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COURSE ON BASIC TELECOMMUNICATIONS SCIENCE

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Radio Relay Link Propagation Path Design (M-Link)

CCIR, Geneva, Switzerland

RADIO RELAY LINK PROPAGATION PATH DESIGN (M-LINK) *)

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JAPAN

RADIO RELAY LINK PROPAGATION PATH DESIGN (M-LINK)

1. Introduction

Recent moves toward the information society have increased the world demand for radio relay links. The radio spectrum is limited, so these links must use it efficiently.

One way to do this, and at the same time reduce interference, is to locate each radio station in the best place. Finding such a place involves complicated calculations. Our new software package, " Radio Relay Link Propagation Path Design", enables anyone to find the best location for a radio station.

We have used this software to make efficient use of the radio spectrum and to provide good links, and we have done this work much faster than was possible before.

This easy-to-operate program will run on IBM PCs and the NEC 9800 series anywhere in the world.

Features

- Written in IBM BASIC .
- Comprises 28 task modules .
- This 300 K byte program fits on one floppy disk .
- Each task can be selected from the task menu, started independently, and accessed directly.
- Conversational interface. The program asks you to input parameters one-by-one .
- Full color display makes the operation easy to understand .

2. Outline

The radio relay link propagation path design program comprises 28 task modules and one final message.

Fig.1 shows how the modules relate to each other.

There are information modules containing design information, and calculation modules. There is also a data file containing propagation parameters and typical antenna constants from the CCIR Green Book. This data is used in the calculations.

Fig.2 shows the task menu, the first screen to appear when the program is started. Any task may be selected and run.

Task 1 Microwave frequency bands and their application

- Actual microwave frequency bands
  Long distance circuit : 4, 5, 6, 8 Ghz bands .
  Branch circuit : 11,15 Ghz bands .
  Short distance circuit : 2, 7,11,15 Ghz bands.
- Indication of input parameter : frequency band, bandwidth, center frequency, system capacity , and CCIR recommendation number correspond to the description.

Task 2 Free space propagation

- Input of input parameters : frequency , section distance, transmitter output power, transmitting/receiving antenna gain, feeder loss.
- Calculation and indication of free space loss and received input power.

Task 3 Line-of-sight propagation

- Description and illustration show how a height pattern occurs at the receiving point becouse of the ground reflected wave.

Task 4 Tropospheric propagation

- Description of how radio propagation in the troposphere is affected by weather .
- Description of three propagation types characterized by the effective radius of earth (K).
- Description of applicable value by classification of K value accordimate the regional weather .

Task 5 Fresnel zone theorem

- Illustration of the radius of the first fresnel zone.
- Description says that the path must be designed to have two-thirds of the radius of the first fresnel zone.

Task 6 Diffraction

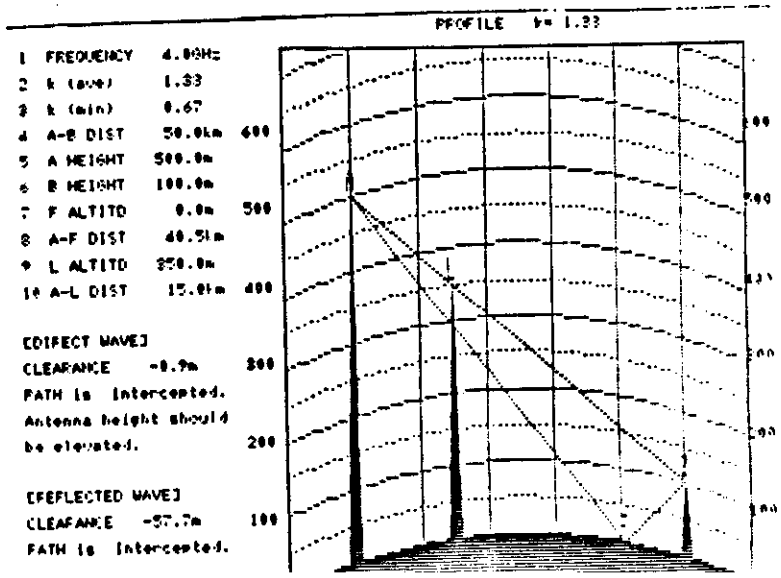
- Description and illustration show how the height of the obstacle affects the received input power.

