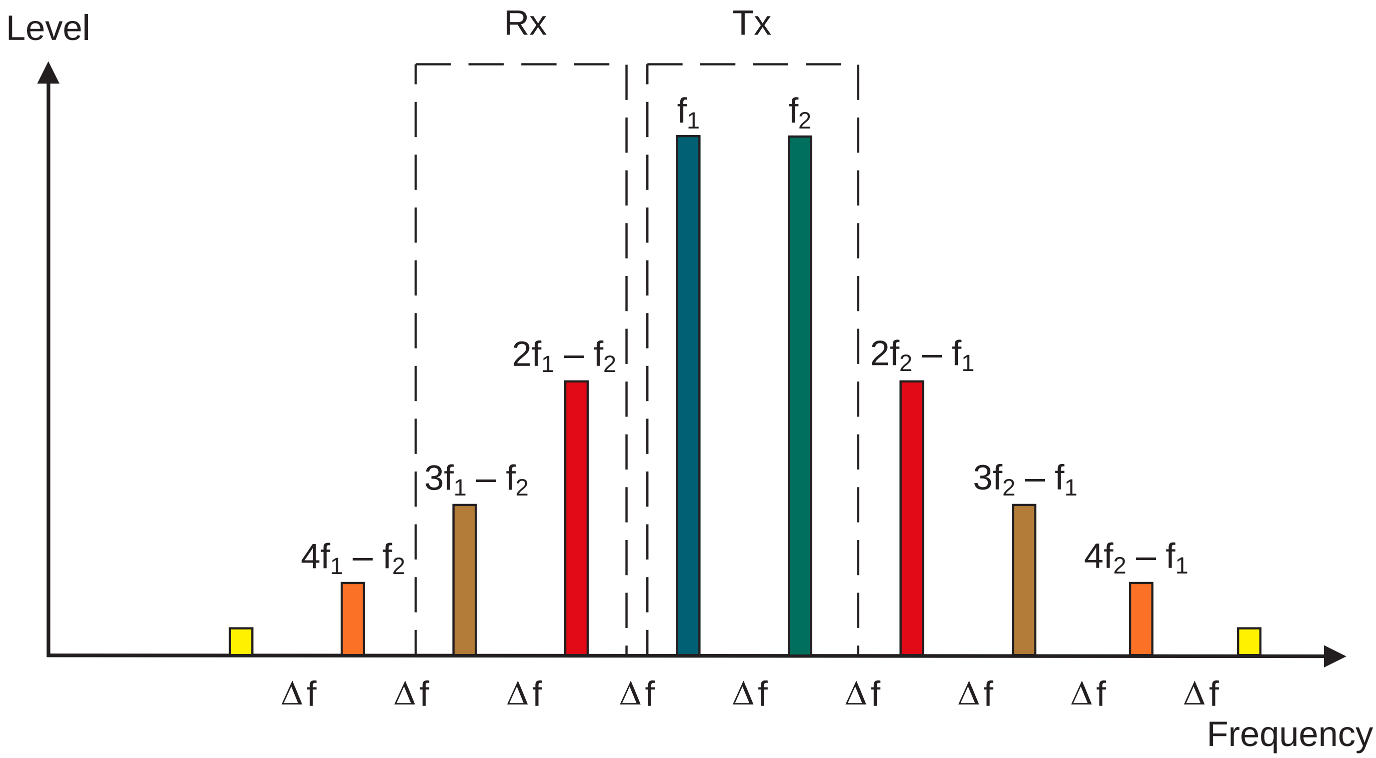
Technical Information and New Products



- Downtilting of antennas
- New antennas with adjustable electrical downtilt
- Passive Intermodulation with Base station antennas
- Antennas for railway communications

Issue No. 3 - 09/2000

KATHREIN
Antennen · Electronic

Contents

Page

Technical information in the next issue:

- ❒ **The influence of reflections on radiation patterns**
- ❒ **General information about antenna installation**

“Quality leads the way”

Being the oldest and largest antenna manufacturer worldwide, we take on every day the challenge arising from our own motto. One of our basic principles is to look always for the best solution in order to satisfy our customers.
Our quality assurance system conforms to DIN EN ISO 9001 and applies to the product range of the company: Antenna systems, communication products as well as active and passive distribution equipment.

Downtilting of antennas

1. Downtilting the vertical pattern

Network planners often have the problem that the base station antenna provides an overcoverage. If the overlapping area between two cells is too large, increased switching between the base station (handover) occurs, which strains the system. There may even be disturbances of a neighbouring cell with the same frequency.
In general, the vertical pattern of an antenna radiates the main energy towards the horizon. Only that part of the energy which is radiated below the horizon can be used for the coverage of the sector. Downtilting the antenna limits the range by reducing the field strength in the horizon and increases the radiated power in the cell that is actually to be covered.

1.1 Mechanical downtilt

The simplest method of downtilting the vertical diagram of a directional antenna is a mechanical tipping to achieve a certain angle while using an adjustable joint. (see Figure 1) But the required downtilt is only valid for the main direction of the horizontal radiation pattern. In the tilt axis direction (+/-90° from main beam) there is no downtilt at all. Between the angles of 0° and 90° the downtilt angle varies according to the azimuth direction.
This results in a horizontal half-power beam width, which gets bigger with increasing downtilt angles. The resulting gain reduction depends on the azimuth direction. This effect can rarely be taken into consideration in the network planning (see Figure 2).

Fig. 1:
Mechanically downtilted A-Panel

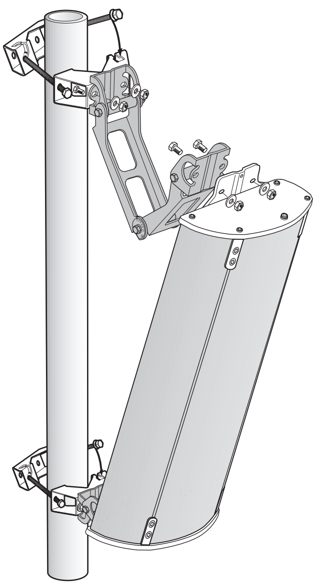
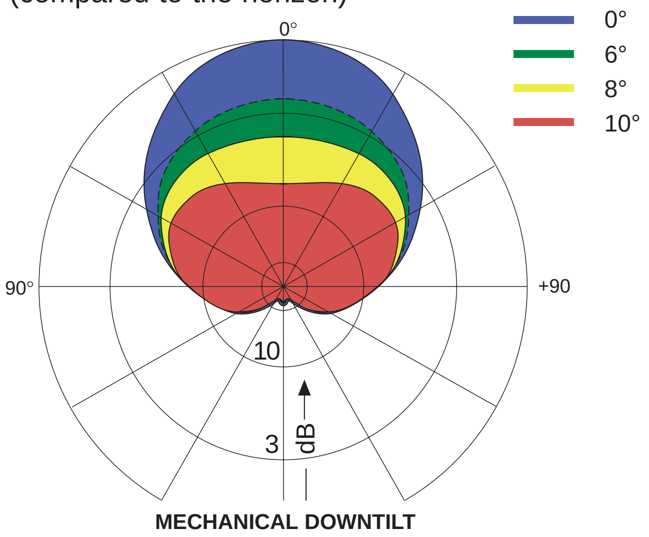


Fig. 2:
Changes in the horizontal radiation pattern when various downtilt angels are used (compared to the horizon)



1.2 Electrical downtilt

In general, the dipols of an antenna are fed with the same phase via the distribution system. By altering the phases, the main direction of the vertical radiation pattern can be adjusted. Figure 3, shows dipols that are fed from top to bottom with a rising phase of 70°. The different phases are achieved by using feeder cables of different lengths for each dipole.

