B2B17TBK

Technika bezdrátové komunikace

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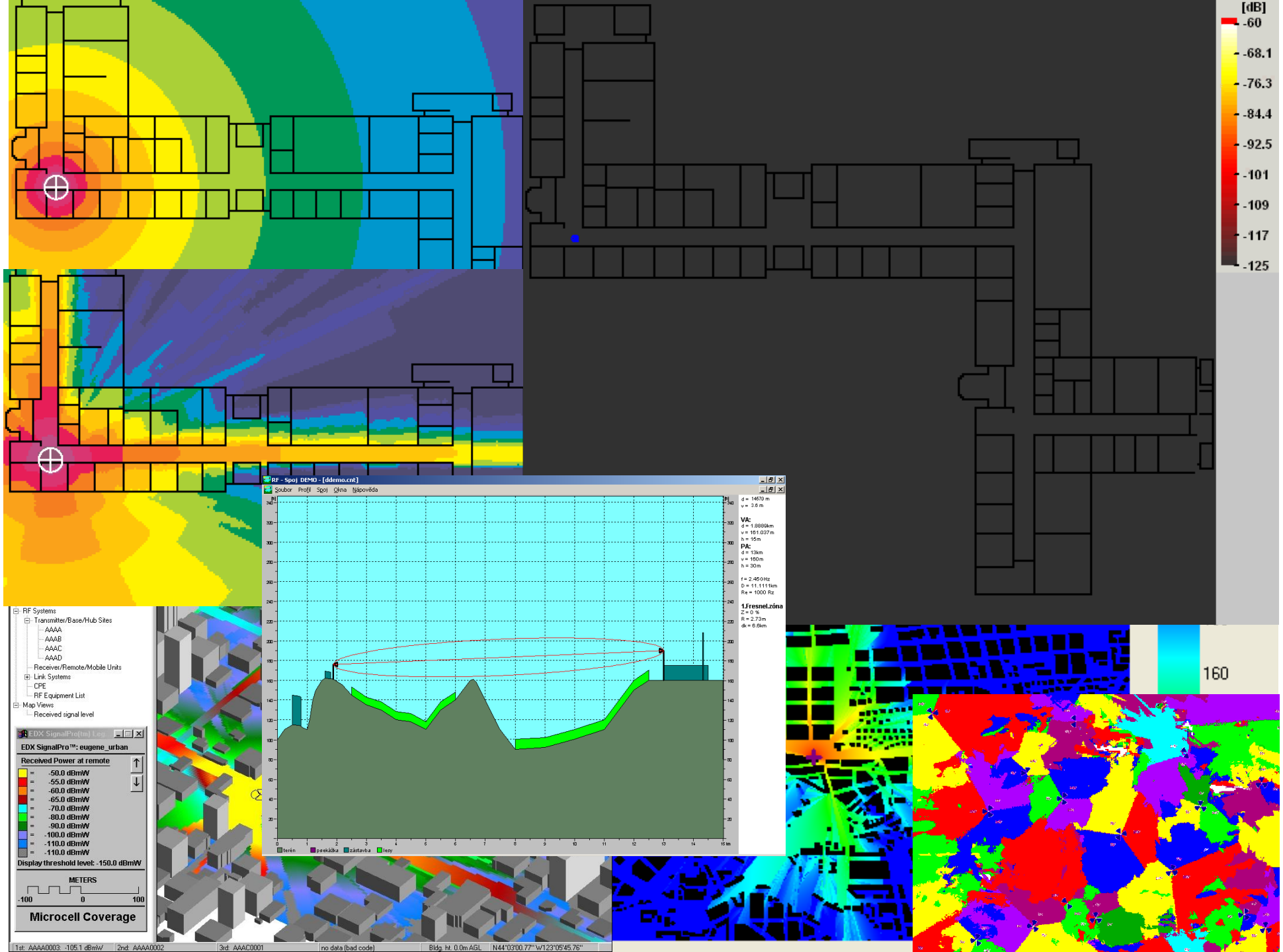
Katedra elektromagnetického pole

ZÁKLADNÍ ANTÉNNÍ PARAMETRY

ÚVOD DO ŠÍŘENÍ VLN PRO RÁDIOVÉ SPOJE

Slidy byly vytvořeny jako podpora při sledování výkladu přednášky. Proto je jejich využití pro samostudium či jako podklad k přípravě na zápočtový text velmi omezené, neboť některé klíčové poznatky a ukázkové příklady jsou vysvětlovány na tabuli a většina obrázků vyžaduje slovní doprovod. Pro samostudium je na Moodlu k dispozici samostatný učební text.


[dB]
-60
-68.1
-76.3
-84.4
-92.5
-101
-109
-117
-125
RF - Spoj DEMO - [ddemo.cnt]
Soubor Profil Spoj Okna Nápověda
160
RF Systems
Transmitter/Base/Hub Sites
AAAA
AAAB
AAAC
AAAD
Receiver/Remote/Mobile Units
Link Systems
CPE
RF Equipment List
Map Views
Received signal level
EDX SignalPro™: eugene_urban
Received Power at remote
-50.0 dBmW
-55.0 dBmW
-60.0 dBmW
-65.0 dBmW
-70.0 dBmW
-80.0 dBmW
-90.0 dBmW
-100.0 dBmW
-110.0 dBmW
-110.0 dBmW
Display threshold level: -150.0 dBmW
METERS
-100
0
100
Microcell Coverage
1st: AAAA0003: -105.1 dBmW
2nd: AAAA0002
3rd: AAAC0001
no data (bad code)
Bldg. ht. 0.0m AGL
N44°03'00.77" W123°05'45.76"

Frekvenční spektrum

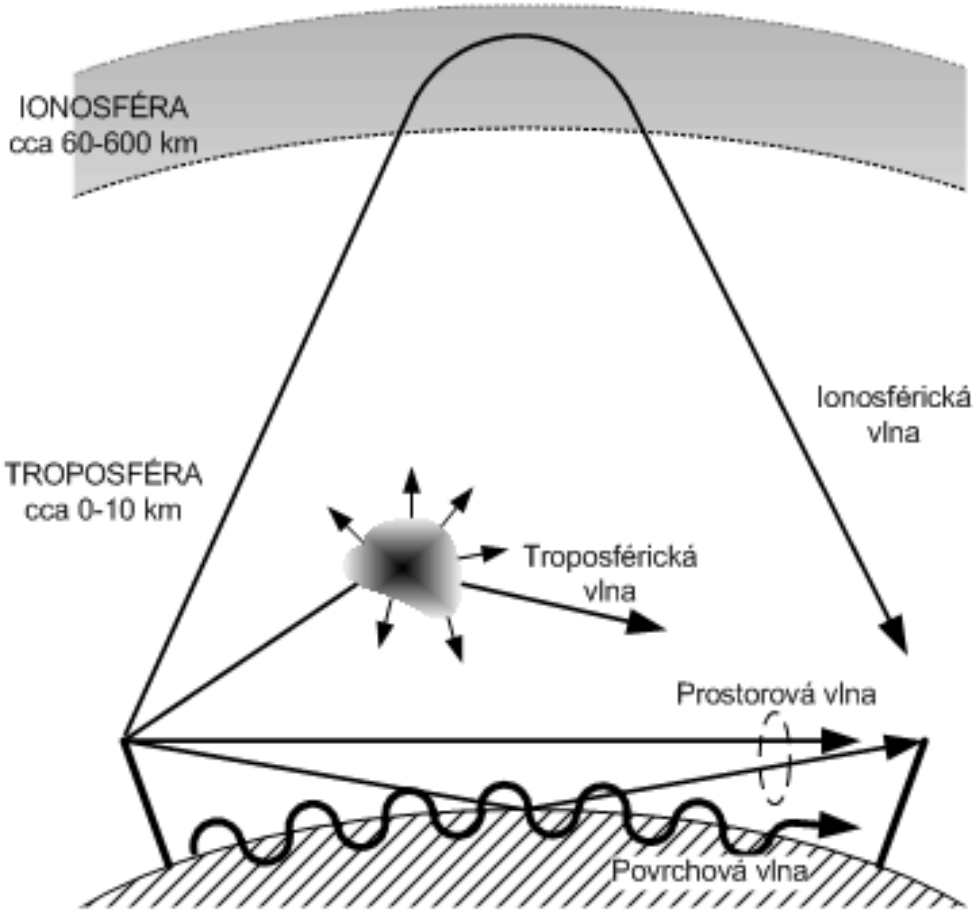
Číslo pásma	Mezinárodní zkratka	Frekvence	Vlnová délka	Český ekvivalent	Metrické označení
3	ULF	300 Hz – 3 kHz	1000 km-100 km	EDV, extrémně dlouhé v.	hkm, hektokilometrické,
4	VLF	3 kHz – 30 kHz	100 km-10 km	VDV, velmi dlouhé vlny	Mam, myriametrové v.
5	LF	30 kHz – 300 kHz	10 km-1 km	DV, dlouhé vlny	km, kilometrové vlny
6	MF	300 kHz – 3 MHz	1 km-100 m	SV, střední vlny	Hm, hektometrové v.
7	HF	3 MHz – 30 MHz	100 m-10 m	KV, krátké vlny	Dm, dekametrové v.
8	VHF	30 MHz – 300 MHz	10 m-1 m	VKV, velmi krátké vlny	m, metrové vlny
9	UHF	300 MHz – 3 GHz	1 m-10 cm	UKV, ultra krátké vlny	dm, decimetrové vlny
10	SHF	3 GHz – 30 GHz	10 cm-1 cm	SKV, super krátké vlny	cm, centimetrové vlny
11	EHF	30 GHz- 300 GHz	1 cm-1 mm	EKV, extrémně krátké vlny	mm, milimetrové vlny

Označení frekvenčních pásem pro rádiový přenos dle ČSN IEC 60050-713 a ITU-R V.431

- Radiokomunikační služby
  - Pevná služba (pevný spoj „bod-bod“)
  - Pozemní pohyblivá službu (mobilní spoj)
  - Rozhlasová službu (spoj „bod-plocha“)
  - Družicové služby – pevná, pohyblivá, rozhlasová
  - …
- Správa frekvenčního spektra
  - ITU, www.itu.int
  - ČTÚ, www.ctu.cz

Způsoby šíření vln pro pozemní rádiové spoje

- Přízemní povrchová vlna
  ground wave – surface w.
- Přízemní prostorová vlna
  ground wave – space w.
- (šíření vlnovodným kanálem – *ducting*)
- Troposférická vlna
  tropospheric wave
- Ionosférická vlna
- *sky wave, (ionospheric w.)*
- …



Základní anténní parametry

RADIOWAVES

2.4 - 2.5 GHz
Parabolic Subscriber Antennas

Features

- Lightweight and rugged design
- Low windload
- Easily installed
- RF Connector Interface: Type "N" female
- Standard antenna mount (NS) provides fine adjustment for both azimuth and elevation. Accommodates a 1.0". to 4.5" diameter pipe
- NL Series removes the fine adjustment feature for both azimuth and elevation. Accommodates a 1.0" to 2.25 " pipe
- Optional mounting kit available for *NL Series* to mount to a 2.5" to 4.5" diameter pipe
- Standard color white; other colors available on request
- Radome standard on 1' model, optional on 2'model
- Polarization: Single

Electrical Specifications (typical performance)

Model Number	Frequency, GHz	Gain dBi (nominal)	Beamwidth ° -3dB	X-Pol. Rejection, dB	F/B Ratio dB	VSWR, Max (R.L., dB)
SP1-2.4	2.4 - 2.5	14.0	28.0	17	25	1.5:1 (14.0)
SP2-2.4	2.4 - 2.5	21.3	14.0	28	28	1.5:1 (14.0)

** All specifications subject to change without notice.*

Radio Waves, Inc.
http://www.radiowavesinc.com

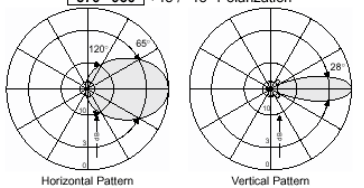
Dual-band A-Panel — 870–960 | 1710–1880
Dual Polarization — X | X
Half-power Beam Width — 65° | 65°
Integrated Combiner — C

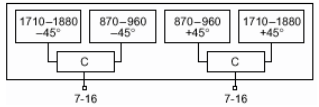
KATHREIN
Antennen · Electronic

XXPol A-Panel 870–960/1710–1880 C 65°/65° 12.5/13dBi

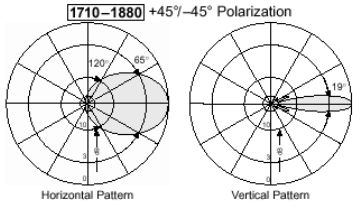
Type No.	741 316	
Frequency range	870–960 870 – 960 MHz	1710–1880 1710 – 1880 MHz
Polarization	+45°, –45°	+45°, –45°
Gain	2 x 12.5 dBi	2 x 13 dBi
Half-power beam width Copolar +45°/–45°	Horizontal: 65° Vertical: 28°	Horizontal: 60° Vertical: 19°
Front-to-back ratio, copolar	> 30 dB	> 30 dB
Isolation, 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 (at 50 °C ambient temperature)	150 Watt
Integrated combiner	The insertion loss is included in the given antenna gain values.	

870–960 +45°/–45° Polarization





1710–1880 +45°/–45° Polarization



Mechanical specifications	
Input	2 x 7-16 female
Connector position*	Bottom or top
Weight	7 kg
Wind load	Frontal: 110 N (at 150 km/h) Lateral: 60 N (at 150 km/h) Rearside: 240 N (at 150 km/h)
Max. wind velocity	200 km/h
Packing size	782 x 287 x 165 mm
Height/width/depth	656 / 262 / 116 mm

* Inverted mounting:
Connector position top: Change drain hole screw.

Mounting accessories are not included in the scope of delivery (see page 159 – 164)

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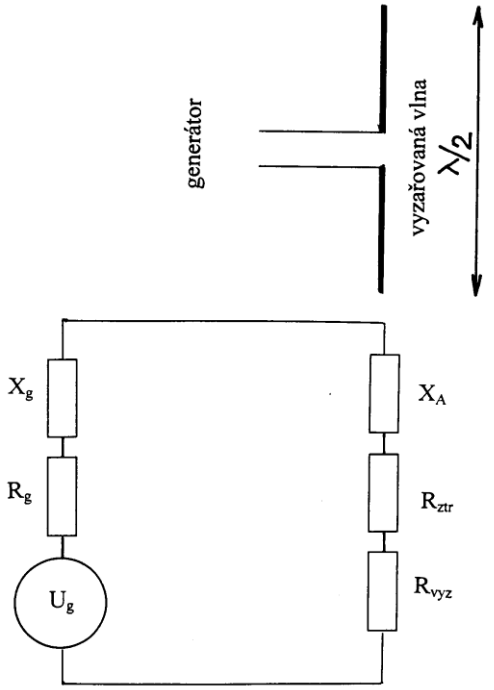
Vstupní impedance antény



$$Z_A = R_A + jX_A$$

$$R_A = R_{vyz} + R_{ztr}$$

R_{vyz} je vyzařovací odpor antény *radiation resistance*

R_{ztr} je ztrátový odpor antény *loss resistance*

$$I_g = \frac{U_g}{Z} = \frac{U_g}{Z_A + Z_g} = \frac{U_g}{\left(R_{vyz} + R_{ztr} + R_g\right) + j\left(X_A + X_g\right)}$$

$$P_{vyz} = \frac{1}{2}\left|I_g\right|^2 R_{vyz} = \frac{\left|U_g\right|^2}{2}\left[\frac{R_{vyz}}{\left(R_{vyz} + R_{ztr} + R_g\right)^2 + \left(X_A + X_g\right)^2}\right]$$

$$P_{ztr} = \frac{1}{2}\left|I_g\right|^2 R_{ztr} = \frac{\left|U_g\right|^2}{2}\left[\frac{R_{ztr}}{\left(R_{vyz} + R_{ztr} + R_g\right)^2 + \left(X_A + X_g\right)^2}\right]$$

$$R_{vyz} + R_{ztr} = R_g$$

$$X_A = -X_g$$

$$P_{vyz} = \frac{\left|U_g\right|^2}{2}\left[\frac{R_{vyz}}{\left(2\left(R_{vyz} + R_{ztr}\right)\right)^2}\right] = \frac{\left|U_g\right|^2}{8}\left[\frac{R_{vyz}}{\left(R_{vyz} + R_{ztr}\right)^2}\right]$$

$$P_{ztr} = \frac{\left|U_g\right|^2}{8}\left[\frac{R_{ztr}}{\left(R_{vyz} + R_{ztr}\right)^2}\right]$$

$$\eta = \frac{P_{vyz}}{P_{vst}} = \frac{\frac{\left|U_g\right|^2}{8}\frac{R_{vyz}}{\left(R_{vyz} + R_{ztr}\right)^2}}{\frac{\left|U_g\right|^2}{8}\frac{R_{vyz} + R_{ztr}}{\left(R_{vyz} + R_{ztr}\right)^2}} = \frac{R_{vyz}}{R_{vyz} + R_{ztr}} = \eta_c \eta_d$$

Impedanční přizpůsobení antény

- Stav výkonového přizpůsobení

$$R_{vyz} + R_{ztr} = R_A = R_g$$

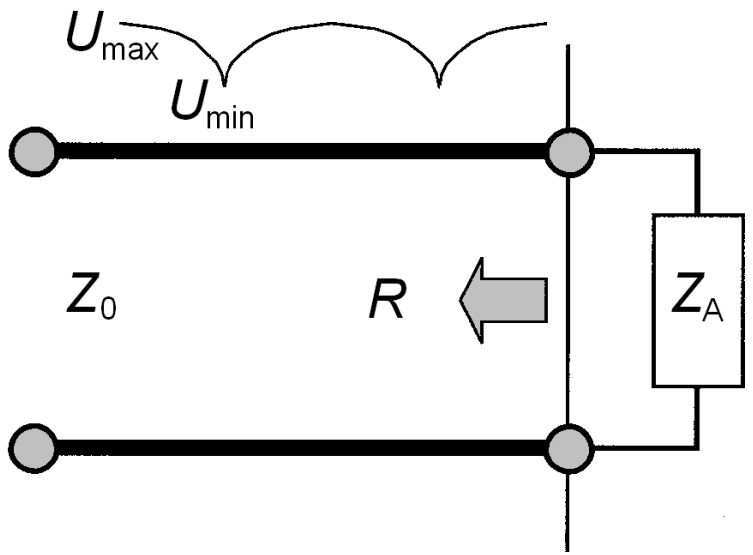
$$X_A = -X_g \quad (=0)$$

- Přizpůsobení k napájecímu vedení

$$R = \frac{Z_A - Z_o}{Z_A + Z_o}$$

$$PSV = \frac{U_{\max}}{U_{\min}} = \frac{1+|R|}{1-|R|}$$

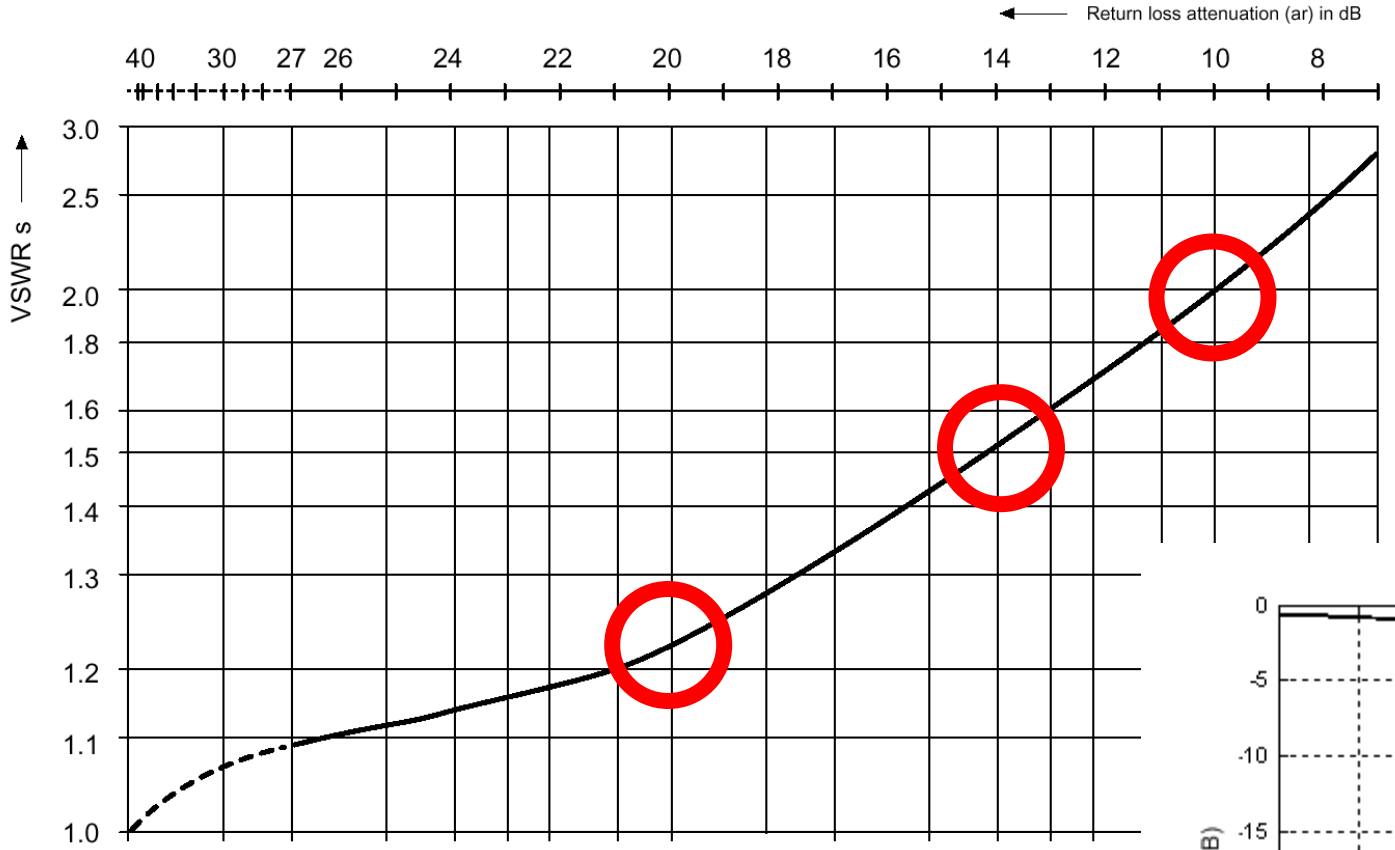
$$|R| = \frac{PSV-1}{PSV+1}$$

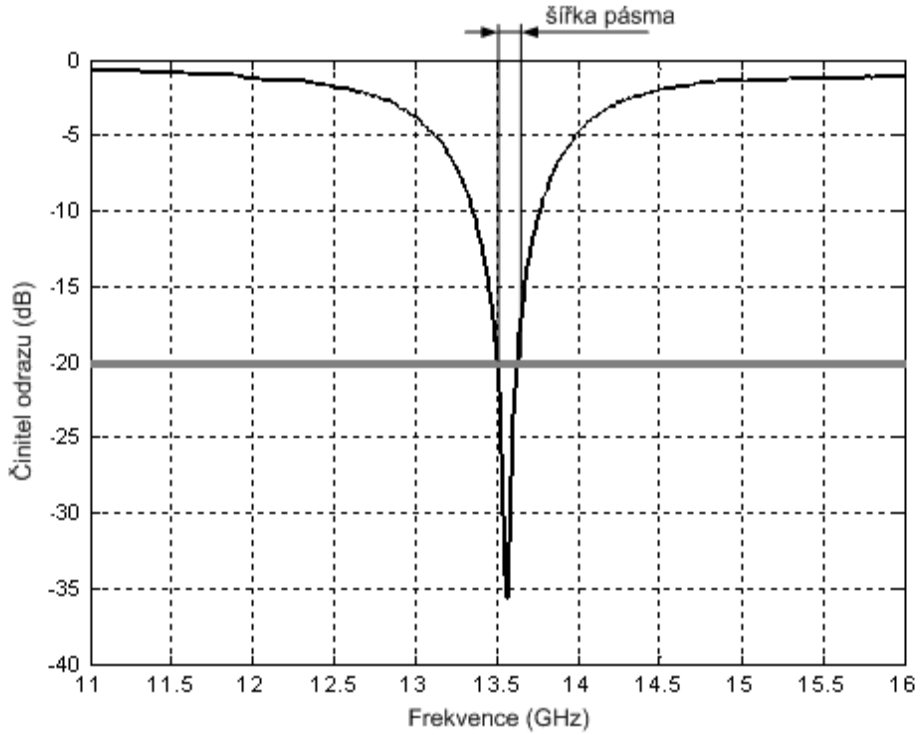


$$RL = 10\log\frac{P_{vst}}{P_{odr}} = 10\log\left(\frac{1}{|R|^2}\right) = -20\log|R|$$

