FM Radio / Transmission Multi-tone detection script notes

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Overview

This information relates to the dScope script "MT Transmission Monitor.dss" which is an automation script to enable the dScope to detect a multi-tone[1] in an FM radio broadcast or other transmission medium and make measurements from it. The script makes use of the dScope Series III FFT detectors to reliably detect the presence of the multi-tone and avoid false triggering from program material. It does this by looking for the presence of each of the audio tones in the program material and only triggers when the required number of tones are present above the background level. At this point, it samples the audio and makes measurements. Measurements are held in memory by default, but can optionally also be logged to a spreadsheet. FFT traces can also be saved to file.

Requirements

dScope Series III, Software version 1.21 or later software

Installation

The installation consists of a script, a configuration, a results spreadsheet (optional) and some wavetable and filter files. These files are: (all paths relative to the dScope installation folder unless otherwise noted)

File Name	**Description**	**Location** (relative to dScope folder)
MT Transmission Monitor.dss	Main dScope automation script	\scripts\automation
MT Transmission.dsc	Main dScope configuration	\configurations
MT Transmission Results.xls	A sample results Excel spreadsheet	\Results
MT Trans.dss	Multi-tone generation script	\User Wavetables
MT Trans (ChA).wfm	Multi-tone waveform (channel A)	\User Wavetables
MT Trans (ChB).wfm	Multi-tone waveform (channel B)	\User Wavetables
MT Trans Spaces.dss	FFTD weighting filter calculation script	\FFT Detector Weighting Filters
MT Trans Spaces.wtg	FFTD weighting filter	\FFT Detector Weighting Filters
MT Trans Tones.dss	FFTD weighting filter calculation script	\FFT Detector Weighting Filters
MT Trans Tones.wtg	FFTD weighting filter	\FFT Detector Weighting Filters
MT Trans NoTones.dss	FFTD weighting filter calculation script	\FFT Detector Weighting Filters
MT Trans Notones.wtg	FFTD weighting filter	\FFT Detector Weighting Filters
MT Transmission Monitor Notes.pdf	This document	\scripts\automation

The files above are supplied in a zip file with a script installer which creates the necessary folders and copies files to the required location. This script reads the dScope installation folder location from the registry then installs the necessary files, creating new folders where necessary.

To install the files:

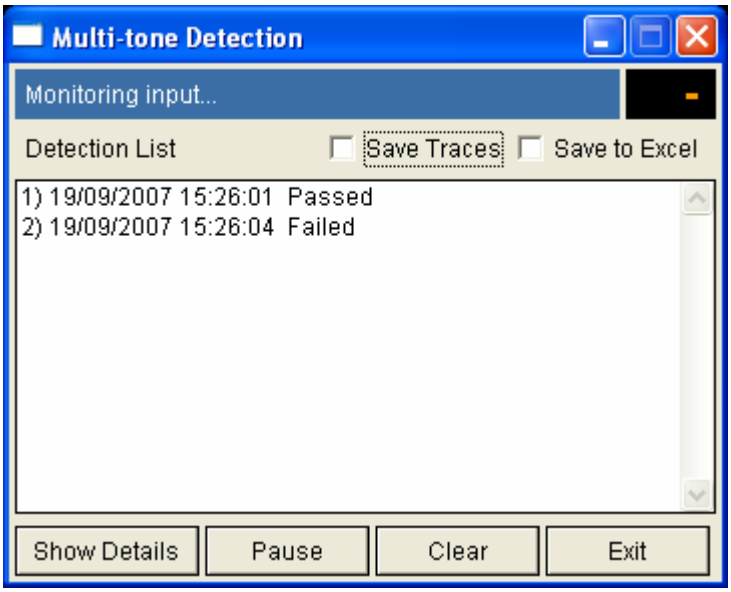
1. unzip the contents of the zip file to an empty folder (location is not important)
2. double click on the file “install test files.vbs”.