The electrical downtilt has the advantage, that the adjusted downtilt angle is constant over the whole azimuth range. The horizontal half-power beam width remains unaltered (see Figure 4). However, the downtilt angle is fixed and cannot be changed.

Figure 3:
Phase variations for a fixed el. downtilt

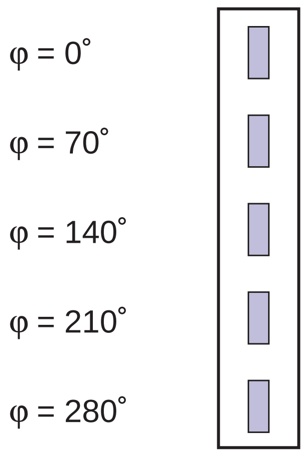
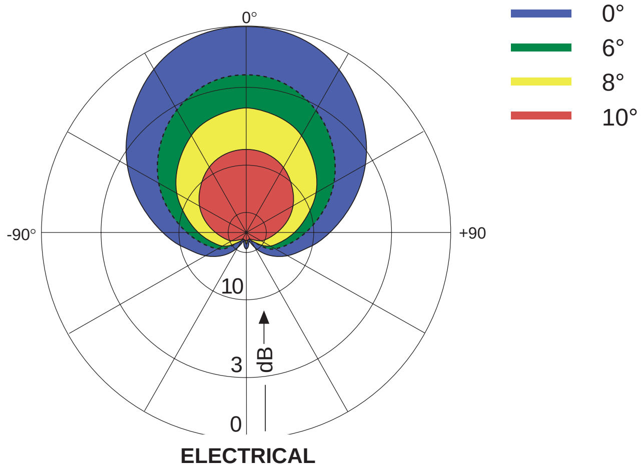


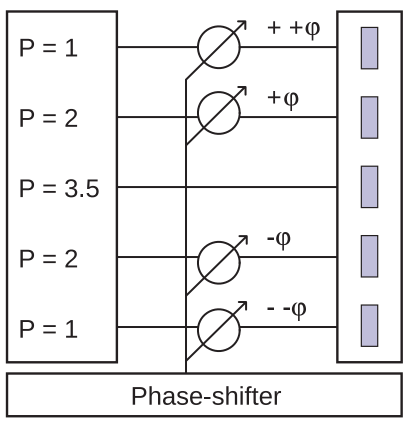
Figure 4:
Changes in the radiation pattern using various downtilt angles



1.3 Adjustable electrical downtilt

With this technique it is possible to combine the advantages of the mechanical downtilt (i. e. adjustment possibility) with those of electrical downtilt (horizontal half-power beam independent of downtilt angle). Instead of using different fixed cables to achieve the various phases for the dipoles, mechanical phase-shifters are used.

Figure 5:
Phase diagram of an adjustable phase-shifter



These phase-shifters can be used to set various downtilt angles which remain constant over the whole azimuth range.

The adjustment mechanisms can be positioned either on the rearside (Eurocell panels) or on the bottom (F-Panels, A-Panels) of the antenna.

Figure 6:
Downtilt adjusting mechanism (with scale) for A-Panels

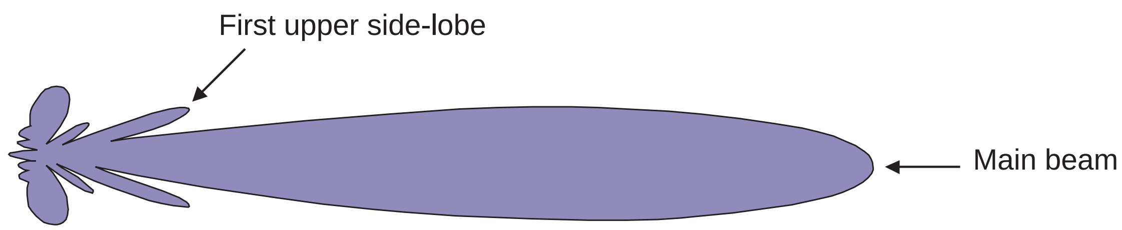
2. Optimum downtilt angles

The optimum tilt angle for a particular antenna depends on the vertical radiation pattern, especially on the half-power beam width, and therefore also on the actual length of the antenna.

2.1 How to calculate the optimum downtilt angle

In standard applications the purpose of using a downtilt is to limit the field strength in the horizon. Considerable limitation is achieved if the radiated power in the horizon is limited by 6 dB. This means that one can easily predict the smallest efficient tilt angle by simply tilting the vertical radiation pattern until the field strength in the horizon is reduced by 6 dB.
But there is also a second important point when calculating the optimum downtilt angle. Apart from the main beam, vertical radiation patterns also have two or more side lobes depending on the number of dipoles within the antenna (see Figure 7).
Maximum field strength reduction in the horizon is achieved if the minimum between the main beam and the first side-lobe is orientated towards the horizon.

Figure 7:
Typical vertical radiation pattern

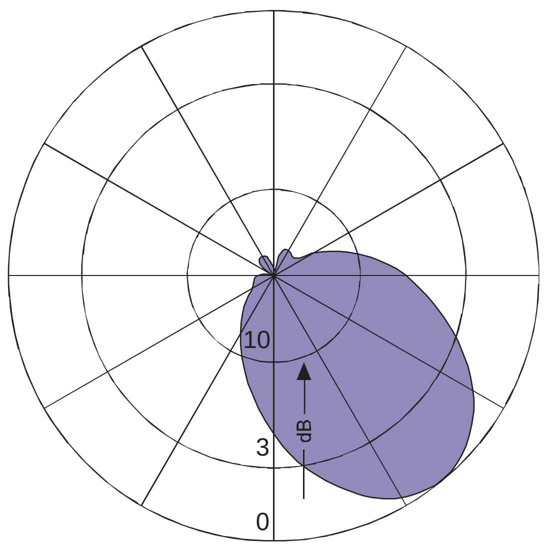


If the tilt angle is set too high, the field strength is not reduced, but is increased again by the first side-lobe.

2.2 Small antennas – vertical half-power beam width 70°

As the Figure 8 shows, the minimum tilt angle that would be efficient lies at around 50° (power in the horizon reduced by 6 dB). Using such an angle, the antenna would beam more or less directly into the ground. Therefore the use of a downtilt with very small antennas (i.e. length up to 500 mm) can not be recommended.

Figure 8:
Minimum efficient tilt angle for small antennas



2.3 Standard antennas – vertical half-power beam width 13°

The minimum efficient tilt angle for these antennas (length 1.3 m) lies at 8°. At an angle of 19° the first side-lobe lies on the horizon. This provides a good range of angles for the efficient tilting of standard antennas.

