Technical Note

Demonstration of MX370107A Fading IQproducer, MS2690A Digitizer, and MATLAB Simulink Visualization

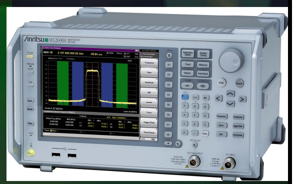
MG3700A Vector Signal Generator
MS2690A Signal Analyzer

Technical Note
- Demonstration of MX370107A Fading IQproducer, MS2690A Digitizer, and MATLAB Simulink Visualization

Anritsu

MG3700A

MS2690A
Signal Analyzer



Vector Signal Generator

May 2008
(1.00)

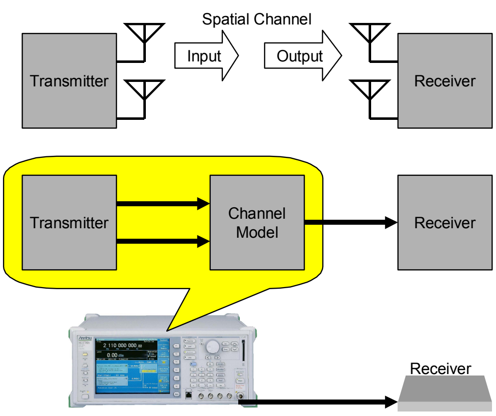
Introduction

This technical note gives technical information for demonstration to promote users' understanding of the MG3700A with Fading IQproducer, MS2690A Digitizer, and importing the digitized I/Q data into MATLAB.

Contents

Fading IQproducer

- The MX370107A Fading IQproducer option for the MG3700A offers simple configuration of spatial channel model simulation using the MG3700A world-leading baseband memory.
  - 2 GB (512 MSa/channel) with memory upgrade option

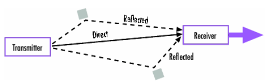


Channel Models

- Communication channels introduce noise, fading, and interference into the transmitted signals. Simulating a communication system involves modeling a channel based on mathematical descriptions of the channel. Different transmission media have different properties and are modeled differently.

Channel Models

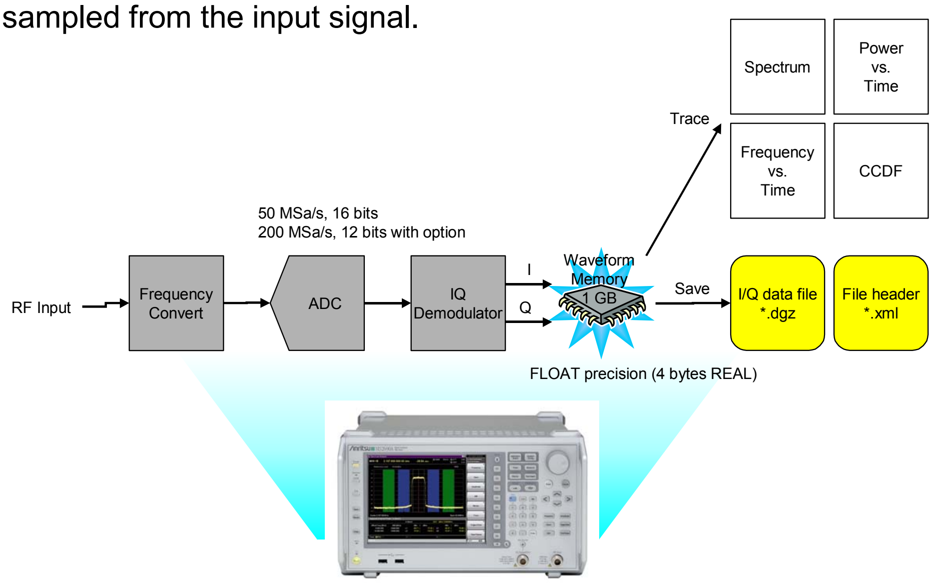
- AWGN Channel
  » The AWGN channel adds white Gaussian noise to the signal passing through it.
- Fading Channels
  » Rayleigh and Rician fading channels are useful models of real-world phenomena in wireless communications. These phenomena include multipath scattering effects, time dispersion, and Doppler shifts that arise from relative motion between the transmitter and receiver.



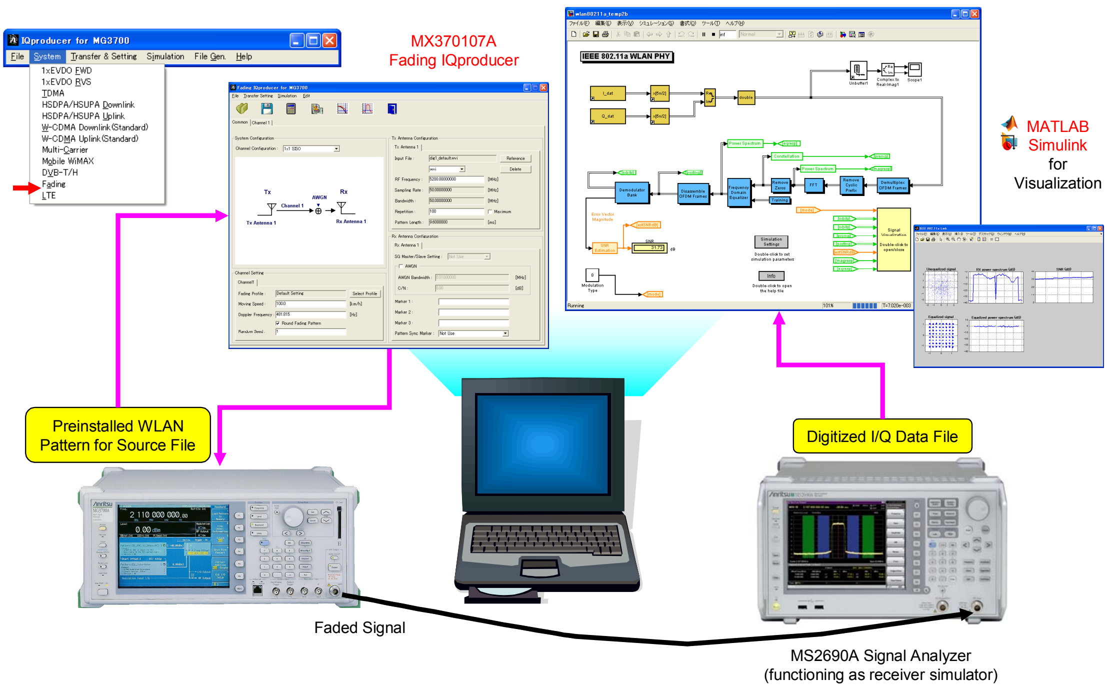
  – The figure depicts direct and major reflected paths between a stationary radio transmitter and a moving receiver. The shaded shapes represent reflectors such as buildings.
  – The major paths result in the arrival of delayed versions of the signal at the receiver. In addition, the radio signal undergoes scattering on a local scale for each major path. Such local scattering is typically characterized by a large number of reflections by objects near the mobile. These irresolvable components combine at the receiver and give rise to the phenomenon known as multipath fading. Due to this phenomenon, each major path behaves as a discrete fading path. Typically, the fading process is characterized by a Rayleigh distribution for a nonline-of-sight path and a Rician distribution for a line-of-sight path.
  – The relative motion between the transmitter and receiver causes Doppler shifts. Local scattering typically comes from many angles around the mobile. This scenario causes a range of Doppler shifts, known as the Doppler spectrum. The maximum Doppler shift corresponds to the local scattering components whose direction exactly opposes the mobile's trajectory.