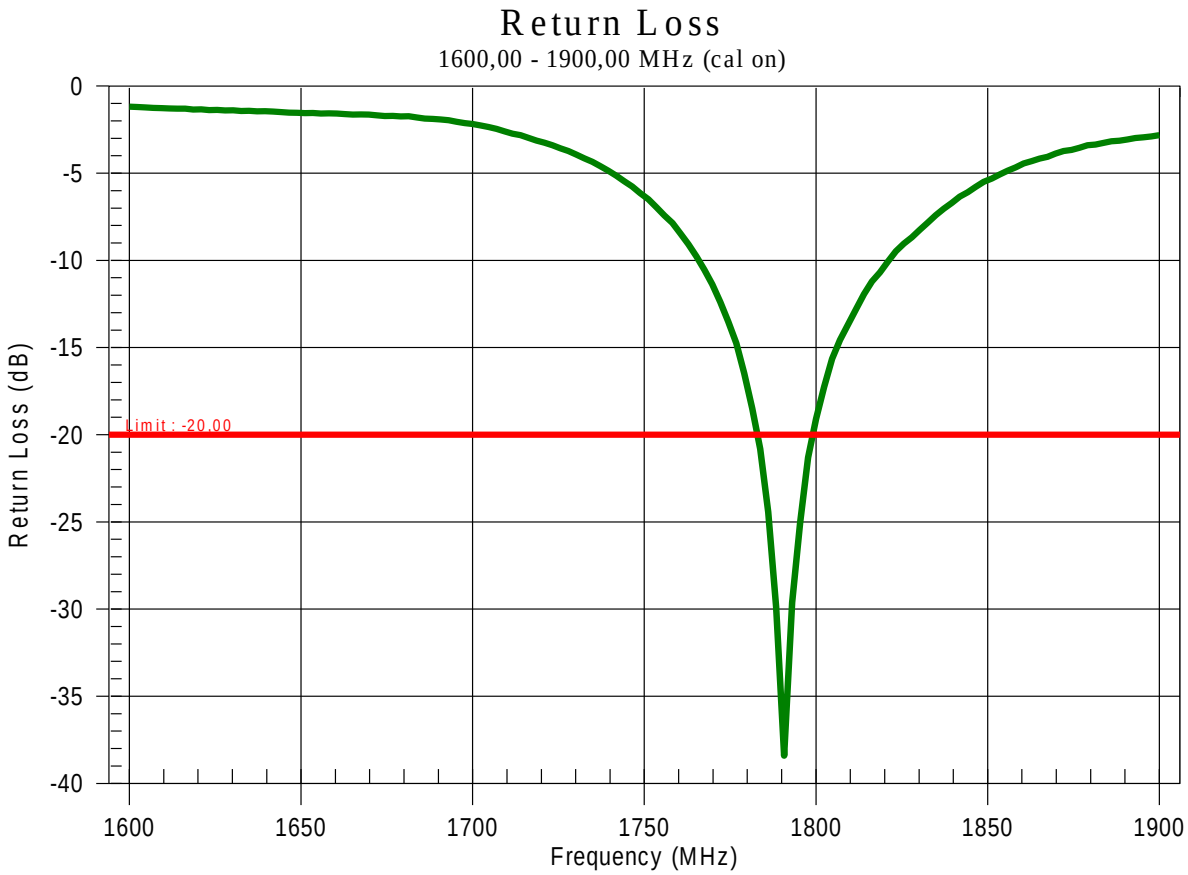
$$L_I = -10\log\left(1-|R|^2\right)$$

Šířka frekvenčního pásma

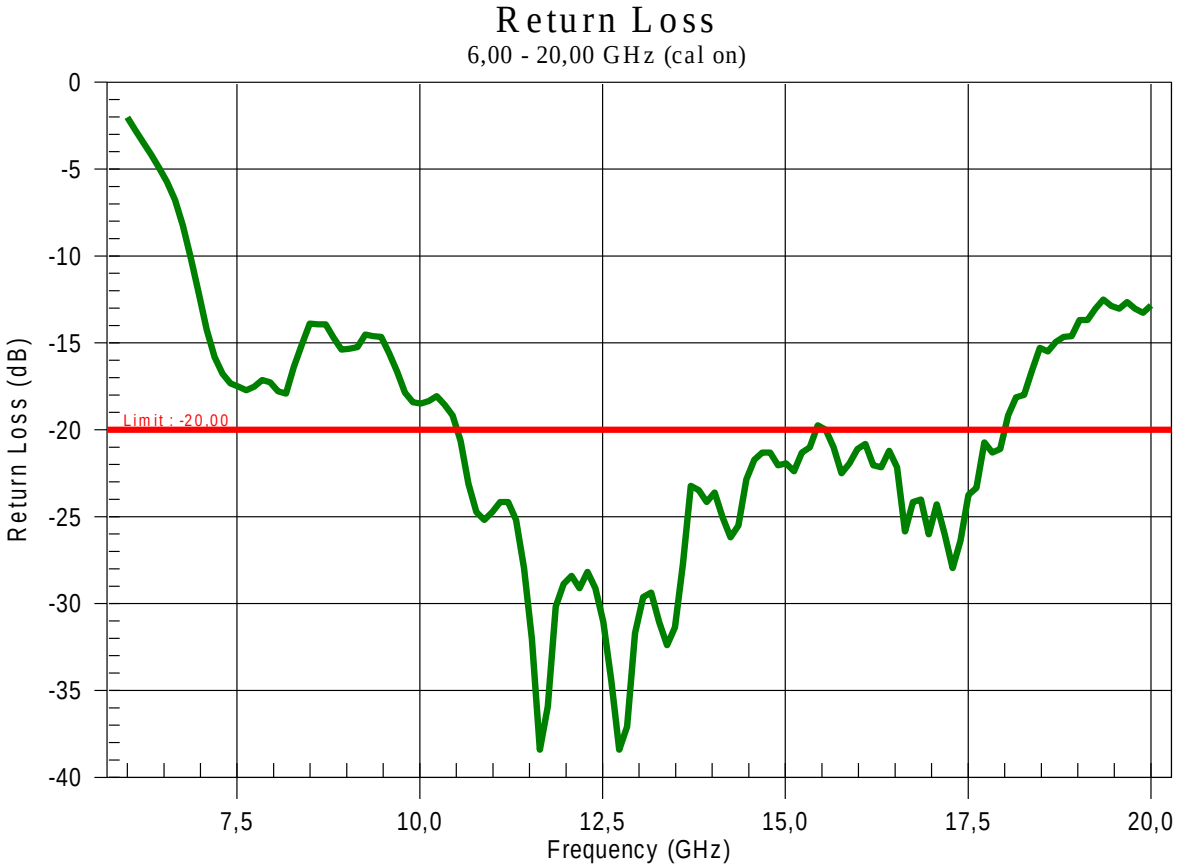




Šířka frekvenčního pásma

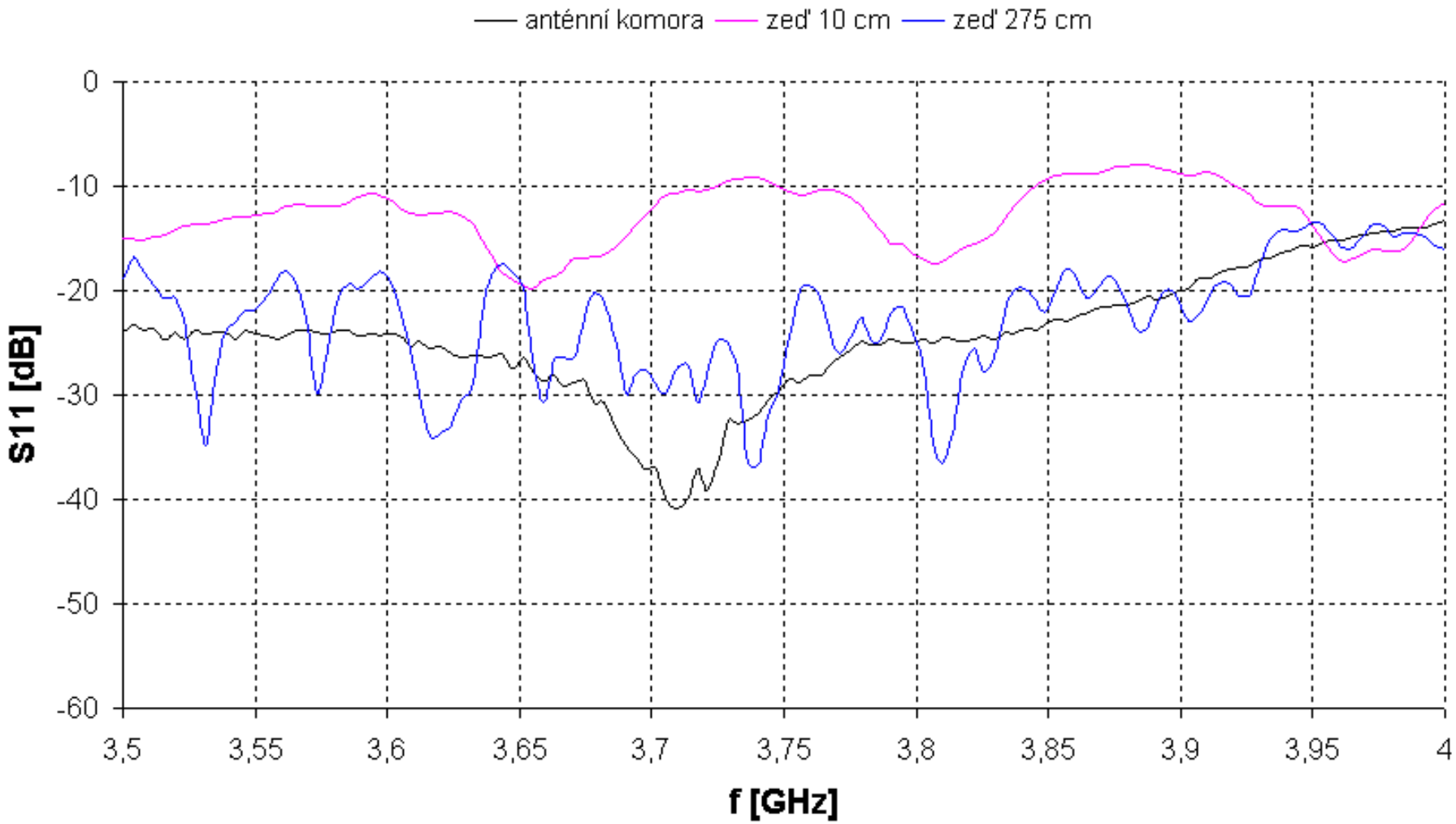


Resolution: 130

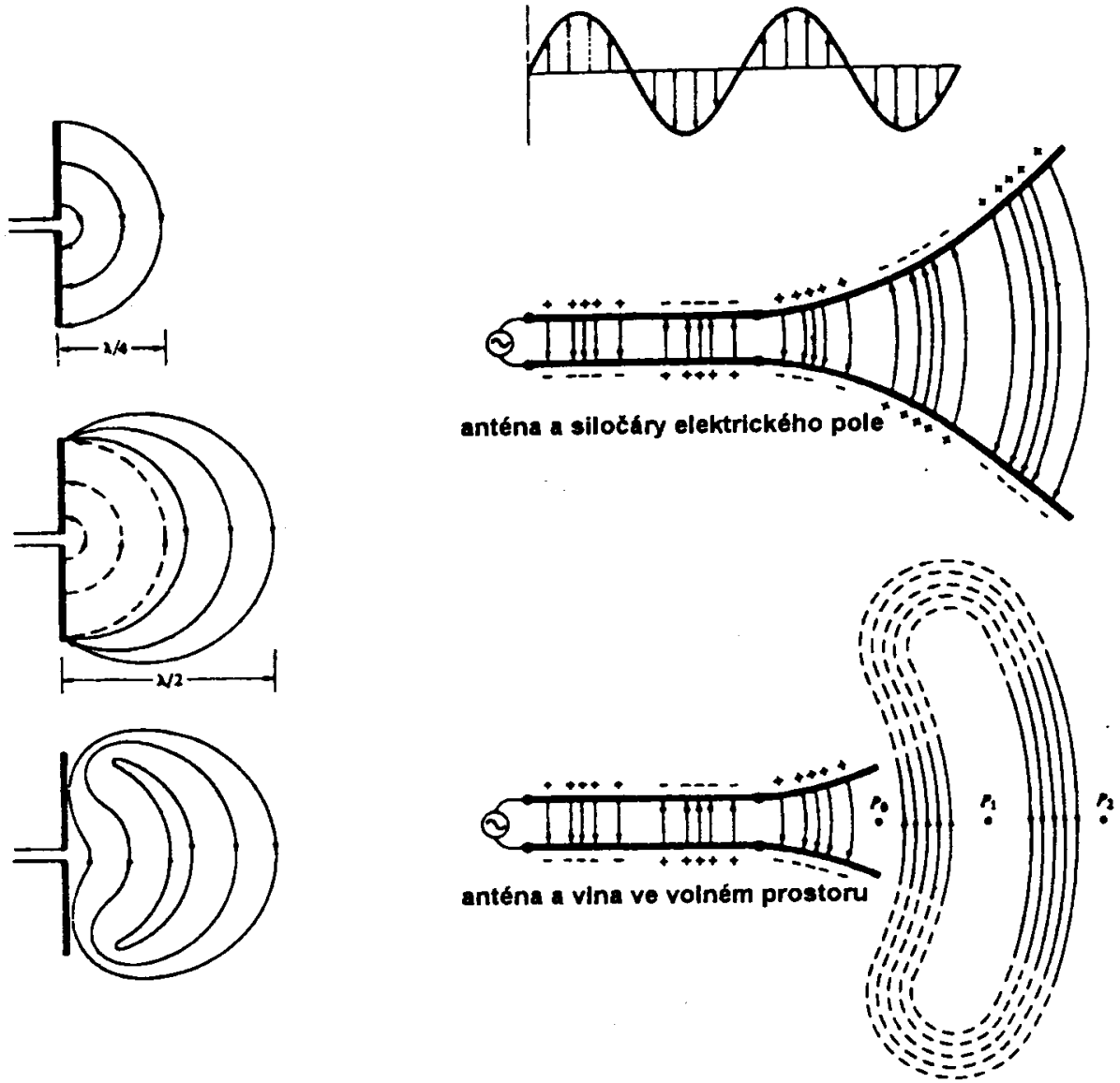


Resolution: 130

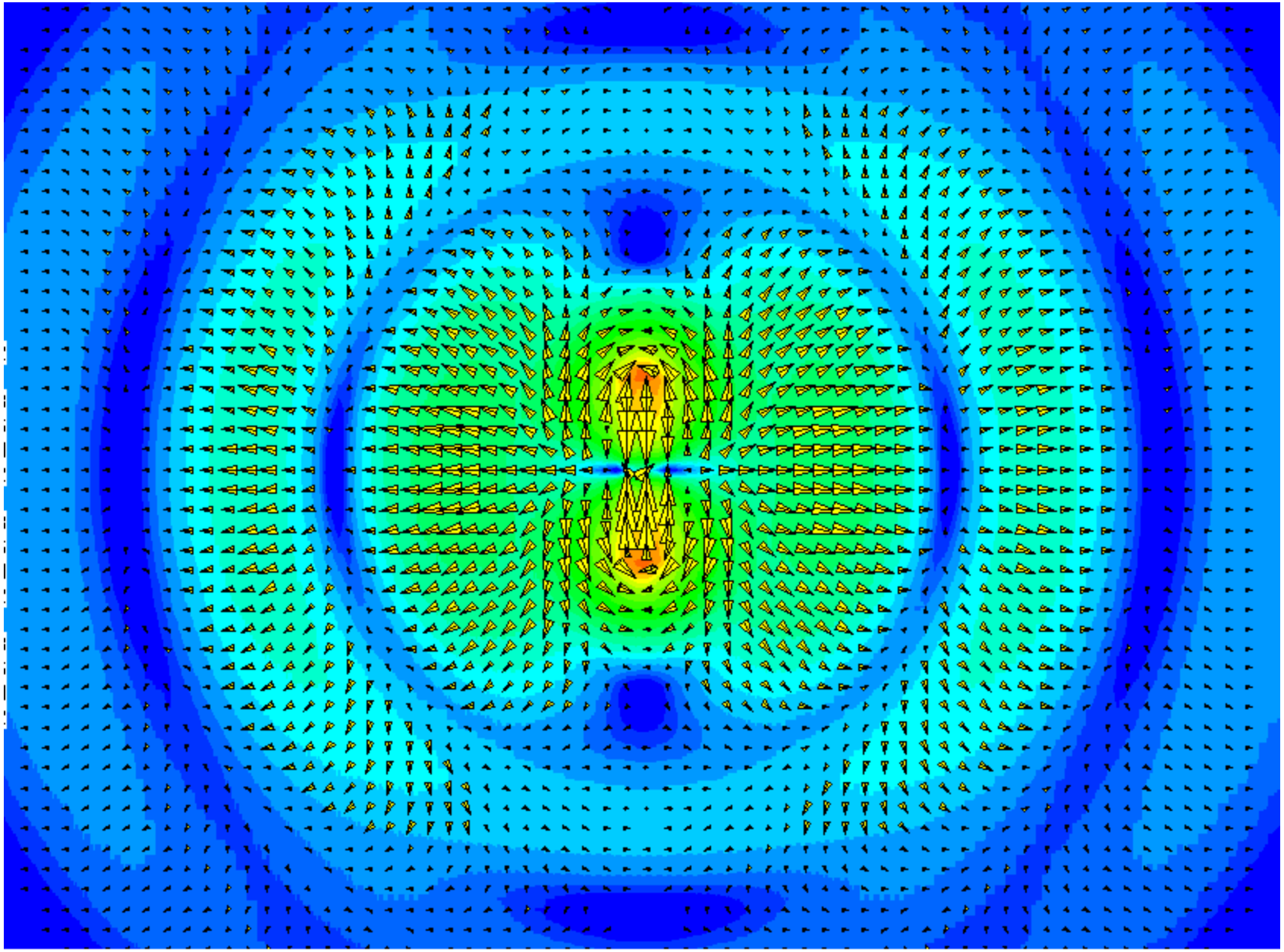
Závislost přizpůsobení trychtýře R32 na jeho umístění