Figure 9:
Minimum efficient tilt angle for standard antennas

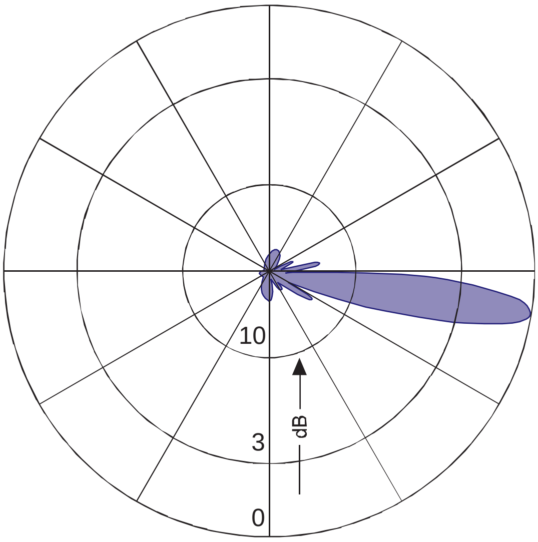
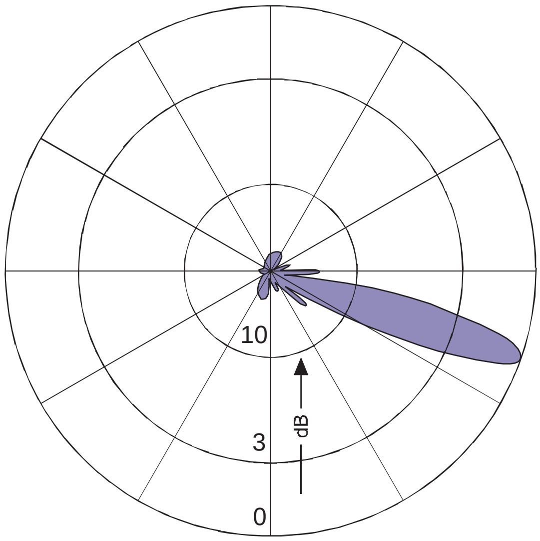


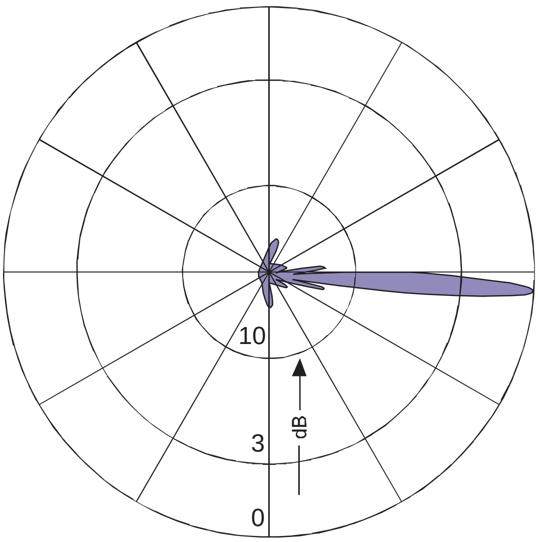
Figure 10:
First side-lobe lies on the horizon



2.4 Long antennas – vertical half-power beam width 6.5°

The minimum efficient tilt angle for these antennas (length 2.6 m) lies at around 3°–4°. At an angle of 8°–9° the first side-lobe lies on the horizon. This provides a good range of angles for the efficient tilting of long antennas.

Figure 11:
Minimum efficient tilt angle for long antennas



2.5 High downtilt angles for special locations

For some special locations (e.g. on the tops of high mountains, on the roof-tops of tall buildings or for coverage in the street below etc.) a very high downtilt angle might be necessary. To achieve such high downtilt angles, a combination of mechanically and electrically downtilted antennas is also possible.

3. Consequences regarding the electrical parameters

Taking all the above into account, it is easy to imagine, how very sophisticated the development of electrically adjustable downtilt antennas is, since intensive measurements have to be carried out.
All the electrical parameters must fulfil the specifications with every single downtilt angle. Electrical values such as those for side-lobe suppression, isola-tion, cross-polar ratio, intermodulation or beam tracking are especially critical.

Kathrein´s lengthy and outstanding experience with vertical polarized electrical adjustable antennas has enabled us to fully optimize the characteristics of the new X-polarized and dual-band X-polarized antenna models.

Eurocell Panel
Vertical Polarization
Half-power Beam Width
Adjust. Electr. Downtilt

Eurocell Panel	824–960
Vertical Polarization	V
Half-power Beam Width	65°
Adjust. Electr. Downtilt	3°–15°

VPol Panel 824–960 65° 15dBi 3°–15°T

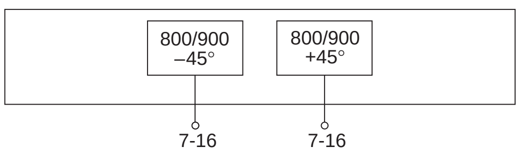
Type No.	741 493
Frequency range	824 – 960 MHz
Polarization	Vertical
Gain	15 dBi
Half-power beam width	H-plane: 65° E-plane: 15°
Electrical downtilt	3°–15°, adjustable in 1° steps
Side lobe suppression	> 12 dB (0°... 20° above horizon)
Front-to-back ratio	> 25 dB
Impedance	50 Ω
VSWR	< 1.4
Intermodulation IM3 (2 x 43 dBm carrier)	< –150 dBc
Max. power	400 Watt (at 50 °C ambient temperature)
Input	7-16 female
Connector position	Bottom
Height/width/depth	1294 / 258 / 103 mm

A-Panel
Dual Polarization
Half-power Beam Width
Adjust. Electr. Downtilt

A-Panel	824–960
Dual Polarization	X
Half-power Beam Width	65°
Adjust. Electr. Downtilt	2°–12°

XPol A-Panel 824–960 65° 15dBi 2°–12°T

Type No.	739 638	
Frequency range	824–960 824 – 880 MHz	880 – 960 MHz
Polarization	+45°, –45°	+45°, –45°
Gain	14.5 dBi	15 dBi
Half-power beam width Copolar +45°/–45°	Horizontal: 68° Vertical: 15.5°	Horizontal: 65° Vertical: 14.5°
Electrical tilt	2°–12°, adjustable	2°–12°, adjustable
Sidelobe suppression for first sidelobe above horizon	2° ... 6° ... 10° ... 12° T 16 ... 14 ... 11 ... 10 dB	2° ... 6° ... 10° ... 12° T 20 ... 20 ... 16 ... 14 dB
Front-to-back ratio, copolar	> 25 dB	> 25 dB
Cross polar ratio Maindirection 0° Sector ±60°	Typically: 25 dB > 10 dB	Typically: 25 dB > 10 dB
Isolation	> 32 dB	
Impedance	50 Ω	
VSWR	< 1.5	
Intermodulation IM3 (2 x 43 dBm carrier)	< –150 dBc	
Max. power per input	400 Watt (at 50 °C ambient temperature)	
Input	2 x 7-16 female	
Connector position	Bottom	
Adjustment mechanism	1x, Position bottom, continously adjustable	
Height/width/depth	1296 / 262 / 116 mm	



