SDA short wave beam

Software Defined Antenna

Four selectable type directional patterns:

Omni directional

Omni directional stereo

Loop antenna

Beam antenna with variable gain

1. Introduction

In former days, the receiving antenna did not present any problem. One constructed an optimal sending antenna and automatically you had a fine receiving antenna.
Nowadays matters are considerably more complicated. The sending antenna should have maximal efficiency while at the same time a nearby strong noise source will not be a problem. Preferably the length is minimally in the order of half a wavelength.
For a good receiving antenna we have other demands. Efficiency is of minor importance. It is all about signal to noise ratio. It is important to stay away from noise sources. Now, that is easiest with small antennas. Besides, with interference and lots of traffic, it is sometimes very convenient to be able to suppress signals that you don't want to hear. A beam antenna is here a logical choice.

For short wave however this is – especially in the lower bands – a rather impractical method. A ten element yagi antenna for the 40-meter band is about 40 meters long! And on top of that it should be mounted rotatable. We do not dare to speak about the 80-meter band.
A structurally different approach is needed. The solution is the Software Defined Antenna. A compact antenna that – for receiving – combines the strong points of different types of antennas, including a beam.

2. The Software Defined Antenna system

The Software Defined Antenna system consists of an antenna linked with a special software defined short wave receiver. The processing of the information of the antenna requires such a specific approach that an integrated system of antenna and signal processing is necessary. In fact the antenna is a sensor measuring the EM-field in three dimensions and transferring the information to a triple receiver. By means of digital signal processing this information is then further processed in a PC.
The antenna is smaller than a cubic meter and can be mounted onto a mast. Because of the digital signal processing, the directional pattern of the antenna can be arranged as you wish. This can be an omnidirectional antenna or a rotatable loop- or beam antenna. As a beam antenna the gain can be set between 3 dBd and 12 dBd with an angular aperture between resp. 85˚ to 38˚. These are values comparable to yagi antennas of two to ten elements.
The function of the loop- and beam antenna can be combined so that, on top of the gain of the beam antenna, simultaneously interference from a certain angle can be suppressed. Obviously the wanted station and the noise source should come from different directions.

2.1 The antenna

The antenna is a sphere with a diameter of app. 80 centimeters. The antenna can be mounted on a mast directly; the rotation function is realized by software. Since this way of antenna rotation has no mechanical limitation, the desired direction can be chosen very swiftly. The mast top needs clean grounding but does not require a lower impedance than app. one hundred ohm. Grounding could also be realized via the shield of the antenna cable.
The impedance of the ground needs to comply with all wanted frequencies. If needed an extra radial is a possibility. It is essential that no noise e.g. from the shack via the shield reaches the antenna ground. Often this is the case and a good common-mode choke is necessary.
When the antenna is used in beam configuration the main lobe will be at zero degrees elevation (i.e. horizontal as with horizontally mounted yagi antennas). Short wave signals however will – with shorter distances – normally have considerably higher signal angles. In such cases a beam antenna will benefit only marginally. The signals will mainly or completely fall outside the main lobe. Moreover, with these signals often multiple paths are followed at the same time, so that with smaller angular apertures a major part of these signals will be missed.
On the other hand, the advantage of a beam antenna will be bigger when signals come from a larger distance making the vertical angle of the signals smaller. The lower the vertical angle – and so the further the DX – the bigger the advantage of a higher gain and smaller angular aperture.
At any moment the received signal can be compared with an omnidirectional antenna. Immediately the effect of the other directional patterns is visible.

2.2 The Software Defined Receiver

The system has three parts. Next to the antenna there is a convertor pre-processing the signals and sending them to a Control unit close to the PC. With this unit the receiving frequency and the direction of the antenna can be operated. The combined information from the Control unit is post-processed in a PC; where the special SDA software runs.
The receiver has a range of 3 to 30 MHz with detectors for LSB, USB and CW. There are six bandwidths available from 3100 to 300 Hz. Four for SSB and two for CW. Furthermore one can use an auto-notch and a noise blanker. The signal strength is shown in S-points as would be received in a half-wave dipole. In loop and beam mode the signal strength is of course also influenced by the directional pattern of the antenna.
The receiver has a test oscillator. As requested or when starting up the receiver automatically performs a calibration. Herewith the deviations of the analogue components are measured and subsequently digitally compensated.

2.3 Listening at short wave

Using a beam antenna at the short wave gives more complications than at VHF and higher. Taking this into consideration is important so that the implications are understood.
Suppose we set the antenna as a beam with a gain of 7 dBd. We then have an angular aperture of 50˚. What is the effect?
When we transmit with an antenna giving 7 dBd gain the result is rather predictable: the signal in the optimal direction of the receiver will be 7 dB louder in comparison with the use of a dipole. With receiving however the situation is more complicated. Admittedly, the station you are listening to from that direction will also be 7 dB stronger, but at the receiving end it is all about signal to noise ratio. The question therefore is: what happens with the interference? If it mainly comes from a different direction than the wanted signal, the interference will be weakened by the beam antenna e.g. 6 dB. Then the signal to noise ratio improves with 13 dB. A much bigger improvement than with transmitting.
On the other hand, if the interference comes from the same direction as the wanted signal, it will be amplified as well and the signal to noise ratio does not improve at all. In that case a beam antenna does not do any good. The results of short wave listening with a beam antenna are quite unpredictable. But most of the time the interference comes from many directions and the advantage will prove to be considerably bigger than just the antenna gain.
An other aspect of a beam antenna with short wave is the occurrence of a higher elevation angle as a result of the propagation by means of reflection via the ionization layers. It may occur that part of the antenna gain is lost because the elevation angle falls somewhat outside the angular aperture of a beam. Still this situation can be beneficial since the interference is more suppressed than the wanted signal. In this case the front-to-back ratio reduces as well. With very high angles it is no longer possible to determine front-to-back and the beam will only give attenuation.
All these aspects go also for physical beam antennas.