MS2690A Digitizer

- The MS2690A/2691A/2692A supports export of I and Q data sampled from the input signal.

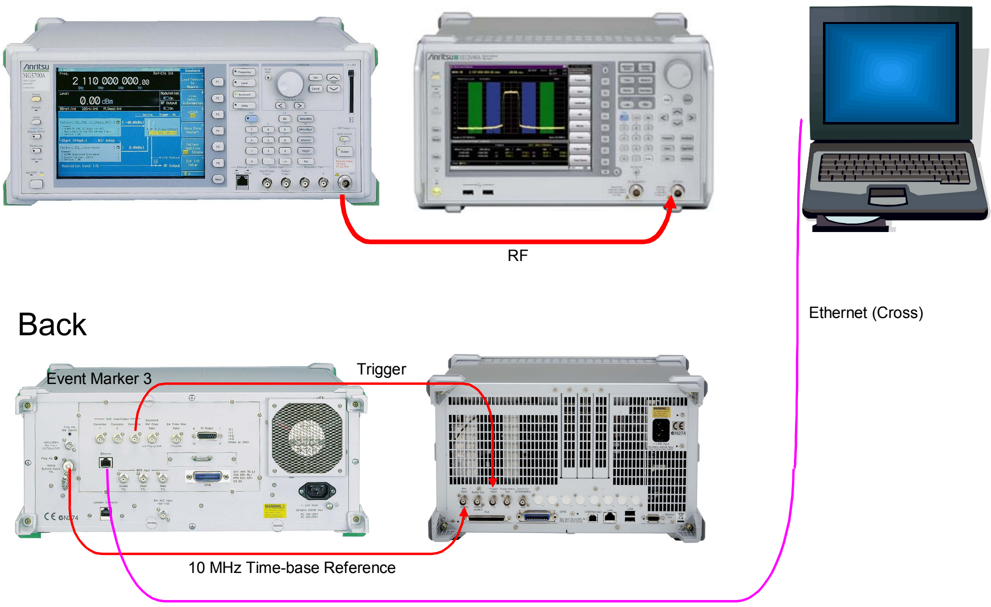


Demo Model



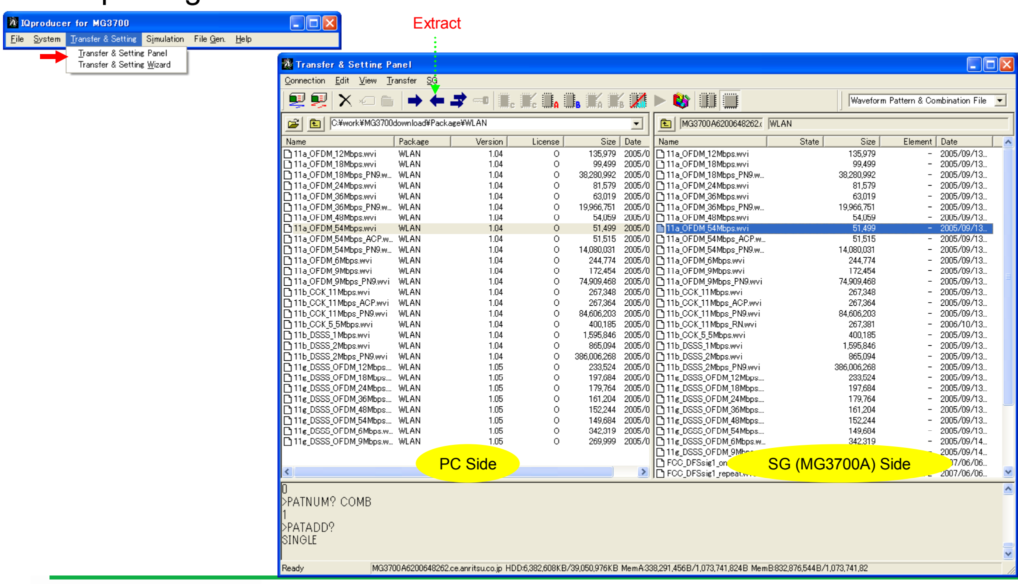
Setup

- Front
- Back

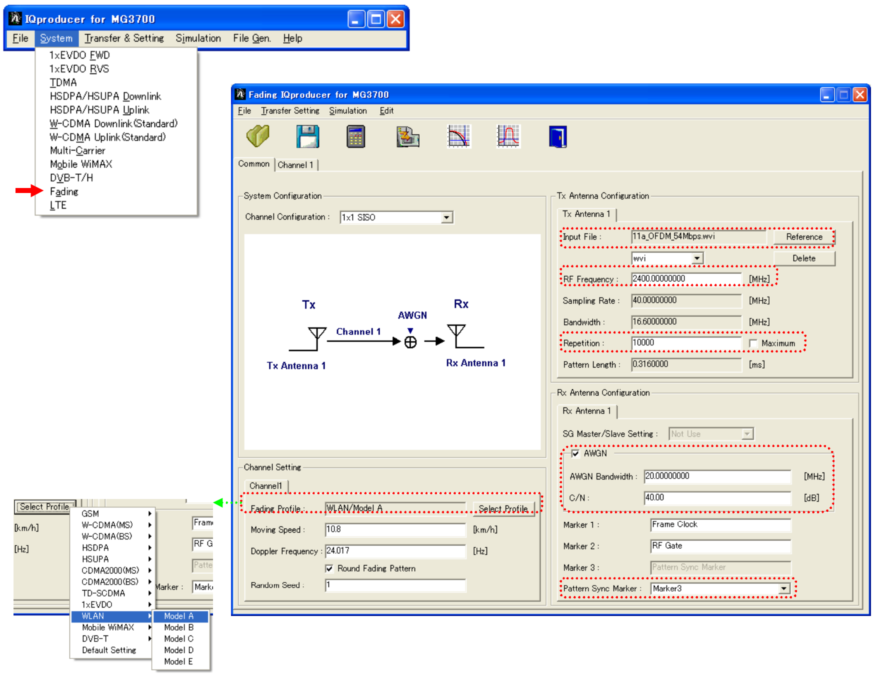


Fading IQproducer Operation

- Extract the IEEE802.11a/g OFDM 54 Mbps pattern file in the WLAN package from the MG3700A built-in HDD in advance.

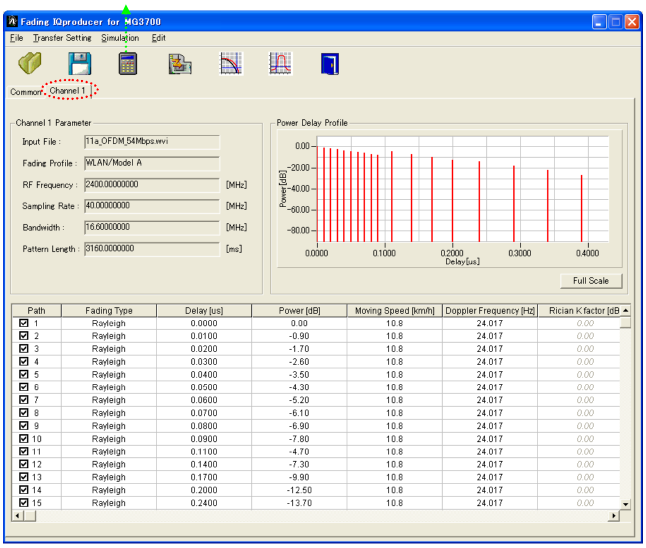


Fading IQproducer Operation



Fading IQproducer Operation

Creating the pattern file requires 9 GB of HDD space and about 1 day to complete, depending on the PC performance.

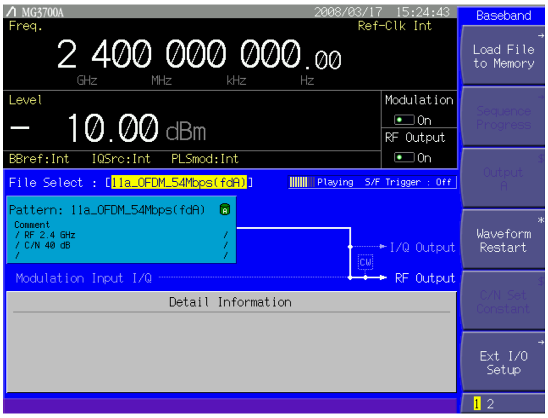


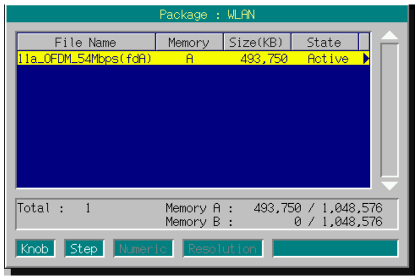
Path	Fading Type	Delay [us]	Power [dB]	Moving Speed [km/h]	Doppler Frequency [Hz]	Rician K factor [dB