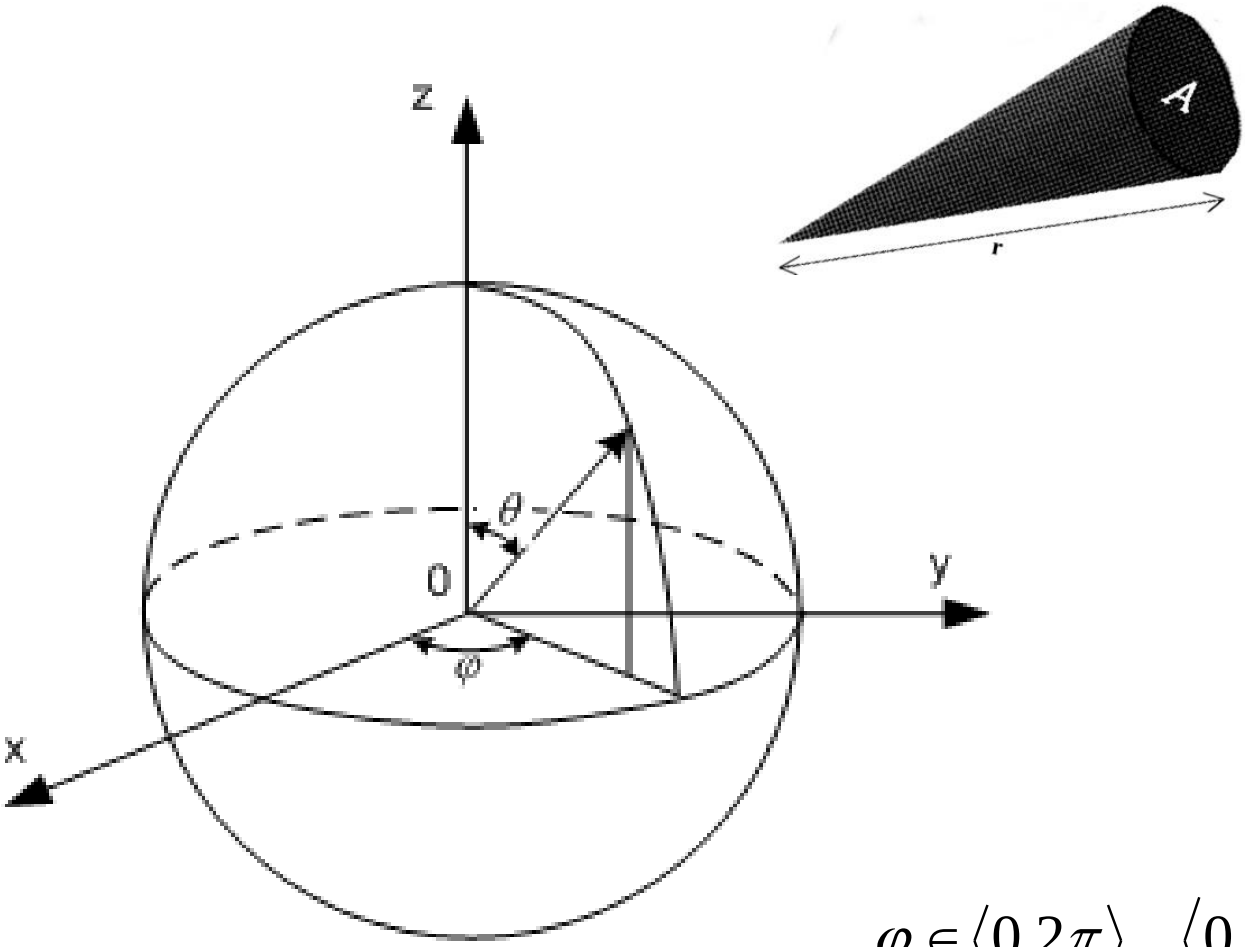
Mechanizmus vyzařování



Vzdálená zóna (Fraunhoferova oblast)



Směrové vlastnosti antén

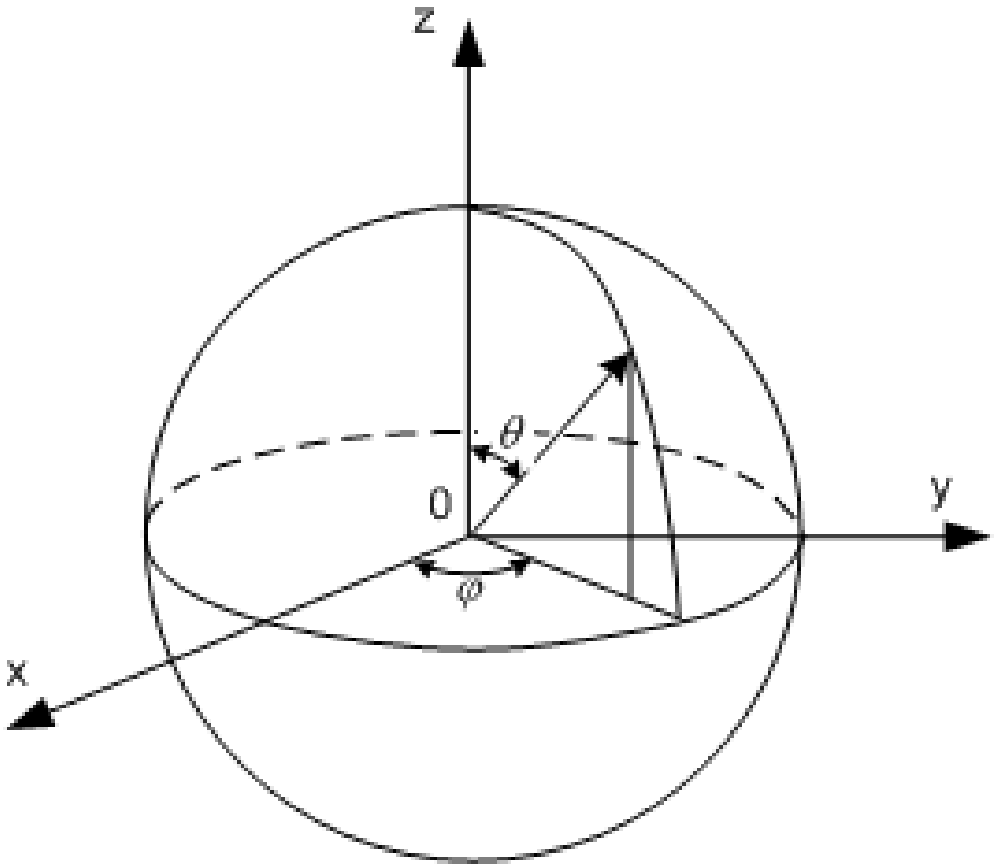


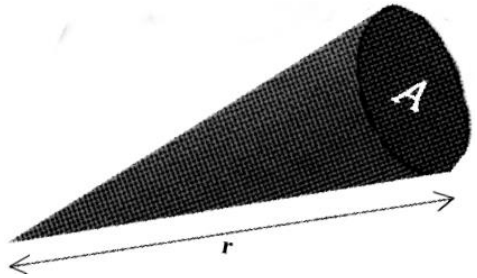
$$\Omega = \frac{A}{r^2}$$

$$\varphi \in \langle 0,2\pi \rangle \quad \langle 0,360^\circ \rangle$$

$$\vartheta \in \left\langle -\frac{\pi}{2},+\frac{\pi}{2} \right\rangle \quad \langle -90^\circ,+90^\circ \rangle \quad \langle 0,\pi \rangle$$

Isotropický zářič



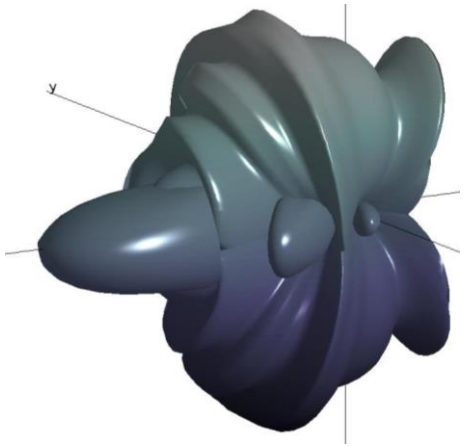


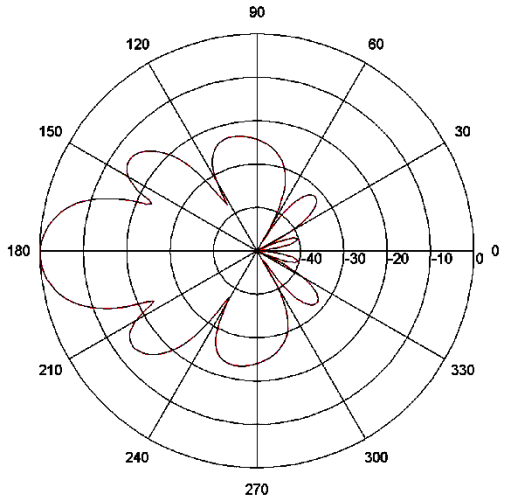
$$\Omega = \frac{A}{r^2}$$

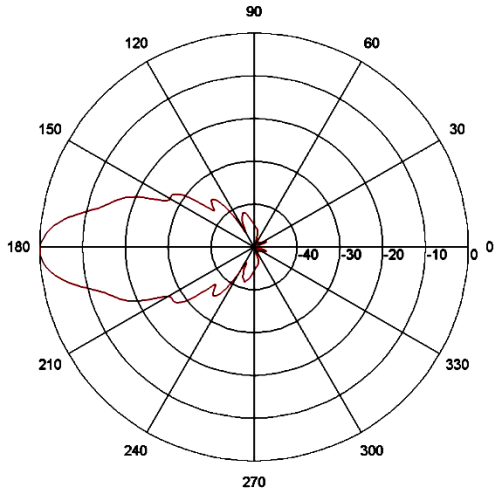
$$P_{\mathrm{vy\,z}} = \oint_{\Omega} U \,\mathrm{d}\Omega = U_0 \oint_{\Omega} \mathrm{d}\Omega = 4\pi U_0$$

$$\vec{E} = E_0 \, e^{j\psi} \vec{a}_o \, \frac{\mathrm{e}^{-jkd}}{d}$$

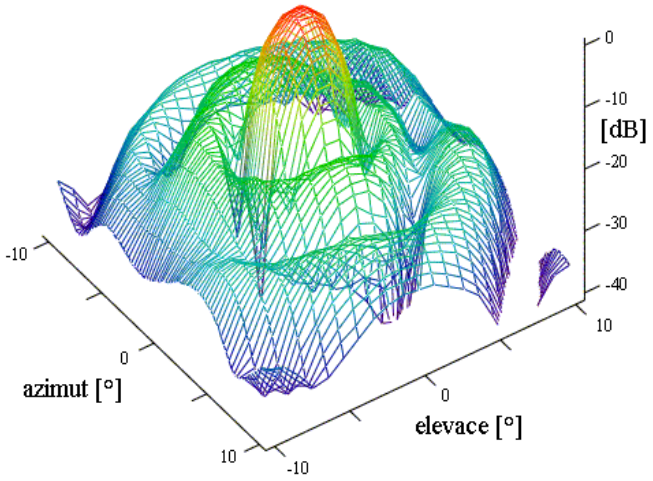
Směrová/vyzařovací charakteristika

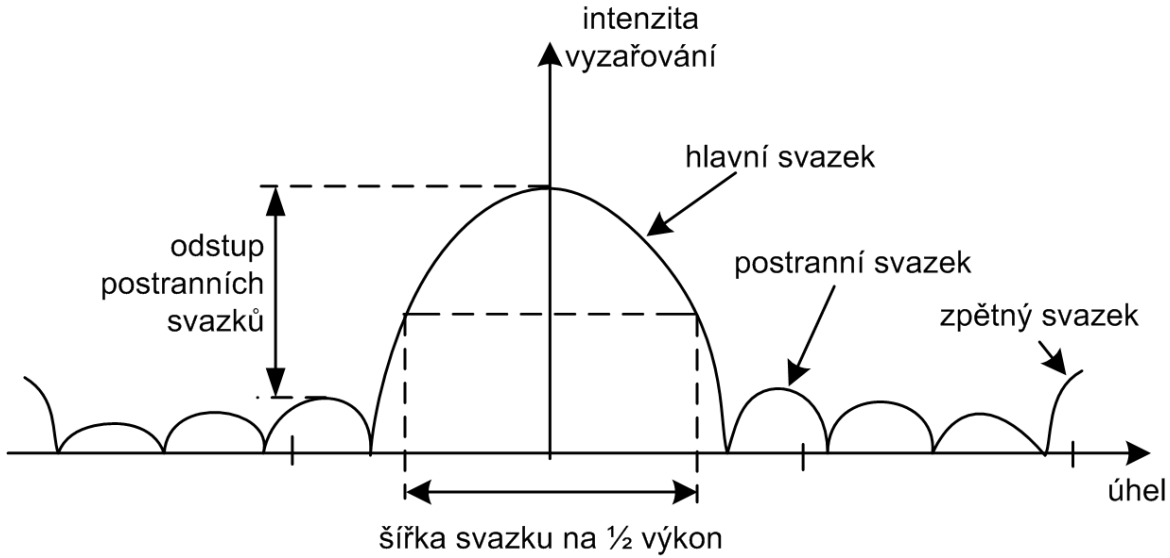




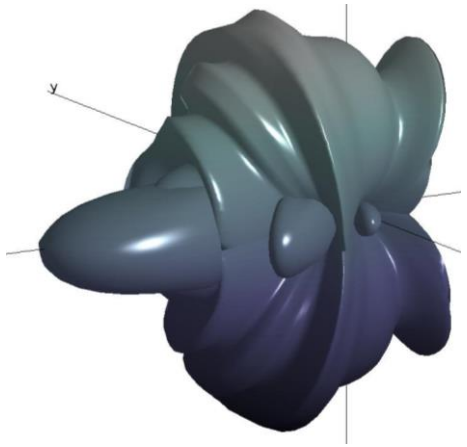


$$\vec{E} = E_0 \, e^{j\psi} \vec{a}_o \, F(\vartheta,\varphi) \frac{\mathrm{e}^{-jkd}}{d}$$





Směrová/vyzařovací charakteristika

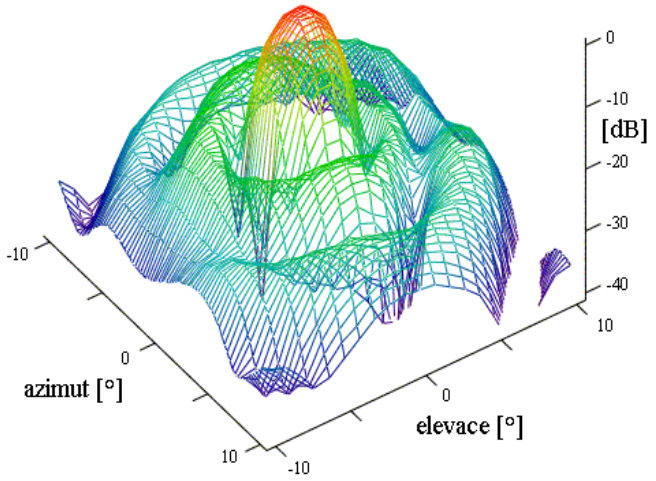


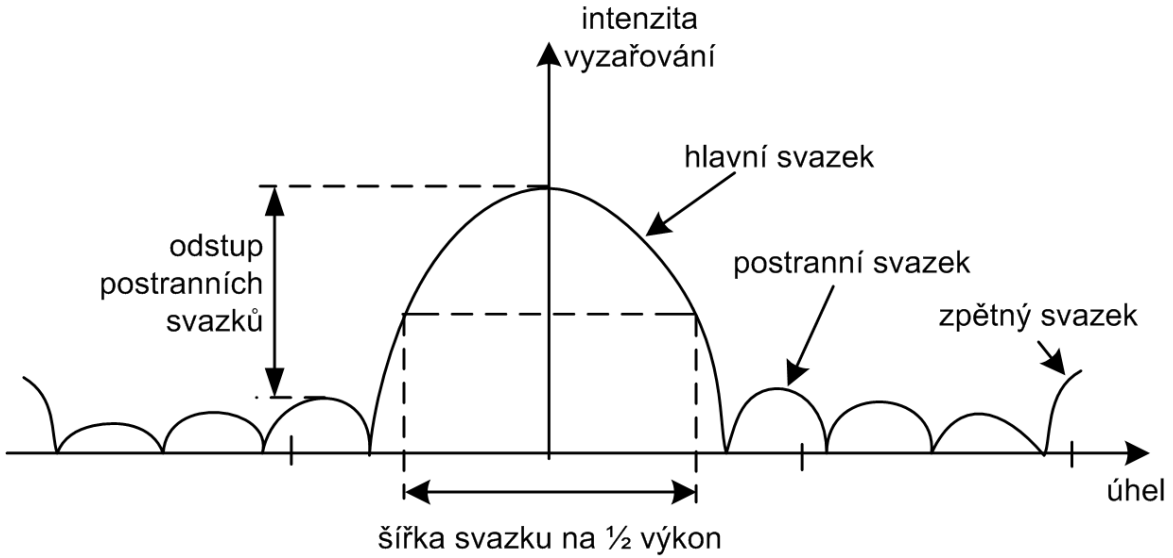
$$P_{vyz} = B_0 \int_0^{2\pi} \int_0^{\pi} \left| F^2(\vartheta,\varphi) \right| \sin\vartheta \, d\vartheta \, d\varphi$$

$$\left| F_n(\vartheta,\varphi) \right| = \frac{\left| F(\vartheta,\varphi) \right|}{\max\left[\left| F(\vartheta,\varphi) \right| \right]}$$

$$\vec{E} = E_0 \, e^{j\psi} \vec{a}_o \, F(\vartheta,\varphi) \frac{e^{-jkd}}{d}$$

$$10 \log\left[\left| F_n(\vartheta,\varphi) \right|^2 \right]$$



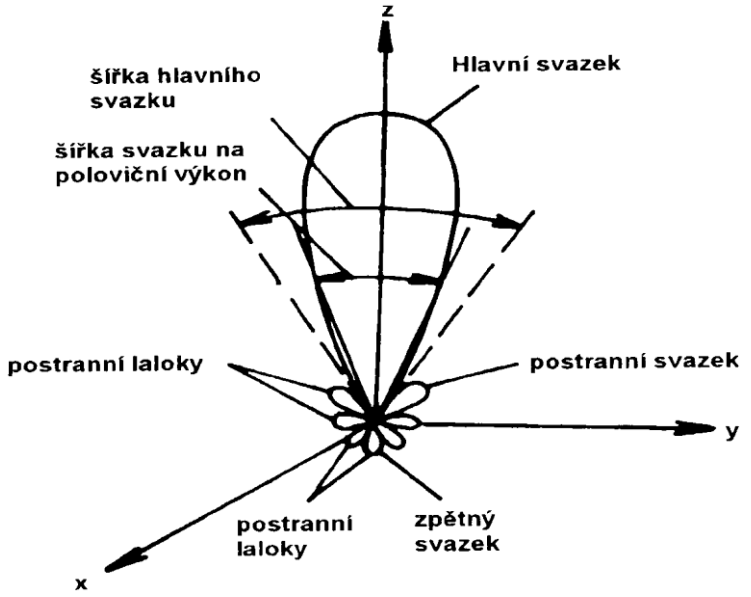


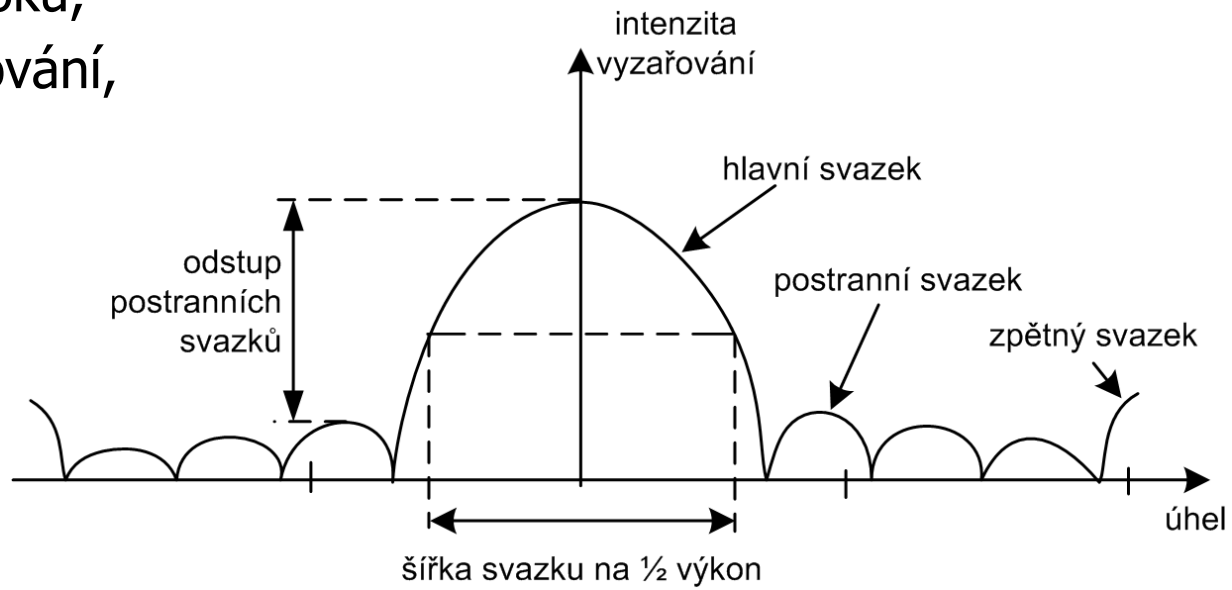
Směrová charakteristika - pojmy

- hlavní maximum (lalok, svazek)
- vedlejší maxima
- postranní maxima
- zpětný svazek

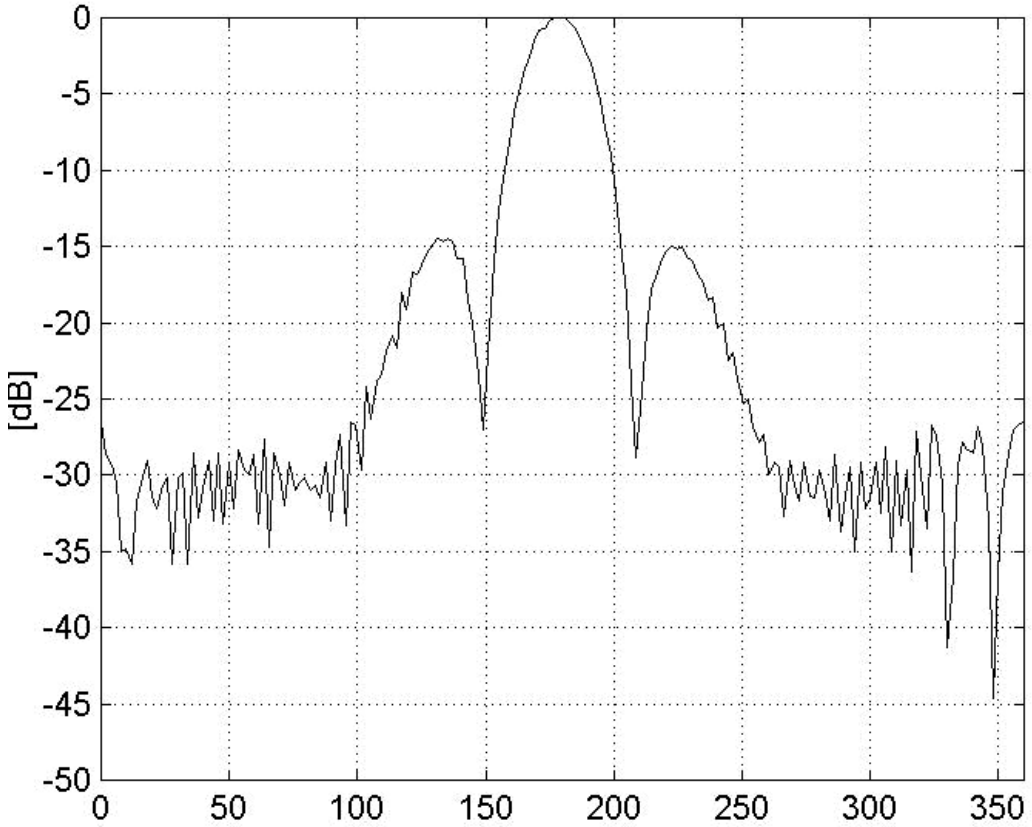
- šířka svazku na 1/2 výkon, *HPBW*
- š. sv. mezi prvními nulami, *FNBW*

