ITURHFProp

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A.U.Thor (someone@mail.com)

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1 Introduction

This program's sole purpose is to act as an input and output data wrapper for P533(). This routine is as an example of how the P533() model can be used in other applications.

ITURHFProp is written in C by Chris Behm and is available for both Windows and Linux platforms. ITURHFProp is a console based application and does not come with any form of GUI.

2 Installation

ITURHFProp requires the presence of the P533 and P372 libraries in addition to a repository of coefficient data containing the following files;

```
COEFF01W.txt   COEFF08W.txt   ionos03.bin   ionos10.bin
COEFF02W.txt   COEFF09W.txt   ionos04.bin   ionos11.bin
COEFF03W.txt   COEFF10W.txt   ionos05.bin   ionos12.bin
COEFF04W.txt   COEFF11W.txt   ionos06.bin  'P1239-3 Decile Factors.txt'
COEFF05W.txt   COEFF12W.txt   ionos07.bin
COEFF06W.txt   ionos01.bin    ionos08.bin
COEFF07W.txt   ionos02.bin    ionos09.bin
```

2.1 Linux

A Linux specific Makefile is provided to simplify Installation on Linux platforms. The following steps are required to install the application using this script;

```
$ cd Linux
$ make clean
$ make
$ sudo make install (Installs the binary and library files)
$ sudo ldconfig
$ sudo make install-data (Installs the data files)
```

The above will build the application and install it along with a man page under `/usr/local/`. The data repository will be installed under `/usr/local/share/p533`. With this configuration, ITURHFProp input files should have the `DataFilePath` set as follows (See Chapter 4 [ITURHFProp Input File Structure], page 7).

```
DataFilePath "/usr/local/share/p533/data/"
```

3 Invoking ITURHFProp

ITURHFProp is run from the command line using a command with the following structure;

```
ITURHFProp [-csthv] input-file [output-file]
```

The simplest invocation just defines an input file as follows;

```
ITURHFProp myInputFile
```

This will call the application, saving the results in a file name created using a timestamp, e.g. `.RPTddmmyy-hhnnss.txt` where the report file is time stamped:

```
dd = day
mm = month
yy = year
hh = hour
nn = minute
ss = seconds
```

Note: The '.' prefix causes auto generated report file names to be recognised as a hidden-file on Linux systems. It is recommended that the output filename is always defined by the user.

The output file may be provided as a second argument as follows;

```
ITURHFProp myInputFile myOutputFile
```

ITURHFProp does not impose any file naming conventions and allowing the user to adopt any naming scheme to suit their particular work flow, e.g. `.txt`, `.in`, `.out` etc.

ITURHFProp supports a number of command line arguments that may be used to define the format of the output file.

`-c` CSV. Create RFC4180 compliant CSV output. The first line of the file is a header with the same format as the subsequent record lines. The header contains names corresponding to the fields in the file and contains the same number of fields as the records in the rest of the file. This type of file may be opened directly with the Python CVS module, supporting access to the records as a dictionary. Selecting this option also removes the header data. The example below illustrates a sample of this file format;

```
month,hour,frequency,OPMUF,PR,BCR
11,1,14.10,5.52,-154.60,0.00
11,2,14.10,4.86,-154.62,0.00
11,3,14.10,7.43,-149.19,1.95
11,4,14.10,12.14,-132.49,46.87
11,5,14.10,14.88,-120.73,79.85
11,6,14.10,16.87,-110.00,93.02
```

`-v` Version. Prints the version numbers of ITURHFProp and the associated P533/P372 libraries and exits the application.

`-h` Help. Prints a short help message and exits the application.

`-s` Silent. Suppress printing progress messages to standard out while processing. Error messages are still reported to the screen.

`-t` Table. Strip the header, saving only the CSV table to the output file.

```
11, 01,  14.10,   5.52,-154.60,   0.00
11, 02,  14.10,   4.86,-154.62,   0.00
11, 03,  14.10,   7.43,-149.19,   1.95
```

```
11, 04,  14.10,  12.14,-132.49,  46.87
11, 05,  14.10,  14.88,-120.73,  79.85
11, 06,  14.10,  16.87,-110.00,  93.02
```

Some examples of invoking ITURHFProp;

```
$ ITURHFProp -h
$ ITURHFProp -s p2pSample.in p2pSample.out
$ ITURHFProp -s -t p2pSample.in p2pSample.out
$ ITURHFProp -c p2pSample.in p2pSample.out
```

4 ITURHFProp Input File Structure

ITURHFProp reads processing input from a formatted text file. Input parameters may appear in any order

Output files are either a CSV table or a Path dump text file.