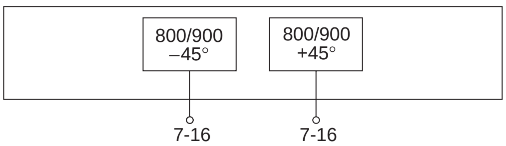
A-Panel
Dual Polarization
Half-power Beam Width
Adjust. Electr. Downtilt

824–960
X
65°
2°–10°

XPol A-Panel 824–960 65° 16.5dBi 2°–10°T

Type No.	739 639	
Frequency range	824–960 824 – 880 MHz	880 – 960 MHz
Polarization	+45°, –45°	+45°, –45°
Gain	2 x 16 dBi	2 x 16,5 dBi
Half-power beam width Copolar +45°/–45°	Horizontal: 68° Vertical: 10°	Horizontal: 65° Vertical: 9,5°
Electrical tilt	2°–10°, adjustable	2°–10°, adjustable
Sidelobe suppression for first sidelobe above horizon (880 – 960 MHz)	2° ... 5° ... 8° ... 10° T 20 ... 16 ... 14 ... 13 dB	2° ... 5° ... 8° ... 10° T 20 ... 18 ... 16 ... 14 dB
Front-to-back ratio, copolar	> 25 dB	> 25 dB
Cross polar ratio Maindirection 0° Sector ±60°	Typically: 25 dB > 10 dB	Typically: 25 dB > 10 dB
Isolation	> 32 dB	
Impedance	50 Ω	
VSWR	< 1.5	
Intermodulation IM3 (2 x 43 dBm carrier)	< –150 dBc	
Max. power per input	400 Watt (at 50 °C ambient temperature)	
Input	2 x 7-16 female	
Connector position	Bottom	
Height/width/depth	1296 / 262 / 116 mm	

Type No. 739 639



A-Panel
Dual Polarization
Half-power Beam Width
Adjust. Electr. Downtilt

824–960
X
65°
2°– 8°

XPol A-Panel 824–960 65° 16.5dBi 2°–10°T

Type No.	739 640	
Frequency range	824–960 824 – 880 MHz	880 – 960 MHz
Polarization	+45°, –45°	+45°, –45°
Gain	2 x 17 dBi	2 x 17,5 dBi
Half-power beam width Copolar +45°/–45°	Horizontal: 68° Vertical: 7,5°	Horizontal: 68° Vertical: 7°
Electrical tilt	2°– 8°, adjustable	2°– 8°, adjustable
Sidelobe suppression for first sidelobe above horizon	2° ... 4° ... 6° ... 8° T 17 ... 17 ... 17 ... 17 dB	2° ... 4° ... 6° ... 8° T 20 ... 18 ... 18 ... 18 dB
Front-to-back ratio, copolar	> 25 dB	> 25 dB
Cross polar ratio Maindirection 0° Sector ±60°	Typically: 25 dB > 10 dB	Typically: 25 dB > 10 dB
Isolation	> 32 dB	
Impedance	50 Ω	
VSWR	< 1.5	
Intermodulation IM3 (2 x 43 dBm carrier)	< –150 dBc	
Max. power per input	400 Watt (at 50 °C ambient temperature)	
Input	2 x 7-16 female	
Connector position	Bottom	
Height/width/depth	2580 / 262 / 116 mm	

KATHREIN
Antennen · Electronic

Dual-band A-Panel Dual Polarization Half-power Beam Width Adjust. Electr. Downtilt Integrated Combiner

	824–960	1710–1880
	X	X
	65°	60°
	0°–10°	2°
	C	

XXPol A-Panel 824–960/1800 C 65°/60° 14.5/16.5dBi 0°–10°T/2°T

Type No.	742 151		
Frequency range	824–960		1710–1880
	824 – 880 MHz	880 – 960 MHz	1710 – 1880 MHz
Polarization	+45°, –45°	+45°, –45°	+45°, –45°
Gain	2 x 14 dBi	2 x 14.5 dBi	2 x 16.5 dBi
Half-power beam width Copolar +45°/–45°	Horizontal: 70° Vertical: 16°	Horizontal: 65° Vertical: 15°	Horizontal: 60° Vertical: 8°
Electrical tilt	0°–10°	0°–10°	2°
Sidelobe suppression for first sidelobe above horizon	0° ... 6° ... 10°T 16 ... 14 ... 12 dB	0° ... 6° ... 10°T 18 ... 16 ... 14 dB	14 dB
Front-to-back ratio, copolar	> 30 dB	> 30 dB	> 30 dB
Cross polar ratio Maindirection 0° Sector ±60°	Typically: 18 dB > 10 dB	Typically: 18 dB > 10 dB	Typically: 18 dB > 10 dB
Isolation, between ports	> 30 dB		> 30 dB
Impedance	50 Ω		50 Ω
VSWR	< 1.5		< 1.5
Intermodulation IM3 (2 x 43 dBm carrier)	< –150 dBc		< –150 dBc
Max. power per input	250 Watt		150 Watt
	(at 50 °C ambient temperature)		
Integrated combiner	The insertion loss is included in the given antenna gain values.		
Height/width/depth	1296 / 262 / 116 mm		

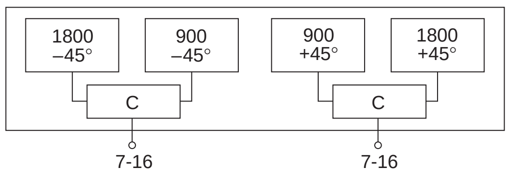
Dual-band A-Panel Dual Polarization Half-power Beam Width Adjust. Electr. Downtilt Integrated Combiner

	900	1800
	X	X
	65°	60°
	2°–8°	2°
	C	

XXPol A-Panel 900/1800 C 65°/60° 17/18dBi 2°–8°T/2°T

Type No.	742 047	
Frequency range	900 870 – 960 MHz	1800 1710 – 1880 MHz
Polarization	+45°, –45°	+45°, –45°
Gain	2 x 17 dBi (–0.5 dB)	2 x 18 dBi (–0.5 dB)
Half-power beam width Copolar +45°/–45°	Horizontal: 65° Vertical: 7°	Horizontal: 60° Vertical: 6°
Electrical tilt	2°–8°, adjustable	2°, fixed
Sidelobe suppression for first sidelobe above horizon	2° ... 4° ... 6° ... 8° T 20 ... 18 ... 17 ... 15 dB	2° T 17 dB
Front-to-back ratio, copolar	> 30 dB	> 30 dB
Isolation, between ports	> 30 dB	> 30 dB
Impedance	50 Ω	50 Ω
VSWR	< 1.5	< 1.5
Intermodulation IM3 (2 x 43 dBm carrier)	< –150 dBc	< –150 dBc
Max. power per input	250 Watt	150 Watt
	(at 50 °C ambient temperature)	
Integrated combiner	The insertion loss is included in the given antenna gain values.	
Height/width/depth	2580 / 262 / 116 mm	

Type No. 742 047



Passive Intermodulation at Base Station Antennas

1. Introduction

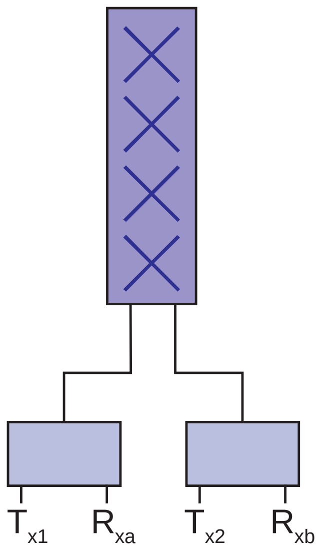
If a base station antenna transmits two or more signals at a time, non-linearities can cause interferences, which may block one or more receiving channels of the base station antenna. This can result in a connection breakdown to a mobile.