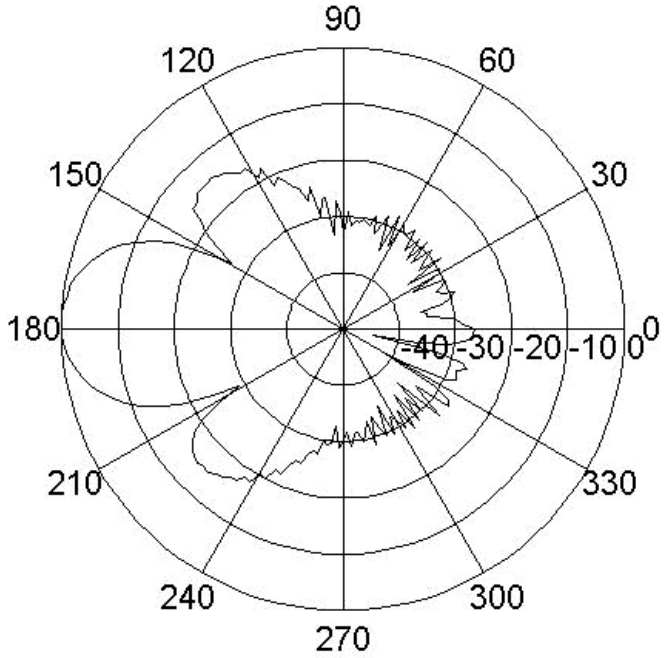
- odstup postranních laloků,
- činitel zpětného vyzařování,





Základní řezy směrovou charakteristikou

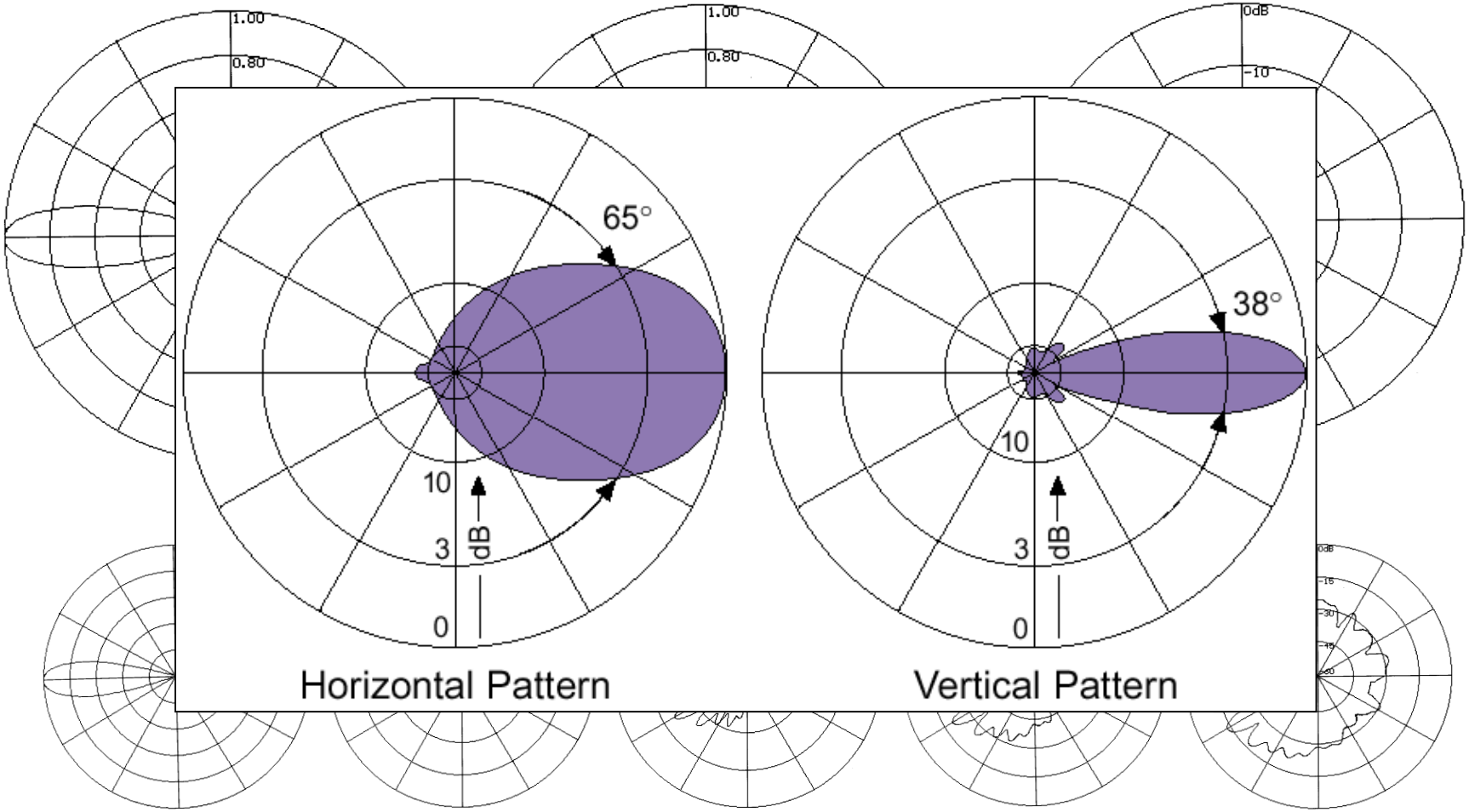




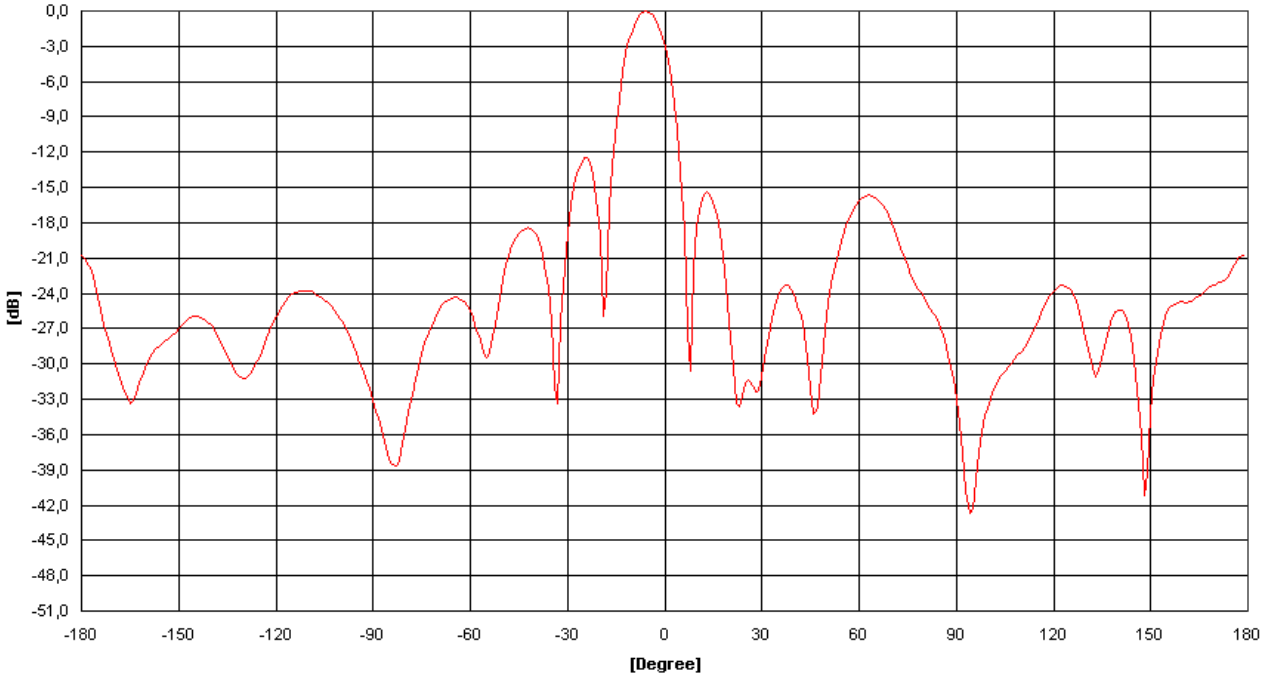
kartézské x polární souřadnice

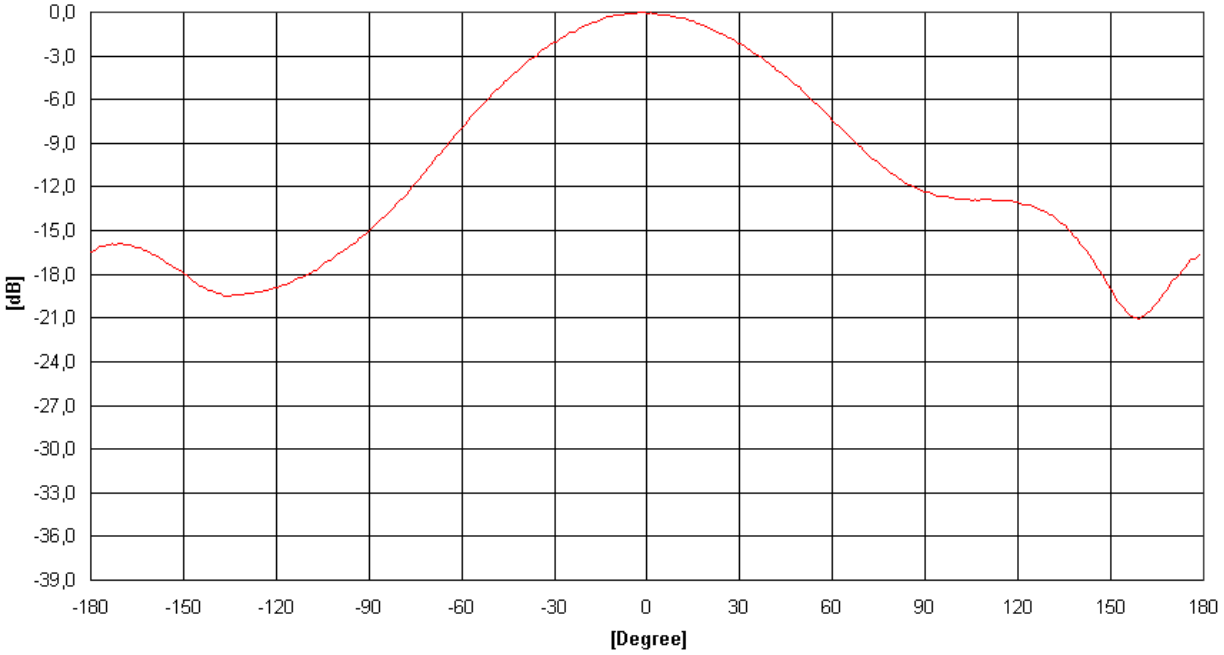
Směrová charakteristika - zobrazení

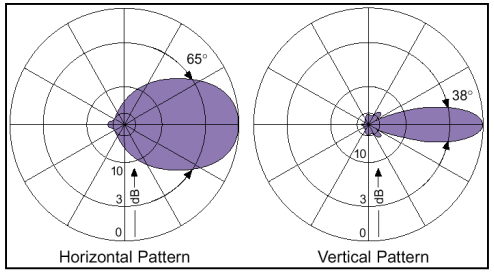
- směrová / vyzařovací
- napěťová (E, U)
- **výkonová** (P, E^2, U^2)
- **normovaná** $F_n(\vartheta,\varphi) = F(\vartheta,\varphi)/F_{max}$
- kartézské / polární souřadnice
- lineární / **logaritmické** (**dB**) měřítko



Příklad výstupů měření směrové charakteristiky (vertikální a horizontální řez) panelové antény GSM 900 MHz







Základní anténní parametry

- Vstupní impedance
- Šířka pásma / imp. přizpůsobení
- Vyzařovací účinnost
- Směrová/vyzařovací charakteristika
  - Šířka svazku
  - Předozadní poměr
  - Odstup vedlejších laloků
  - …
- Směrovost
- Zisk
- Efektivní plocha
- Polarizace (odstup křížové pol.)

Směrovost

$$D(\vartheta,\varphi) = \frac{U(\vartheta,\varphi)}{U_0} = \frac{4\pi U(\vartheta,\varphi)}{P_{\mathrm{vyz}}}$$

$$P_{\mathrm{vyz}} = 4\pi U_0$$

$$D_{\max} = \frac{U_{\max}}{U_0} = \frac{4\pi U_{\max}}{P_{\mathrm{vyz}}}$$

$$U_{\max} = B_0 \left| F_{\max}^2(\vartheta_0,\varphi_0) \right|$$

$$P_{\mathrm{vyz}} = \oint_{\Omega} U(\vartheta,\varphi)\,\mathrm{d}\Omega = B_0 \int_0^{2\pi}\int_0^{\pi} |F^2(\vartheta,\varphi)| \sin\vartheta\,\mathrm{d}\vartheta\,\mathrm{d}\varphi$$

$$D(\vartheta_0,\varphi_0) = 4\pi \frac{\left|F^2(\vartheta_0,\varphi_0)\right|}{\int_0^{2\pi}\int_0^{\pi} |F^2(\vartheta,\varphi)| \sin\vartheta\,\mathrm{d}\vartheta\,\mathrm{d}\varphi}$$

$$D_{\max} = 4\pi \frac{\left|F_{\max}^2(\vartheta_0,\varphi_0)\right|}{\int_0^{2\pi}\int_0^{\pi} |F^2(\vartheta,\varphi)| \sin\vartheta\,\mathrm{d}\vartheta\,\mathrm{d}\varphi} = \frac{4\pi}{\int_0^{2\pi}\int_0^{\pi} |F_{\mathrm{n}}^2(\vartheta,\varphi)| \sin\vartheta\,\mathrm{d}\vartheta\,\mathrm{d}\varphi}$$

$$D_{dB} = 10\log D \quad [\mathrm{dB}\,(\mathrm{dBi})]$$

Zisk antény

$$G = \eta_{vyz} D = \frac{4\pi U}{P_v}$$

Anténa	*G* (-)	*G* (dBi)	HPBW (º)
Izotropický zářič	1	0	360
Elementární dipól	1,5	1,75	90/360
Půlvlnný dipól	1,64	2,15	78/360
Parabolická refl. ant. ø 1 m, 1 GHz	60	18	26
Parabolická refl. ant. ø 2 m, 1 GHz	250	24	13
Parabolická refl. ant. ø 5 m, 1 GHz	1 580	32	5
Parabolická refl. ant. ø 1 m, 2 GHz	250	24	26
Parabolická refl. ant. ø 1 m, 10 GHz	6 300	38	2,5
Parabolická refl. ant. ø 1 m, 50 GHz	158 000	52	0,5

Efektivní plocha (apertura) antény

$$P_p = S_{dop} A_{ef}$$

P_v … výkon antény dodaný na zátěá [W]

S_{dop} … dopadající výkonová hustota [W/m^2]

A_{ef} … efektivní plocha (effective aperture/area) [m^2]

$$A_{ef\,\max} = \left(\frac{\lambda^2}{4\pi} \right) G_{\max}$$

$$G = \frac{4\pi}{\lambda^2} \eta A$$

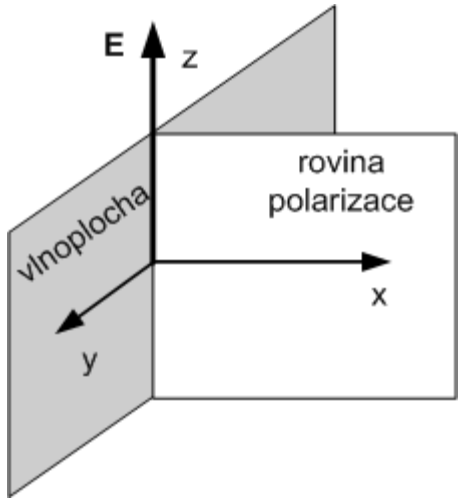
G ... zisk plošné antény

η ... účinnost využití apertury
(u reflektorových antén cca 0,45-0,65)

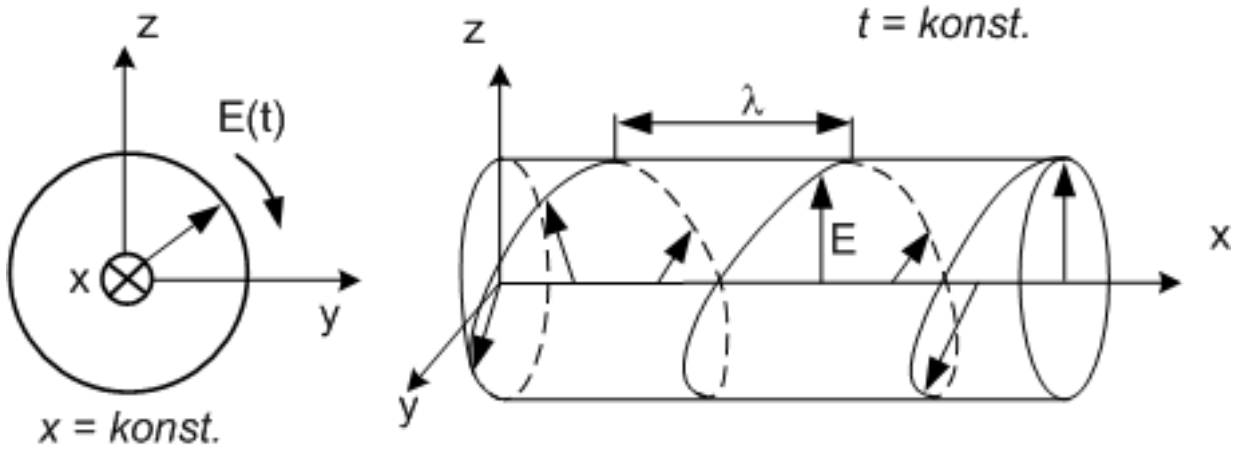
A ... fyzická plocha/apertura ústí antény

Polarizace

- Lineární

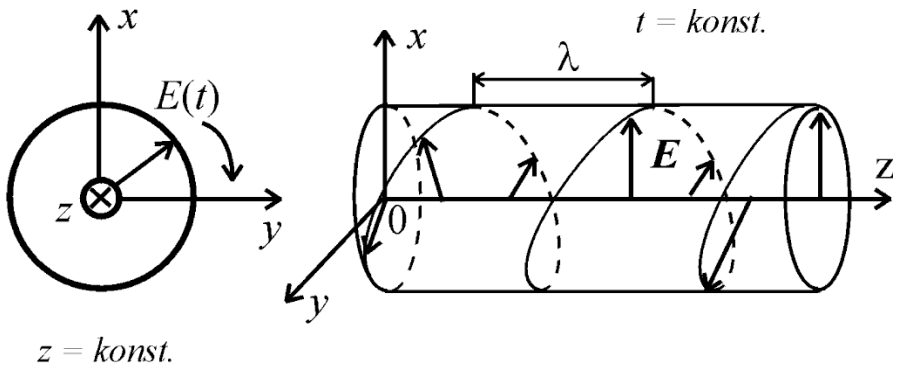


- Kruhová ($E_z = E_y$ a $\varphi = \pm\pi/2$)



Polarizace

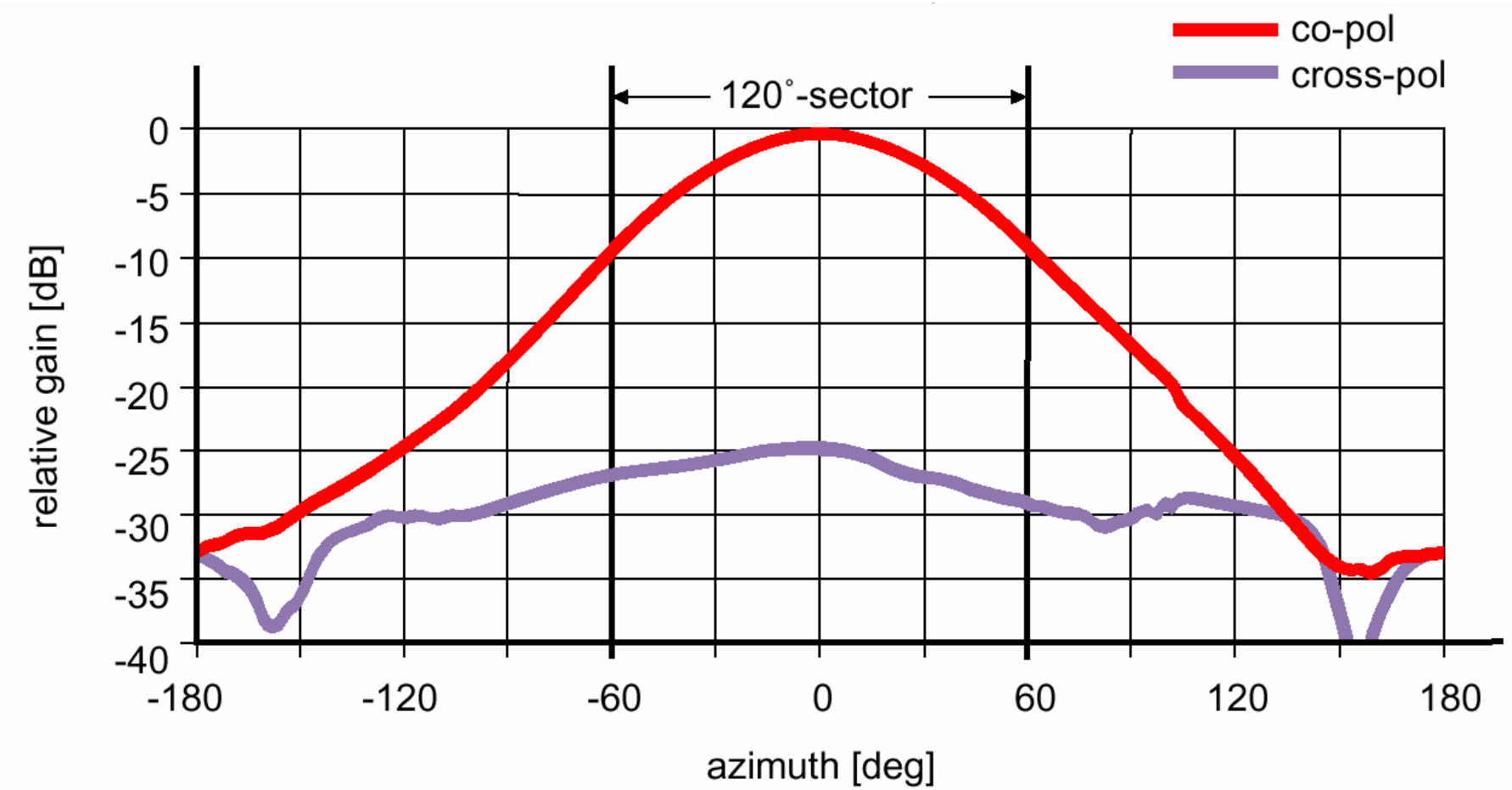
- Kruhová
  - pravotočivá
  - levotočivá
- Lineární (liniová, přímková)
  - vertikální
  - horizontální
- Eliptická