Comment lines in an ITURHFProp input file begin with two forward slashes "//", blank lines are ignored.

String fields, such as the transmitter name or path name etc., must appear between quotes.

Directory paths (e.g. to data files) must end in a file path separator ('\' for Windows, '/' for Linux/Mac OS).

`//` Comment line. Comments are not reproduced in the output file.

`PathName` Text name of path which will be printed in the output file. This string has no bearing on the calculations and is provided as a user convenience.

Example;

```
PathName "London - Tangier, SSB, 400W"
```

`PathTXName`

Text name of transmitting site. This string has no bearing on the calculations and is provided for user convenience.

Example;

```
PathTXName "London"
```

`Path.L_tx.lat`

Transmit antenna latitude in decimal degrees -90.0 to 90.0

Example;

```
Path.L_tx.lat 34.5
```

`Path.L_tx.lng`

Transmit antenna longitude in decimal degrees -180.0 to 180.0

Example;

```
Path.L_tx.lng -24.4
```

`TXAntFilePath`

Path and filename to transmitter antenna pattern or "ISOTROPIC". The path may be expressed relative to the working directory or as a full system path (recommended).

Examples;

```
TXAntFilePath "ISOTROPIC"
TXAntFilePath "C:\path_to_dir\my_antenna.n13" (Windows)
TXAntFilePath "/path_to_dir/my_antenna.n13" (Linux)
```

`TXGOS` Transmit antenna gain offset (in dB), typically this is 0.0.

`PathRXName`

Text name of receiving site

`Path.L_rx.lat`

Receive antenna latitude in decimal degrees -90.0 to 90.0

`Path.L_rx.lng`

Receive antenna longitude in decimal degrees -180.0 to 180.0

`RXAntFilePath`
: Path and filename to transmitter antenna pattern or "ISOTROPIC". The path may be expressed relative to the working directory or as a full system path (recommended).

`RXGOS` Receive antenna gain offset (in dB), typically this is 0.0

`AntennaOrientation`
: Orientation of antenna, "`TX2RX`" when transmit antenna points to receive antenna or "ARBITRARY" when user defined. Antenna bearings default to 0 degrees (North) if the bearing is not specified with the TXBearing / RXBearing parameters.

`TXBearing`
: Bearing of the transmit antenna expressed in degrees clockwise from North, between 0° and 360°. This value will only represent the main beam of the antenna file has the main beam at 0°. This parameter is optional and only used when AntennaOrientation is set to "`ARBITRARY`".

`Path.year`
: Path year, between 1900 and 2100. This parameter is used as a label and is not used in calculations.

`Path.month`
: Path month, from 1 to 12.

`Path.hour`
: Path hour in UTC, from 1 to 24. This can be a comma separated list of integers i.e, 1,4,7,18.

`Path.SSN` Sunspot number R12, between 1 and 311.

`Path.frequency`
: Frequency (MHz), between 1.6 and 30.0. This can be a comma separated list of decimal values i.e, 3.45, 11.553, 17.7756, 23.0008.

`Path.txpower`
: Transmit power (dB(kW)), between -30.0 and 60.0.

`Path.BW` Bandwidth (Hz), between 0.005 to 3000000.0.

`Path.SNRr`
: Required Signal-to-noise ratio (dB), between -30.0 and 200.0.

`Path.SNRXXp`
: Percent of month in which signal-to-noise exceed, between 1 and 99.

`Path.ManMadeNoise`
: Path noise environment, "CITY", "RESIDENTIAL", "RURAL", "QUIETRURAL","QUIET", "NOISY" or in dB, between 100.0 AND 200.0.

`Path.Modulation`
: Modulation type, "ANALOG" or "DIGITAL". If the modulation type is set to "`DIGITAL`", the parameters defined in section ?? may also be used in the input file.

`Path.SorL`
: Path between the Transmitter and Receiver either "SHORTPATH" or "LONGPATH"

`RptFilePath`
: The program outputs CSV text files starting with the prefix RPT for a report file and PDD for a path dump text file. A time stamped text file is only created in

the directory indicated by RptFilePath if no filename is given on the command line. The RPT or PDD filename format described below for DUMPPATH.

`RptFileFormat`
: The value of this parameter defines the content of the analysis. One or more data types may be defined. If multiple data types are required, they must be separated with a'`|`' character as shown in the examples below. See Section 4.1 [Report Options], page 9, for a list of valid report format values.