2.4 Pointing the beam antenna

Via software the three dimensional information from the antenna can be processed in such a way that it results in the properties of a beam antenna. The rotation of the antenna is electronic and therefore the SDA antenna can be fixed on a mast. This also gives the advantage that the antenna can be rotated over 360˚ with great speed. If the antenna would rotate slowly, as is the case with a physical antenna, the optimum by fading would be hard to find.
Furthermore it is special that it is possible that several beam antennas simultaneously can be pointed to different directions. While the chosen signal is received, at the same time, two beam antennas that are set 20° left and right of each other, can be measured. In this way it can be achieved that the antenna always follows the optimal direction. Here the mode 'TRACKING' can be set. Then automatically the direction of the signal within the angular aperture will be followed. This can be handy to reduce fading originating from fluctuation of the incoming direction, especially when a small angle is set.
Besides the function 'SIGNAL DIAGRAM' can be switched on. Now a beam antenna is created that rotates 360° ten times per second. With each rotation the antenna measures the field strength every eight degrees and places the readings in the azimuthal map. Hereby one can see, in real time, the direction of all incoming signals whilst the antenna for the receiving signal is normally audible. This can be very useful to quickly see the direction of the wanted incoming signal. When lots of signals or interference from all directions is incoming more or less a circle is shown. But when a moment the wanted signal is fractionally stronger a protrusion in the circle occurs so it's clear how the antenna should be pointed. This can also be done automatically with the function 'AUTO FOLLOWING'. The beam then automatically follows the direction of the strongest signal; handy for a round table.
On top of that a useful extra tool here is the mode 'ROTATE'. In this mode the beam antenna will automatically rotate with a considerably lower speed of approximately five seconds per rotation. In this case the received signal from the rotating direction is audible and by ear one can determine from which direction the several signals are coming.
So, all-in all, four different beam antennas can simultaneously yet independently work at the same time.

2.5 The directional pattern

The directional pattern of the SDA antenna in the vertical plane is equal to the one in the horizontal plane. The pattern consequently has the form of a cone. With a horizontal angular aperture of 60˚ the angular aperture in the vertical plane is also 60˚. This means that when signals with a vertical angle of 30˚ are received, the gain of the antenna has decreased by 3 dB. Accordingly, in this example it will be counter productive when the gain is set higher than 7 dBd resulting in a lower angular aperture of the antenna.

Although the gain increases, the signal then arrives next to the main lobe which results in attenuation. Yet most of the time this will be advantageous; though the signal gain is less, unwanted signals are more repressed giving an improvement with higher vertical angles. With this kind of higher angles less dissimilarity will occur between front-to-back, with the subsequent lower front-to-back ratio of the antenna.
With DX and the according low elevation angle however, the beam antenna – especially when a higher gain is set – will be at an advantage. Next to that, signals are created by ground-reflection, making the incoming angle appear to be lower (also see 2.5.1).
As with every beam antenna there is a connection between antenna gain and angular aperture:

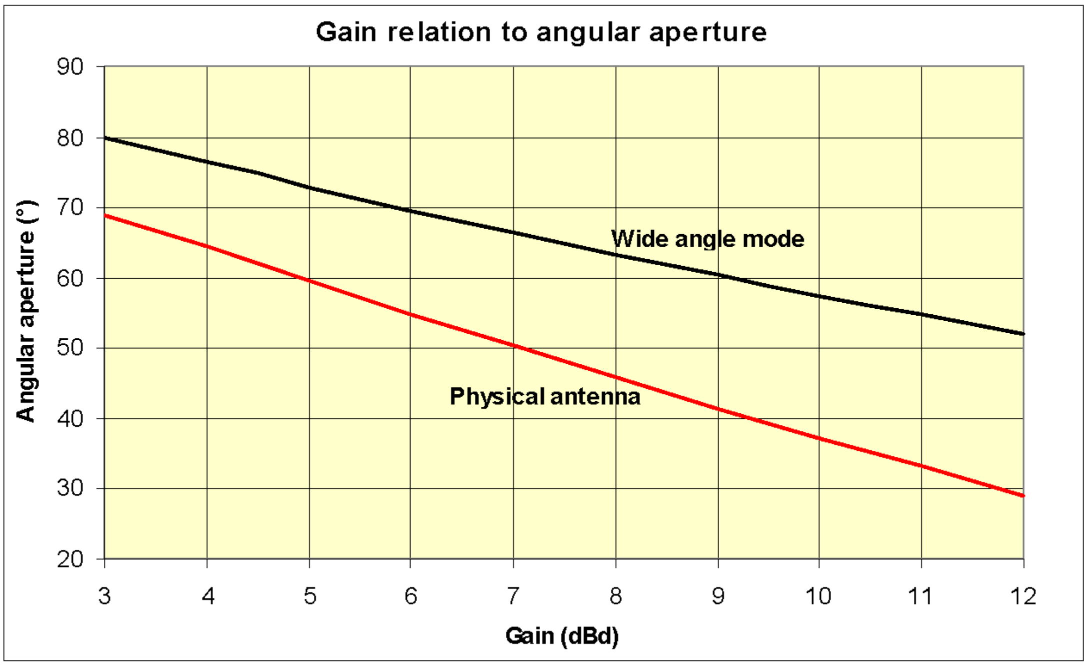


Figure a. Setting the gain of the antenna higher reduces the angular aperture.

As an extra feature the system has a wide-angle mode. With a high gain a physical antenna can not cope with a big angular aperture. But with a simulation by digital signal processing this is quite possible. In this 'Wide angle mode' therefore a higher gain can be set without resulting in a very small angular aperture. Thus with such a beam antenna, in some cases, one can still profit from a higher gain.

Of course this affects the performance, because signals from a wider angle are now amplified as well. When however, most interference falls outside the wider angular aperture this setting can be beneficial.

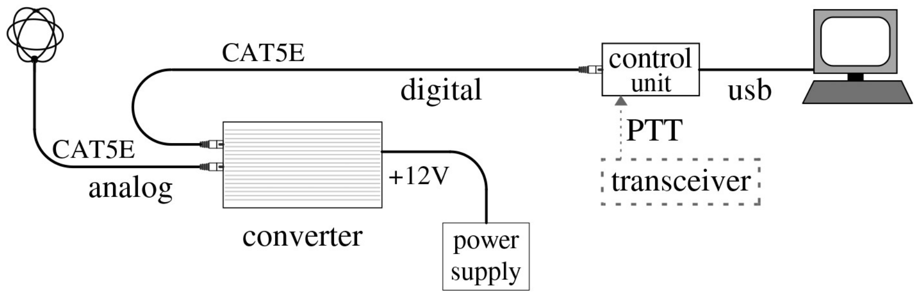
There is an other aspect that plays a role. Often multiple propagation paths alongside one another are possible. The effect here is that the signal arrives from several parallel directions at the same time. Now it gives the impression that the antenna has a wider angular aperture and in these circumstances it usually has no use to reduce the angular aperture in order to increase the gain, unless a specific noise source can be suppressed.