Task 7 Planning of relay route

- Description and indication of the basic data of route planning : relay distance, path clearance, ground reflection, repeating angle, and station frequency .

Task 8 Profile drawing

- Input of input parameters : frequency, section distance, transmitting/receiving antenna height, distance to the reflection point , altitude of reflecion point, altitude of ridge, distance to ridge, and K value.
- Illustration of profile. We have prepared 24 scales of profile, which are adopted automatically to suit the given input parameters.
- Calculation and illustration of a profile showing the clearance by direct wave and reflected waves.
  These route are judged by the propagation standard.
  A comment is shown to help the designer choose whether to continue the calculation of the input parameters of this section or to change the route plan.



Task 9 Path clearance at ridge point

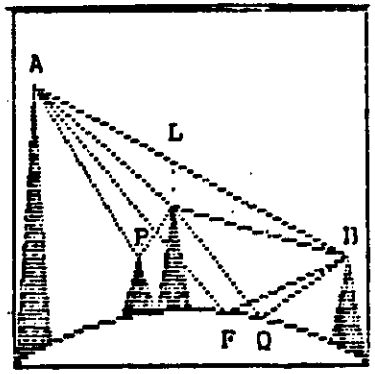
- Calculation and illustration of the clearance.
- Calculation of procedure and illustration of the clearance of reflected wave.

Task 10 Ridge diffraction loss

- Input of input parameters : K value (average, minimum), section distance, transmitting/ receiving antenna height, distance to the obstacle, altitude at the reflection point.
- Calculation and illustration of the ridge diffraction loss by direct wave and reflected wave.

Task 11 Direct wave and reflected wave losses

- Description of the effective ridge loss by direct wave and reflected wave.
- Description of the path of the reflected wave.



Task 12 Ground reflection loss

- Illustration of the reflected wave loss (experimental value for Japanese territory) by the classification of frequency and geographical and geological features at the reflect point.

Task 13 Locating the reflection point

- Input of input parameters : hop distance, transmitting/ receiving antenna height, K value (average) and altitude of reflect point.
- Calculation and illustration of the location of reflection point.
- The 3rd equation uses Newton's approximate quantity value calculation method.

Task 14 Included angle between direct and reflected waves

- Input of input parameters : hop distance, transmitting/ receiving antenna height, K value (average) and altitude of reflection point.
- Calculation and illustration of the included angle between direct and reflected wave.
- The third equation in Newton's approximate quantity value calculation method is used.

Task 15 Antenna directivity

- Description of the general pattern of antenna directivity. Uses the experimental values of the four meter diameter parabolic antenna that generally in Japan.

Task 16 Fading in line-of-sight transmission

- Description of increase of thermal noise by fading, and fading margin.

Task 17 Transmission quality standard on hypothetical reference circuit

- Illustration and description of the constitution of Hypothetical Reference Circuit.
- Description of standard of the allowable noise.
- Description of standard of the circuit dropout rate.

Task 18 Regulation regarding max. EIRP

- Description of standard of antenna radiated power limitation to limit mutual interference between terrestrial and satellite systems.

18 Distribution of received power during short term fading

- Description of standard of Rayleigh Fading Occurrence Probability and circuit dropout rate.
- Input of input parameters : frequency, hop distance, geographical features, effective reflective attenuation, transmitting/receiving antenna height.
- Calculation of Rayleigh Fading Occurrence Probability and circuit dropout rate, and comparison with CCIR Recommendatio
- Indication of whether the space diversity system is needed.

20 Space diversity system

- Description and illustration of applicable condition of spac diversity and antenna spacing pitch.