  The order that the desired parameters appear in the output file is fixed and does depend on the order in which the report options are specified.

```
RptFileFormat "RPT_BCR"
RptFileFormat "RPT_OPMUF | RPT_BCR | RPT_PR | RPT_SNR"
RptFileFormat "RPT_DUMPPATH"
```

  The last example above illustrates the use of a special report type called `RPT_DUMPPATHDATA` which may be used as a single option. The option, `RPT_DUMPPATHDATA`, typically is used for troubleshooting and for detailed analysis that may be required for point-to-point links. This option generates a large amount of data.

  `RPT_DUMPPATHDATA` outputs most of the calculated values. Note the output from this option is path length dependent. Note for links that are > 9000 km the output printed by the option, `RPT_DUMPPATHDATA`, only applies to a small number of the control and penetration points necessary to do the prediction.

  The file created by the option is named `PDDddmmyy-hhnnss.txt` where the path data dump file is time stamped:

```
dd = day
mm = month
yy = year
hh = hour
nn = minute
ss = seconds
```

`DataFilePath`
: The path to the data directory containing the coefficient files.

4.1 Report Options

The RptFileFormat indicates to ITURHFProp what data outputs are desired. The options can be entered in any order, except `OPTION RPT_DUMPPATH` which must appear alone. The output file will indicate how the desired output parameters are ordered.

The supported report output data options are;

`RPT_D` Path distance (km)

`RPT_DMAX` Path dmax (km) and Slant Range (km)

`RPT_ELE` Path elevation (rad)

`RPT_BMUF` Path basic MUF (MHz)

`RPT_BMUFD`
: BMUF deciles MUF50, MUF90 & MUF10

`RPT_OPMUF`
: Operational MUF (MHz)

`RPT_OPMUFD`
: OPMUF deciles OPMUF90, OPMUF10

`RPT_NO_F2`
: Lowest order F2 layer mode

`RPT_NO_E` Lowest order E layer mode

`RPT_E` Field Strength (dB(1uV/m)) Es, El or Ei depending on distance

`RPT_PR` Median received power, Pr, and the receive antenna gain, Grw

`RPT_NOISESOURCES`
: Noise (Atmospheric) FaA, (Man-made) FaM & (Galactic) FaG (dB)

`RPT_NOISESOURCESD`
: DuA, DlA, DuM, DlM, DuG, & DlG Noise component deciles (dB)

`RPT_NOISETOTALD`
: DuT & DlT Total noise deciles (dB)

`RPT_NOISETOTAL`
: Total Noise, FamT (dB)

`RPT_SNR` Signal-to-noise ratio (dB)

`RPT_SNRD` SNR Deciles DuSN & DlSN

`RPT_SNRXX`
: Signal-to-noise ratio (dB) at the desired reliability XX %

`RPT_SIR` Signal-to-interference ratio (dB)

`RPT_SIRD` SIR decile variations DuSI & DlSI

`RPT_RSN` Digital modulation performance parameters RSN, RT & RF

`RPT_BCR` Basic Circuit Reliability (%)

`RPT_OCR` Overall Circuit Reliability (%) without the consideration of scattering

`RPT_OCRS` Overall Circuit Reliability (%) considering of scattering and Probocc (%)

`RPT_MIR` Digital Modulation Multimode interference ratio (%)

`RPT_RXLOCATION`
: Receiver location

`RPT_DOMMODE`
: Dominant Mode only relevant to short paths < 7000 km

`RPT_GRW` For path distances <= 7000 km, Grw is the "lossless receiving antenna of gain (dB relative to an isotropic radiator) in the direction of signal incidence". Grw will be the dominant mode gain. For path distances >= 9000 km, Grw is the "largest value of receiving antenna gain at the required azimuth in the elevation range 0 to 8 degrees."

`RPT_ESL` Field Strength (dB(1uV/m)) Es and El

`RPT_LONG` Long path parameters Gap, E0, fM, fL, Ly and K[2]

`RPT_ALL` All of the above

`RPT_DUMPPATH`
: A special report type which may be used as a single option. `RPT_DUMPPATHDATA` is typically used for troubleshooting and for detailed analysis that may be required for point-to-point links. This option generates a large amount of data.