This may get stopped by antivirus software as it uses the registry to get the path to the dScope folder. If so, you will need to tell the antivirus software to allow the script to run. Once it has run, it generates a text file called “report.txt” which lists the actions taken by the script. To un-install the scripts, you would need to look at this report and remove the files and folders it has copied and created. In this instance the installer creates 1 folder (called “Results”) and copies 13 files. It makes no changes to the registry.

[1] A multi-tone is a single stimulus containing multiple frequencies or tones. The ability to analyze these frequencies in the frequency domain using FFTs (Fast Fourier Transforms) makes it possible to make several measurements simultaneously.

Running the Script
When the above files are copied to the locations indicated, the script can be run by running the automation script "MT Transmission Monitor.dss" from within the dScope application. This can be done from either the "Automation" menu, "Run Script" option, or using the "Run Script" button on the toolbar. Alternatively, if this script is to be run frequently, a shortcut can be added to the "User Toolbar".

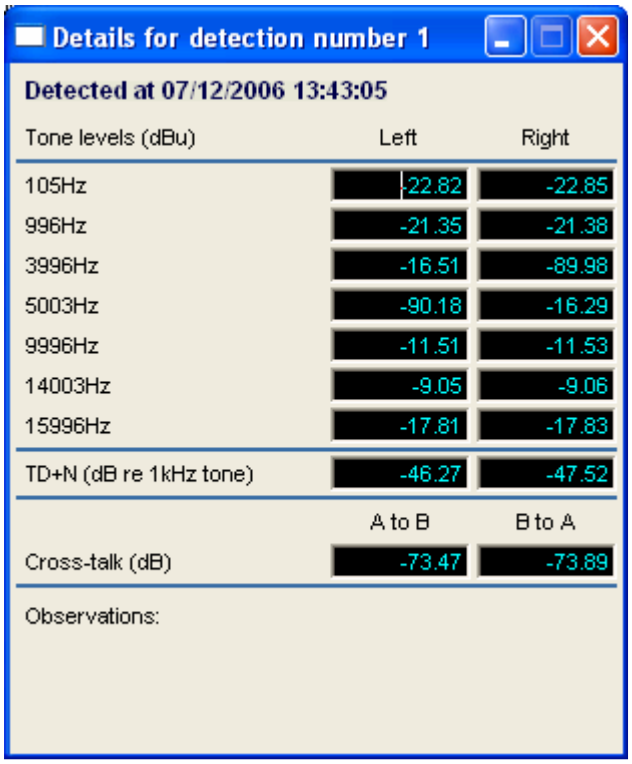
Running the script loads a configuration which then monitors the analogue audio inputs of the dScope for the presence of the required multi-tone. The user interface is shown below.



This interface has the following features:

- **Information box:** this blue area at the top of the screen indicates what the script is currently doing. It will normally say "Monitoring input..." but will also indicate when the script has detected a multi-tone, when it is writing information to Excel etc.
- **Indicator box:** the small black box at the top right indicates the activity of the script. While the script is monitoring the input, the small orange box moves back and forth. If it stops, the script is not running, and if it slows down significantly, the script may not be able to detect a short multi-tone burst. When a multi-tone is detected, the orange box will turn to a green "+" sign, and then revert to monitoring the input. If the script is paused, this box will also show a flashing pause sign.
- **Detection List:** the largest part of the interface is taken up with the detection list. This is simply a list of all the multi-tones detected by the script since it was started or since it was last reset with the "Clear" button. This indicates the count of the multi-tones detected, the date and time of the detection, and whether the multi-tone signal was severely compromised by the presence of a compressor in circuit.
- **Save Traces checkbox:** when checked, the script will save a copy of the traces captured. These are saved as dScope .tra trace files which can be re-loaded into the dScope trace window for viewing. The trace can only be saved at the time it is captured, so this box must be checked before the multi-tone is detected.
- **Save to Excel checkbox:** when checked, the script will save the measurement data to the results spreadsheet. This is done at the time the multi-tone is detected and measured. It cannot be done retrospectively, so the box must be checked before the multi-tone is detected.
- **Show Details button:** This button toggles a separate window (shown below) which shows the measurement details of the selected detection from the detection list. To use it, you will need to select a detection event from the list and press this button. Changing the selection in the list updates the contents of the details window. The "Observations" section at the bottom of the details window will

indicate if the compression was on, if the channels were swapped over, if the traces were saved and if the results were logged to the spreadsheet.