21 Antenna elevation angle

- Calculation and illustration of transmitting/receiving anten elevation and depression angle from the horizontal.

22 Azimuth and distance to each station

- Input of latitude and longitude of each station.
- Calculation and illustration of azimuth from true north and distance toward station.
- Spherical trigonometry is adopted and the distance calculate is the great circle distance.

23 Estimation of propagation path performances

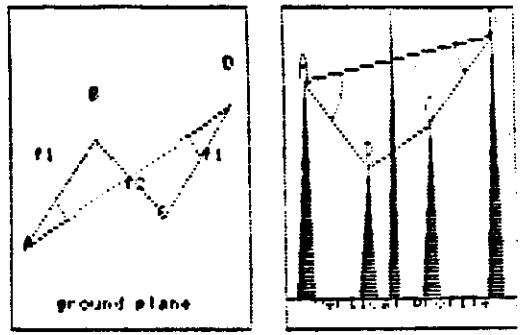
- Calculation together from item 2 until item 21 for propagati performances.
- Input parameter and output data are registered by data file and indicate together in item 29.

Task 24 Over-reach interference

- Input of input parameters : frequency, antenna height, each section distance, azimuth toward respective station, altitude of ridge, distance to ridge point.
- Calculation and illustration of interference noise (D/U value).

OVER-REACH (SELF ROUTE INTERFERENCE) d.0 GHz

1	A HEIGHT	500.0m					
2	B HEIGHT	300.0m					
3	C HEIGHT	400.0m					
4	D HEIGHT	600.0m					
5	A-B DISTANCE	10.0km					
6	B-C DISTANCE	10.0km					
7	C-D DISTANCE	10.0km					
8	A-D DISTANCE	26.6km					
9	ANGLE RAD	4: 0: 0					
10	ANGLE ADC	30: 0: 0					
11	RIDGE ALTITD	700.0m					
12	RIDGE DISTANCE	14.0km					



	A side		D side	
A side span loss difference	8.5dB	D side span loss difference	8.5dB	
horizontal deflection	4.0deg	22.0dB	horizontal deflection	30.0deg	d3.0dB
vertical deflection	1.3deg	8.0dB	vertical deflection	0.3deg	d.5dB
A-D ridge loss		32.3dB	A-D ridge loss		32.3dB
A side D/U		72.4dB	D side D/U		84.4dB

Task 25 Interference with other routes

- Input of input parameters : frequency, each latitude and longitude,transmitter output power, transmitting feeder loss, antenna polarization.
- Calculation and illustration of interference noise (D/U value).
- Can calculate mutual D/U for up to four routes.
- This program can be used by the relative location of station method, working selection is needed but in this case.

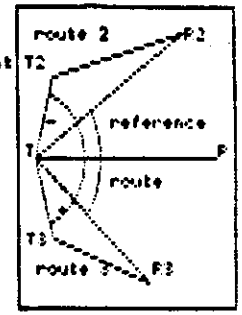
** Relative location of transmitting and receiving stations in each route **

(1) Designate a reference route and a reference point from among the routes to be examined.

(2) The reference point is meant for the transmitting point in the reference route.

(3) By using maps, obtain azimuths and distances towards the transmitting and receiving points in other routes measured from the reference point.

(4) Azimuth should be expressed as
plus(+) sign for clockwise direction,
minus(-) sign for anti-clockwise direction.



Task 26 Interference to geostationary satellite orbit

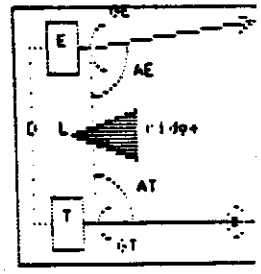
- Calculation of direction angle difference between a station in the radio relay links and a geostationary satellite orbi
- Judgement of whether the direction angle difference is grea or less than two degrees. The mutual interference is observ to help make this judgement.