- Polarizační nepřizpůsobení – ztráty
  - Pro lineární polarizaci:

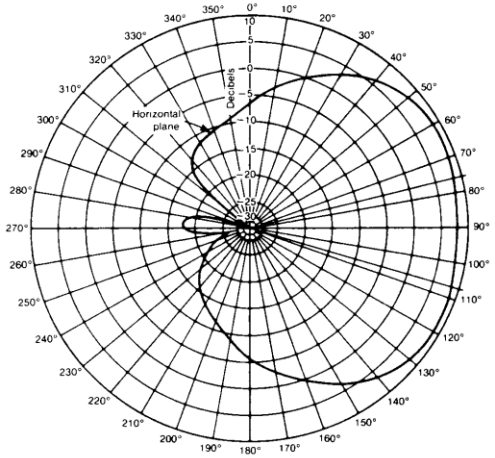
$$L_{pol} = \left|\cos\psi\right|^2$$

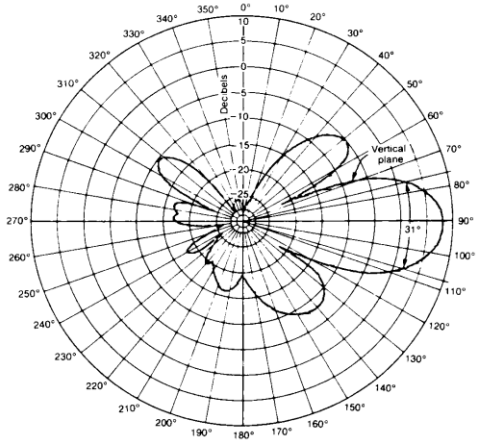
Odstup křížové polarizace



Anténní parametry - shrnutí

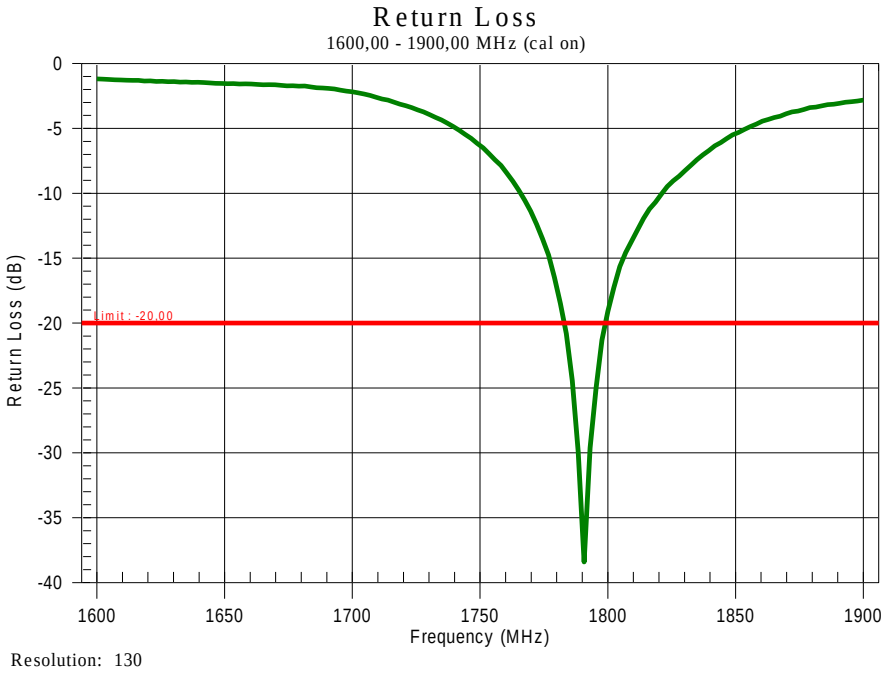
- zisk, *gain* [dB]
- vstupní impedance, *input impedance* [Ω]
- šířka frekvenčního pásma, *frequency bandwidth* [% (Hz)]
- polarizace, *polarization* - L (V, H), C (CR, CL); křížová pol.
- směrová/vyz. charakteristika, *radiation pattern* [dB]

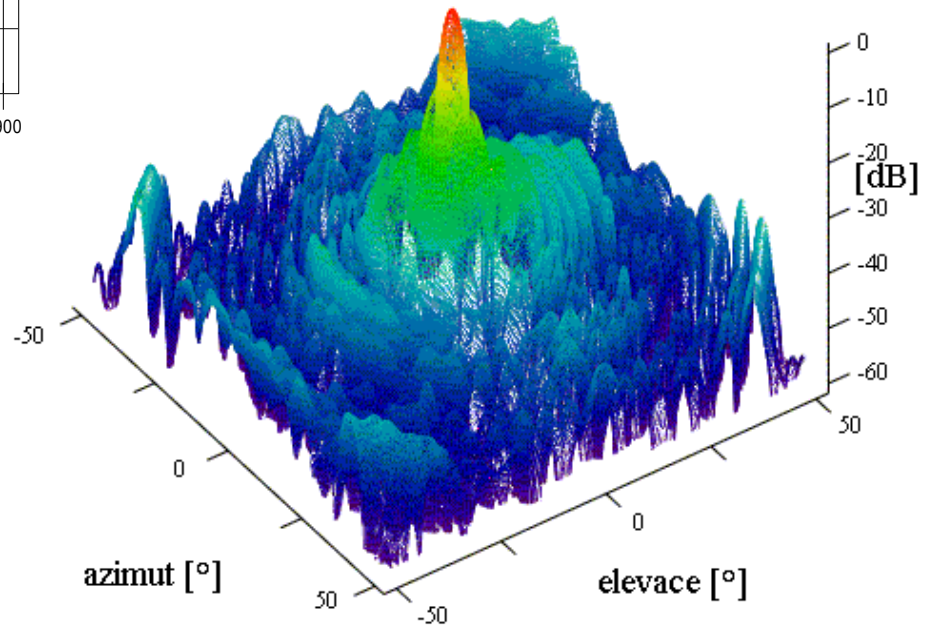




- šířka svazku, *HPBW* [°]
- odstup postranních maxim, *sidelobe ratio (level)* [dB]
- činitel zpětného vyzařování, *front-to-back ratio* [dB]

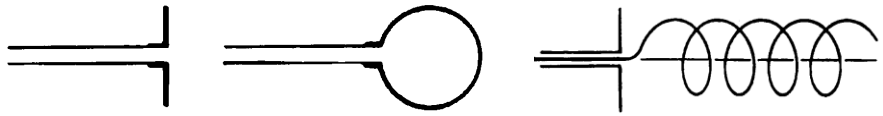
Anténa jako frekvenční a prostorový filtr

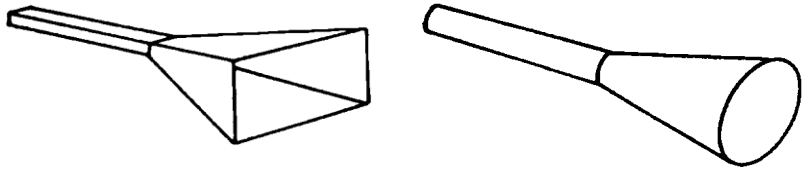


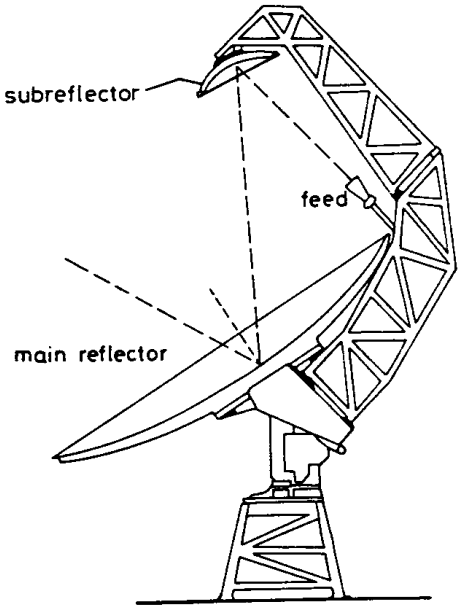


Základní typy antén

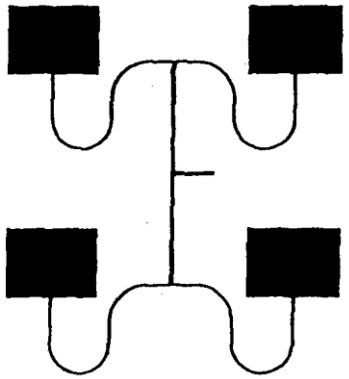
- drátové *(wire antenna)*
- plošné *(aperture antennas)*

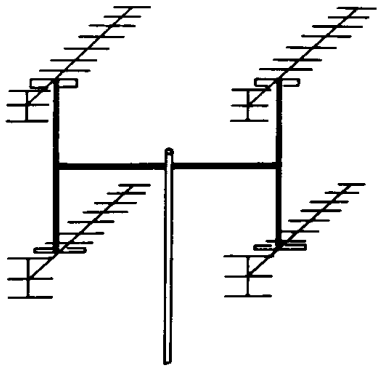


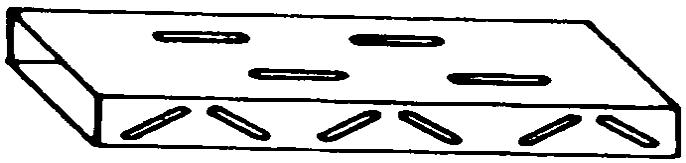




- reflektorové *(reflector antennas)*
- mikropáskové, štěrbinové *(microstrip, slot)*
- anténní čočky *(lens antennas)*
- *...*
- anténní řady/pole *(antenna arrays)*







RADIOWAVES

2.4 - 2.5 GHz
Parabolic Subscriber Antennas

Features

- **Lightweight and rugged design**
- **Low windload**
- **Easily installed**
- **RF Connector Interface:** Type "N" female
- **Standard antenna mount (NS) provides fine adjustment for both azimuth and elevation. Accommodates a 1.0". to 4.5" diameter pipe**
- **NL Series removes the fine adjustment feature for both azimuth and elevation. Accommodates a 1.0" to 2.25 " pipe**
- **Optional mounting kit available for *NL Series* to mount to a 2.5" to 4.5" diameter pipe**
- **Standard color white; other colors available on request**
- **Radome standard on 1' model, optional on 2'model**
- **Polarization:** Single

Accommodates a 1.0". to 4.5" diameter pipe

- NL Series removes the fine adjustment feature for both azimuth and elevation. Accommodates a 1.0" to 2.25 " pipe
- Optional mounting kit available for *NL Series* to mount to a 2.5" to 4.5" diameter pipe
- Standard color white; other colors available on request
- Radome standard on 1' model, optional on 2'model
- **Polarization:** Single

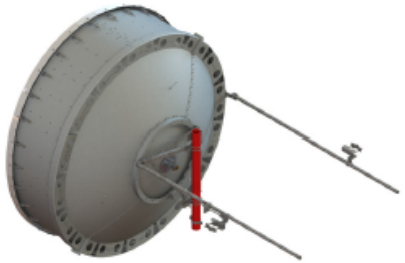
ELECTRICAL SPECIFICATIONS (typical performance)

Model Number	Frequency, GHz	Gain dBi (nominal)	Beamwidth ° -3dB	X-Pol. Rejection, dB	F/B Ratio dB	VSWR, Max (R.L., dB)
SP1-2.4	2.4 - 2.5	14.0	28.0	17	25	1.5:1 (14.0)
SP2-2.4	2.4 - 2.5	21.3	14.0	28	28	1.5:1 (14.0)

** All specifications subject to change without notice.*

Radio Waves, Inc.
http://www.radiowavesinc.com

HX10-11W



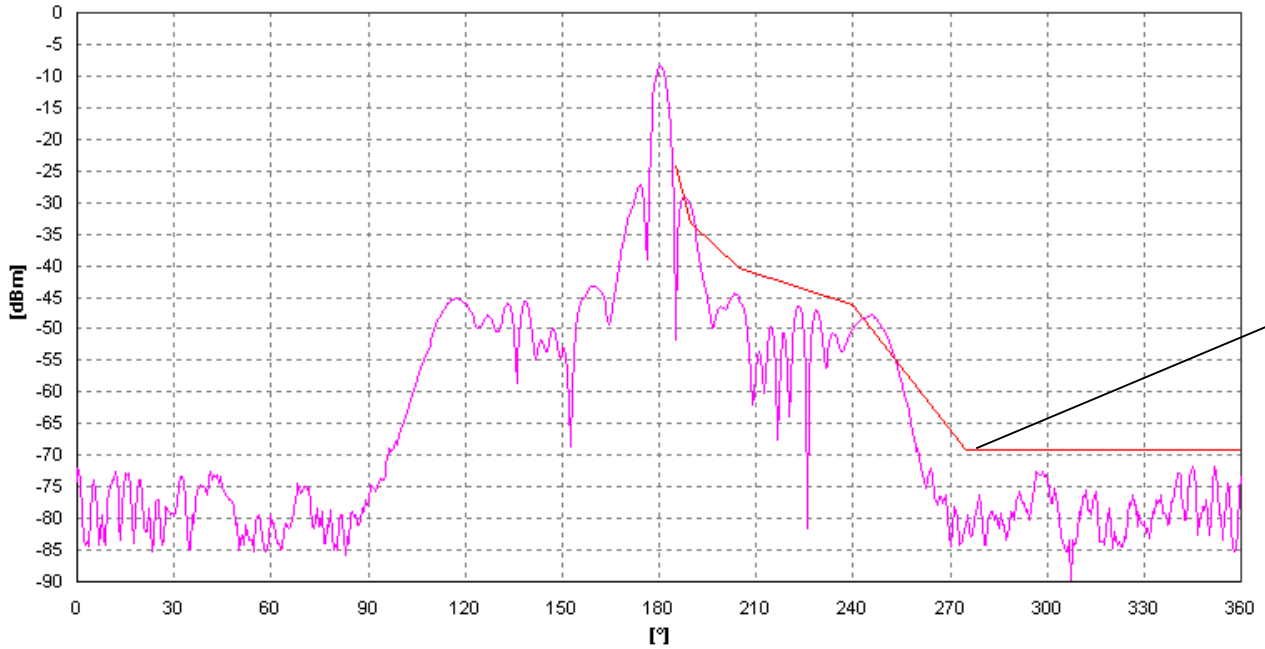
3.0m | 10ft ValuLine® High Performance, High XPD Antenna, dual-polarized, 10.000 – 11.700 GHz

Electrical Specifications

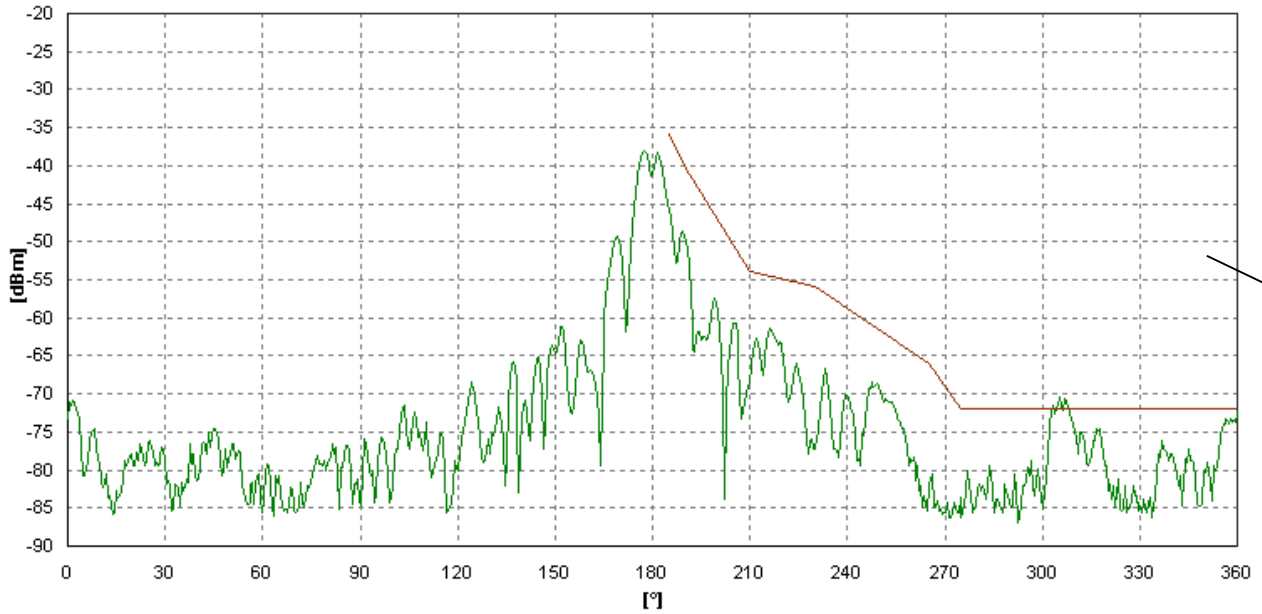
Operating Frequency Band	10.000 – 11.700 GHz
Gain, Low Band	47.2 dBi
Gain, Mid Band	47.9 dBi
Gain, Top Band	48.5 dBi
Boresite Cross Polarization Discrimination (XPD)	33 dB
Front-to-Back Ratio	76 dB
Beamwidth, Horizontal	0.7 °
Beamwidth, Vertical	0.7 °
Return Loss	26 dB

COMMSCOPE®

Parabola 0,35 m; 19GHz



obálka 14-20 GHz
podle normy



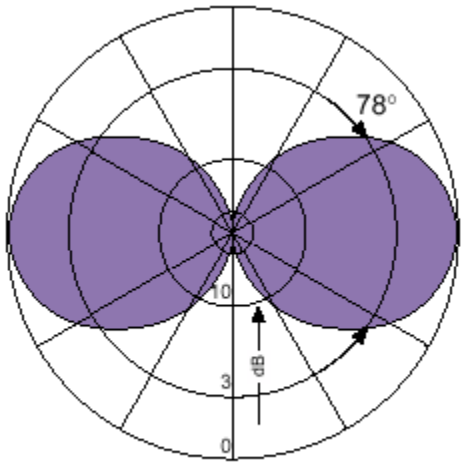
křížová
polarizace

Omnidirectional Antenna – Vertical Polarization
Indoor and outdoor use
738 450

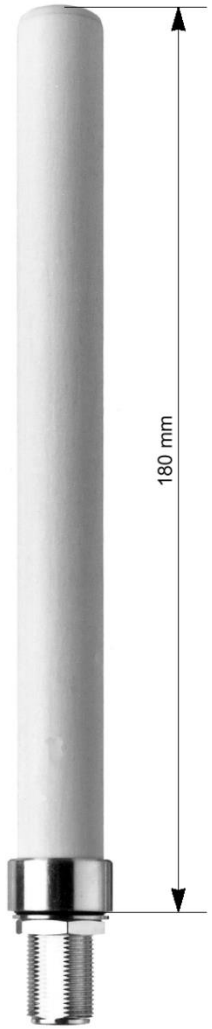
KATHREIN
Antennen · Electronic

Omni 900 360° 2dBi

Type No.	738 450
Input	N female
Connector position	Bottom or top
Frequency range	870 – 960 MHz
VSWR	< 1.5
Gain	2 dBi
Impedance	50 Ω
Polarization	Vertical
Max. power	150 Watt (at 50 °C ambient temperature)
Weight	200 g
Radome diameter	20 mm
Height	180 mm



Vertical Pattern



Panel 870–960
Vertical Polarization V
Half-power Beam Width 120°

KATHREIN
Antennen · Electronic

VPol Panel 870–960 120° 16dBi

Type No.	730 382
Frequency range	870 – 960 MHz
Polarization	Vertical
Gain	16 dBi
Half-power beam width	H-plane: 120° E-plane: 6.5°
Front-to-back ratio	> 20 dB
Impedance	50 Ω
VSWR	< 1.3
Intermodulation IM3	< –150 dBc (2 x 43 dBm carrier)
Max. power	500 W (at 50 °C ambient temperature)

Horizontal Pattern

Vertical Pattern

Mechanical specifications	
Input	7-16 female
Connector position	Rearside
Weight	12 kg
Wind load	Frontal: 740 N (at 150 km/h) Lateral: 830 N (at 150 km/h) Rearside: 1270 N (at 150 km/h)
Max. wind velocity	200 km/h
Packing size	2702 x 272 x 160 mm
Height/Width/depth	2574 / 258 / 103 mm

KATHREIN-Werke KG · Anton-Kathrein-Straße 1 – 3 · P.O. Box 10 04 44 · 83004 Rosenheim · Germany · Phone +49 8031 184-0 · Fax +49 8031 184-973