1	Rayleigh	0.0000	0.00	10.8	24.017	0.00
2	Rayleigh	0.0100	-0.90	10.8	24.017	0.00
3	Rayleigh	0.0200	-1.70	10.8	24.017	0.00
4	Rayleigh	0.0300	-2.60	10.8	24.017	0.00
5	Rayleigh	0.0400	-3.50	10.8	24.017	0.00
6	Rayleigh	0.0500	-4.30	10.8	24.017	0.00
7	Rayleigh	0.0600	-5.20	10.8	24.017	0.00
8	Rayleigh	0.0700	-6.10	10.8	24.017	0.00
9	Rayleigh	0.0800	-6.90	10.8	24.017	0.00
10	Rayleigh	0.0900	-7.80	10.8	24.017	0.00
11	Rayleigh	0.1100	-4.70	10.8	24.017	0.00
12	Rayleigh	0.1400	-7.30	10.8	24.017	0.00
13	Rayleigh	0.1700	-9.90	10.8	24.017	0.00
14	Rayleigh	0.2000	-12.50	10.8	24.017	0.00
15	Rayleigh	0.2400	-13.70	10.8	24.017	0.00

18 paths

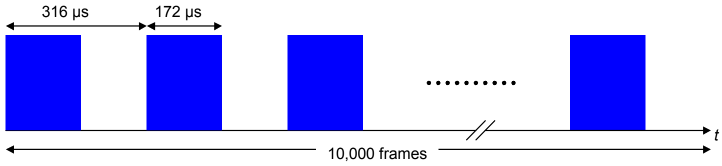
- Supported parameters setting file
  - » 11a_OFDM_54Mbps_Demo.xxx
    - – Change the file name to 11a_OFDM_54Mbps_Demo.xml after saving the embedded file.