2.5.1 Ground-reflection

A side effect is ground-reflection. For somewhat lower elevation angles the antenna is sensitive for vertical polarization. When a vertical polarized radio wave reflects the phase does not invert. This implies that when the antenna is not mounted that high, the direct and from the ground reflected wave, arrive together at the antenna almost in phase.
When the reflection were not attenuated, the resultant of both signals would approach an incidence angle of zero degrees. In reality the reflection will be attenuated, depending on the type of soil. This leads to a higher angle of arrival of the radio signal of the resultant.
In general the angle of arrival will be lowered by the ground-reflection and the advantage of a beam antenna will be greater.

3. Installation of the system

The system consists of four parts: the antenna, the converter the Control unit, and a PC (with speaker). The antenna is connected with the converter by means of a CAT5 shielded LAN-cable. The converter is linked via a second CAT5 shielded LAN-cable to the Control unit. The Control unit is placed next to the PC and is connected with a usb cable. For the converter a power supply (12V/2A) is needed. A connection to the PTT connector of a transmitter is possible. During transmission the receiver is then switched off. This PTT connection is located on the Control unit. Be aware that if the sender is connected via PTT and the transmitter is switched off, the SDA can be switched off as well.



The cable between the antenna and the converter is preferably not longer than 30 meters and the length of the cable between the converter and the control unit, not longer than 20 meters. First the location where the antenna is best placed is determined. As far away as possible from noise sources and metal parts that can locally distort the EM-field. Then follows the location for the converter. It would be nice when the converter can be placed in the shack, but often at this point the antenna cable is not long enough. Then the solution is to find a useful spot closer to the antenna. From this spot the cable runs from the converter to the shack adding another 20 meters. The control unit and the PC with speakers can then be placed in the shack.

3.1 The antenna

The antenna can, without rotor, be mounted directly onto a mast. On the antenna the orientation (N) is indicated. Because of the relatively small dimensions of the antenna, the EM-field is also picked up in smaller spaces. Local distortion of the EM- field can have considerable impact on the way the antenna measures the field. This is not necessarily a problem, but when the antenna is used as a beam the direction of the signal can seem to diverge.
Therefore it is of importance to keep metals away from the antenna as much as possible, especially when they can come in resonance with operational frequencies.

3.1.1 Height

The signal strength will give good results with low antenna heights because the magnetic registration has the upper hand. The antenna will however give the best directivity in free space. This is of course not a realistic option; the ground is always nearby. The question then arises: what is the optimal antenna height in relation to the front-to-back ratio. In general one can state that a quarter-wave is a good height. Also three quarters of a wave length, five quarters, etc. are optima. Avoided should be heights close to the ground and heights of half a wave length and multiples of this. For sure, the influence of the ground diminishes with increasing heights and frequencies.
If a good directivity from 3 MHz and higher is desired, then a height of 6 meters is a good choice. With this antenna height the directivity between 24 en 26 MHz slightly falls back.
If 3.5 MHz and above is sufficient, a height of five meters should be sufficient for good directivity. From 30 MHz directivity will decrease admittedly, but the 10m band is still operable. Eight meters height has only a slight decrease around 19 MHz, but is good for all other amateur bands. Higher than 12 meters no problems are expected.
Another phenomenon also plays a role. As known, signals that reach the beam antenna with a higher vertical angle of arrival are received less well. But, with smaller angles of arrival the antenna is sensitive for vertical polarization. In this case the phase of these signals will, with reflection against the ground, not be inverted. The resultant of direct and reflected signals consequently has a lower angle of arrival. With 100% reflection in theory almost zero degrees. Thus, signals with a higher angle of arrival give a better result with the use of a beam configuration.

3.1.2 Grounding

The antenna needs a ground system. It does not really require low resistance to earth. An impedance of about one hundred ohm is sufficient for the relevant frequencies. Lower of course is always better.
For this grounding some special demands are required: resonance at frequencies in the range of 3 to 30 MHz should be minimized and ambient noise must be avoided.
It is therefore wise to follow the installation directions for the antenna and the cable. (https://sd-antenna.com/installation_instructions).

3.1.3 Correction of the electromagnetic field

Electric conductive parts can distort the electromagnetic field, especially in the case of resonance. Standing waves in the shield of the antenna cable can also cause this. Since the antenna is relatively small, local distortion can have a considerable influence. Most of the time this implies that the measured direction of the signal deviates slightly. So with choosing the location of the antenna it is advisable that it is as free as possible from these influences.
One can correct the deviations by mapping and compensating the distortion of the electromagnetic field. To achieve this a small beacon transmitter that generates a signal between 3 tot 30 MHz can be placed at a distance of 10 to 30 meters (4.4.3). Starting from the antenna the position of the beacon can be established accurately with the help of a compass or with Google Maps or a well known point of reference.

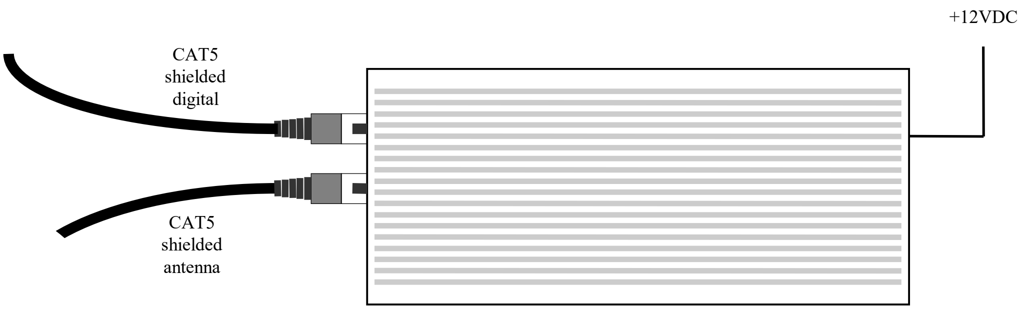
When the function ‘Calibrate antenna’ is activated the Software Defined Antenna system asks for the position of the beacon in degrees. Next, the system measures the distortion from the perspective of the beacon. This process can be repeated, with a maximum of four times, to map the distortion further, with as many as possible different angles in the beacon. Advantageously (among other things) an important direction for DX can be chosen. The measured distortion is stored on hard disk and can then subsequently, as well as possible, be compensated for reception.