- **Pause Button:** the pause button simply pauses the monitoring so that multi-tones will not be detected. Press again to start to run the monitoring again.
- **Clear Button:** the "Clear" button clears and resets the detection list.
- **Exit Button:** as expected, this will close the script. It will finish the current operation first (if a multi-tone has just been detected, the logging etc. will be completed before the program exits.) All the contents of the detection list will be lost.

Using the Script

The script is intended to be used on the receiving end of a transmission path where it will continuously monitor the incoming audio for the presence of the multi-tone. Connect the analogue audio outputs from the device at the receiving end of the path to the analogue inputs of the dScope and run the script. It is very unlikely that the script will be triggered by anything but the multi-tone as it effectively uses the FFT of the multi-tone as a key to trigger the measurements.

The script is set up so that the generator is continuously outputting the required multi-tone. Connecting the dScope outputs to the inputs will trigger the multi-tone detection and make a measurement. This is an easy way of checking that the script is working. Recording the multi-tone and re-playing it through the transmission path with the dScope running the script will enable testing the transmission path over very long distances with arbitrary delay times. You will probably need to record about 2 seconds of the multi-tone in order to be able to make a reliable measurement and detection. The dScope can be left unattended to monitor the connection, typically overnight, over which time it will keep track of every time the multi-tone was detected, make measurements and, optionally, save the results to a spreadsheet and keep copies of the FFT spectra of the detected multi-tones.

It is possible to modify the script to email the results back to the originating station. This can be done with attachments containing the data and/or with the data in the body of the email, including in HTML format. The

ability to do this will depend on the availability of a suitable mail server and fire-wall settings etc. The script here does not have this feature. Contact Prism Sound for more information.

Limit Checking
The script incorporates the ability to make a pass/fail decision on the measured multi-tone based on limits stored either in the script itself or in the spreadsheet. The script can run without the spreadsheet in which case it makes use of limits stored in the script itself. These will need to be edited in a text editor - See notes later in this document under "Script Configuration". If an Excel spreadsheet is being used, the limits will be imported from the spreadsheet and these will be used in preference to the ones in the script. The pass/'fail is indicated on the detection list as well as in the measurement details list. In the latter list, each individual measurement is indicated in red if it fails.

Results Spreadsheet
The results spreadsheet is a Microsoft Excel spreadsheet set up to record each new multi-tone detection in a new row, with columns for the amplitude of each tone, distortion and cross-talk measurements for each channel. If enabled, the spreadsheet is opened by the script only at the point when a measurement is taken and is closed again as soon as the results have been saved. The spreadsheet is opened in the background and will not be visible, even when the script has it open. This has the problem that if the spreadsheet is open when the script wants to write to it, it will open a read-only copy, and then not be able to save it. To avoid this situation, **do not open the results spreadsheet while the script is actively monitoring**: either exit from the script or pause it if you want to look at the spreadsheet.

Saved Traces
If the "Save Traces" checkbox is enabled, the script will save copies of the FFT spectrum of the multi-tones it captures. It does this by saving the actual traces as dScope trace files (.tra) to the dScope "Traces" folder. The traces are named by the date and time when they were captured and can be viewed by re-loading them into the dScope trace window. To do this, go to the trace window and click the "add/load trace" button. In the dialogue that appears, select the "Saved Trace" radio button on the left side, then using the ">>" browse button to the right, select the file you want to view. This will load it into the trace window where the cursors and markers are available for analysis of the trace.