VPol Panel 870–960 120° 16dBi

Type No.	730 382
Frequency range	870 – 960 MHz
Polarization	Vertical
Gain	16 dBi
Half-power beam width	H-plane: 120° E-plane: 6.5°
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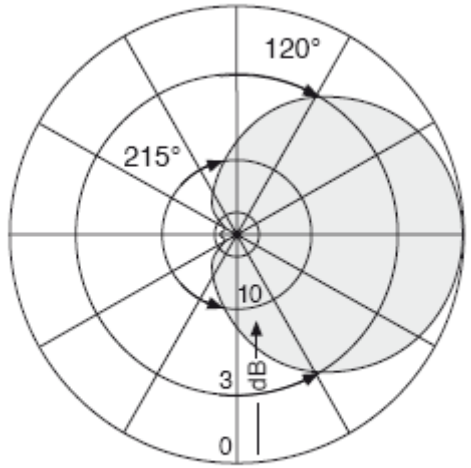
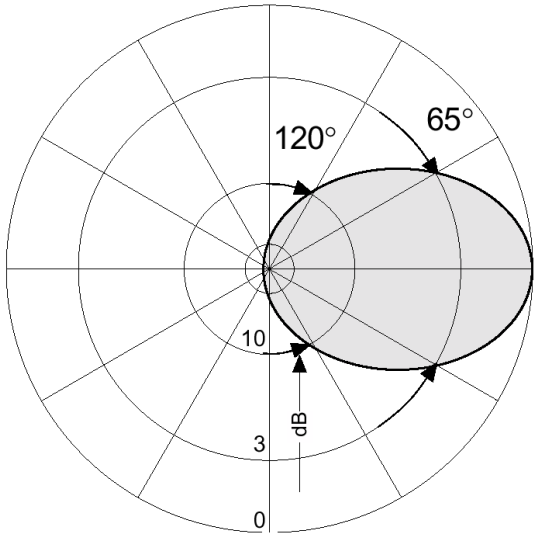
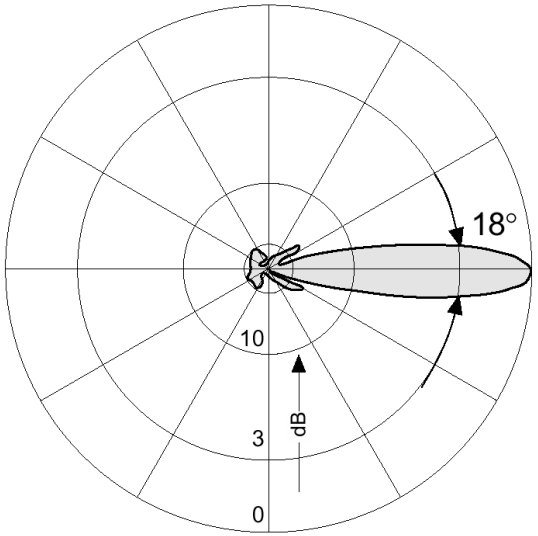
Max. power	500 W (at 50 °C ambient temperature)



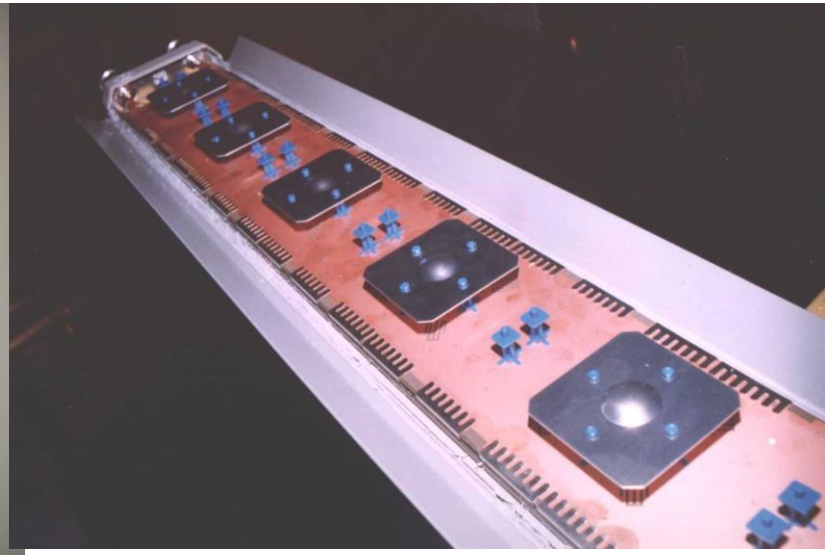
Horizontal Pattern



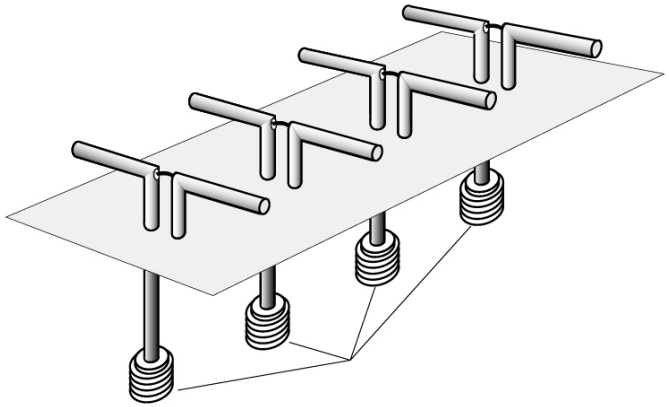
Horizontal

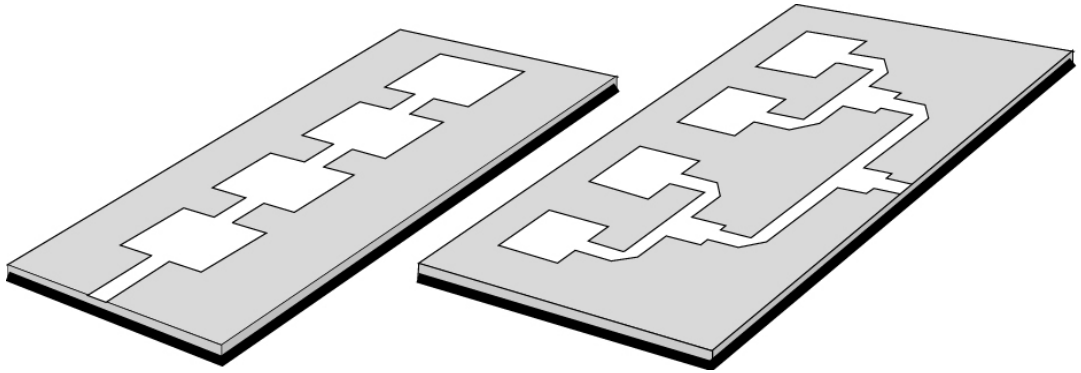


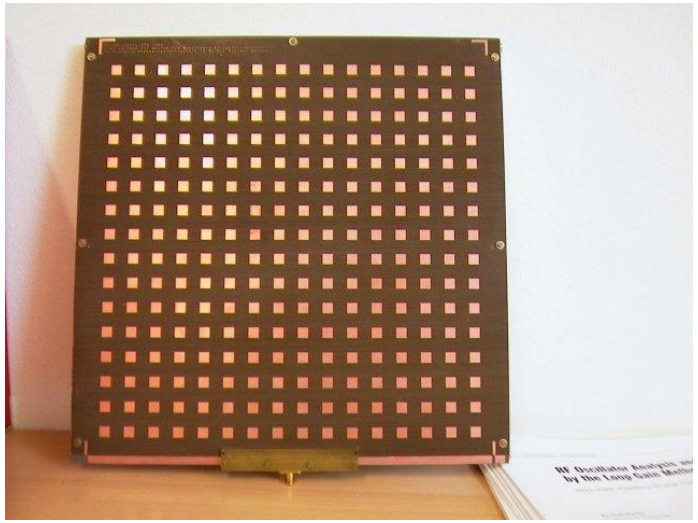
Vertical

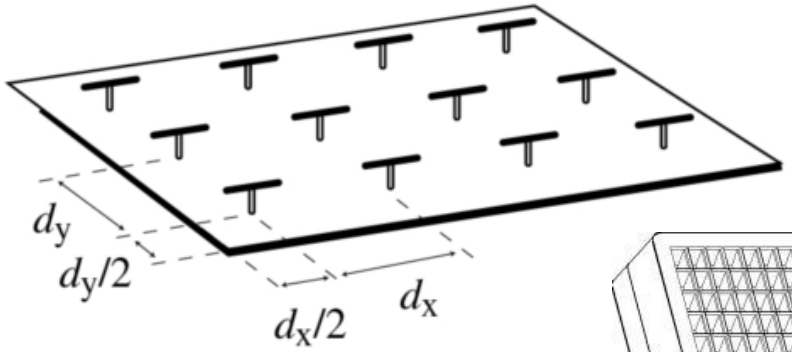


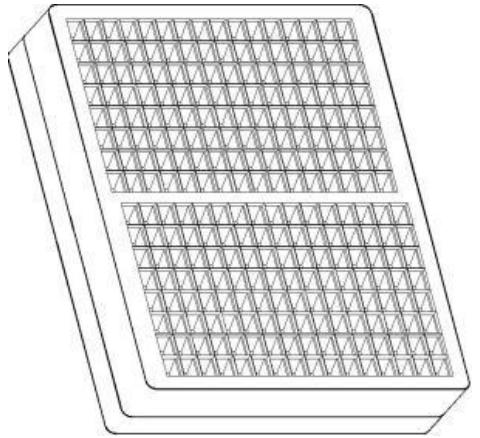
Anténní řady (pole), *Antenna Arrays*



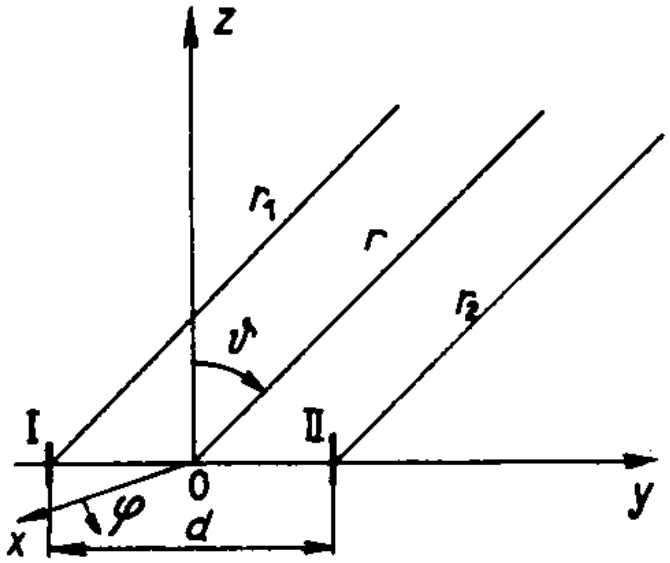








Dvojice zářičů



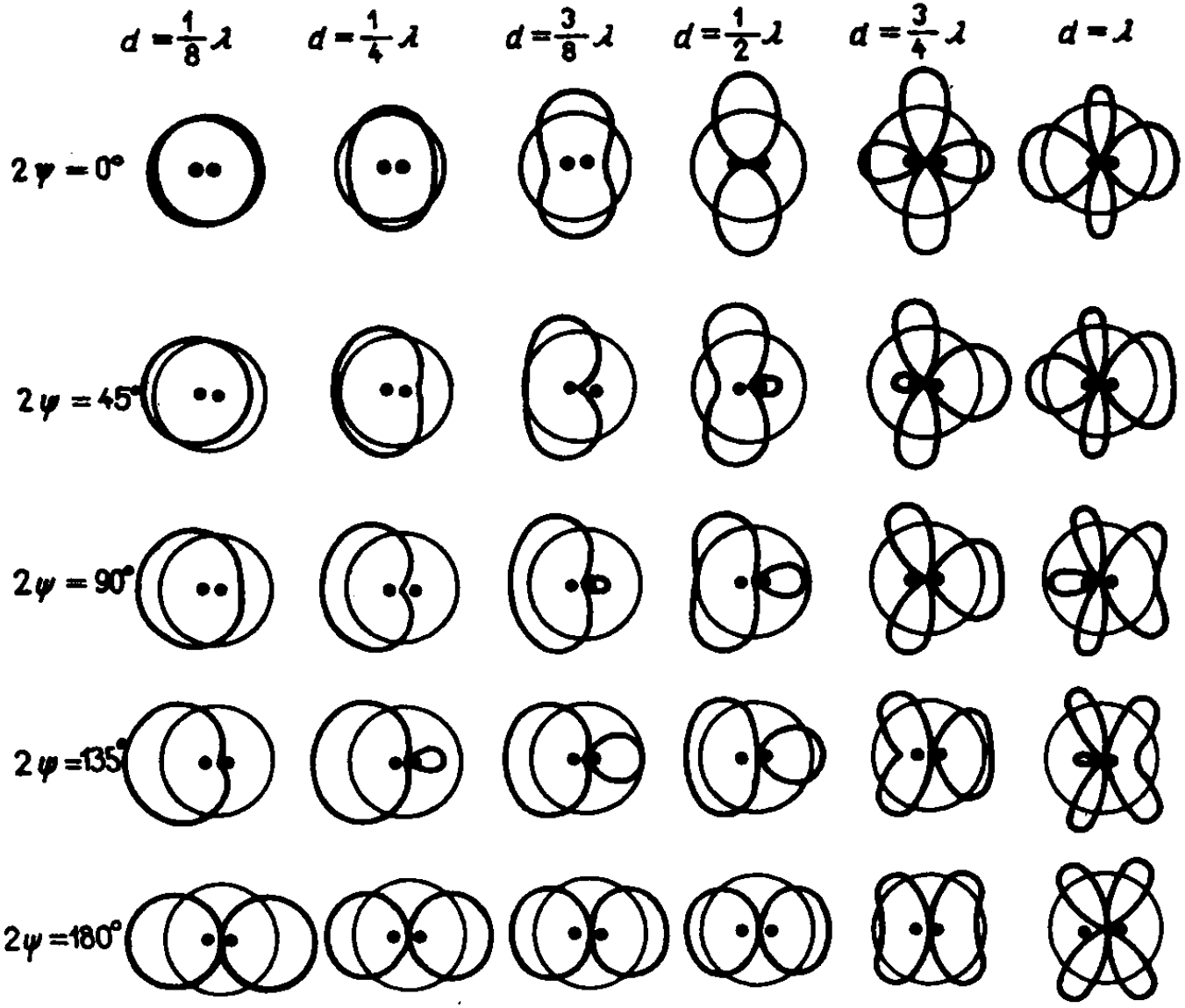
$$E_\vartheta = E_{\vartheta 1} + E_{\vartheta 2} = \mathrm{j}\cdot 60\,\frac{\cos\left(\frac{\pi}{2}\cos\vartheta\right)}{\sin\vartheta}\left[I_1\frac{\mathrm{e}^{-\mathrm{j}kr_1}}{r_1} + I_2\frac{\mathrm{e}^{-\mathrm{j}kr_2}}{r_2}\right]$$

$$r_1 \doteq r + \frac{d}{2}\sin\vartheta\sin\varphi;\; r_2 \doteq r - \frac{d}{2}\sin\vartheta\sin\varphi$$

$$E_\vartheta = AF_1(\vartheta)\frac{\mathrm{e}^{-\mathrm{j}kr}}{r}\left[I_1\mathrm{e}^{-\mathrm{j}k(d/2)\sin\vartheta\sin\varphi} + I_2\mathrm{e}^{+\mathrm{j}k(d/2)\sin\vartheta\sin\varphi}\right]$$

- charakteristická funkce řady, *array factor*
  - směrová charakteristika řady izotropních zářičů

Charakteristická funkce dvojice

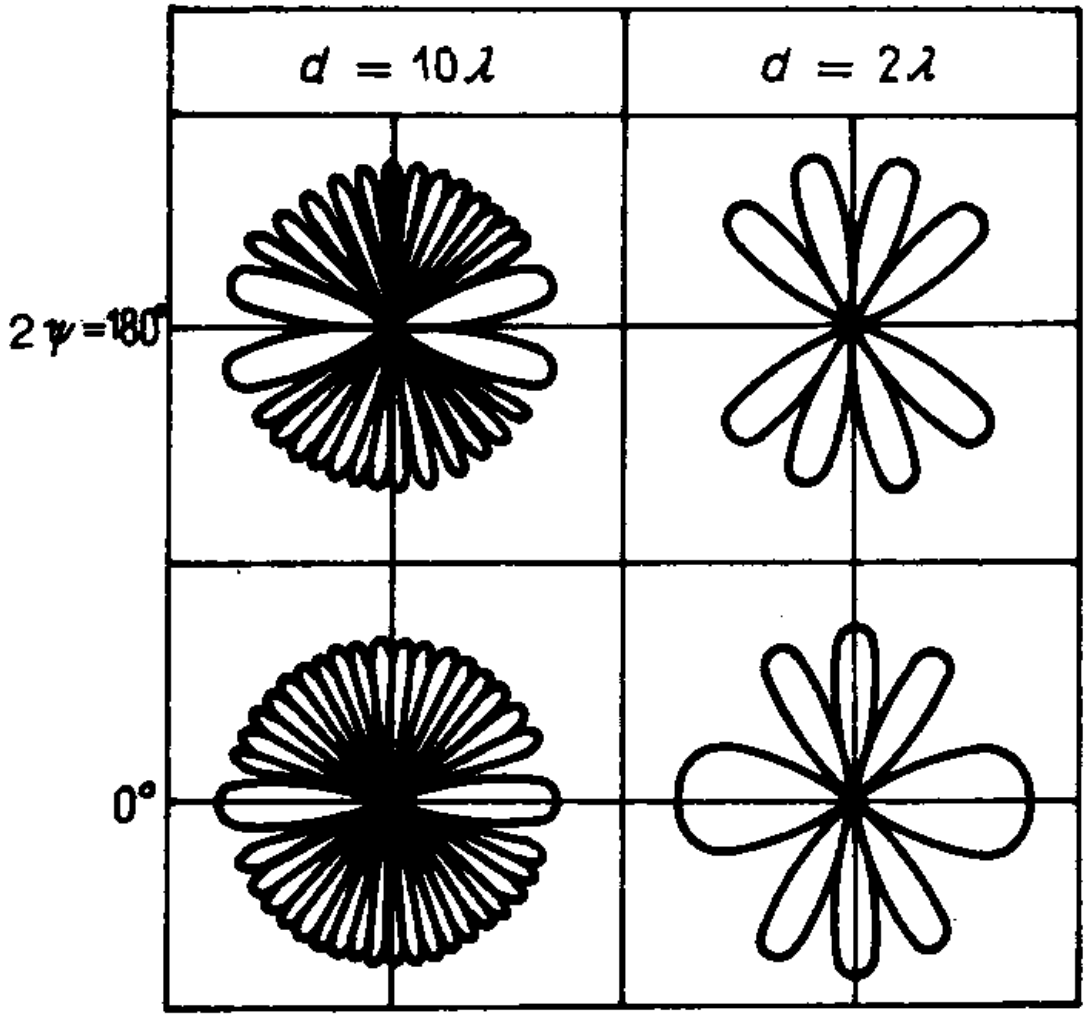


- příčné vyz.
  $\psi = 0$
- podélné v.
  $\psi = 2\pi d / \lambda$
- jednosměrné
  $d = \lambda / 4$
  $\psi = 2\pi d / \lambda$

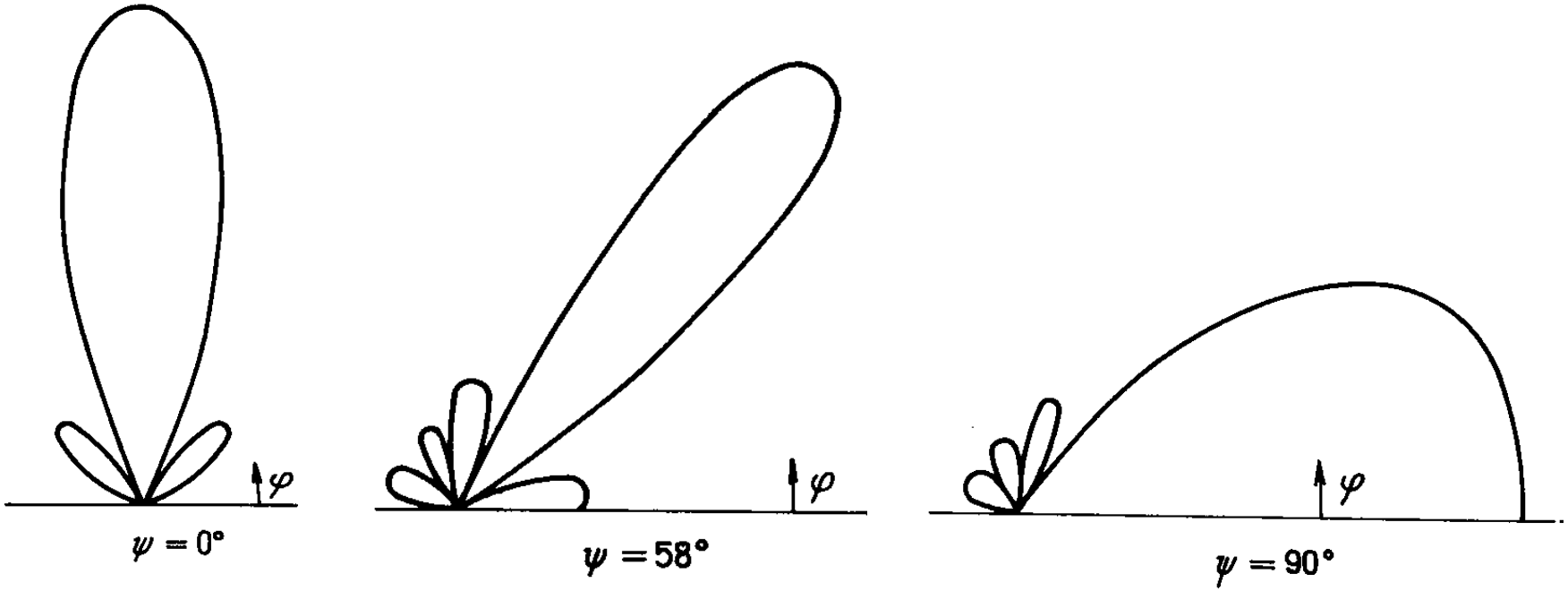
$$I_1 = I_0 e^{j\psi}; \quad I_2 = I_0 e^{-j\psi};$$