4.2 Digital Mode Input Parameters

The following six options `Path.SIRr`, `Path.A`, `Path.TW`, `Path.FW`, `Path.T0` and `Path.F0`) are applicable only when the Path.Modulation is "`DIGITAL`";

`Path.SIRr`
: Required Signal-to-interference ratio (dB), between -30.0 and 200.0

`Path.A` Required Amplitude Ratio (dB), between 0.0 and 50.0

`Path.TW` Time window (ms), between 0.0 and 50.0

`Path.FW` Frequency window (Hz), between 0.0 and 1000.0

`Path.T0` Time spread for simple BCR (ms), between 0.0 and 1000.0

`Path.F0` Frequency dispersion for simple BCR (Hz), between 0.0 and 1000.0

4.3 Defining the Analysis Area

ITURHFProp supports analysis of both Point-to-Point and Area coverage circuits. In both cases, the analysis area is specified as a rectange encompassing the geographic region of interest. The convention for coordinates is up is north (positive values) and right is East (positive values).

Point-to-Point predictions are a special case of an area plot in which the corners of the analysis area are collapsed to a single point. In this case, all four latitudes are the same and all four longitudes are the same.

It should be noted that the analysis area is independant of and defined seperately to the `Path.L_rx.lat` and `Path.L_rx.lng` parameters. `Path.L_rx.lat` and `Path.L_rx.lng` are used by ITURHFProp to determine antenna alignment.

The granularity of the analysis is controlled by the values of `latinc` and `lnginc` which define the spacing of sample points within the analysis area. The following example shows how global coverage may be defined, with sample points at every 15° latitude and longitude, yielding a total of 325 prediction points. `latinc` and `lnginc` are left undefined when performing a Point-to-Point analysis.

```
LL.lat -90.0
LL.lng -180.0
LR.lat -90.0
LR.lng 180.0
UL.lat 90.0
UL.lng -180.0
UR.lat 90.0
UR.lng 180.0
latinc 15.00
lnginc 15.00
```

Appendix A Sample Input File: Point-to-Point

This example considers a circuit between London and Rome for which the following assumptions have been made;

- Time: 16:00 UTC, November 2018.
- Power: A transmit power of 400W (-3.98 dB(kW)) has been assumed.
- An SNR of 15dB has been defined with a bandwidth of 3000Hz, typical for a reasonable SSB channel.
- A user specified Type 14 antenna has been defined at the transmit site. An isotropic receive antenna with a gain of 2.14dBi (corresponding to the maximum gain of a dipole) has been assumed at the receive end.
- SSN: The SIDC website predicts an SSN value of 8 for this time period. This example demonstrates how the analysis area is collapsed to a single point for Point-to-Point Predictions.

```
PathName "Sample Point-to-Point Analysis"
Path.L_tx.lat 51.540700
Path.L_tx.lng -0.130500
TXAntFilePath "data_file_path/antenna/voaant/d20m.n14"
TXGOS 2.16
Path.L_rx.lat 41.804100
Path.L_rx.lng 12.553700
RXAntFilePath "ISOTROPIC"
RXGOS 2.16
Path.year 2018
Path.month  11
Path.hour 16
Path.SSN 8
Path.frequency 14.1
Path.txpower -3.98
Path.BW 3000.0
Path.SNRr 15.0
Path.SNRXXp 90
Path.ManMadeNoise "CITY"
Path.Modulation "ANALOG"
Path.SorL "SHORTPATH"
RptFileFormat "RPT_OPMUF | RPT_BCR | RPT_PR"
LL.lat 41.804100
LL.lng 12.553700
LR.lat 41.804100
LR.lng 12.553700
UL.lat 41.804100
UL.lng 12.553700
UR.lat 41.804100
UR.lng 12.553700
DataFilePath "/path/to/data/"
```

Appendix B Sample Input File: Area

[TODO Include a sample input file]

Appendix C Antenna Files

ITURHFProp supports either Isotropic radiators or antennas with characteristics defined in

C.1 Isotropic Radiators

The gain of isotropic radiators may be controlled by the value of `TXGOS` or `RXGOS`.

C.2 Type 13 Antennas

Type 13 antenna files are typically used to model fixed directional antennas, tabulating radiation pattern in all azimuth directions (0-359) and all elevation angles (0-90), in 1° increments.

ITURHFProp supports Type 13 files containing data for a single frequency. Analysis of multiple frequencies requies multiple runs with a different Type 13 file called each time.