3.2 The antenna cable

The antenna is connected with the converter via a shielded CAT5 LAN-cable. The shorter the LAN-cable, the better. Up to a length of 20 meters reception will be good. With lengths to 30 meters performances for the higher frequencies can somewhat decline. One thing or another depends on the atmospheric noise level. An other solution to realize a shorter antenna cable is choosing a handy spot for the converter.
The installation of the cable asks for special skills. The shielding of the cable is connected with the antenna and influences its grounding. Environmental disturbance leading to the antenna should be avoided, as well as resonances over the cable shield, and also unwanted signals induced via the shield.
It is therefore wise to follow the installation guidelines for the antenna.
(https://sd-antenna.com/installation_instructions).

3.3 The converter

The converter supplies the power for the antenna via the shielded CAT5 antenna cable. The converter itself is connected with the Control unit via a second shielded CAT5 cable. Finally the converter should be powered with 12 VDC.



The converter has no controls. Since the length of the antenna cable is preferably not too long the converter can be placed closer to the antenna in an appropriate housing.
The heat development in the converter can be considerable – especially with higher frequencies – so a cool place with ventilation is recommended.

3.4 The Control unit

The Control unit is digitally connected to the converter. This unit holds most controls and is situated next to the PC in the shack. This device has a rotary knob and a number of switches. The PC is connected via a usb-connection.
Besides, the Control unit can be connected to the PTT-connector of a transmitter, enabling switching off the receiver and the antenna during transmit, thus protecting the system. Pay attention to the fact that when the PTT-facility is connected while the transmitter is switched off, mostly the SDA-system will be shut off as well.

3.5 The computer

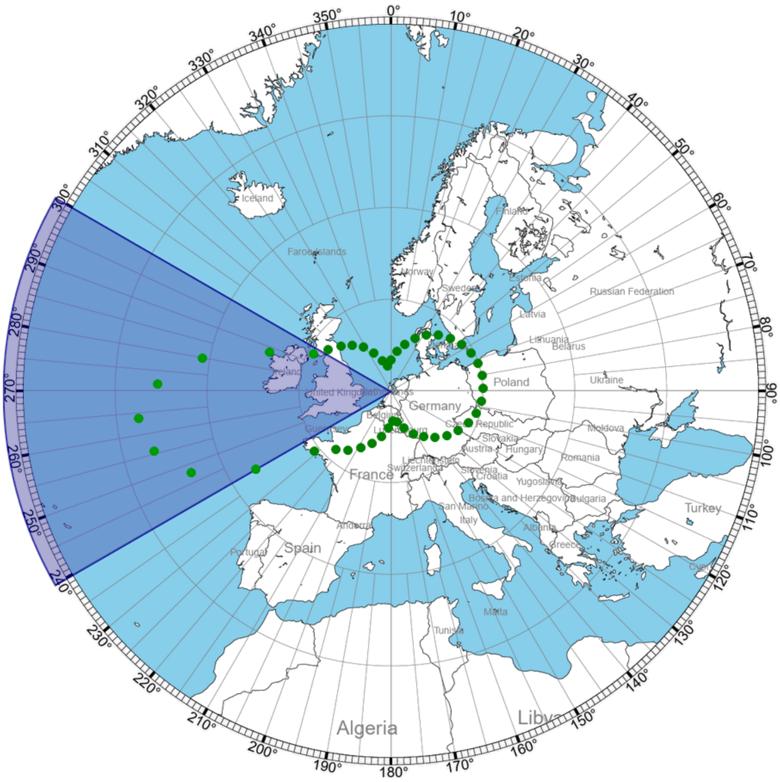
The main part of the software of the SDA runs in a PC. A suitable PC is required. Handling and signal processing are controlled here. The information exchange runs via a usb-connection. The audio output can be connected to one or two loudspeakers.
Prevent the data stream from coming in when the computer is booted. Only switch on the converter after the computer has booted.

4. Functionality

4.1 The antenna

From the PC the antenna can be set to omnidirectional antenna, as rotatable loop antenna or as beam antenna.
When omnidirectional antenna is selected it is also possible to listen ‘spatial’. The spacial property of the electromagnetic field is transferred to a spatial stereo signal. Although the signals from all the directions are audible, it is still possible to focus on certain signals from a specific angle. Much like focusing on a certain sound in a big noisy hall.
When rotatable loop antenna is selected, local interference can be reduced by turning it in the dead angle of the loop. Signals with high angles of arrival are not affected.
In case a beam antenna is selected, the desired gain can be set between 3 dBd and 12 dBd. Opting for a higher gain will reduce the angular aperture. Signals arriving with a higher angle of arrival will consequently be limited in gain, since those signals will fall outside the main lobe of zero degrees elevation. Here one can choose for ‘Wide angle mode’. Then the angular aperture is maintained wider to receive signals from higher angles of arrival with a somewhat higher gain. Obviously this wider angle affects the performance. No doubt, the antenna will amplify more unwanted signals as well.
Finally a combination of loop-and beam antenna is also possible. Making it possible to turn a specific local noise source in the null direction while at the same time a wanted signal from another direction is amplified by the beam.
An omnidirectional antenna seems simple, but on the contrary it is not. It is very difficult to make an antenna that nowhere has any cancelation. These antennas are hard to be found. If this kind of antenna is chosen for SDA, curious effects can occur. With local stations with a high radiation angle, more paths can easily be created. A phase difference with equal amplitude can lead to nearly total cancellation because the antenna is equally sensitive all around. In case of local QSO’s it is therefore better to go for a loop antenna or for stereo mode.
Not only the radiation pattern can be determined via software, multiple independent antennas can be ‘constructed’ at the same time. The number of simultaneous antennas that can be constructed is solely limited by the computing power of the PC. For a common computer four antennas can be put in use at the same time. Hence three beam antennas can be active simultaneously; the desired signal and two beams 20° left and right of this direction measuring signal strength. In this way ‘Auto tracker’ can be realized. With this function switched on, when a signal within the angular aperture is received, the antenna will try to follow small variations in the signal direction caused by propagation. Resulting in decrease in fading. Moreover (if desired during Auto tracking) a fourth antenna can be used. While the signal from the chosen antenna mode is audible, a beam antenna rotates ten times per second. While during each revolution every eight degrees the strength is measured, on the azimuthal map the signal strength is plotted: the Signal diagram.
When the received signal has a somewhat lower angle of arrival, far from the noise level and the frequency furthermore is clean, the radiation pattern of the antenna itself is visible because no other signals are coming in.