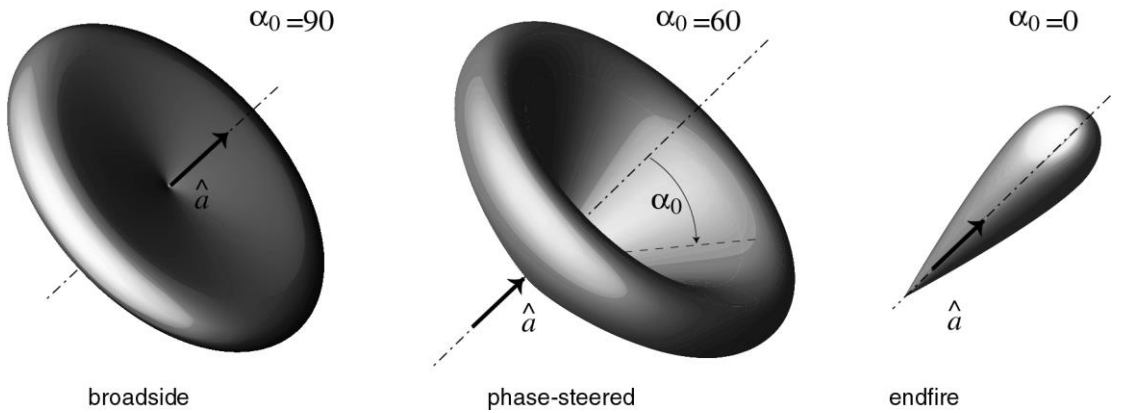
$$F_2 = 2I_0 \cos\left(\frac{kd}{2}\sin\vartheta\sin\varphi - \psi\right)$$

Dvojice zářičů - zvětšování rozteče



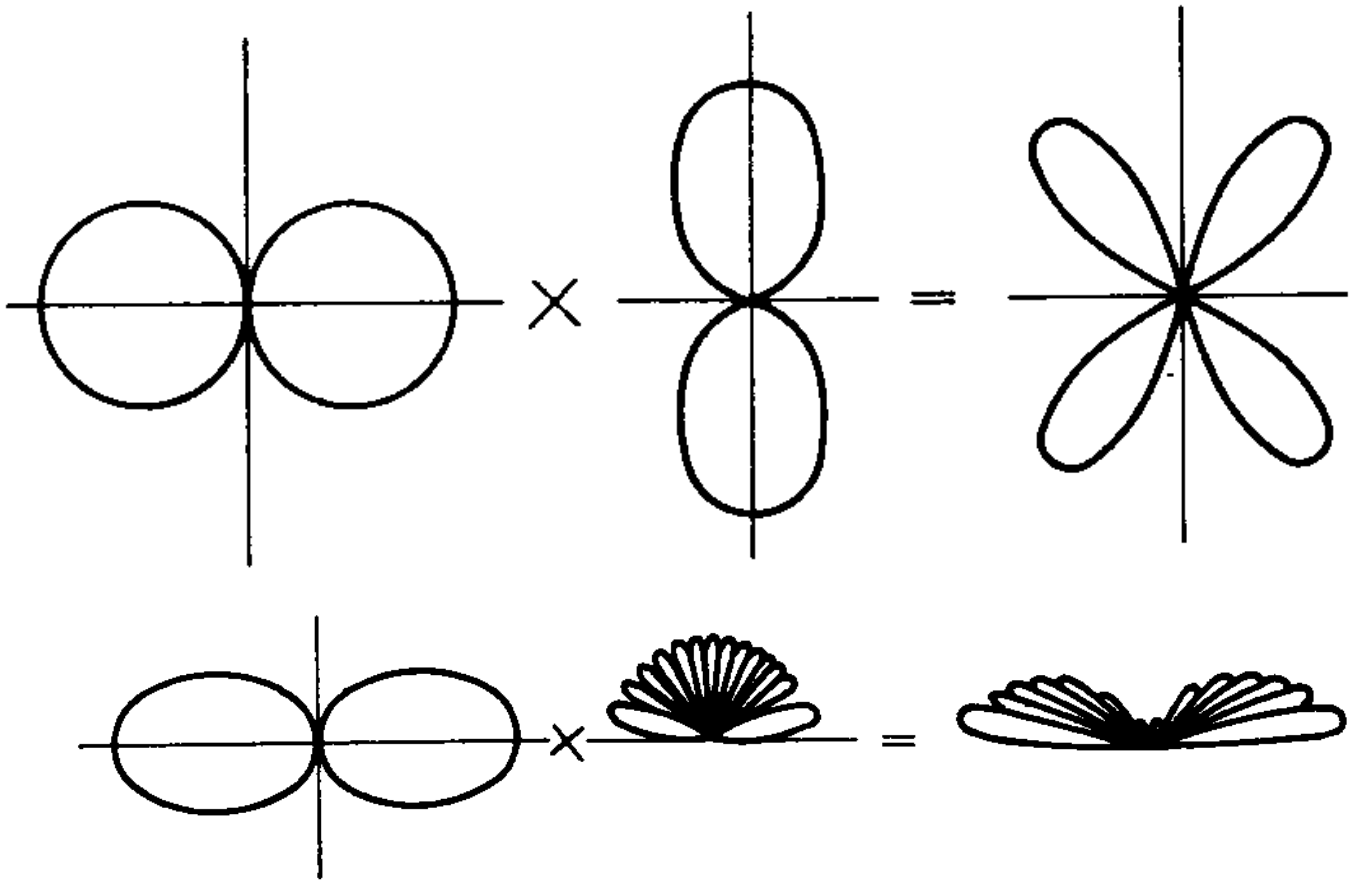
Fázovaná anténní řada

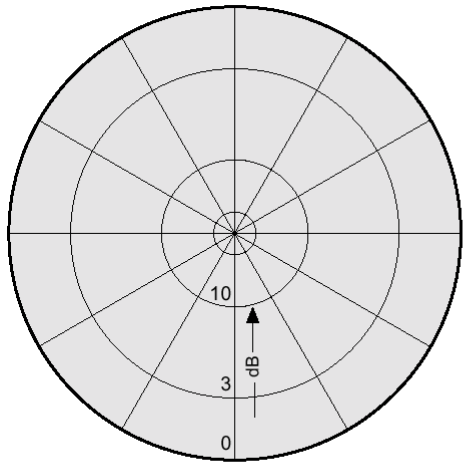




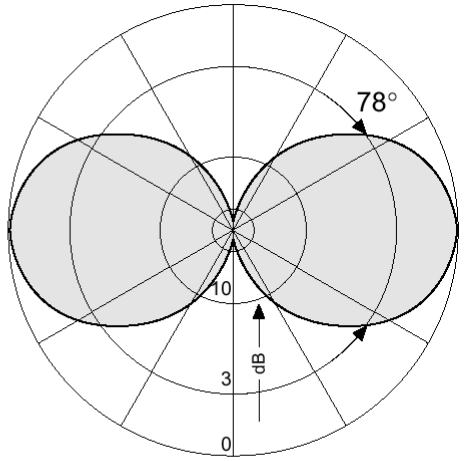
Směrová charakteristika anténní řady

- součin charakteristické funkce řady a směrové charakteristiky jednoho samotného zářiče (pro řadu izotropických zářičů jsou charakteristická funkce řady a výsledná směrová charakteristika celé řady shodné)

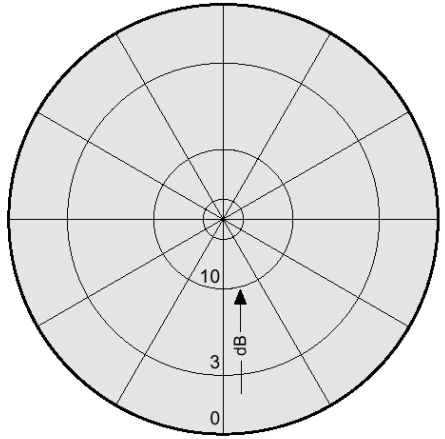




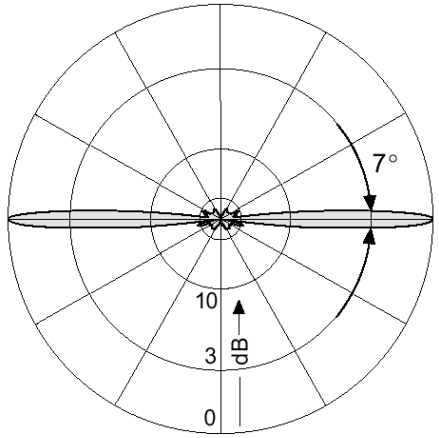
Horizontal



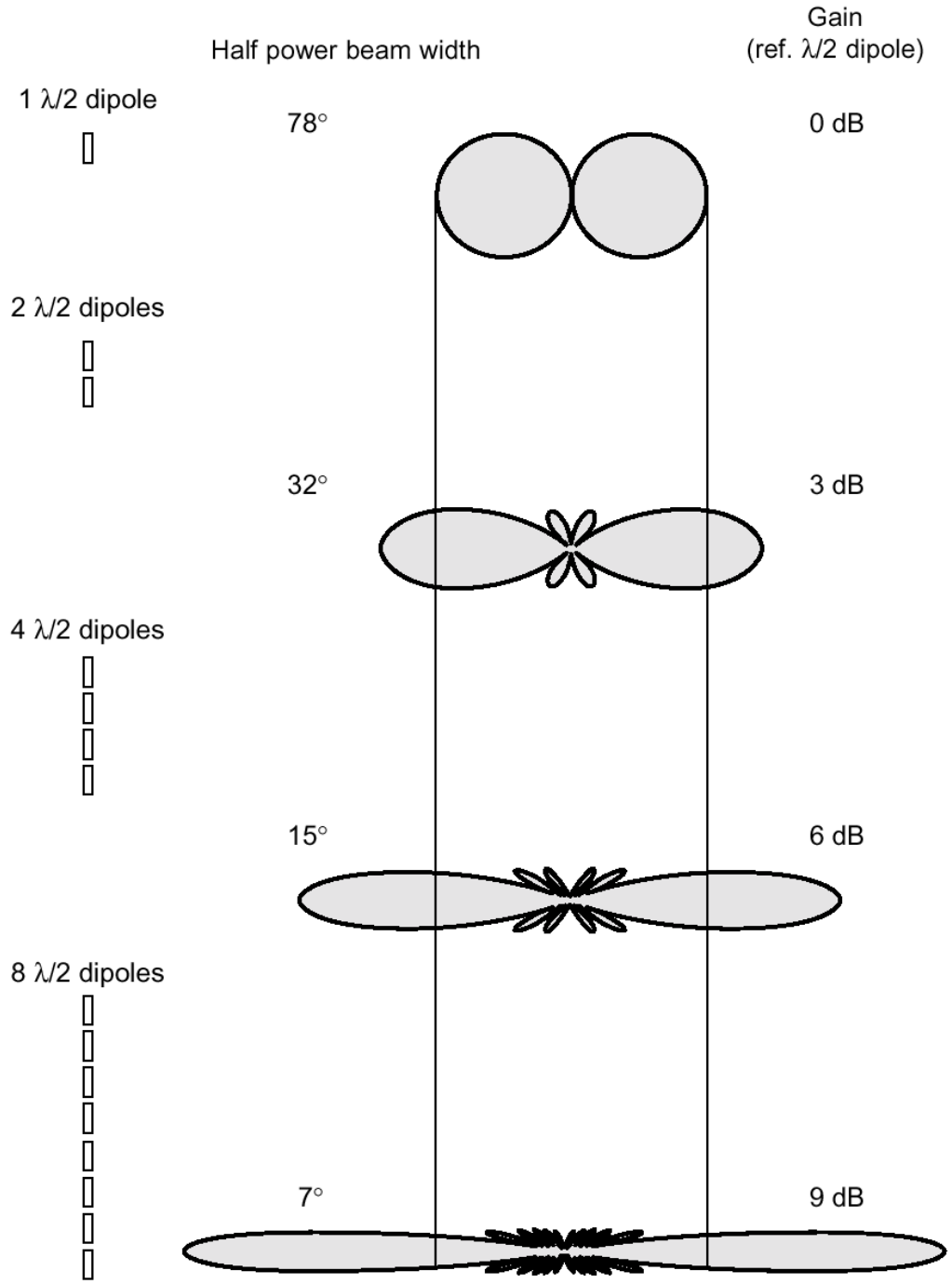
Vertical

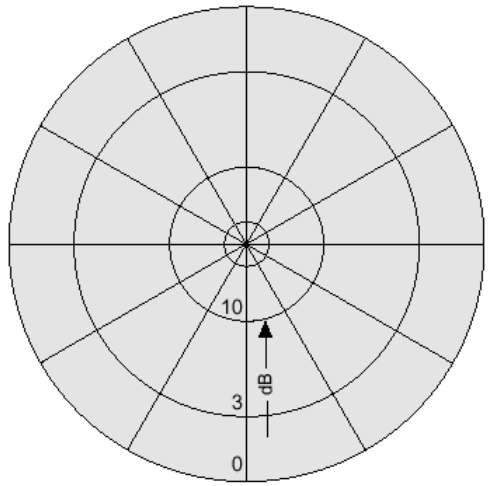


Horizontal

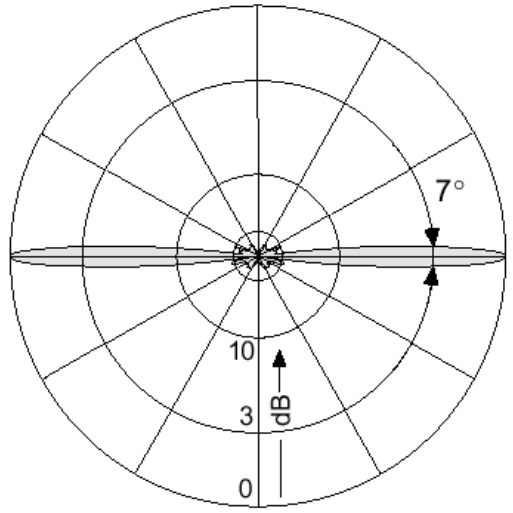


Vertical





Horizontal

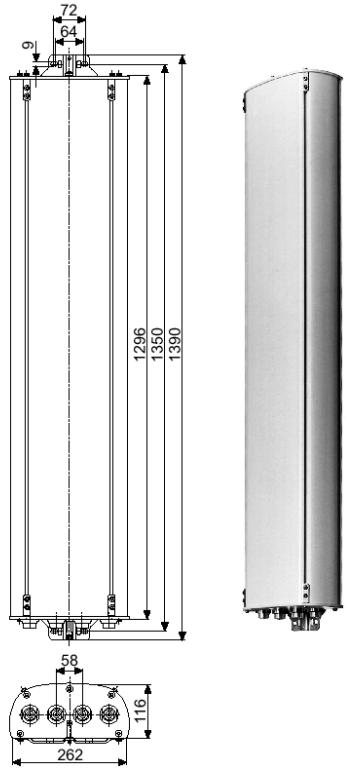


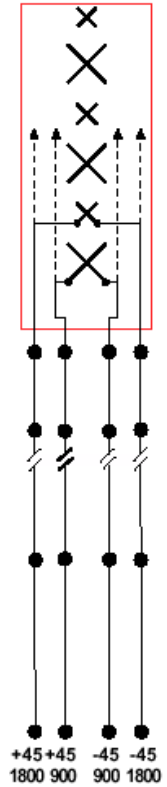
Vertical

736 347
870 – 960 MHz

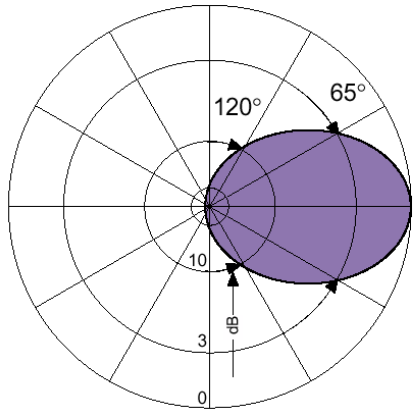
XXPol A-Panel 900/1800 65°/60° 15/17dBi

Type No.	741 326	
Frequency range	GSM 900: 870 – 960 MHz	GSM 1800: 1710 – 1880 MHz
VSWR	< 1.5	< 1.5
Gain	2 x 15 dBi	2 x 17 dBi
Impedance	50 Ω	50 Ω
Polarization	+45°, -45°	+45°, -45°
Front-to-back-ratio (copolar)	> 30 dB	> 30 dB
Half-power beam width	+45°/ -45°	+45°/ -45°
	– Horizontal: 65°	– Horizontal: 60°
	– Vertical: 14°	– Vertical: 8°
Max. power per input	400 Watt	200 Watt
	(at 50 °C ambient temperature)	
Isolation	> 30 dB (GSM 900 – GSM 900)	
	> 30 dB (GSM 1800 – GSM 1800)	
	> 30 dB (GSM 900 – GSM 1800)	
Input	4 x 7-16 female	
Connector position	Bottom or top	
Weight	13 kg	
Wind load	Frontal: 220 N (at 150 km/h)	

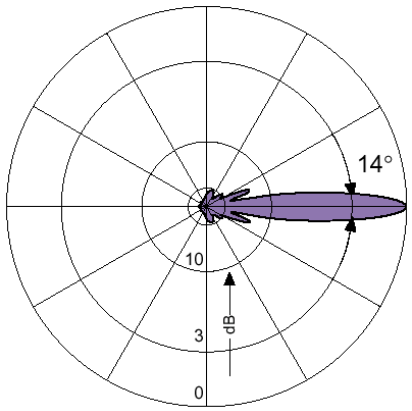




GSM 900: +45°/-45° Polarization

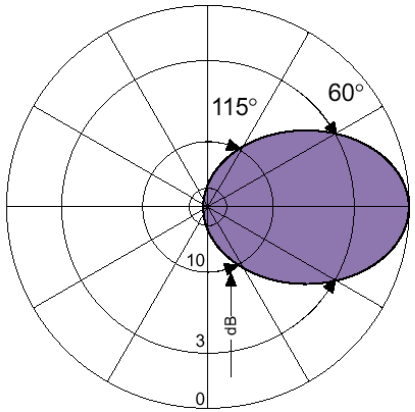


Horizontal Pattern

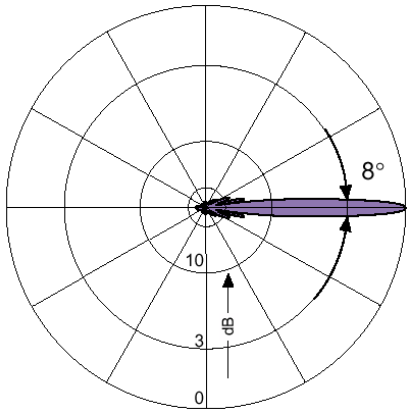


Vertical Pattern

GSM 1800: +45°/-45° Polarization



Horizontal Pattern



Vertical Pattern

12-Port Antenna

	R1	R2	Y1	Y2	Y3	Y4
Frequency Range	698–960	698–960	1427–2690	1695–2690	1695–2690	1427–2690
HPBW	65°	65°	65°	65°	65°	65°

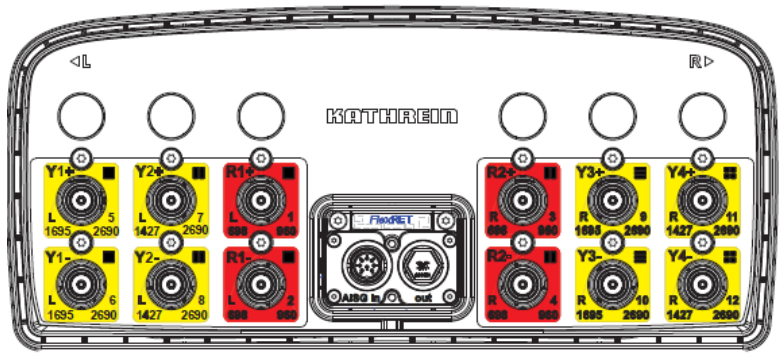
12-Port Antenna 2LB/4HB 1.5m 65° | 2x698–960 14.6dBi | 2x1427–2690 17.8dBi | 2x1695–2690 17.2dBi

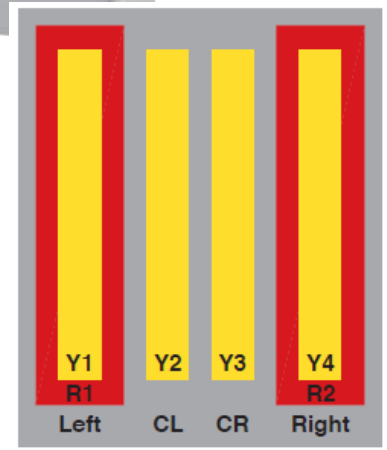
Type No.		800482001			
Left side, lowband		**R1, connector 1–2**			
		698–960			
Frequency Range	MHz	698 – 806	791 – 862	824 – 894	880 – 960
Gain at mid Tilt	dBi	13.8	14.2	14.4	14.6
Gain over all Tilts	dBi	13.8 ± 0.4	14.1 ± 0.3	14.4 ± 0.4	14.6 ± 0.3
Horizontal Pattern:					
Azimuth Beamwidth	°	59 ± 6.3	56 ± 3.1	53 ± 5.5	50 ± 4.9
Front-to-Back Ratio, Total Power, ± 30°	dB	> 20	> 19	> 20	> 22
Vertical Pattern:					
Elevation Beamwidth	°	16.1 ± 1.1	15.1 ± 0.9	14.6 ± 0.7	13.6 ± 1.2
Electrical Downtilt continuously adjustable	°	2.0 – 12.0			
Tilt Accuracy	°	< 0.5	< 0.5	< 0.6	< 0.9
First Upper Side Lobe Suppression	dB	> 15	> 16	> 17	> 16
Cross Polar Isolation	dB	> 25			
Port to Port Isolation	dB	> 25 (R1 // R2, Y1, Y2, Y3, Y4)			
Max. Effective Power per Port	W	300 (at 50 °C ambient temperature)			
Max. Effective Power Ports R1	W	600 (at 50 °C ambient temperature)			

Values based on NGMN-P-BASTA (version 10.0) requirements.

AISG Antenna Interface Standards Group

FlexRET





Right side, lowband		R2, connector 3–4			
		698–960			
Frequency Range	MHz	698 – 806	791 – 862	824 – 894	880 – 960
Gain at mid Tilt	dBi	13.8	14.1	14.4	14.8
Gain over all Tilts	dBi	13.8 ± 0.3	14.1 ± 0.3	14.3 ± 0.3	14.7 ± 0.4
Horizontal Pattern:					
Azimuth Beamwidth	°	60 ± 5.7	56 ± 4.1	54 ± 5.8	50 ± 6.4
Front-to-Back Ratio, Total Power, ± 30°	dB	> 20	> 20	> 20	> 21
Vertical Pattern:					
Elevation Beamwidth	°	16.1 ± 0.8	15.1 ± 0.8	14.6 ± 0.6	13.6 ± 0.9
Electrical Downtilt continuously adjustable	°	2.0 – 12.0			
Tilt Accuracy	°	< 0.6			
First Upper Side Lobe Suppression	dB	> 16			
Cross Polar Isolation	dB				
Port to Port Isolation	dB				
Max. Effective Power per Port	W				
Max. Effective Power Ports R2	W				

Values based on NGMN-P-BASTA (version 10.0) requirements.