MG3700A Operation





- 316 µs frame period
- 10,000 frames periodic playback

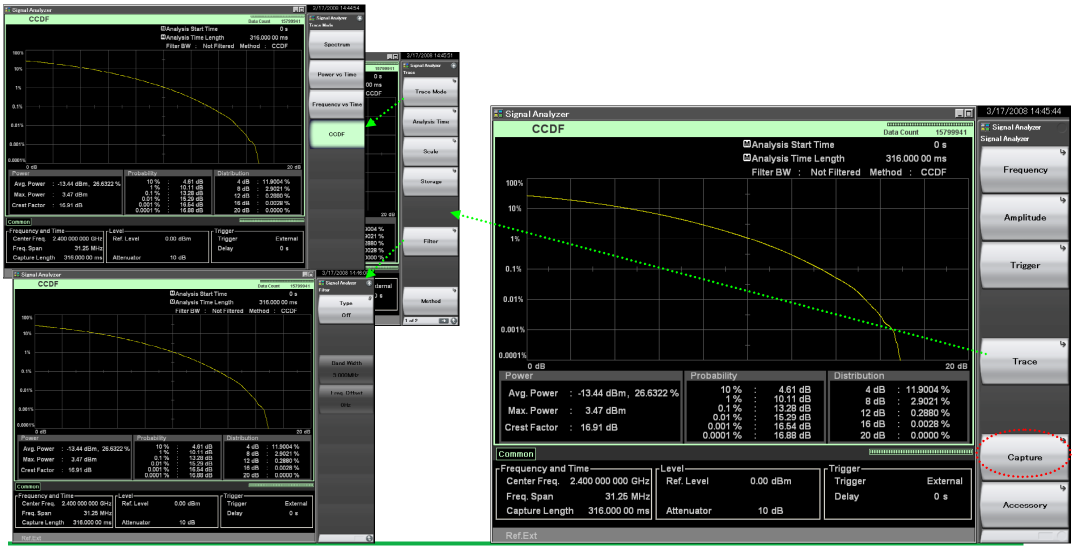


MS2690A Digitizer Operation

- External Trigger Source
- 316 ms Analysis Time Length
  - Maximum 2 s

MS2690A Digitizer Operation

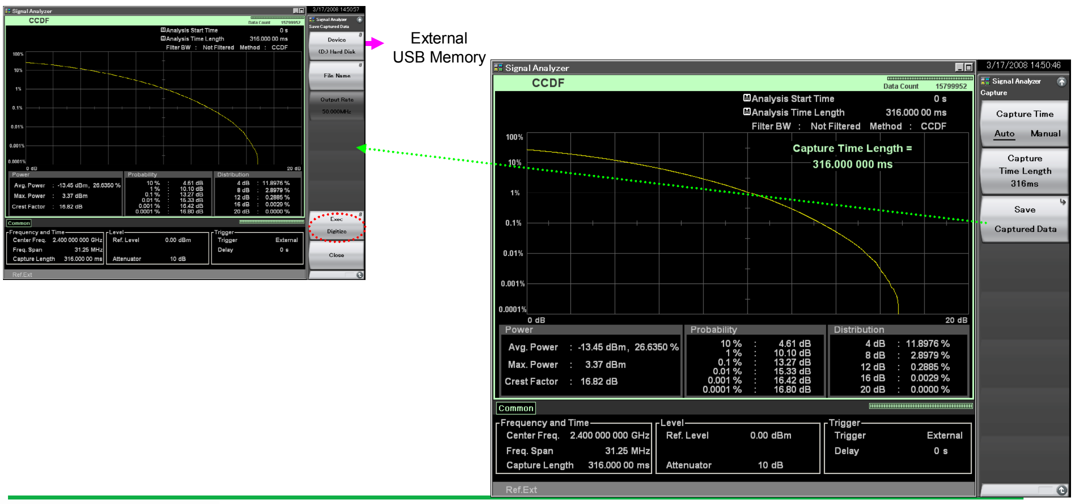
- Filter Off



MS2690A Digitizer Operation

Capture

- Auto Capture Time
- Digitize
  - » 316 ms, 1000 frames duration



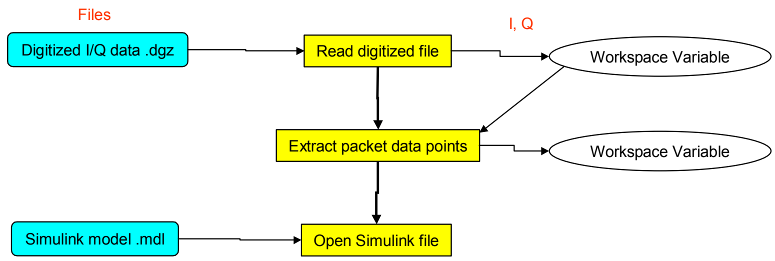
Digitized File Format

- Digitized files consist of two files:
  - » File header .xml
  - » Data file .dgz
    - – The file header (.xml) and data file (.dgz) have the same file name. The MS2690A stores the files in the following folder in external USB memory or built-in HDD.
      - – Drive:/Anritsu Corporation/Signal Analyzer/User Data/Digitized Data/Signal Analyzer/
- The file header contains the digitized settings, such as sample rate, number of samples, center frequency, etc.
- The data file (.dgz) contains the I and Q data points.
  - » Floating single-precision, 4 bytes for each I and Q data point).

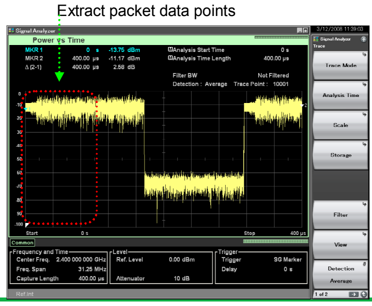
Point	*I*	*Q*
1	4-byte float (real)	4-byte float (real)
2		
:		