In this example the station Shannon Volmet at 13.264 MHz is audible and visible from the Netherlands. Around the clock, this station sends meteorological data from the south-west of Ireland near Shannon airport.



It is visible that at this moment the signal is received from an angle 12 degrees lower than the transmitting station. This is not exceptional; the reception of radio signals varies constantly. In some cases the signal can even come from the most unexpected directions (e.g. because of back scatter).

When multiple stations from different directions are alternately listened to (e.g. during a round table), the function ‘Auto following’ is handy. Here, the beam automatically follows the strongest signal, based on the Signal diagram.

On top of that the antenna can, in beam mode, automatically rotate with app. five revolutions per second whilst per revolution the directional pattern of the revolving antenna is audible; again with the option that the Signal diagram is shown at the same time. In fact two independent revolving beam antennas are then active.

When the PTT-function is activated, all antenna functions are shut down. Settings like Auto tracking are put ‘on hold’.

Ten antenna settings with their frequencies and modes can be saved and later on recovered. This makes it possible to change quickly between stations from different directions and frequencies. Via the keyboard data can be saved with the keys shift F1 t/m F12. Without shift, the keys F1 t/m F12 retrieve the data.

4.2 The receiver

When the system is installed correctly, the receive range of the system is 3 to 30 MHz. The receiving system is handled from a Control unit and a PC. The operational frequency can be set in kilohertz and after a decimal point in a resolution of 10 Hz. The frequency is shown on the screen. With a transmitter or a time base with a reliable frequency, the time base of the SDA can be calibrated. From this moment onwards the frequency is corrected for this deviation. For this kind of less occurring functions a background page is available. (DETAILS).
For frequencies lower than 10 MHz in mode AUTO, LSB is automatically selected and for higher frequencies: USB. This selection can be overruled by manually setting LSB or USB. Finally one can go for mode CW. The bandwidth can be set to 3100 Hz, 2800 Hz, 2500 Hz, 2200 Hz, 1100 Hz and 300 Hz. The CW tone is 1000 Hz. These functions are available on screen via the mouse. The bandwidths for 1100 and 300 Hz are intended for CW and therefore centered around 1000 Hz.
If it turns out that an annoying interference tone is audible, AUTO NOTCH can be switched on via the mouse. It will search for the interference tone and suppress it. In principle it also works with several tones at the same time.
If ignition noise hampers reception the noise blanker NOISE BLANK can be used via the mouse. This will reduce the hindrance of this type of noise.
With the mouse there is also the possibility to attenuate the RF-signal with 6, 12 or 18 dB. In case of extremely strong signals intermodulation can be avoided or reduced. While switching the RF attenuator, the amplification is compensated, so the S meter is not affected because of the use of this attenuator.
If desired ten frequencies with related modes and antenna settings can be stored and later retrieved. This makes it possible to alternate between stations from several directions. Using the keyboard, data can be stored with the keys shift F1 t/m F12. Without shift the keys will retrieve the data.
At any moment one can start a calibration via the background page. Now the system will measure and compensate deviations of the analog parts.

4.3 Functions

The different functions of the Software Defined Antenna can be operated via the keyboard, the mouse and the manual handling of the Control unit.

4.3.1 Control unit

With the Control unit one can directly operate the most important functions. There are four controls.

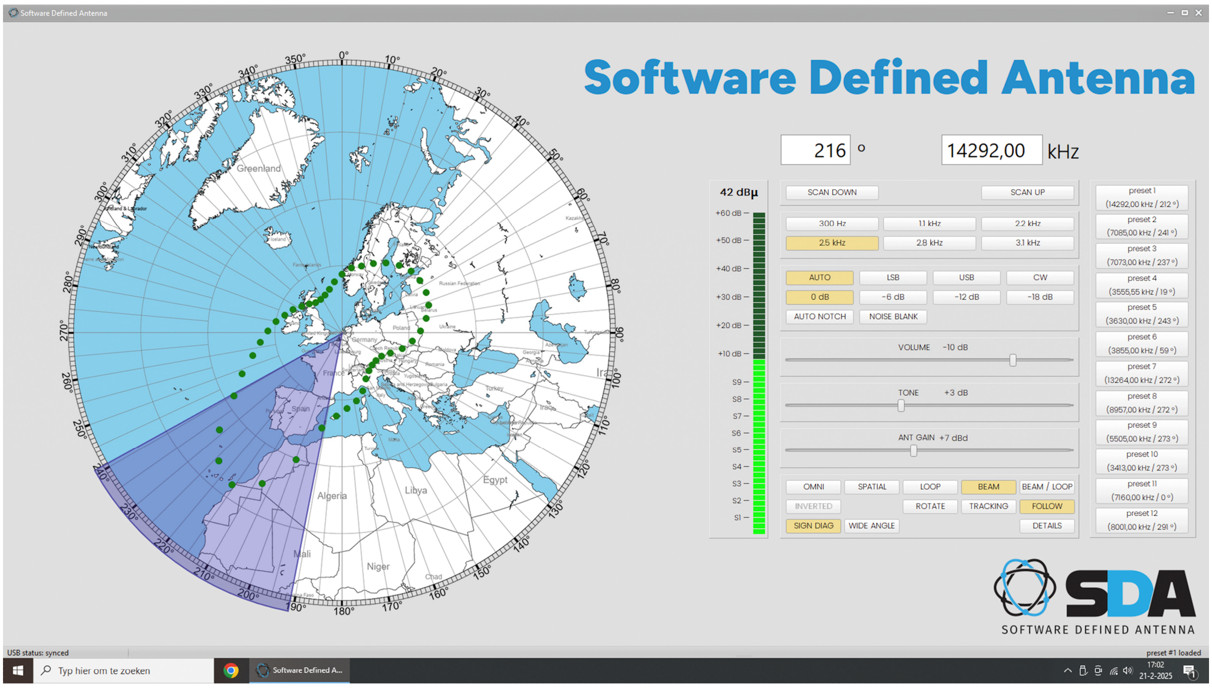
- a rotary knob to manage the frequency, antenna rotor and volume
- a red or green led respectively indicates the frequency mode / direction mode
- a momentary switch to select the frequency mode or direction mode
- a shift function with which the current function can be adapted
- a compare function
- when shift as well as compare are pressed the volume can be set

