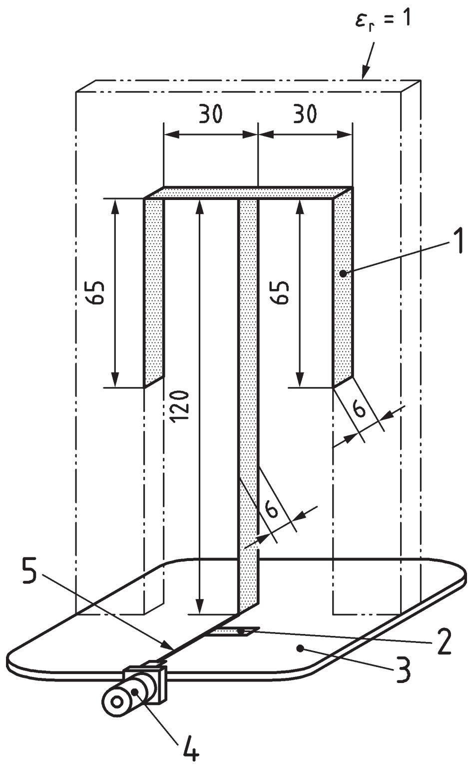
— Gain: Typically −9 dB ± 1 dB

— VSWR < 2:1 over the entire band

C.11.2 Antenna construction and integration into casing

The antenna is produced from a type-FR4 printed circuit and supplied in its centre by a microstrip line. The enlarged, symmetrically folded radiating element is as shown in Figure C.15a.

The construction details of the casing are indicated in Figures C.15b and C.15c.



Key

1 brass thickness 0,5 mm

2 stub 12/2 mm (for movement along microstrip line for frequency adjustment)