MATLAB Script

Programming Flowchart



Extract packet data points

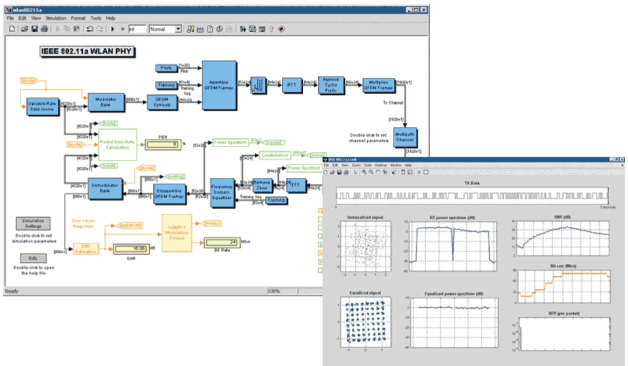


MATLAB Script

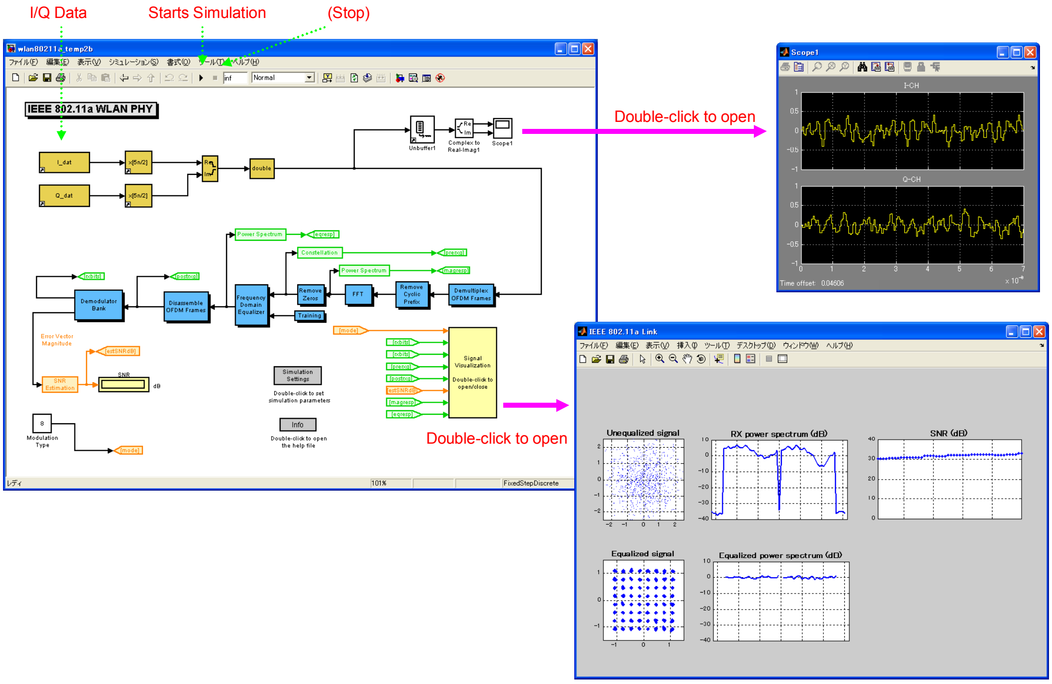
```
clear all, close all, clc

fileName = uigetfile('*.dgz','Open I/Q data file');
fid = fopen(fileName,'r');
data = fread(fid,'float=>float');
fclose(fid);

Idata = data(1:2:end);
Qdata = data(2:2:end);

Fs = 50E6;                    % sampling rate 50 MSa/s
fsFFT = 20E6;                 % FFT sampling frequency 20 MHz
samples_packet = 1920 * Fs/fsFFT;     % samples/packet (30 symbol * 64 FFT points * 5/2 =
    4800)
samples_frame = 6320 * Fs/fsFFT;      % samples/frame
frames = fix(length(Idata)/samples_frame);             % number of frame

I_dat = [];
Q_dat = [];
for framecounter = 1:frames
    packet_start = 1 + (framecounter-1) * samples_frame;
    packet_end = samples_packet + (framecounter-1) * samples_frame;
    I_dat = [ I_dat;Idata(packet_start:packet_end) ];
    Q_dat = [ Q_dat;Qdata(packet_start:packet_end) ];
end

open('wlan80211a_temp2b.mdl');
```


Simulink Model

- This Simulink model was made from part of the Communications Blockset Demos.
  – Communications Blockset Demos
  > Application-Specific Examples
  > IEEE 802.11a WLAN Physical Layer
    - Model of physical layer of IEEE 802.11a Wireless LAN standard, including adaptive modulation, using blocks in Communications Blockset
    - Requirements: Communications Toolbox, Communications Blockset, Signal Processing Blockset, Signal Processing Toolbox



Simulink Operation



Supported MATLAB Script and Simulink Model

- The MATLAB script and Simulink model can be demonstrated.
  - Run.m
    - M-file to run on MATLAB
  - wlan80211a_temp2b.mdl
    - Simulink model called from within Run.m
  - wlan80211a_settings_temp1b.m
    - M-file function called from within wlan80211a_temp2b.mdl

- Embedded object contains the above 5 files.
  - » DemoDigitizedWLAN.zzz (23 KB)
    - Change the file name to DemoDigitizedWLAN.zip after saving the embedded file.

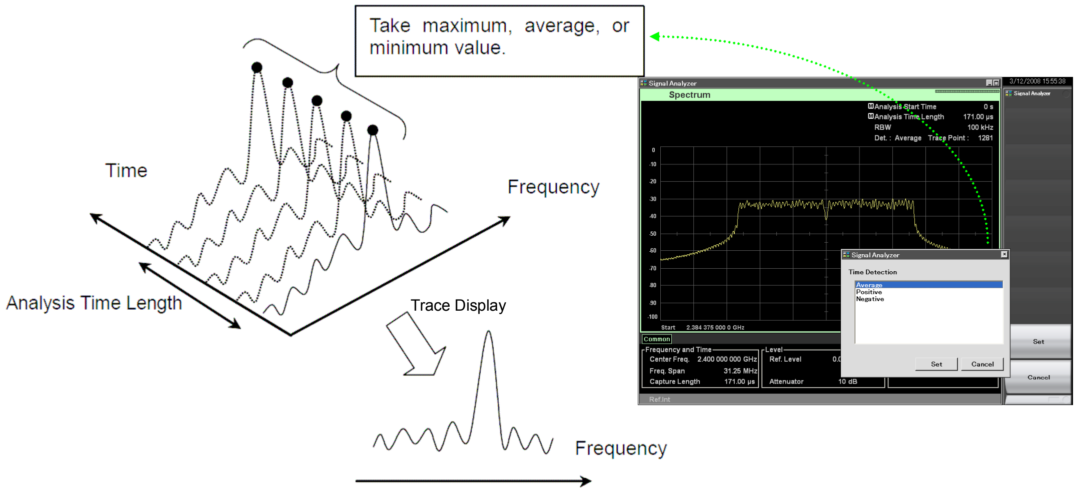
Appendix

Required Digitizing Duration

- Extra time is required for FFT computation and filtering in addition to the capture time. The different traces automatically determine the data length required for computing to trace the signal analysis. The exported digitized data includes the extra digitized data.
- More information about the digitizing duration on each trace follows below.
  - » Spectrum Trace
  - » Power vs Time Trace
  - » Frequency vs Time Trace
  - » CCDF Trace