The following extract shows the file header followed by the first two complete blocks (corresponding to azimuths of 0° and 1°).

```
Fan Dipole 9m above ground (12.00MHz)
 4     4 parameters
 5.940  [ 1] Max Gain dBi..:
  13    [ 2] Antenna Type..: 360 x 91 gain values follow
  -0.9  [ 3] Efficiency (for IONCAP)
12.000  [ 4] Frequency
    0    -99.990-70.637-41.283-11.930 -9.973 -8.017 -6.060 -4.957 -3.853 -2.750
          -1.997 -1.243 -0.490  0.060  0.610  1.160  1.577  1.993  2.410  2.737
           3.063  3.390  3.640  3.890  4.140  4.337  4.533  4.730  4.877  5.023
           5.170  5.280  5.390  5.500  5.577  5.653  5.730  5.777  5.823  5.870
           5.893  5.917  5.940  5.940  5.940  5.940  5.927  5.913  5.900  5.870
           5.840  5.810  5.767  5.723  5.680  5.630  5.580  5.530  5.473  5.417
           5.360  5.297  5.233  5.170  5.110  5.050  4.990  4.927  4.863  4.800
           4.743  4.687  4.630  4.573  4.517  4.460  4.413  4.367  4.320  4.283
           4.247  4.210  4.183  4.157  4.130  4.110  4.090  4.070  4.067  4.063
           4.060
    1    -99.990-70.638-41.286-11.934 -9.978 -8.022 -6.066 -4.962 -3.858 -2.754
          -2.001 -1.249 -0.496  0.054  0.604  1.154  1.571  1.987  2.404  2.731
           3.057  3.384  3.635  3.885  4.136  4.332  4.528  4.724  4.871  5.019
           5.166  5.275  5.385  5.494  5.571  5.647  5.724  5.771  5.817  5.864
           5.887  5.911  5.934  5.935  5.935  5.936  5.923  5.909  5.896  5.866
           5.836  5.806  5.763  5.721  5.678  5.628  5.578  5.528  5.471  5.415
           5.358  5.295  5.231  5.168  5.108  5.048  4.988  4.925  4.861  4.798
           4.741  4.685  4.628  4.572  4.516  4.460  4.413  4.367  4.320  4.283
           4.247  4.210  4.183  4.155  4.128  4.109  4.089  4.070  4.067  4.063
           4.060
    3    -99.990-70.641-41.291-11.942 -9.987 -8.033 -6.078 -4.973 -3.867 -2.762
          -2.011 -1.259 -0.508  0.042  0.592  1.142  1.559  1.975  2.392  2.719
           3.045  3.372  3.624  3.876  4.128  4.323  4.517  4.712  4.861  5.009
           ... ... ...
```

Each Type 13 antenna file requires an ASCII file about 265kB long to include all elements of the pattern in the proper format.

C.3 Type 14 Antennas

Type 14 files are typically used to characterise omni-directional or rotatable antenna types. The files comprise tables of antenna gain at each elevation (0°-90°) for multiple frquency blocks.

The following extract shows the file header followed by the first two complete blocks, corresponding to gains at elevations of 0° to 90° at frequencies of 1MHz (no data), 2MHz;

```
3EL Yagi @40M
 3     3 parameters
  0.00  [ 1] Max Gain dBi..:
```

```
 14    [ 2] Antenna Type..: 30 x (efficiency + 91 gain values) follow
 14.0  [ 3] Frequency
1  0.00   0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
          0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
          0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
          0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
          0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
          0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
          0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
          0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
          0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
          0.000
2  0.00 -30.000-16.883-10.911 -7.442 -5.002 -3.128 -1.614 -0.350  0.729  1.667
          2.491  3.223  3.877  4.466  4.998  5.480  5.919  6.319  6.683  7.016
          7.319  7.596  7.848  8.078  8.286  8.474  8.644  8.797  8.932  9.052
          9.158  9.249  9.326  9.391  9.444  9.485  9.515  9.533  9.542  9.540
          9.529  9.509  9.480  9.442  9.396  9.342  9.280  9.210  9.134  9.050
          8.960  8.863  8.760  8.650  8.535  8.414  8.288  8.156  8.019  7.877
          7.730  7.579  7.423  7.263  7.098  6.930  6.757  6.581  6.401  6.217
          6.030  5.840  5.646  5.449  5.249  5.046  4.840  4.631  4.419  4.205
          3.988  3.768  3.545  3.320  3.092  2.861  2.628  2.391  2.153  1.911
          1.666
3  0.00 -30.000-14.570 -8.612 -5.162 -2.744 -0.895  0.590  1.822  2.866  3.765
          4.547  5.233  5.839  6.375  6.852  7.275  7.652  7.986  8.281  8.541
          ... ... ...
```

Each Type 14 antenna file requires an ASCII file about 23kB long to include all elements of the pattern in the correct format.

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