Figure 1:
Base station communicating with two mobiles

The risk for this problem to occur increases with the number of transmitting (Tx) frequencies connected to one base station antenna.

With the standard XPol-antennas 2 Tx-antennas are combined (see Figure 2).

Figure 2:
XPol antenna with two duplexers



The latest technology using dual-band, dual-polarised (XXPol) antennas, now again doubles the number of antennas and hence also the number of carriers in one radome, to combine both the 900 and 1800 MHz systems. But this also means a further possible increase in interferences problems.

These interference problems are called "Intermodulation".

2. What is Intermodulation?

Intermodulation (IM) is an undesirable modulation which leads to unwelcome alterations to the high frequency carrier output.

An input signal put into a linear passive device at a certain frequency f_1 will produce an output signal with no modification to the frequency.
Here only the amplitude and the phase can be modified.
However, if the same signal is put into a passive device with non-linear transmission characteristics, then this will result in distortions to the time-scale, leading to changes in the frequency. This means that, in addition to the carrier frequency f_1, several harmonics are produced: $2\,f_1$, $3\,f_1$, $4\,f_1$, ..., $n\,f_1$.
Moreover, if the input signal contains two or more frequency components, f_1 and f_2, the output signal will generate a spectral composition. In addition to the harmonics, this new spectral composition also includes all possible frequency combinations. These frequency combinations can be expressed by the equation:

$$\mathbf{IMP = nf_1 \pm mf_2}$$

IMP: **I**nter **M**odulation **P**roducts
n,m = 1, 2, 3, ...
Only the IMP > 0 are physically relevant.

The order of the IMP can be equated as: **O = n + m**

There are IMP of even and odd orders. The products of even orders have a large spacing to the original Tx frequencies and therefore cause no problems with single band antennas. The most troublesome IMP are those of the odd orders:

Intermodulation products of even orders	Intermodulation products of odd orders
2nd Order $f_1 + f_2$ / $f_2 - f_1$	3rd Order $2f_1 - f_2$
4th Order $2\,f_1 + 2\,f_2$ / $2\,f_2 - 2\,f_1$	5th Order $3f_1 - 2f_2$
	7th Order $4f_1 - 3f_2$
Large spacing compared to the original frequencies	Close to the original frequencies

Since the IMP frequencies of the odd orders lie very close to the original frequencies, they can appear within the received signal band-width and thereby degrade the overall communication system.

Figure 3:
Input signals

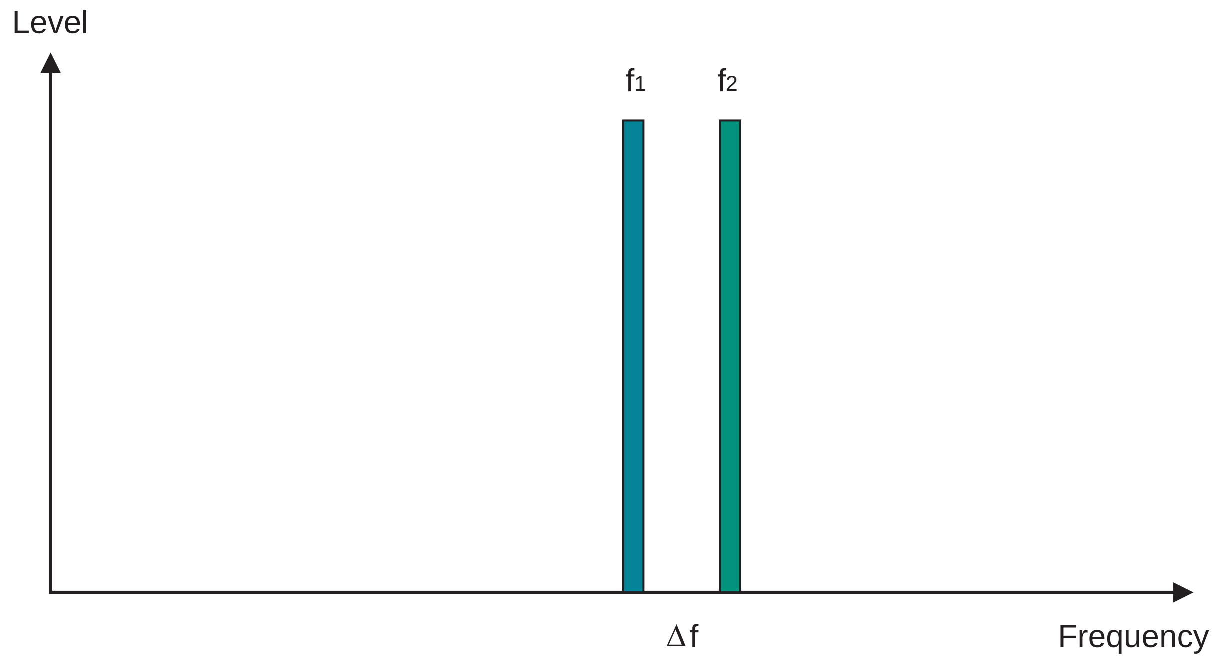
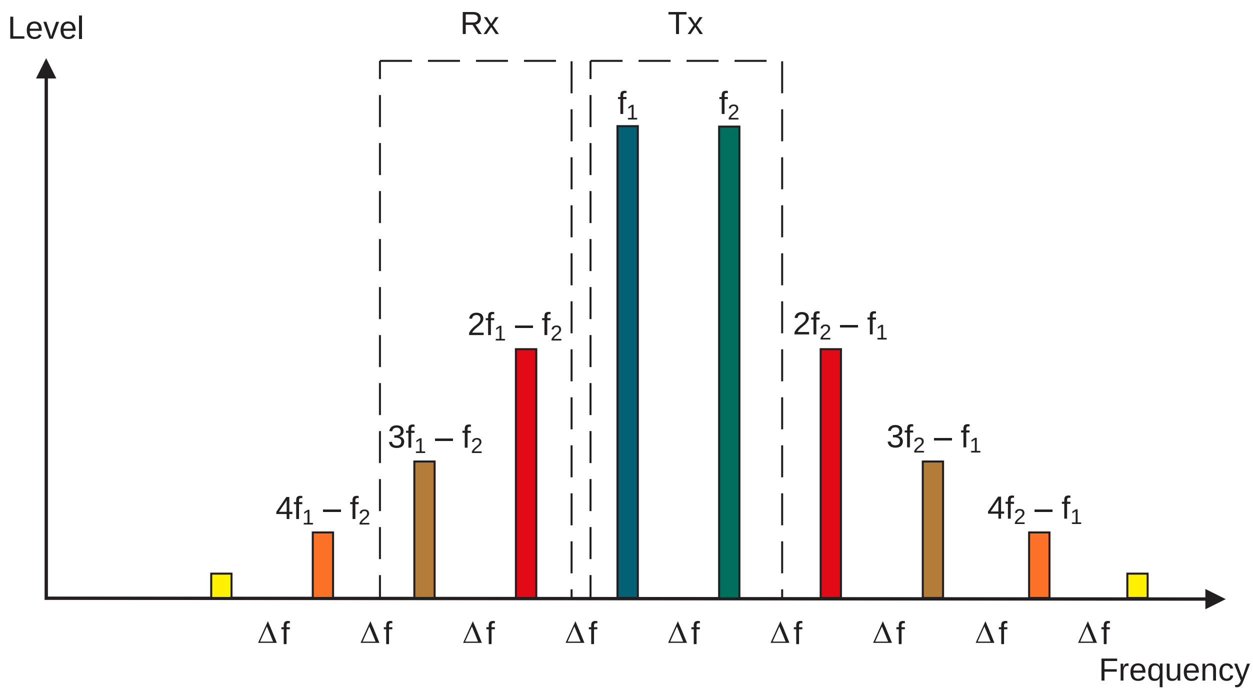