The front view shows:

At switching on the Control unit, it starts up in reception mode and the led shows red. The rotary knob then changes the reception frequency in steps of 1 kHz to 85 kHz per revolution. At more than 10 kHz per second the tuning speed is increased. Most phone stations transmit with frequencies with a grid of one kilohertz. The frequency also uses steps of 1 kHz making the tuning very simple. In CW-mode steps are 100 Hz. If one wants to receive outside the grid the shift function can be used. This is possible in steps of 10 Hz with 850 Hz per revolution. By pressing ‘selector’ receiver/antenna one can switch between the mode ‘antenna’ and ‘receiver’. In the mode ‘antenna’ the led lights green and with the rotary knob the direction of the beam- or the loop antenna can be turned with 512° per revolution. In case the beam antenna is activated, with pressing the shift key, the gain and the corresponding angular aperture of the antenna can be chosen with the dial. When in ‘antenna mode’ the key ‘compare’ is pressed, temporarily the antenna is switched to omnidirectional to compare the effect of the directional antenna.
Simultaneously pressing shift and compare (in frequency mode only compare is needed) enables setting the volume.

4.3.2 Screen

Lots of functions are accessible via the screen:



The on-screen available functions and displays in alphabetical order are:

0 dB	Attenuator set to 0 dB
-6 dB	Attenuator set to -6 dB
-12 dB	Attenuator set to -12 dB
-18 dB	Attenuator set to -18 dB
300 Hz	Bandwidth set to 300 Hz
1.1 kHz	Bandwidth set to 1.1 kHz
2.2 kHz	Bandwidth set to 2.2 kHz
2.5 kHz	Bandwidth set to 2.5 kHz
2.8 kHz	Bandwidth set to 2.8 kHz
3.1 kHz	Bandwidth set to 3.1 kHz
7 dBd	The gain of the beam antenna as a result of the chosen angular aperture
AUTO	At frequencies lower than 10 MHz detector to LSB; at higher to USB
AUTO NOTCH	The function looks for interference tones and suppresses them
BEAM	Antenna is set to beam mode.
BEAM/LOOP	Antenna is put in beam mode, while the noise is kept in the null direction of the loop antenna
CW	Detector op CW with tone of 1000 Hz
DETAILS	Opens background functions for special procedures
FOLLOWING	In beam mode the beam direction will follow the strongest signal

INVERTED	Optimal phase for omnidirectional and spatial mode
LOOP	Antenna is set in loop mode. Noise can be set at null direction
LSB	Detector on LSB
NOISE BLANK	Switches on the noise blanker suppressing ignition noise
OMNI	Antenna is set to omnidirectional mode
PHYSICAL	Antenna in beam mode takes the angular aperture of a physical antenna
ROTATE	The beam turns automatically scanning all directions
SIGNAL DIAG	The beam turns automatically 10 revolutions per second whereby strength measurements are made and plotted in the azimuthal map, while reception from the manually set direction is audible
SPATIAL	Antenna is put in omnidirectional mode, whereby the electromagnetic field is presented in spatial stereo
TRACKING	In beam mode the beam direction will be followed to the direction where the maximum signal is detected within the angular aperture
USB	Detector on USB
VOLUME	Set volume level
WIDE ANGLE	Antenna in beam mode opens a wider angular aperture than that of a physical antenna

4.3.3 Keyboard

The reception frequency can be selected via the keyboard by choosing the frequency in kilohertz. At higher resolutions this is also possible using a decimal point.
Several short cuts are available to swiftly start certain functions with a single key, such as:

omnidirectional	o	omnidirectional antenna
stereo	s	stereo antenna
magnetic loop	m	loop antenna
beam	b	beam antenna
null	n	beam / loop antenna
rotate	r	rotate mode
tracking	t	tracking mode
follow	f	follow mode
auto	a	receiver will automatically set at LSB or USB
LSB	l	receiver is set at LSB
USB	u	receiver is set at USB
CW	c	receiver is set at CW
memory	F1 – F12	with shift: saving data; without shift: recall

The space bar

For quickly changing frequently used functions the space bar can be used as a toggle button. The last activated function will be reversed. When for instance the attenuator is switched from 6 dB to 12 dB, using the space bar will put it back to 6 dB. With tapping space again the attenuator will return to 12 dB. When tracking is on, it can be switched on and off by just using the space bar.

4.4 Background functions

For a number of detailed background functions is not handy to have a ‘mix’ of common functions. Here we have the key DETAILS. Now the background screen opens making a number of specific functions available:

4.4.1 Calibrate frequency

When a transmitter with a reliable frequency receives zero beat, a calibration order can be given with this key (Calibrate). The receiver now alternates between the frequencies 400 Hz too high and too low. The signal should now be set to two tones with equal pitch with the use of the tuning knob. The frequency resolution automatically goes to 10 Hz. By closing this function the system assumes that the receiver is accurately set on one whole kilohertz and from that moment on the frequency will be corrected using this information. Furthermore this calibration correction will be saved in non-volatile memory so each time after switching on the receiver stays calibrated.
When terminating the procedure (Cancel), the calibration doesn’t change. When matters are not clear the calibration can be removed with the function Reset.

4.4.2 Calibrate receiver

When the system is started for the very first time the receiver is automatically controlled and calibrated with the help of an internal test oscillator. Preferably, at this point, no antenna is connected. Afterwards calibration can still be activated manually. During calibration the antenna is automatically disengaged, but it may happen that accidentally very strong signals leak through on one of the test frequencies. In that case the calibration ignores this measurement.
Apart from that, with operational use, with every bigger frequency step an automatic calibration will take place around the newly chosen frequency.

4.4.3 Calibrate antenna

Because of distortions of the electromagnetic field around the antenna, by buildings, metal objects, (antenna) wires, connection cables inducing electromagnetic fields, etc., deviations in the antenna direction can be found. Two kinds of deviations around the antenna can arise: phase deviation and distortion of the electromagnetic field.

4.4.3.1 Correction of phase deviation

When the system starts up for the very first time automatically a calibration of the antenna is requested. This measurement is essential. For this a small beacon transmitter that can produce multiplications of a megahertz between 3 to 30 MHz is needed. The test signal is alternately switched on and off for 699 ms to detect interference.
Find a suitable spot for the small beacon transmitter at a distance of 10 to 30 meters and determine the direction towards the antenna in degrees of the compass rose. Preferably the direction most interesting for the reception of the signals. For the first measurement a single beacon position is sufficient. When calibration is started, the system asks for the position of the beacon transmitter in degrees regarding the antenna. Based on this position the system measures the phase deviation and corrects it.