3 FR4 1,6 mm/35 µm Cu - ground plane on lower side - dimension 74/74 mm

4 BNC connector (EMERSON ref: VBM511–1502)

5 microstrip line 35/1,2/0,8 mm

Figure C.15a — Antenna geometrical characteristics

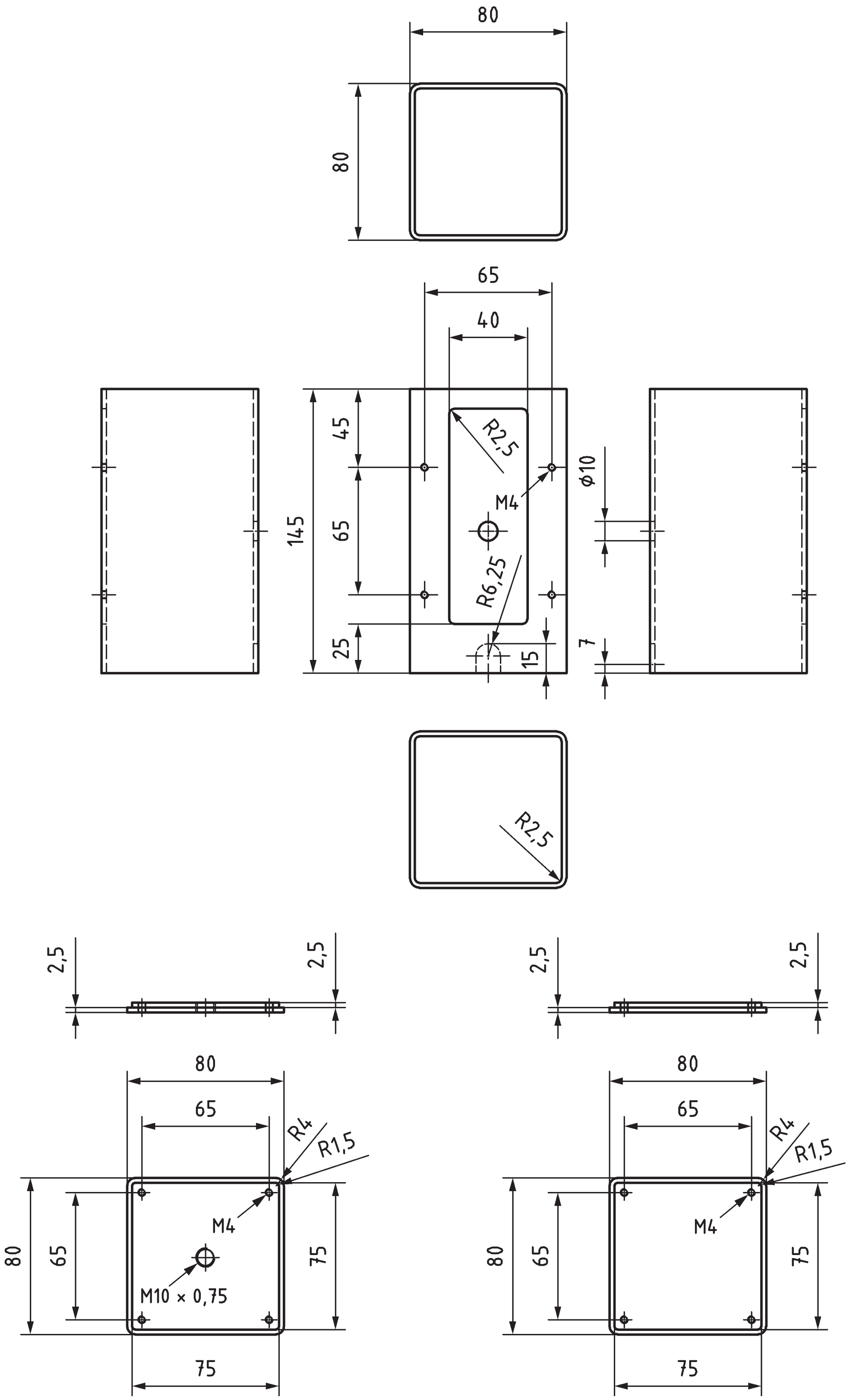


Figure C.15b — Casing construction — Details

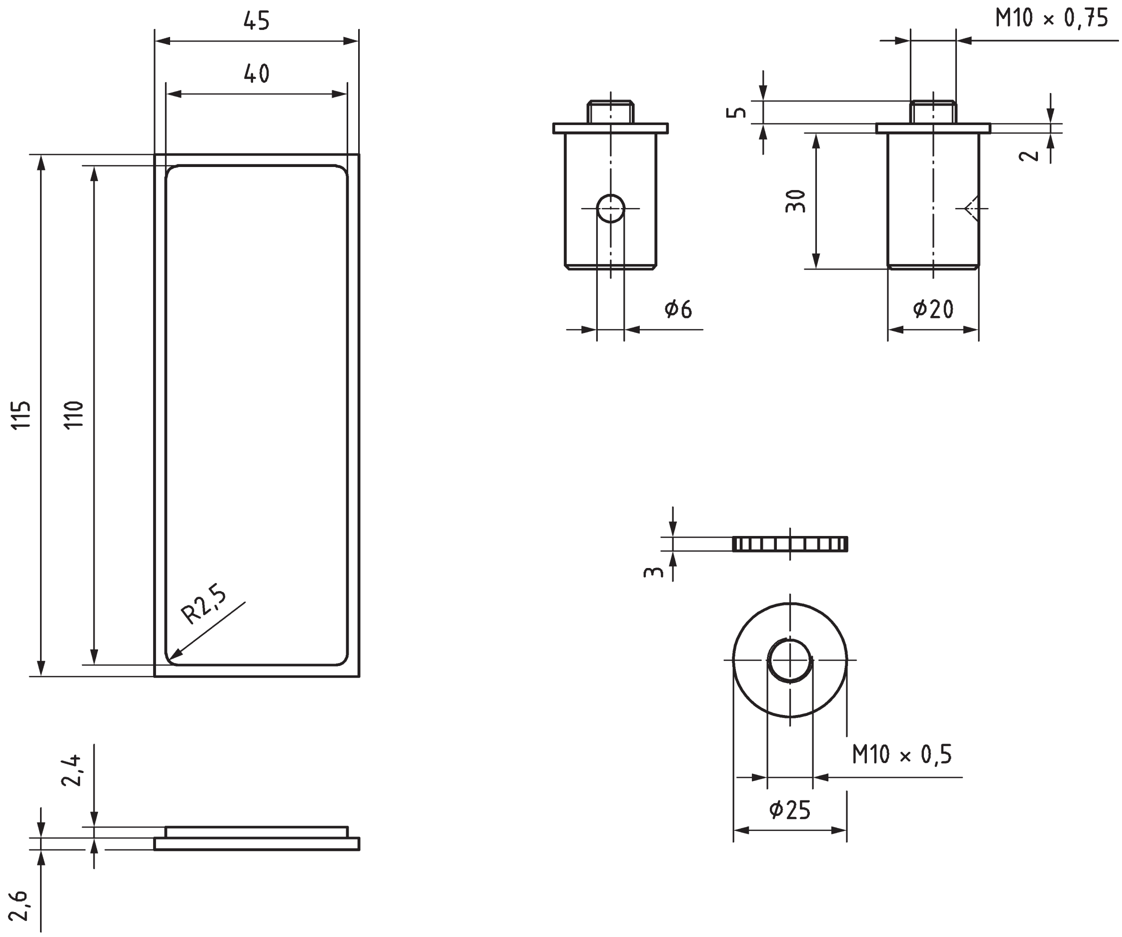


Figure C.15c — Casing construction — Details (continued)

C.12 Antenna for 430 MHz to 470 MHz frequency band

C.12.1 Typical characteristics

— Antenna bandwidth: 430 MHz to 470 MHz (min.)