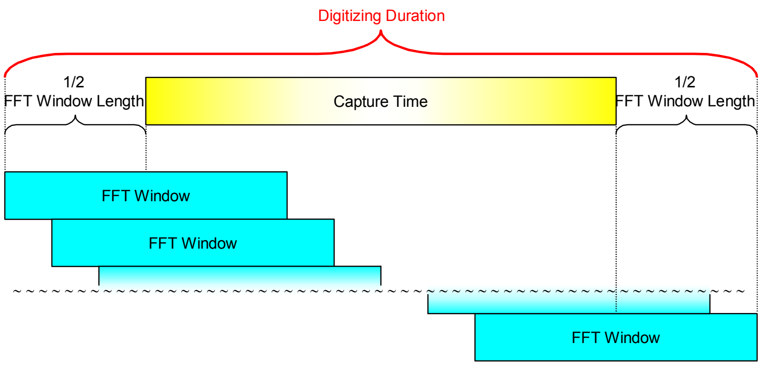
Spectrum Trace

- The Spectrum trace uses the FFT algorithm for frequency spectrum analysis.



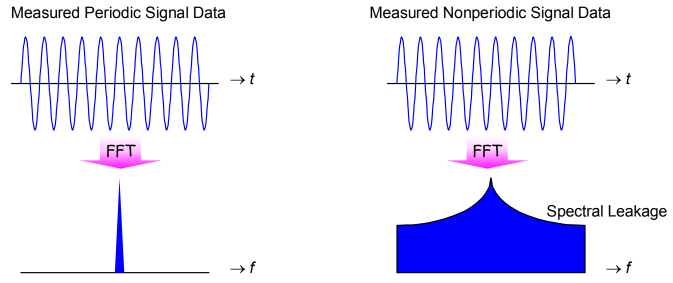
Spectrum Trace

- The digitizing duration includes the capture time and FFT window length.



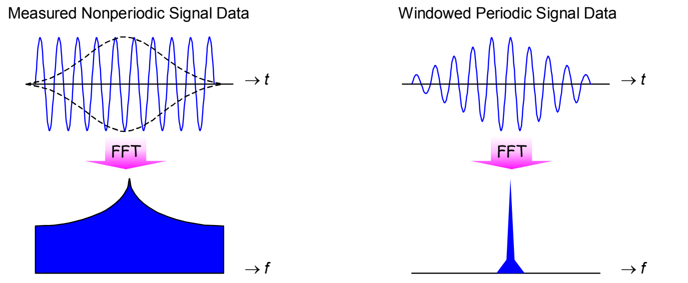
FFT Window Function

- FFT-based measurement assumes that the signal is periodic in the FFT size (time frame). If the measured signal is not periodic, spectral leakage occurs, resulting in misleading information about the spectral amplitude and frequency.
- The FFT window must be used to reduce the effects of spectral leakage.



FFT Window Function

- The MS2690A uses the Gaussian window function.
- The window is shaped so that it is exactly zero at the beginning and end of the data block and has a special shape between. This function is then multiplied by the time data block, forcing the signal to be periodic.

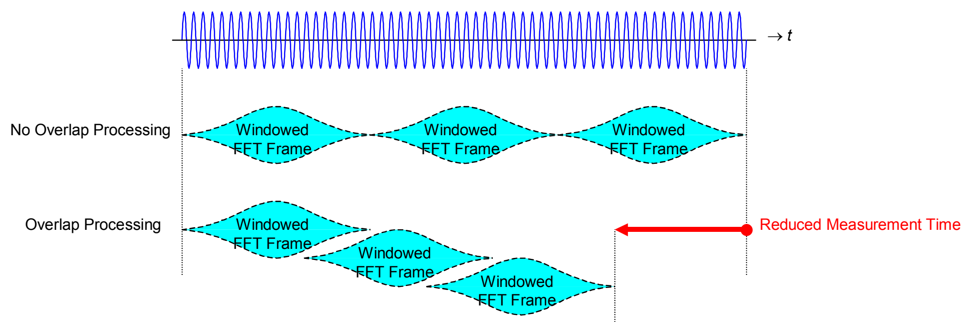


FFT Window Length

RBW [Hz] / Span	1 Hz	3 Hz	10 Hz	30 Hz	100 Hz	300 Hz	1 kHz	3 kHz	10 kHz	30 kHz	100 kHz	300 kHz	1 MHz	3 MHz	10 MHz
125 M 100 M	With Option 04 Wideband Analysis Hardware								2^{18}	2^{16}	2^{15}	2^{13}	2^{11}	2^{11}	2^{11}
50 M								2^{18}	2^{16}	2^{15}	2^{13}	2^{11}	2^{11}	2^{11}	
31.25 M 25 M						2^{19}	2^{18}	2^{16}	2^{15}	2^{13}	2^{11}	2^{11}	2^{11}		
10 M						2^{18}	2^{17}	2^{15}	2^{13}	2^{12}	2^{11}	2^{11}			
5 M					2^{19}	2^{17}	2^{16}	2^{14}	2^{12}	2^{11}	2^{11}	2^{11}			
2.5 M					2^{18}	2^{16}	2^{15}	2^{13}	2^{11}	2^{11}	2^{11}				
1 M				2^{19}	2^{17}	2^{15}	2^{13}	2^{12}	2^{11}	2^{11}					
500 k			2^{19}	2^{18}	2^{16}	2^{14}	2^{12}	2^{11}	2^{11}						
250 k			2^{18}	2^{17}	2^{15}	2^{13}	2^{11}	2^{11}	2^{11}						
100 k		2^{19}	2^{17}	2^{15}	2^{13}	2^{12}	2^{11}	2^{11}							
50 k	2^{19}	2^{18}	2^{16}	2^{14}	2^{12}	2^{11}	2^{11}								
25 k	2^{18}	2^{17}	2^{15}	2^{13}	2^{11}	2^{11}	2^{11}								
10 k	2^{17}	2^{15}	2^{13}	2^{12}	2^{11}	2^{11}									
5 k	2^{16}	2^{14}	2^{12}	2^{11}	2^{11}										
2.5 k	2^{15}	2^{13}	2^{11}	2^{11}	2^{11}										
1 k	2^{14}	2^{12}	2^{11}	2^{11}											