4.4.3.2 Correction of distortion of the EM field

Electromagnetic field distortion leads to deviations in the found direction. To neutralize these deviations the distortion of the electromagnetic field must be mapped.
After the first calibration has taken place it is useful to measure this electromagnetic field distortion with more beacon positions. For this a beacon transmitter is needed that can produce signals of multiplications of one megahertz between 3 to 30 MHz. The test signal is switched on and off for 699 ms to detect interference.
Find a suitable spot for the small beacon transmitter at a distance of 10 to 30 meters and determine the direction towards the antenna in degrees of the compass rose. Preferably the direction most interesting for the reception of the signals. For the first measurement a single beacon position is sufficient. When calibration is started, the system asks for the position of the beacon transmitter in degrees regarding the antenna. Based on this position the system measures the phase deviation and corrects it.
After only one measurement already a fairly accurate correction of the antenna is possible. Every measurement is followed by an assessment of the quality of the measurement. The mark 10 is excellent, 9 is also good, with the mark 5 or under one can consider to renew the measurement with the same beacon position: possibly using a longer antenna or at a shorter distance.
After this, there is an opportunity to move the beacon transmitter and place it at another angle for a new measurement. Especially when the position of the beacon differs significantly from the previous measurement the measurement will result in a better analysis of the distortion. If a third measurement can be performed the accuracy will increase even further; a fourth will give little extra information. After the fourth measurement the analysis will therefore be blocked automatically.
The results will be saved on hard disk, so the data will be functional with a new start up. Only in case of a new antenna situation it is useful to do a new calibration.
It is important that the calibration takes place at around 12 o'clock local time when minimal external signals are to be expected. Particularly critical are the frequencies of 3 and 4 MHz where the beacon is weak. If the beacon is too weak – i.e. because the beacon can only be placed somewhat further – the antenna can be extended until sufficient signal is received.
During these measurements the system automatically first measures the highest frequency, so afterwards the (possibly) small frequency deviation is known. Narrow filters will be set to reduce the possibility of interference.

4.4.4 Tone setting

For an optimal sound in combination with an adapted speaker or a headphone the tone setting can be individually chosen. The setting balances the frequency specter around 1 kHz. The reach is between -5 dB and +15 dB for high frequencies. Default is the setting +3 dB.
The setting is saved on hard disk so the timbre is also saved.

4.4.5 Azimuthal map

Several sources for an azimuthal map are available. They can be imported into the antenna system. Good maps are made by NS6T. SDA has permission to download these maps automatically. They are free for all uses, but there are no guarantees or warranties about its accuracy or usefulness for any particular purpose. After the request to automatically download the maps, the software asks for the location of the antenna and within a few minutes the needed data are available. Now the desired azimuthal map can be zoomed in and out.

4.4.6 Installation settings

For a correct functioning a number of parameters must be entered:
- length of the antenna cable in meters (default 20 meters)
  according to the length of the antenna cable and the accompanying attenuation, the S meter can be corrected.
- RF gain in dB (default headroom 6 dB)
  when there is no RF-signal and the RF gain is high, the noise from the receiver will be set to the maximal volume level by the AGC. Normally this is not desirable. Depending on the receiving frequency the maximal gain is limited.

4.4.7 Monitoring of the grounding

There are demands for the grounding conditions of the antenna. Sufficient grounding is required and not too much noise may enter. For control purposes it is therefore possible to link the ground system to the receiver. In this way one can get an indication of the noise and signal strength based on the ground system. If the reception performance on this base is considerably less than expected, the installation was possibly incorrect.

4.4.8 Return

The background screen is closed and the control returns to the operational screen.