Figure 4:
IM spectrum of odd orders



3. Where do intermodulation products come from?

If high-power signals of different frequencies exist, any device with non-linear voltage-current characteristics will generate intermodulation products. The level will depend on the degree of the non-linearity and on the power-ratings of the incident frequencies.

There are two main categories of non-linearities:

Contact non-linearities at metal/metal joins

Contact non-linearities arise where discontinuities exist in the current path of the contact. They may have various causes and are not normally visible to the naked eye. The following are potential causes:

- Surface condition of the join, e.g. dirt, surface textures, ...
- Electron tunnelling effect in metal insulator metal joins
- Contact mating: Poor contact spring force or poor contact quality

Material and surface-plating non-linearities

- Non-linear conductive materials or treated surfaces (e.g. the treatment of copper foils on printed circuit boards (PCB´s) – patch antennas on PCB)
- Magneto-resistance effect in non-magnetic materials
- Non-linearity due to non-linear dielectric
- Non-linearity due to variations of permeability into ferromagnetic materials

Material non-linearity is an important source of intermodulation products if two or more signals pass through ferro-magnetic material. But the result of a poor contact join is of far more significance!

4. Why is intermodulation a problem?

Current mobile telephone systems are designed to operate with a transmitting frequency range Tx and a slightly shifted receiving frequency range Rx.
Problems arise when intermodulation products occur in the receiving Rx frequency range (see also Figure 4) which degrade the reception performance. The following example for GSM 900 shows that, under certain conditions, the intermodulation products of 3rd, 5th and even 7th or higher orders may fall in the receiving band.

GSM 900			
	Tx Band		Rx Band
	935 – 960 MHz		890 – 915 MHz
Intermodulation Products	f_1	f_2	f_{IM}
3^{rd} Order $2f_1 - f_2$	936 MHz	958 MHz	**914 MHz**
5^{th} Order $3f_1 - 2f_2$	938 MHz	956 MHz	**902 MHz**
7^{th} Order $4f_1 - 3f_2$	941 MHz	952 MHz	**908 MHz**

The most disturbing intermodulation products in the GSM 900 and 1800 systems are those of the 3rd order. These are the products with the highest power level and also the ones that lie closest to the original transmitting frequencies. These products may block the equivalent Rx channels. It is therefore absolutely essential to keep the IMP´s to a minimum level below the sensitivity of the receiving equipment.

These products are measured as Intermodulation Levels in either dBm or dBc.
The total intermodulation level compared to a power-rating of 1 mW is expressed in dBm:

$$\mathbf{IM = 10 \log P_{IMP3} \ [dBm]}$$

On the other hand, dBc is defined as the ratio of the third order intermodulation product to the incident Tx carrier signal power:

$$\mathbf{IM = 10 \log(P_{IMP3}/P_{Tx} \ [dBc]}$$

The levels of intermodulation products according to the GSM standard are shown in the following table:

Level of IM products accord. GSM Standard (3rd order)	**< – 103 dBm**
Referred to two carriers of 20 W each (43 dBm)	**< – 146 dBc**
IM attenuation of **Kathrein** antennas	**Typically < –150 dBc**

A comparison of the carrier level and the level of the IMP expressed in distances clearely illustrates this fact:

Comparison	**Carrier**	**IM Product**
	0 dBm	— 150 dBm
Average distance earth – sun	150 Mill. kilometer	
Equivalent distance		0,15 mm

5. What solutions are there?

In view of all the facts mentioned, the following points must be taken into consideration when designing passive devices such as antennas, cables and connectors:

- All components such as feeder cables, jumpers, connectors etc. must fulfil the IM standards.
- All connectors must have good points of contact.
- Particular materials such as copper, brass or aluminium are recommended. Other materials like steel and nickel should to be avoided in the signal path.
- Material combinations with a high chemical electrical potential should not be used as any thin corrosion layer between the materials will act as a semi-conductor.
- All points of contact should be well-defined and fixed.
- All cable connections should be soldered.

Engineers at KATHREIN have been researching ways of reducing intermodulation (IM) products for more than 15 years now. Long before other such devices became available on the market, Kathrein developed a company-designed IM product measuring device for the 450 MHz frequency with an operating sensitivity of –160 dBc.

Kathrein´s long-standing and extremely valuable experience is incorporated into all our antenna designs and helps to determine for example the best material to use, all possible material combinations and also what a point of contact between two antenna parts should look like.

Kathrein antennas typically show a 3rd order intermodulation product attenuation of –150 dBc, where two transmitters each with an output power-rating of 20 W (43 dBm) are used.

As explained earlier, there is an increased risk of intermodulation with XX-pol. antennas since four Tx antennas are used. IMP´s of the 2nd order may also cause problems with XX-pol. antennas due to the combination of the 900 and the 1800 MHz frequencies. Kathrein has therefore introduced a 100% final test rate for intermodulation products in their serial production of all XX-pol. antennas.

Railway Communications

1. GSM-R, the new digital railway communications network

The current analog railway communications network requires various systems in different frequency bands:

- Communication between train drivers and operation centers at 460 MHz
- Maintenance communications at 160 and 460 MHz
- Shunting communications at 80, 160 and 460 MHz
- Tunnel communications
- Paging systems for the train service staff

All the various above systems will be replaced and integrated into a single, new digital communications network called GSM-R (R for railway). Already 1993 the 32 most important European railway authorities agreed upon the implementation of this system. In some countries such as France, Sweden and Germany, work on installation of the new digital communications network started this year, regular operation is planned for 2002.

The system is based on the GSM standard but has been enlarged to include additional features specifically designed for railway purposes. It is separated from the public cellular networks through its own frequency range: uplink at 876 – 880 MHz, downlink at 921 – 925 MHz.

The GSM-R standard features the following characteristics:

- Constant high signal quality, even at train speeds of up to 500 km/h
- High network availability (> 99.9%)
- Advanced speed call items such as group calls and priority emergency calls
- Remote train controlling
- Train positioning applications (together with the GPS)
- Transmission of diagnostic data
- Communication access to individual trains via the train number

For the final coverage of all railway tracks in Germany, 2800 base stations have to be set up. Due to the fact that their operating frequency range starts at 870 MHz, Kathrein´s well-known GSM base station antennas are also suitable for GSM-R purposes.