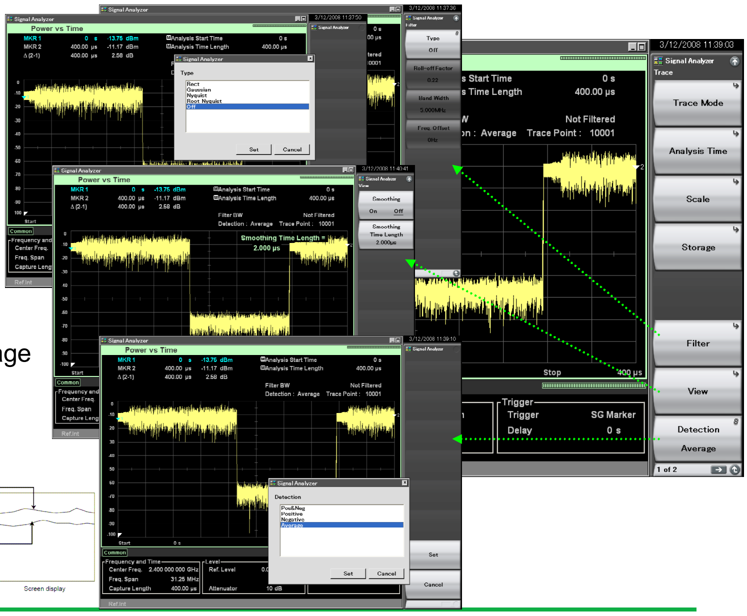
Overlap Processing

- The disadvantage of windowing is that the beginning and end of the signal are attenuated.
- Overlap processing can recover the lost data and reduce the measurement time by recovering the lost part of each previous FFT frame due to the effect of the window function.

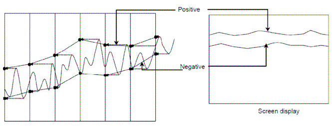


Power vs Time Trace

- The Power vs Time trace performs filtering, smoothing and detection.

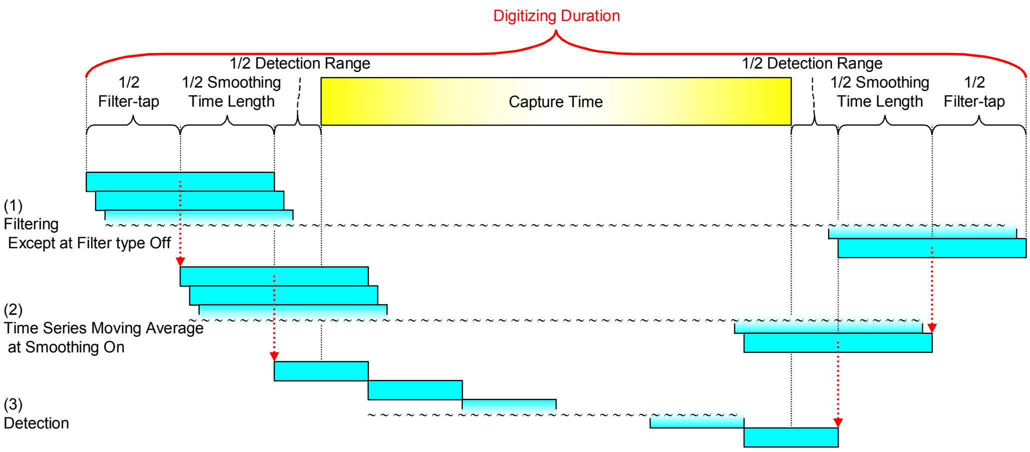


  - » Filtering
  - » Smoothing
    - – Time Series Moving Average
  - » Detection



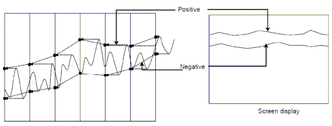
Power vs Time Trace

- The digitizing duration includes capture time, filter-tap, smoothing time length, and detection range.



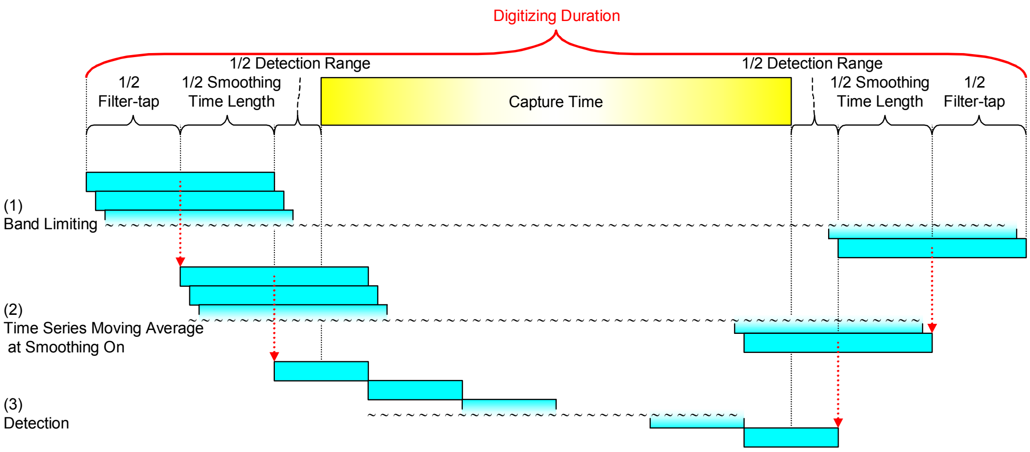
Frequency vs Time Trace

- The Frequency vs Time trace performs band limiting, smoothing and detection.
  - » Band Limiting
  - » Smoothing
    - – Time Series Moving Average
  - » Detection