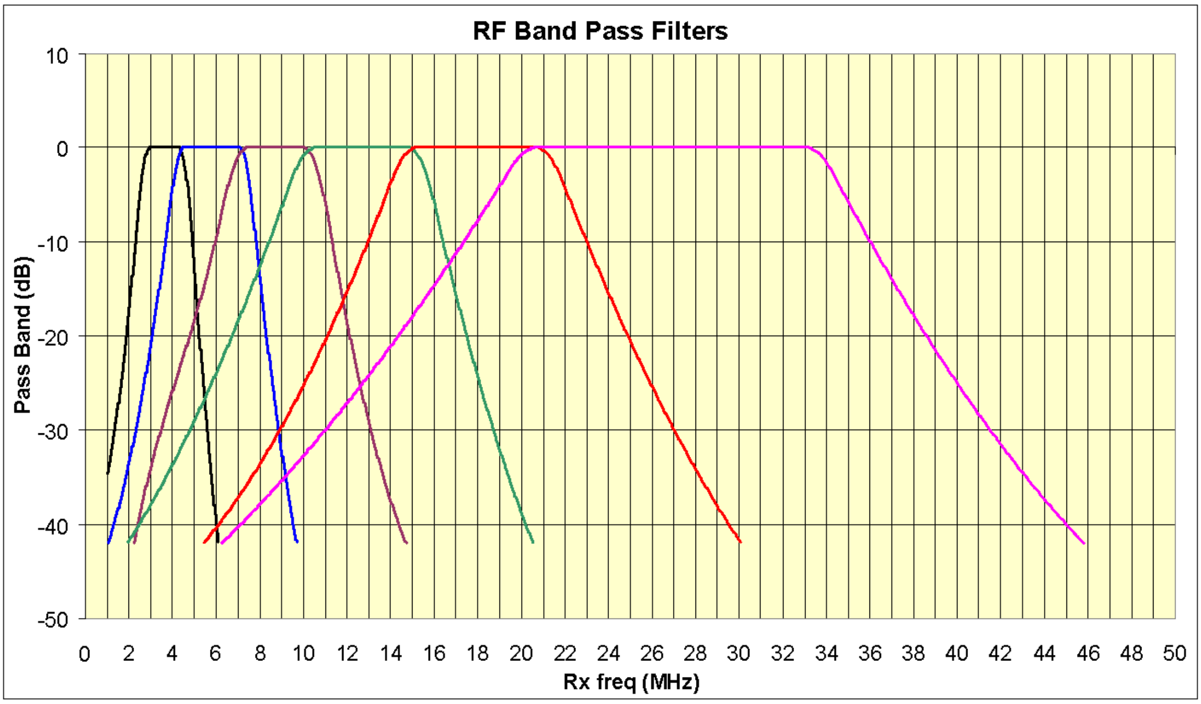
5. Specifications

The S meter is defined as S9 at 50 µV in a dipole. S1 is 0,2 µV in a dipole.
6 dB per S-point. The S meter does not depend on the adjustable internal attenuators.
The frequency accuracy amounts (without calibration) ± 20 ppm. After calibration of the time base it will be ± 1 ppm for a longer period because of the saving of the frequency deviation in a non-volatile memory.
The required supply voltage for the converter is 11 - 13 VDC at max. 2 A.
The PTT sense for a possible transmitter should be open at reception or have a voltage higher than 3 V. With a voltage lower than 1 V the receiver switches off and the antenna goes in safe mode. The voltage may not be higher than 50 V.

5.1 RF stage

Frequency range: 3 – 30 MHz.
The preselector of the antenna signals is controlled by six switchable filters.

3000 – 4450 kHz	(black)
4450 – 7210 kHz	(blue)
7210 – 10300 kHz	(brown)
10300 – 15100 kHz	(green)
15100 – 20800 kHz	(red)
20800 – 30000 kHz	(purple)

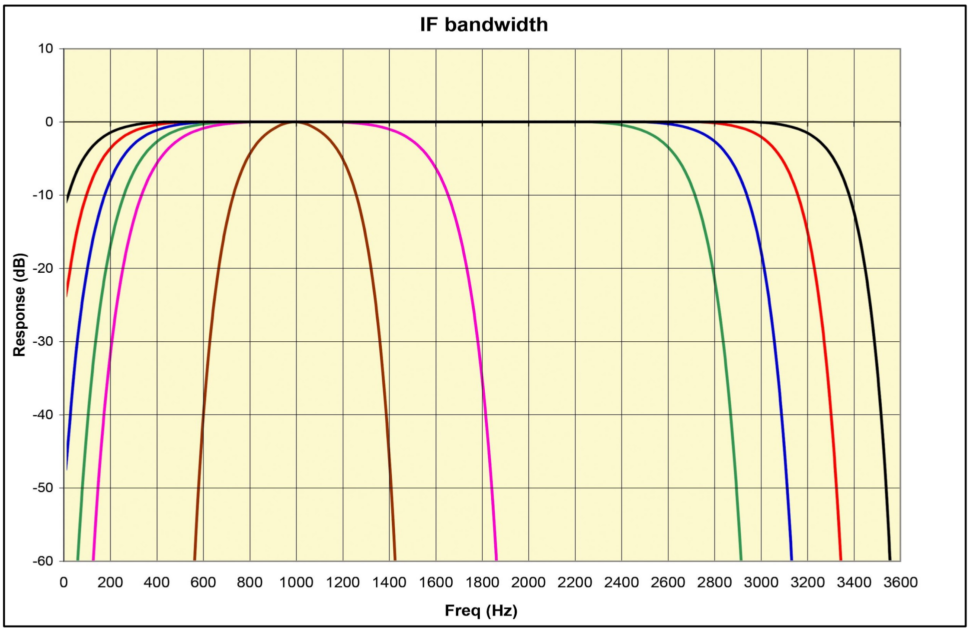


5.1.1 RF attenuator

RF attenuation can be set manually to: 0dB, 6dB, 12 dB en 18 dB.
The changes of RF gain by the attenuator are compensated by the gain after the IF filter. The S meter and the audio are thus not influenced by the attenuator.
When the signal strengths are so high that the linearity can be influenced negatively and the antenna noise does not undergo any disadvantage, the RF attenuator can be activated automatically.

5.2 IF bandwidth

The IF is 10 kHz. For the IF filters six different band filters are available. The selectable bandwidths that are available, are shown according to the curves (with the tone setting at 0 dB):

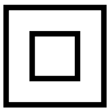


Curves:	Black	3100 Hz	suitable for SSB
	Red	2800 Hz	suitable for SSB
	Blue	2500 Hz	suitable for SSB default
	Green	2200 Hz	suitable for SSB
	Pink	1100 Hz	suitable for CW central round 1 kHz
	Brown	300 Hz	suitable for CW central round 1 kHz

6. Safety

6.1 Mains connection

If one uses a power supply linked to the power grid it should be double insulated:



6.2 In case of a chance of thunderstorms

When there is a risk of thunderstorms, disconnect the antenna for safety reasons.

6.3 EU declaration of conformity

Also see EU declaration of conformity:

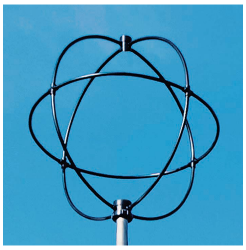
https://sd-antenna.com/EU_declaration_of_conformity

6.4 EU declaration of conformity

Declares that the following line of products: **Software Defined Antenna** revision V1.2

Manufacturer: **sd-Antenna BV**
Hobrede 3
1477EH Hobrede
The Netherlands

This declaration of conformity is issued under the sole responsibility of the manufacturer.



Antenna

AD converter

Control unit

The object of the declaration described above is in conformity with the relevant Union harmonisation legislation.
Fulfills all relevant provisions of the RED directive 2014/53/EU.
According to the harmonized standards:

EN 300 330 (V2.1.1)	**Short Range Devices (SRD); Radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU**

Fulfills all relevant provisions of the EC EMC directive 2014/30/EU.
According to the harmonized standards:

EN 301 489-1 (V2.2.3)	**Electromagnetic compatibility and Radio spectrum Matters (ERM); Electro Magnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements**
EN 301 489-15(V2.2.1)	**Electro Magnetic Compatibility (EMC) standard for radio equipment and services; Part 15: Specific conditions for commercially available amateur radio equipment; Harmonised Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU**

Fulfills all relevant provisions of the Low voltage directive 2014/35/EU.
According to the harmonized standards:

EN 62368-1 (2014)	**Audio/video, information and communication technology equipment - Part 1: Safety requirements**

Fulfills all relevant provisions of the EC RoHS directive 2011/65/EU.
According to the harmonized standards:

EN IEC 63000 (2018)	**Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances**

sd-Antenna BV **Hobrede 01-05-2025**

Olof Bosma (managing director)