Left side, highband		Y1, connector 5–6					
		1427–2690					
Frequency Range	MHz	1427 – 1518	1695 – 1880	1850 – 1990	1920 – 2180	2300 – 2400	2490 – 2690
Gain at mid Tilt	dBi	15.9	17.0	17.2	17.4	17.5	17.8
Gain over all Tilts	dBi	15.9 ± 0.6	17.0 ± 0.6	17.2 ± 0.6	17.3 ± 0.7	17.5 ± 0.8	17.8 ± 0.8
Horizontal Pattern:							
Azimuth Beamwidth	°	73 ± 3.9	67 ± 4.1	63 ± 4.8	61 ± 4.8	60 ± 4.0	55 ± 3.9
Front-to-Back Ratio, Total Power, ± 30°	dB	> 30	> 29	> 28	> 29	> 29	> 28
Vertical Pattern:							
Elevation Beamwidth	°	8.4 ± 0.5	7.0 ± 0.5	6.5 ± 0.4	6.2 ± 0.4	5.6 ± 0.3	5.2 ± 0.2
Electrical Downtilt continuously adjustable	°	2.0 – 12.0					
Tilt Accuracy	°	< 0.3	< 0.3	< 0.3	< 0.3	< 0.2	< 0.2
First Upper Side Lobe						> 17	> 19

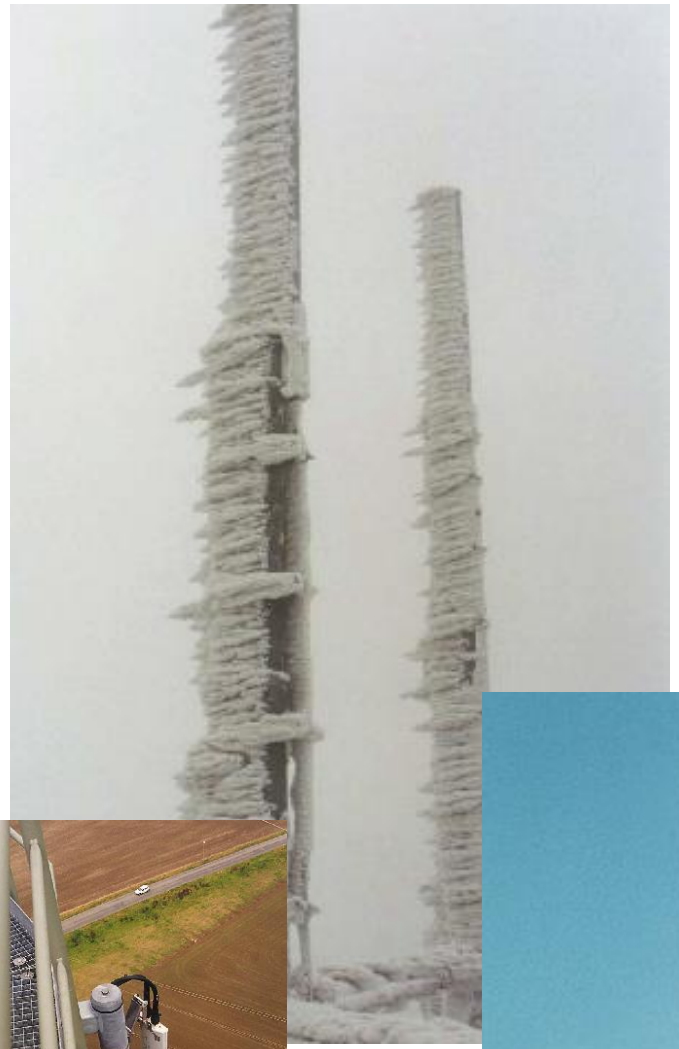
Left side, center highband		Y2, connector 7–8				
		1695–2690				
Frequency Range	MHz	1695 – 1880	1850 – 1990	1920 – 2180	2300 – 2400	2490 – 2690
Gain at mid Tilt	dBi	17.0	17.0	17.1	17.2	17.4
Gain over all Tilts	dBi	16.9 ± 0.7	17.0 ± 0.7	17.0 ± 0.8	17.2 ± 0.7	17.4 ± 0.8
Horizontal Pattern:						
Azimuth Beamwidth	°	61 ± 7.9	60 ± 6.5	63 ± 6.7	65 ± 4.6	60 ± 4.3
Front-to-Back Ratio, Total Power, ± 30°	dB	> 29	> 27	> 28	> 30	> 29
Vertical Pattern:						
Elevation Beamwidth	°	7.2 ± 0.6				
Electrical Downtilt continuously adjustable	°					
Tilt Accuracy	°	< 0.4				
First Upper Side Lobe Suppression	dB	> 16				
Cross Polar Isolation	dB					
Port to Port Isolation	dB					
Max. Effective Power per Port	W					
Max. Effective Power Ports Y2	W					

Values based on NGMN-P-BASTA (version 10.0) requireme

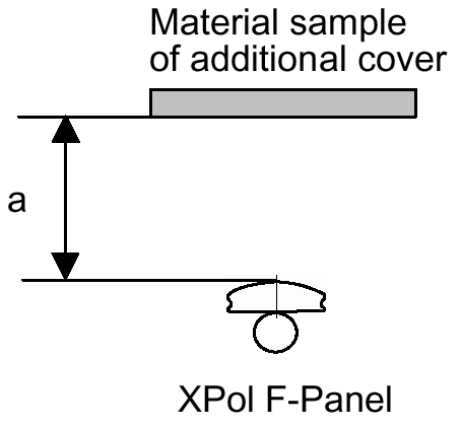
Right side, center highband		Y3, connector 9–10				
		1695–2690				
Frequency Range	MHz	1695 – 1880	1850 – 1990	1920 – 2180	2300 – 2400	2490 – 2690
Gain at mid Tilt	dBi	16.9	17.1	17.0	17.2	17.2
Gain over all Tilts	dBi	16.9 ± 0.8	17.0 ± 0.7	17.0 ± 0.7	17.1 ± 0.6	17.2 ± 0.8
Horizontal Pattern:						
Azimuth Beamwidth	°	61 ± 9.2	60 ± 8.4	64 ± 8.9	64 ± 4.1	62 ± 4.6
Front-to-Back Ratio, Total Power, ± 30°	dB	> 28	> 28	> 28	> 28	> 29
Vertical Pattern:						
Elevation Beamwidth	°	7.4 ± 0.5	6.8 ± 0.3	6.5 ± 0.4	6.0 ± 0.3	5.7 ± 0.4
Electrical Downtilt continuously adjustable	°	2.0 – 12.0				
Tilt Accuracy	°	< 0.4	< 0.3	< 0.3	< 0.2	< 0.3
First Upper Side Lobe	dB	> 14	> 17	> 18	> 19	> 20

Right side, highband		Y4, connector 11–12					
		1427–2690					
Frequency Range	MHz	1427 – 1518	1695 – 1880	1850 – 1990	1920 – 2180	2300 – 2400	2490 – 2690
Gain at mid Tilt	dBi	15.9	17.0	17.2	17.4	17.5	17.8
Gain over all Tilts	dBi	15.9 ± 0.5	17.0 ± 0.6	17.2 ± 0.6	17.4 ± 0.7	17.4 ± 0.7	17.8 ± 0.9
Horizontal Pattern:							
Azimuth Beamwidth	°	74 ± 6.1	69 ± 3.5	66 ± 4.6	63 ± 5.8	63 ± 4.9	56 ± 4.4
Front-to-Back Ratio, Total Power, ± 30°	dB	> 29	> 29	> 29	> 28	> 29	> 28
Vertical Pattern:							
Elevation Beamwidth	°	8.3 ± 0.5	6.9 ± 0.5	6.5 ± 0.3	6.2 ± 0.5	5.6 ± 0.3	5.2 ± 0.2
Electrical Downtilt continuously adjustable	°	2.0 – 12.0					
Tilt Accuracy	°	< 0.3	< 0.3	< 0.4	< 0.3	< 0.2	< 0.2
First Upper Side Lobe Suppression	dB	> 16	> 17	> 17	> 16	> 17	> 19
Cross Polar Isolation	dB	> 25					
Port to Port Isolation	dB	> 25 (Y4 // R1, R2, Y1, Y2, Y3)					
Max. Effective Power per Port	W	200 (at 50 °C ambient temperature)					
Max. Effective Power Ports Y4	W	400 (at 50 °C ambient temperature)					

Values based on NGMN-P-BASTA (version 10.0) requirements.

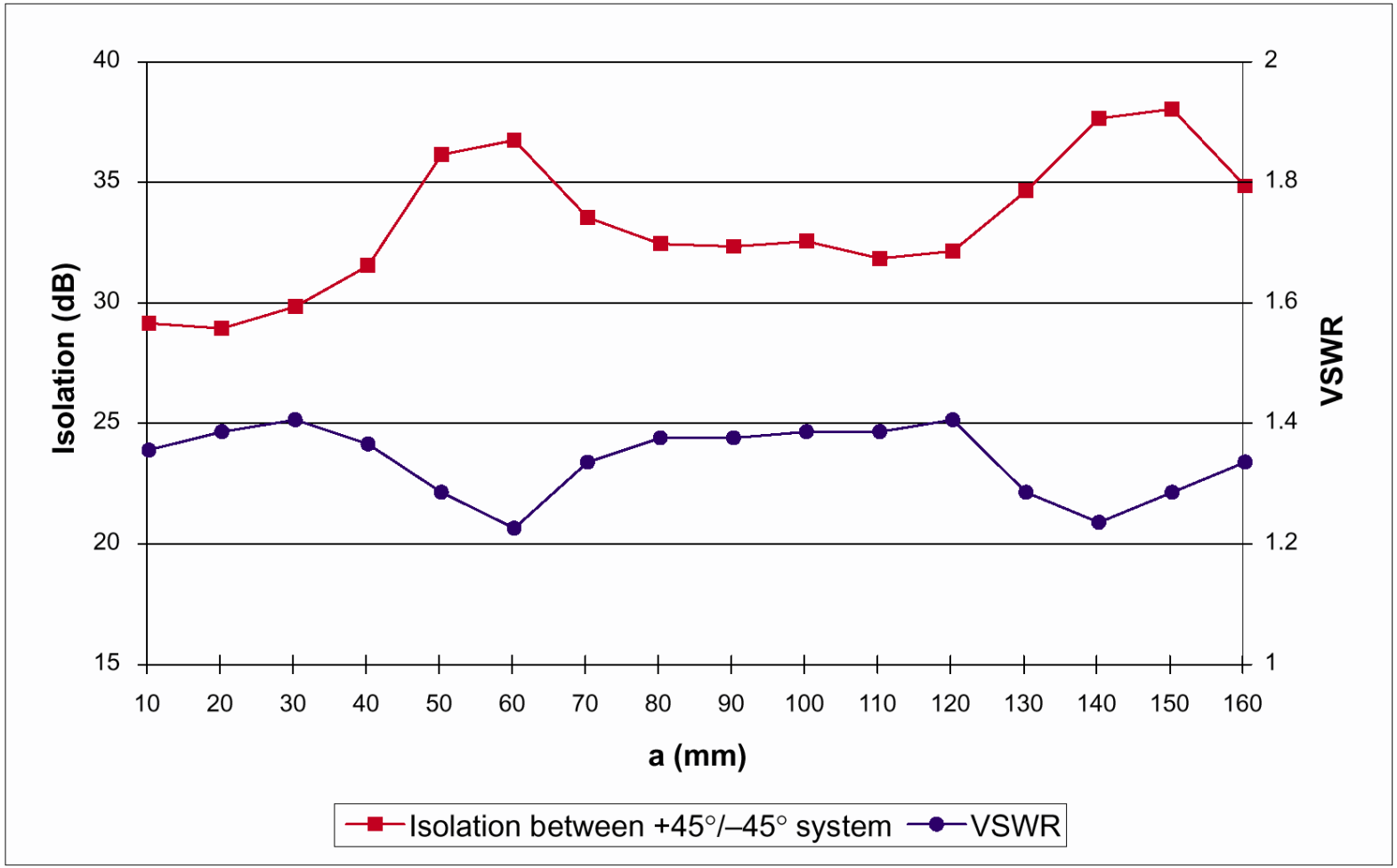


Překážky v blízkosti antény, radomy



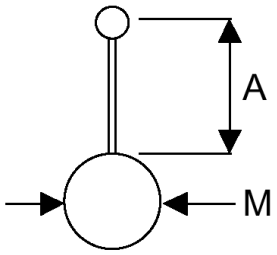
Measurement without additional cover:

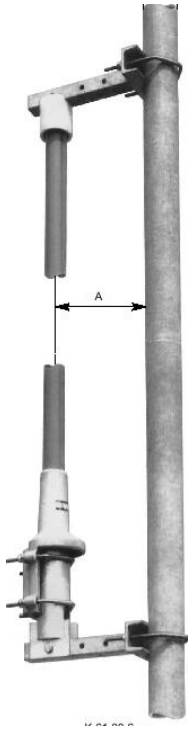
Isolation: 38.4 dB
VSWR: 1.28

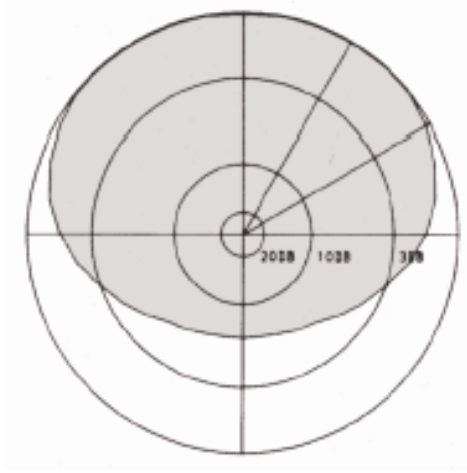
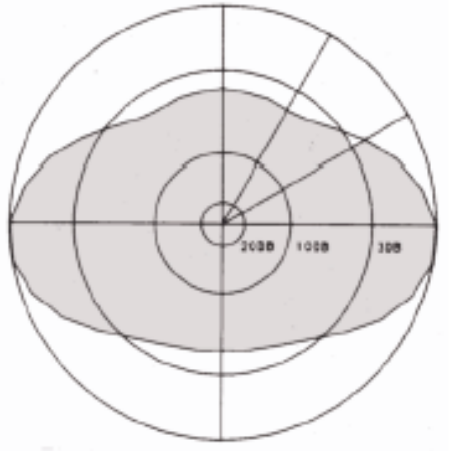
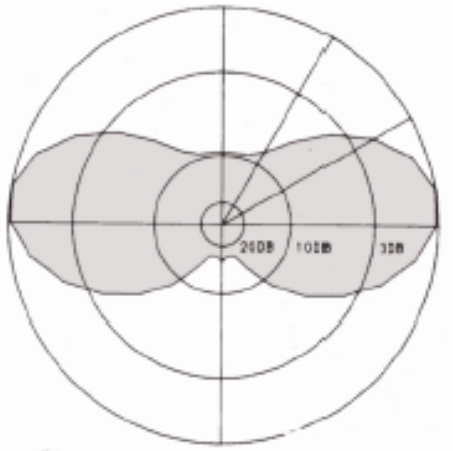


KATHREIN	Date	Isolation and VSWR measurement with material sample: 2.5 mm fiberglass 1710 – 1880 MHz	Type No.: 739 495
	Name		Sh. No.

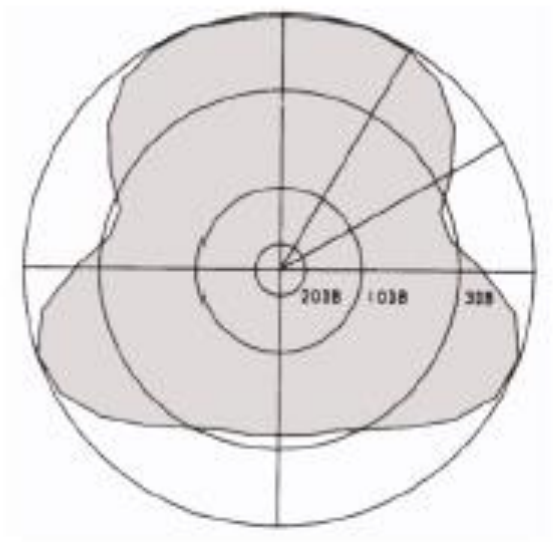
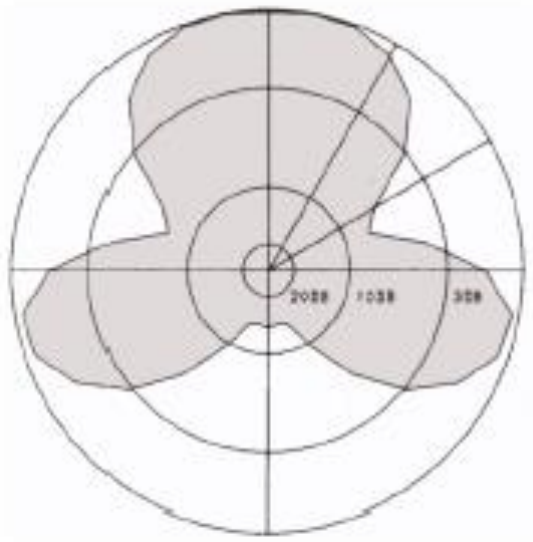
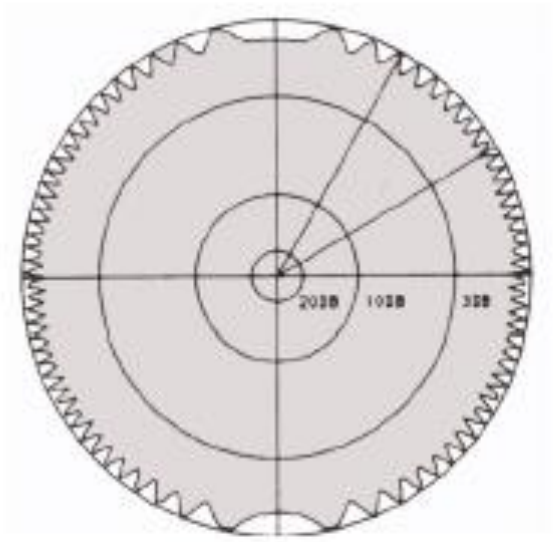
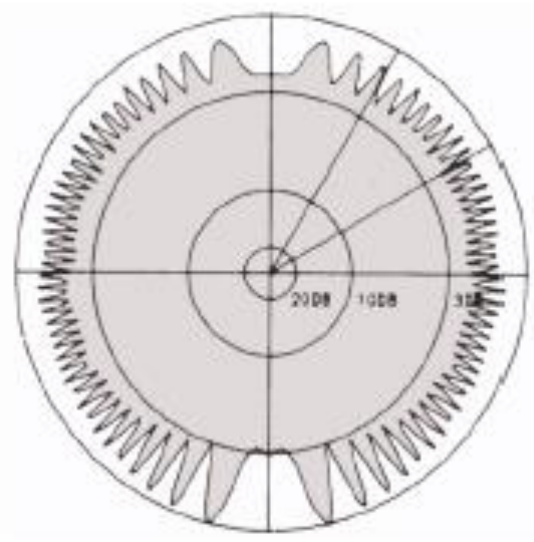
Vliv stožáru na směrový diagram antény





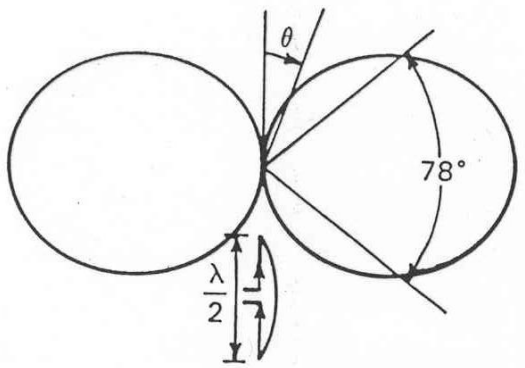
Distance (A)	Mast diameter 0.04 λ	Mast diameter 0.6 λ
0.25 λ		
0.5 λ		

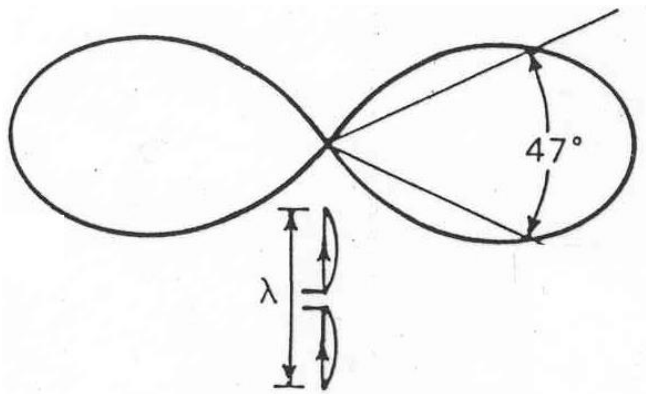
Vliv stožáru na směrový diagram antény

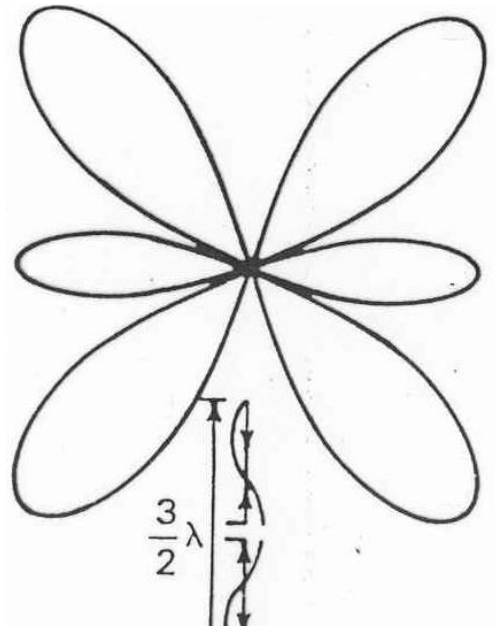
0.75 λ		
20 λ		

Způsoby výpočtu

- rozložení proudů => impedanční i směrové vlastnosti







- analyticky (jen elementární struktury)
- numerické metody (MM, FDTD, ...)
- geometrická optika
- anténní řady
- empirické vztahy
- (anténní měření)