Task 27 Interference between terrestrial station and earth station

- Judgement of mutual interference between terrestrial statio and earth station by total transmission loss.

** Interference between terrestrial station and earth station (4.0 GHz) **

1	E ANT HEIGHT(m)	100.0
2	E ANT GAIN (dB)	50.0
3	ANGLE AE(d.m.s)	100:30: 0
4	E ANT DIRECTIVITY(dB)	66.0
5	T ANT HEIGHT(m)	500.0
6	T ANT GAIN (dB)	42.5
7	ANGLE AT(d.m.s)	90: 0: 0
8	T ANT DIRECTIVITY(dB)	61.5
9	E-T DISTANCE(km)	20.0
10	RIDGE ALTITD (m)	400.0
11	E-L DISTANCE(km)	10.0
12	k(average value)	1.50



(E-T SPAN PROPAGATION LOSS 130.5dB)
(RIDGE DIFFRACTION LOSS 30.7dB)

EFFECTIVE TRANSMITTING LOSS 161.2dB

This path meets the standards, the route plan is acceptable.

eld survey

scription of necessary items for desk work, primary survey
id secondary survey.

TEM	CONTENT	DESI	PRIM.	SECO.
ute map	hop distance, altitude	○		
	azimuth	○		
te	topography, geology (steep,plain,sandy,rocky)		○	○
	latitude, longitude	○		
	altitude	○		○
	land area (land readjustment)	○		○
	acquisition of water for installation			○
ad	path, driveway	○	○	
	necessary length for new construction, repair		○	○
wer	antenna height above roof/ground	○		○
	radome	○	○	
wer supply	in-take line length, reliability			○
opagation	profile	○		○
th	visibility(mirror test)			○
	topography around the reflection point	○		○
	topography in the proximity of the site			○
	sketch			○
intenance	access route, time (summer, winter)			○

Determination of system meeting required performances
Description of various calculation necessary for judgement,
and indication of actual dimensions.
Indicate refer to the conclusion of works after read out data
from datafile.

EXECUTIVE SUMMARY	POINT A	POINT B
Antenna Height(m)	554.3 m	100.0 m
Antenna elevation angle	-0.07deg	0.37deg
Included angle(direct and reflected waves)	0.22deg	1.95deg
Antenna directivity effect	1.0 dB	0.5 dB
Distance(km) to reflection point	41.4 km	8.6 km
Diffraction loss of ridge	12.5 dB	
Geographical feature at reflection point	water face	
Reflection loss	0.0 dB	
Attitude(m) at reflection point	0.0 m	
Effective loss of reflected wave	20.0 dB	
Span distance(km)	50.0 km	
Span loss	141.4 dB	
Clearance(m)	0.0 m	
Circuit dropout rate(month) of path	1.15×10⁻⁷	
Circuit dropout rate(month) of CCIF REC.395-4	20.00×10⁻⁷	
Space diversity system	not necessary	

Termination

3. Conclusion

This program can be used anywhere in the world. The only adjustment needed is to modify the data file according to the propagation constant of the country you are in. We are sure that this program will help you to design radio relay links that use the spectrum efficiently.