For the antennas on the trains it self, Kathrein offers a wide range of different versions which are summarized on page 21.

Until the new digital system is fully installed European-wide (planned for 2007), the old analog systems will have to operate simultaneously. In order to reduce the number of antennas required for both the base stations and the trains themselves, some dual-band versions for 460 MHz and 900 MHz are also offered, such as the log.-per. antenna 739 990 or the train antenna K 70 20 61.

2. GPS applications

New trains will be equipped with a **G**lobal **P**ositioning **S**ystem (1575 MHz) for any new passenger services relating to a trains actual posi-tion, such as automatic announcements and ticket sales.
In connection with the GSM-R system it will be possible to trace individual railway carriages across Europe and improve operation logistics.
For these applications Kathrein has developed the new dual band train antenna 741 806 for both GPS and GSM (R). This antenna has now been type-approved and is available. A GPS amplifier for compensating the losses incurred through the longer cables will follow as an option.

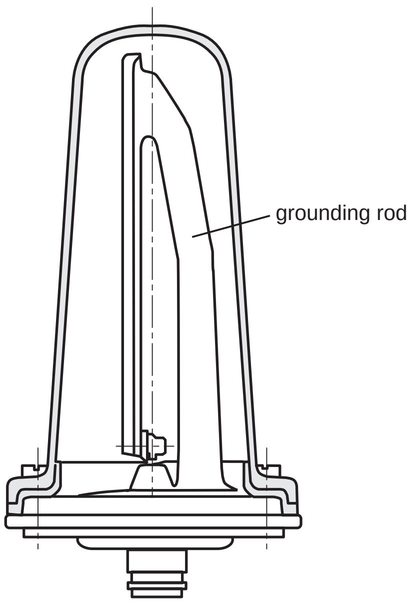
3. WLL

A brand-new system for data transfer purposes with trains is currently being tested in some European countries. This system is based on WLL (**W**ireless **L**ocal **L**oop) operating at 2400 – 2500 MHz for which Kathrein already offers the train antenna 741 747.

4. General information about train antennas

Whilst base station antennas for railway commu-nication purposes are part of Kathrein´s serially produced range, vehicle antennas for use on trains must fulfil other criteria than those for nor-mal car antennas. In view of the fact, that train antennas mostly operate in the vicinity of high-tension wires, special safety aspects must also be considered. In case of a line-break and a direct contact with the antenna radiator, all risk of endangering the train driver and the passengers must be avoided. This requires a specific anten-na design (see Figure 1).

Figure 1:
Example of a 450 MHz antenna



Unlike car antennas, where the whips are not grounded, all metal parts of train antennas, including the radiators, are DC grounded with a large crosssectional area. High voltages are thereby kept away from the inner conductors of the antenna terminations and the connected feeder lines. Due to the electrical lenght of the short circuit of approx. $\lambda/4$, the antenna "cannot see" the grounding within its operating frequency band.

Most of Kathrein´s train antennas have been type approved by the "Deutsche Bahn AG", passing the following test procedures:

- Breakdown voltage through the radome up to 42 kV / 16 2/3 Hz
- Short-circuit voltage of 15 kV directly at the radiator; max. permitted voltage at the antenna output = 60 V
- Short-circuit current of 36 KA; min. time until destruction = 100 ms

Summary of antennas for trains and buses

Frequency band	Type No.	Operating frequency range	Type approved by "Deutsche Bahn AG"	Remarks
4m band	K 50 21 41	Tunable in the range 68 ... 87.5 MHz	Yes	
	726 127	74.2 – 77.7 MHz and 84.0 – 87.5 MHz		Pressure-sealed
FM radio	727 313	87.5 – 108 MHz	Yes	Only for receiving purposes
2m band	K 50 21 22	Tunable in the range 146 ... 174 MHz	Yes	Low-profile
	K 50 22 21 . K 50 22 22 .	146 – 156 MHz 156 – 174 MHz		Low-profile
	728 286	165 – 174 MHz	Yes	Pressure-sealed
	733 707	146 – 147 MHz 166 – 172 MHz	Yes	
2m/70cm band	731 495	165 – 174 MHz 457.4 – 468.3 MHz		Dual-band antenna
70cm band	K 70 23 2.	406 ... 470 MHz		Low-profile
	732 997	380 – 412 MHz		
	K 70 20 21	410 – 470 MHz	Yes	
	725 892 K 70 21 21	410 – 430 MHz 450 – 470 MHz	Yes	Gain = 2 dB
	722 582	450 – 470 MHz		One-hole mounting
	729 003	444 – 461,5 MHz		Special radome for high-speed trains
	721 232	457 – 470 MHz		Special radome for high-speed trains
70cm/35cm band	733 706	414 – 428 MHz 870 – 960 MHz		Dual-band antenna
	K 70 20 61	450 – 470 MHz 806 – 960 MHz	Yes	Dual-band antenna
35cm band	741 009	870 – 960 MHz	Yes	Special radome for high-speed trains
	K 70 21 62 1 K 70 21 63 1 K 70 21 64 1	806 – 869 MHz 865 – 930 MHz 890 – 960 MHz	Yes Yes Yes	Gain 3.0 dB Gain 3.5 dB Gain 3.5 dB
GSM and PCN band	737 495	870 – 1900 MHz	Yes	Dual-band antenna
GSM and GPS	741 806	870 – 1900 MHz 1575.42 ± 1 MHz	Yes	Dual-band antenna
WLL	741 747	2350 – 2550 MHz	Yes	

Train Antenna
870 – 960 MHz and GPS

- Dual-band antenna: GSM 900 and GPS.
- The antenna can be operated in both frequency ranges simultaneously.
- Low-profile antenna in fiberglass radome.

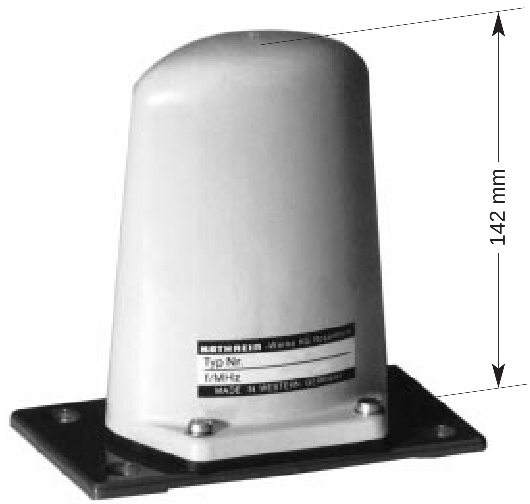
Type No.	741 806
GSM 900 Antenna	
Input	N female
Frequency range	870 – 960 MHz
VSWR	< 1.5
Gain	0 dB (ref. to the quarter-wave antenna)
Impedance	50 Ω
Polarization	Vertical
Max. power	100 Watt (at 50° C ambient temperature)
Inner conductor	D.C. grounded
GPS Antenna	
Input	Cable RG 316/U of 160 mm length with TNC male connector
Frequency range	1575.42 ± 1 MHz
VSWR	< 1.5
Polarization	Right hand circular
Gain (90° elevation)	2 dB (ref. to the circularly polarized isotropic antenna)
Axial ratio	3 dB
Impedance	50 Ω
Inner conductor	D.C. grounded
Isolation	≥ 28 dB (870 – 960 MHz) ≥ 20 dB (1575.42 ± 1 MHz)
Weight	0.5 kg
Packing size	161 x 152 x 88 mm
Height	96 mm

Optional low-noise GPS pre-amplifier Type No. 742 185 will be available soon.