Script Configuration
The script contains several options that can be changed by the user. These are clearly commented in the script below the initial variable declarations. They can be edited in a text editor or the dScope script editor. The things that can be edited are as follows (the variable name is given in brackets):

- Whether or not to use an Excel spreadsheet for the results (bUseExcel = "true" or "false")
- The name and path of the Excel spreadsheet relative to the dScope folder (StrXLfile)
- The configuration file to load on start-up (strConfig)
- The title that appears on message boxes, the user interface etc. (strtitle)
- Whether to take statistics of the detection at each loop if the detection fails (bTakeStats)
- The Place to store the statistics, relative to the dScope folder (strStatsLog)
- The Multi-tone Detection threshold in dB (dMTThreshold)
- Compressor detection threshold in dB (dCompThreshold)
- The time to wait after making a reading before re-setting in ms (dResetTime)

Test Limits can also be set in the script. For each amplitude parameter there is a maximum and minimum limit, and for the cross-talk and distortion readings there are maximum limits only. All the amplitude limits are in dBu, and the cross-talk and distortion limits are in dB. Note that the distortion here is not THD+N - the measurement from the multi-tone is based on the ratio between the level of the 1kHz tone and the level of the sum of the FFT bins between the tones. It will tend to be significantly less than the THD+N for this device.

Changing the Multi-tone
Changing the frequencies of the multi-tone is fairly involved and would include:

- Modifying the Multi-tone generation script and running it to generate the new tones
- Modifying each of the FFT weighting filter to be able to work with the new tones
- Modifying the filter frequencies of the FFT detector band pass filters
- Modifying the results spreadsheet (if used) to reflect the new frequencies

Adding frequencies would additionally require modification of the script to accommodate the additional frequencies in the frequency array. Adding lower frequencies may require using a longer FFT buffer which will require all the steps above to be done again with the longer FFT size. The easiest thing is to contact us at the factory with your requirements and we can modify it for you.

Technical Specification

Multi-tone:
The multi-tone consists of 7 tones, with a pair of offset tones for cross-talk measurement
Tone(0) = 105.47Hz
Tone(1) = 996.09Hz
Tone(2) = 3996.09Hz (Left Channel Only)
Tone(3) = 5003.91Hz (Right Channel Only)
Tone(4) = 9996.09Hz
Tone(5) = 14003.91Hz
Tone(6) = 15996.09Hz

Measurements

- **Amplitude:** For each tone of the multi-tone, the amplitude is measured in dBu using FFT detectors and a window-notch band pass filter.
- **Distortion:** distortion is measured using FFT detectors with window-notch[2] band reject filters at each of the multi-tone frequencies to measure noise and distortion. This value is then expressed in dB relative to the 1kHz tone amplitude. Note that this is not equivalent to THD+N, and will tend to give a worse reading than measuring with a single tone, mainly due to the reference tone not being the maximum possible, given that there are 6 other tones present. It is possible to change this measurement so that it is expressed relative to the RMS amplitude of the multi-tone which will give a reading more similar to the traditional THD+N measurement.
- **Cross-talk:** The multi-tone is set up so that there is a tone at 4kHz on the left channel only and at 5kHz on the right channel only. Cross-talk from A to B is therefore measured at 4kHz using window-notch band pass filters, and at 5kHz for B to A (where A is expected to be connected to the left channel of a stereo system, and B to the right channel.) The result is expressed in dB relative to the level in the opposite channel.

It is possible to make more measurements than these from the multi-tone data, but this script is only set up for these.

[2] Window-Notch: when using FFT detectors, the FFT window function used in the time domain causes a certain amount of spreading of the energy in the frequency domain. This is normally expressed as a number of FFT bins (e.g., a sine wave viewed using a Prism 5 FFT window will have a *half* window spread of 5 FFT bins. Setting an FFT detector filter to window-notch with this FFT window function will result in a filter that measures the energy in 10 bins, 5 either side of the centre bin. This filter is a "brick wall" filter with infinite cut-off either side (for band-pass) and is implemented in the frequency domain.