4. Annex

Fig.1 STRUCTURE CHART OF M-LINK SOFTWARE

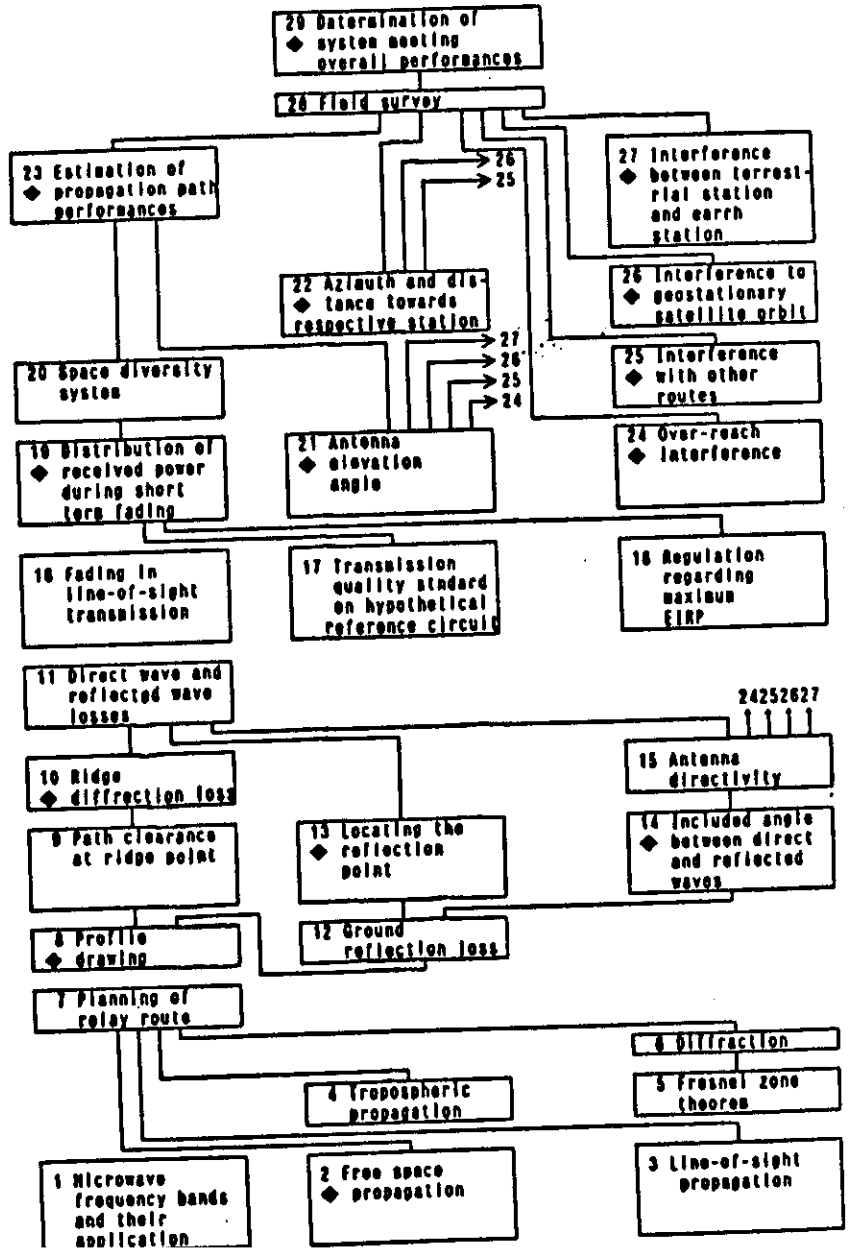


Fig.2 TASK MENU OF M-LINK SOFTWARE

◇ Calculation or Estimation

icrowave frequency bands and their application	
ree space propagation	◇
ine-of-sight propagation	
ropospheric propagation	
resnel zone theorem	
iffraction	
lanning of relay route	
rofile drawing	◇
ath clearance at ridge point	
idge diffraction loss	◇
irect wave and reflected wave losses	
round reflection loss	
ocating the reflection point	◇
ncluded angle between direct and reflected waves	◇
ntenna directivity	
ading in line-of-sight transmission	

17 Transmission quality standard on hypothetical reference circuit	
18 Regulation regarding maximum EIRP	
19 Distribution of received power during short term fading	◇
20 Space diversity system	
21 Antenna elevation angle	◇
22 Azimuth and distance towards respective station	◇
23 Estimation of propagation path performances	◇
24 Over-reach interference	◇
25 Interference with other route	◇
26 Interference to geostationary-satellite orbit	◇
27 Interference between terrestrial station and earth station	◇
28 Field survey	
29 Determination of system meeting overall performances	
30 Termination	

Select item number (1-30) ?