Train Antenna
2350 – 2550 MHz

- Low-profile broadband antenna in fiberglass radome.

Type No.	741 747
Input	N female
Frequency range	2350 – 2550 MHz
VSWR	< 1.5
Gain	0 dB (ref. to the quarter-wave antenna)
Impedance	50 Ω
Polarization	Vertical
Max. power	100 Watt (at 50° C ambient temperature)
Weight	0.5 kg
Packing size	155 x 90 x 200 mm
Height	142 mm



Eurocell A-Panel – Dual Polarization 30° Half-power Beam Width

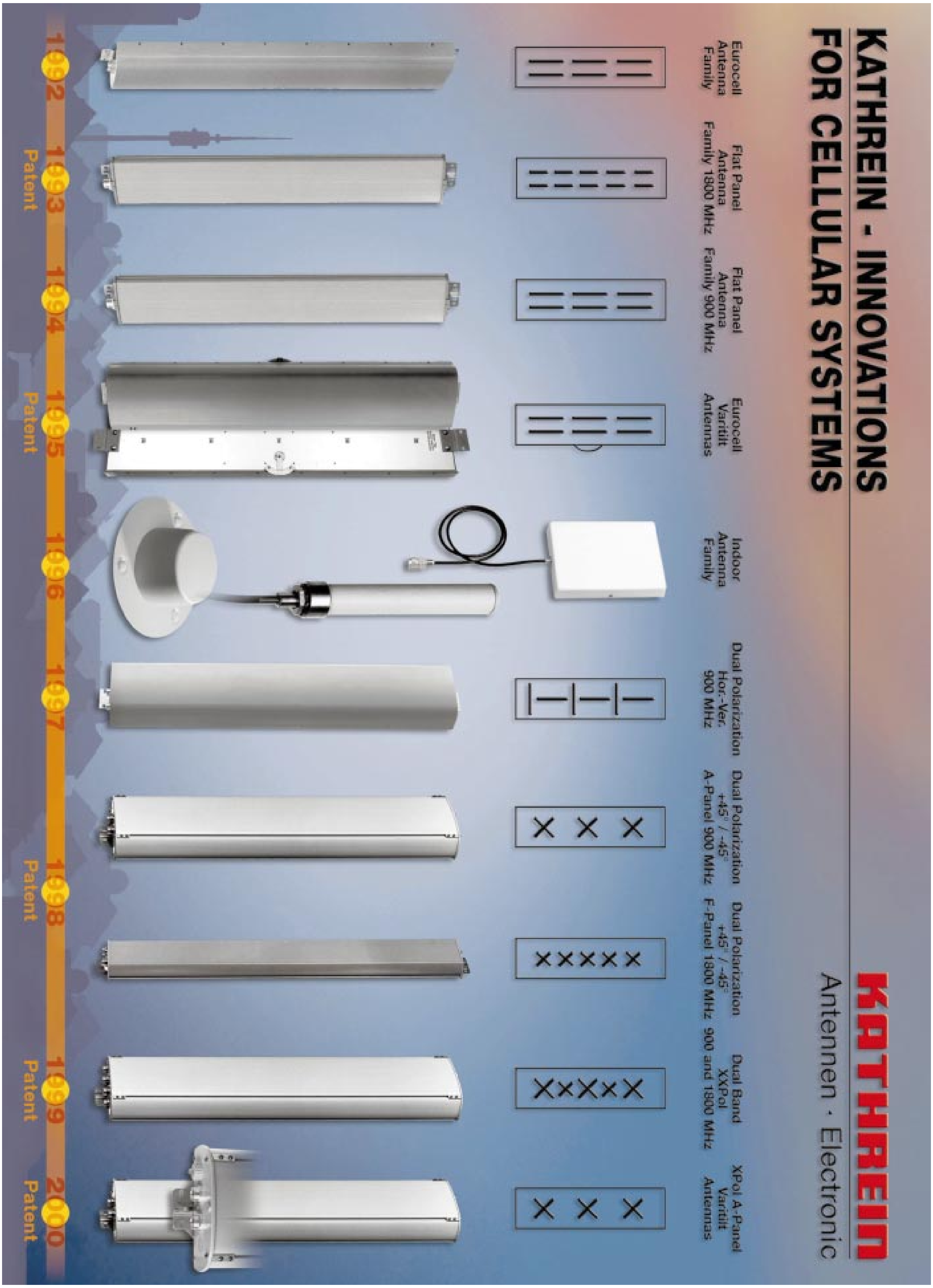
XPol A-Panel 900 30° 21dBi

Type No.	741 785
Input	2 x 7-16 female
Connector position	Bottom
Frequency range	870 – 960 MHz
VSWR	< 1.5
Gain	2 x 21 dBi
Impedance	50 Ω
Polarization	+45°, -45°
Front-to-back ratio, copolar	> 30 dB
Half-power beam width	+45° polarization Horizontal: 30°, Vertical: 7° -45° polarization Horizontal: 30°, Vertical: 7°
Isolation	> 30 dB
Max. power per input	400 Watt (at 50 °C ambient temperature)
Weight	40 kg
Wind load	Frontal: 1460 N (at 150 km/h) Lateral: 280 N (at 150 km/h) Rearside: 2090 N (at 150 km/h)
Max. wind velocity	180 km/h
Packing size	2672 x 572 x 254 mm
Height/width/depth	2580 / 560 / 116 mm

Logarithmic-periodic Multiband Antenna 440 – 512 / 824 – 960 MHz

LogPer 450/900 68/60° 10.5/11.5dBi

Type No.	739 990	
Input	7-16 female	
Frequency range	440 – 512 MHz	824 – 960 MHz
VSWR	< 1.4	
Gain	10.5 dBi	11.5 dBi
Impedance	50 Ω	
Polarization	Vertical	
Half-power beam width		
H-plane	68°	60°
E-plane	54°	48°
Front-to-back ratio	> 23 dB	> 25 dB
Max. power	100 Watt (at 50 °C ambient temperature)	
Weight	9 kg	
Wind load	Frontal: 55 N (at 150 km/h) Lateral: 440 N (at 150 km/h)	
Max. wind velocity	180 km/h	
Packing size	1172 x 372 x 225 mm	
Length/width/depth	1160 / 350 / 170 mm	



Subject to alteration.

9986.223/0900/8/PF/PF

Please contact for: **Sales queries, orders, catalogues or CD-ROM:**

Fax: (++49)8031/184-820 · E-Mail: central.sales@kathrein.de

Technical Information:

Fax: (++49)8031/184-973 · E-Mail: antennas.mobilcom@kathrein.de

Internet: http://www.kathrein.de

KATHREIN-Werke KG · Telephone (++49) 8031/184-0 · Fax (++49) 8031/184-991
Anton-Kathrein-Straße 1 – 3 · P.O. Box 10 04 44 · D-83004 Rosenheim · Germany

KATHREIN
Antennen · Electronic