Antenna Lab – Report#2

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Report #1

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Summary: How a Signal Generator Works

Introduction & Motivation

Every **communication system** consists of 3 main components: **(1**. Transmitter **2**. Receiver **3**. Media of Communication**)**. To communicate any kind of information, we should **start** from a **base-band sinusoidal** (a monotone (frequency bin) as seen in the spectrum analyzer), then we try to **put information** on the signal **via** different types of **modulation.**

A sinusoidal has **3 main parameters** that can be modulated: (**1.** Amplitude **2.** Frequency **3.** Phase**)** resulting in **AM, FM, PM modulation**. In addition, **pulse modulation** of a signal is also used, that corresponds to injecting information through **pulse width**, duty cycle, etc. The **signal generator** is **capable** of **shaping a basic sinusoidal**, produced by an oscillator into the **intended signal** we need via different **modulation** schemes.

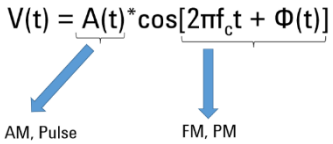

Figure 2.1: Modulated parameters of a simple sinusoidal

Characteristics & Applications of Modulation Schemes (*: stated by myself)

Modulation Characteristics	Parameter Symbol (Abbreviation)	Stands for …	Reported Unit	Details	Applications
AM (Amplitude Modulation)	f_c	Carrier Frequency	Hz	Frequency of the modulated sinusoidal	AM radio Antenna scan ASK (early 100101)
	F_m	Modulation Frequency (Rate)	Hz	Shows how fast amplitude changes over time, corresponds to information rate	
	-	Depth of modulation	% or dB	$= \frac{V_{peak(mod)}}{V_{peak(carrier)}}$	
	-	Distortion	%	Max Distortion on Amplitude (Power) through modulation	
FM (Frequency Modulation)	ΔF_{dev}	Frequency Deviation	Hz	Amplitude of modulated signal determines how far the carrier will reach via modulation	* FM Radio Mobile Communication Frequency Hopping
	F_m	Modulation Frequency (Rate)	Hz	Shows how fast frequency changes over time, corresponds to information rate	
	β	Modulation Index	-	$= \frac{\Delta F_{dev}}{F_m}$	
	Acc.	Accuracy	%	How accurate the frequencies are constructed	
	–	Frequency Resolution (step width)	Hz	Least frequency separation between constructed monotones	
	-	Distortion	% or dBm	Max Distortion on Amplitude (Power) through modulation	
	-	Sensitivity	Dev/volt	Dependency of Deviation on Amplitude	
PM (Phase Modulation)	$\Delta\theta_{dev}$	Phase Deviation	rad	Amplitude of modulated signal determines how far the carrier will reach via modulation	PSK (early 1010) Radar (Pulse Coding)
	β	Modulation Index	rad	$= \Delta\theta_{dev(\max)}$	
	F_m	Modulation Rate	Hz	Shows how fast the carrier changes phases over time, corresponds to information rate	
	Acc	Accuracy	%	How accurate the phases are constructed	
PWM (Pulse Width Modulation)	PRI	Pulse Repetition Interval	ns	How long it takes the pulse to repeat its pattern (Period)	Radar High Power Stimulus/Response Communications
	PRF	Pulse Repetition Frequency	Hz	$= \frac{1}{PRI}$	
	t_{rise}	Rise Time	ns	How fast the pulse reaches max on edges	
	-	Duty Cycle	%	$= \frac{On\ Time}{On\ Time + Off\ Time}$	
	-	On/off ratio	dB	How low should the signal be considered off relative to up	

Different parts of a Signal Generator

Main Parts of a Signal Generator	Purpose	Parameters Involved	Further Info.
Reference Section	Constructing base-band signals	Aging Rate (ppm/year) Temp. Effect(ppm) Line Voltage(ppm)	TCXO ages 20 times faster, gets affected by temperature 100 times more & has 500 times larger line voltage
Synthesizer	Modulation to intended frequency, based on a PLL Loop	Reference frequency f_c * Modulated (final) frequency f_{final} *	Main Component: VCO (Voltage Controlled Oscillator) Frequency Control is done via Frac-N box + Multiplier(x2)
Output Section	Amplitude Construction based on an ALC modulator, Output Attenuator	(Not mentioned)	ALC modulator adds/subtracts power(amplitude) to the modulated signal Attenuator provides a wide range of output amplitudes (power levels) ex: -127 to 23 dB

Signal Generator Specifications (Key Parameters)

Domain of Analysis	Static Performance		Dynamic Performance			
	Parameter	Info.	Parameter			Info.
Frequency Domain	Frequency Range	= $f_{max} - f_{min}$	Frequency Sweep	Step Sweep	Acc.	Amplitude Acc. important in AM
	Frequency Resolution	Min step between intended frequencies (Δf_{min}) Ex: PAM with low deviation needs high resolution			Num Of Points	Describes Resolution of Sweeping
	Accuracy	-			Sweeping Time	How fast is happens
	Switching Speed	About how fast we can generate signals		Ramp Sweep	Acc.	-
	Aging	Frequency error grows over time Ex: 1GHz ± 152Hz/year			Resolution	Min Δ_f step
					Sweeping Time	How fast is happens
	Phase Noise	Phase noise spreads energy in adjacent channels, so it should be low Depends on Reference + Synth. Section		Flatness		How much distortion along f
Amplitude Domain	Power/Amplitude Range	= $A_{max} - A_{min}$	Amplitude Sweep	Sweep Range		= $P_{max} - P_{min}$
	Amplitude Resolution	About how small quantization levels get		Power Slope Range		Better to have less deviation on slope
	Accuracy	-				
	Switching Speed	Modulation frequency that was mentioned (About how fast Amplitudes can vary over time)		Source Match		Common Factor with frequency domain
	Reverse Power Protection	Generator should be resistant to power reflection caused by mismatch				

Signal Generator Applications

1. **Local Oscillator:** It provides the **baseband signal** needed for exterior modulation via a signal generator, the mixer multiplies base-band and IF signal to **obtain various frequencies**.
2. **In Channel Receiver Testing:** Every receiver should be tested before usage in different frequencies and this testing is done by means of a signal generator.
3. **Amplifier Testing:** Signal generator s can also be used to test **amplifier responses** and **passive devices** such as **antennas**, especially for **testing non-linearity effects** and **tone intermodulation**