— Input impedance: 50 Ω

— Permissible power: 50 W

— Connector: Type BNC

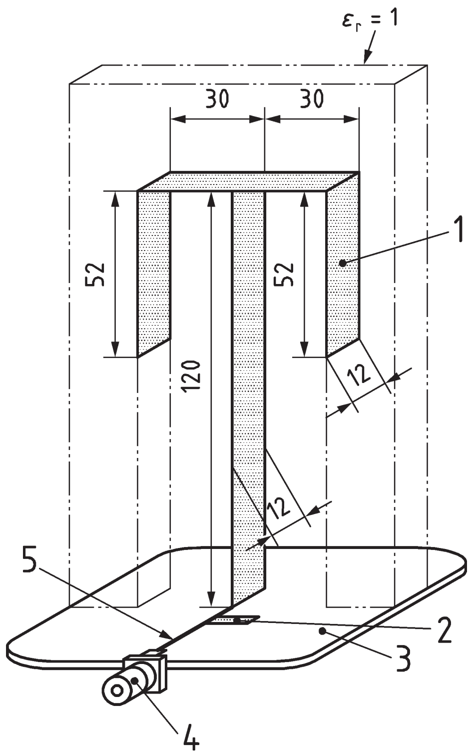
— Gain: Typically −8 dB ± 1 dB

— VSWR < 2:1 over the entire band

C.12.2 Antenna construction and integration into casing

The antenna is produced from a type-FR4 printed circuit and supplied in its centre by a microstrip line. The enlarged, symmetrically folded radiating element is as shown in Figure C.16a.

The construction details of the casing are indicated in Figures C.16b and C.16c.



Key

1 brass thickness 0,5 mm

2 stub 20/2 mm (for movement along microstrip line for frequency adjustment)