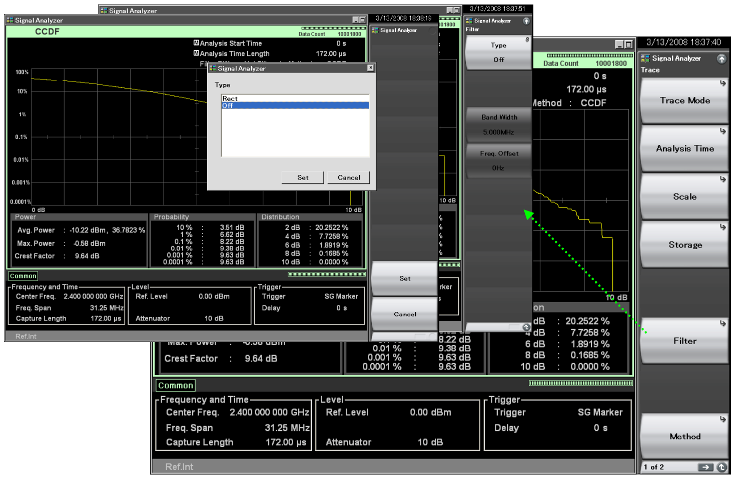
Frequency vs Time Trace

- The digitizing duration includes capture time, filter-tap, smoothing time length, and detection range.



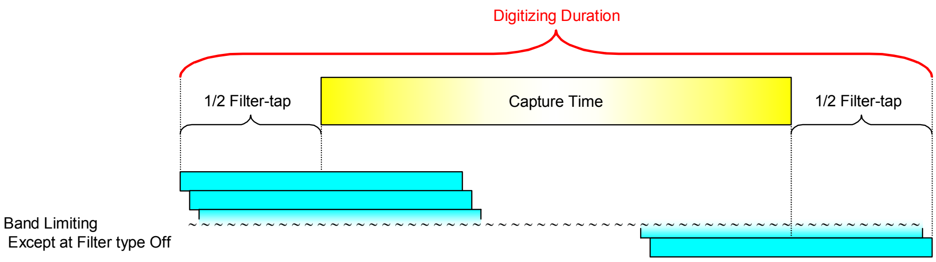
CCDF Trace

- The CCDF trace performs band limiting.
  - » Band Limiting



CCDF Trace

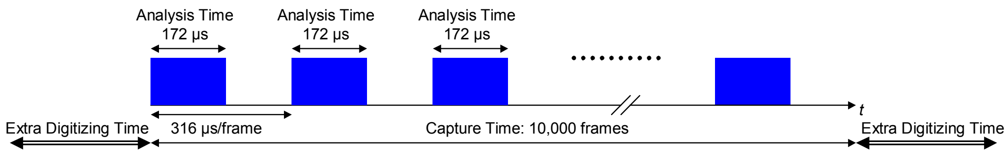
- The digitizing duration includes capture time and filter-tap.



Capture Time Auto/Manual

- Auto Capture Time
  - » The capture time is equal to the analysis time.
  - » The digitizing duration is set automatically to the minimum time for the displayed trace.
    - – For example, the digitizing duration is equal to the capture time at CCDF Trace and Filter Type Off.

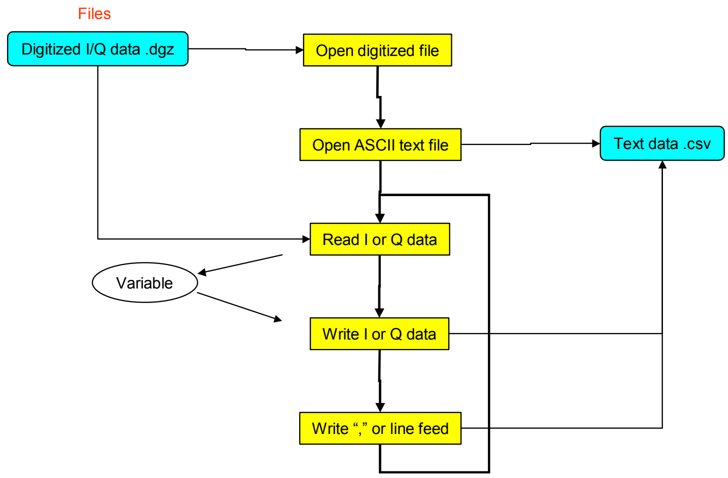
- Manual Capture Time
  - » The digitizing duration is set automatically to the maximum time for all traces and processing parameters. The same digitized data can be analyzed for all traces and different processing parameters.
    - – For example, even at Power vs Time Trace, Filter Type Off and Smoothing Off, the digitizing duration includes filter-tap and Smoothing Time Length.



Available Sample C Program

- This source code converts a digitized I/Q data file to an ASCII text file.

Programming Flowchart

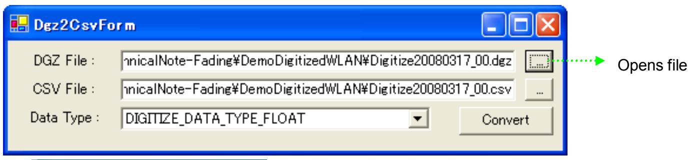


C Program Source Code

```
#include "stdafx.h"

int _tmain(int argc, _TCHAR* argv[])
{
	FILE *fin;
	FILE *fout;
	float buffer;
	int counter;

	fin=fopen("Digitize20080317_00.dgz","rb");
	fout=fopen("IQ.csv","w");
	counter=0;

	while(feof(fin)==0){
			fread(&buffer,sizeof(float),1,fin);
			fprintf(fout,"%le",buffer);
			if((counter&0x01)==0){
					fprintf(fout,",");
			}
			else{
					fprintf(fout,"¥n");
			}
			counter++;
	}
	return 0;
}
```

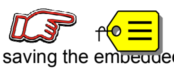

Available Converter from Digitized File to CSV File

- Windows Utility
  - » DigitizeToCsvTool.exe
    - – Executable file
  - » Dgz2Csv.dll
    - – DLL file called from within executable file
      - Executing



- CSV file
  - – I,Q

- Embedded object contains the above 2 files.
  - » DigitizeToCsvTool.zzz (40 KB)



– Change the file name to DigitizeToCsvTool.zip after saving the embedded file.

Specifications are subject to change without notice.

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