3 FR4 1,6 mm/35 µm Cu - ground plane on lower side - dimension 74/74 mm

4 BNC connector (EMERSON ref: VBM511–1502)

5 microstrip line 35/1,2/0,8 mm

Figure C.16a — Antenna geometrical characteristics

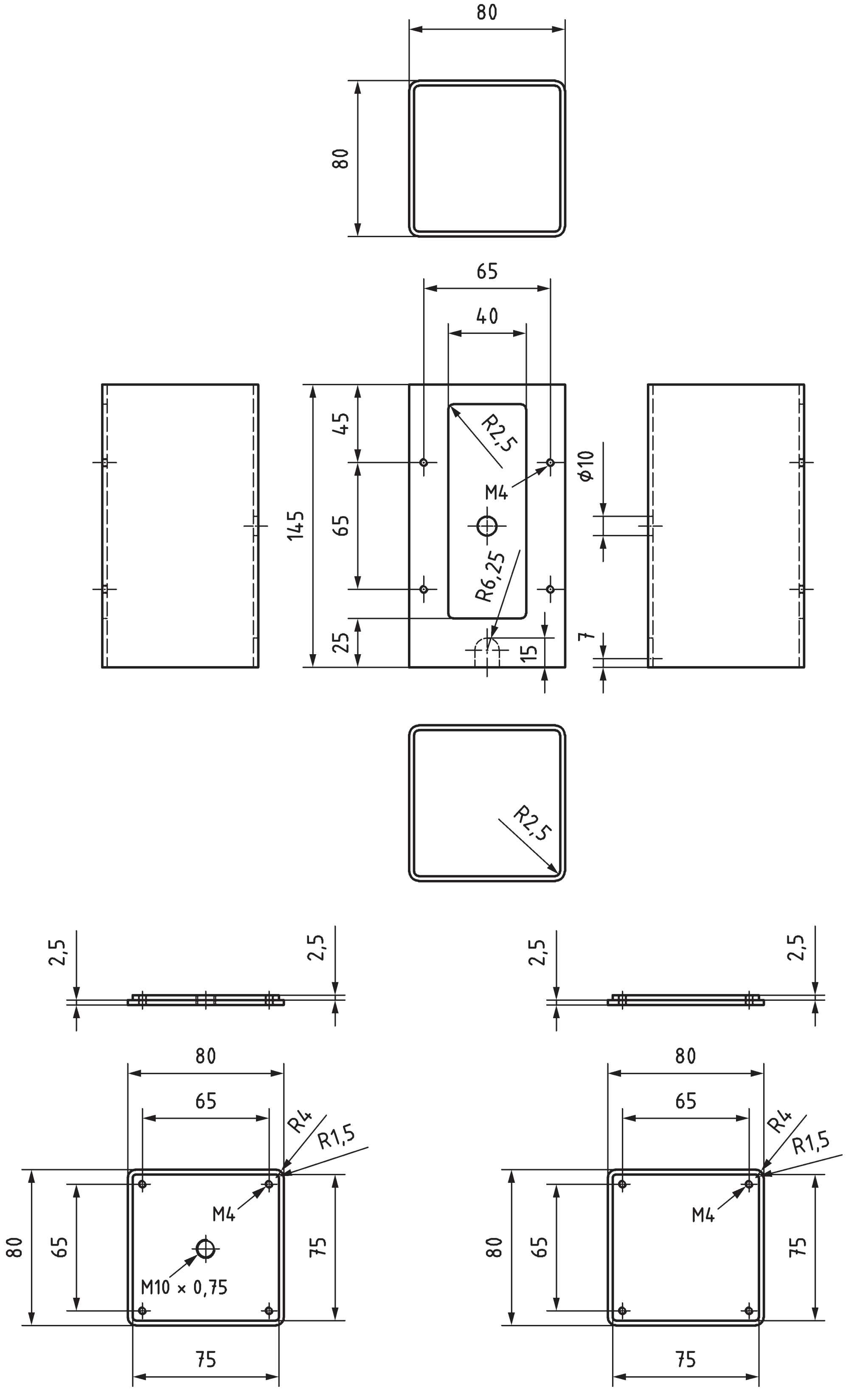


Figure C.16b — Casing construction — Details

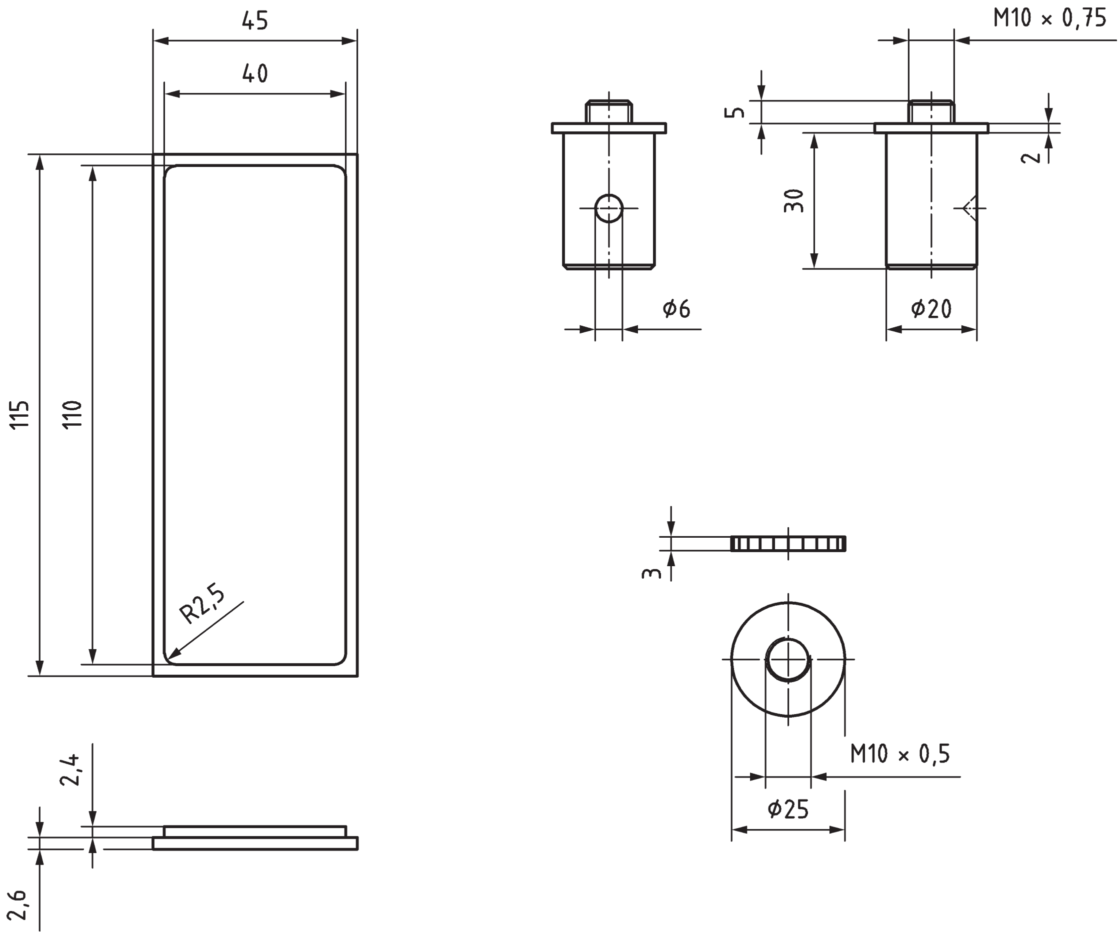


Figure C.16c — Casing construction — Details (continued)

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[2] Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz – 100 kHz) published in Health Physics 99 (6): 818-836; 2010

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