**İSTANBUL MEDİPOL UNIVERSITY**



**EECD1212913: DIGITAL COMMUNICATION LABORATORY**

**Lab report No:.5: Digital modulation techniques**

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**Introduction**

**Amplifiers and Nonlinearity**

**Question 3**

The power amplifier is designed to amplify signals at frequency f0, when the amplifier reaches saturation (non-linear region) the output signal gets clipped, causing a rectangular shaped output pulse.

In frequency domain, the rectangular pulse approximates a sinc pulse and occupies wider bandwidth (theoretically infinite bandwidth). The harmonics occur as periodic occurrences of integer multiples of fundamental frequency in the occupied bandwidth which can thus be amplified by the amplifier. The first one being at 2f0

Since the larger harmonics are far from the fundamental frequency, their amplification will not be the same as those at fundamental frequency, it can be related to internal capacitances of the amplifier which attenuate the signal, it can also be attributed to internal resistances which become amplified with higher frequencies.

**Question 4**

**Comment on Spectral Density**

Since the received signal contains modulated data, we expect the energy to spread among symbols at different frequencies hence the occupied bandwidth will increase compared to single tone transmission as seen in the image. This will cause (increase in signal power) on the frequencies close to central frequency causing Spectral regrowth.

**Question 5**

1. At lower gains eg. -30dBm, the spectral regrowth is inexistent, with increasing transmitter gain, they slowly build up. It can be observed that at certain point when increasing the transmitter gain, the gain at the fundamental frequency reaches a maximum over which no increase is observed even with increasing transmitter gain and at the highest possible gain from the amplifier. On the other hand, the frequencies close to the fundamental frequency (spectral regrowth frequencies) get amplified because they have not reached saturation yet.

Harmonics become significant only when the saturation point of the amplifier is reached, from there onwards their peak power keeps growing.

1. At low tx powers, and especially when the amplifier is not operating in its saturation region, the spectral regrowth is in significant and hence the PAPR is low, the CCDF curves shows a good trend, when we increase the Tx power and approach the saturation region of the amplifier, the spectral regrowth becomes significantly higher, thus affecting the dynamic range of the received signal and hence the CCDF curve shows higher probability of finding symbols at higher power than the average.

**Question 6**

A low pass filter of 470 Mhz is introduced, and it can be observed that the harmonics disappear from the spectrum, showing that these high frequency components are filtered out

**Oscillators and Mixers**

**Question 9**

By fixing the control voltage and changing the supply voltage, we are fixing the frequency of the VCO while changing the output power of the VCO, the received signal spectrum shows increase and decrease of peak power corresponding to increase/decrease of the power supply voltage of VCO. The measured VCO frequency pushing is

Question 10

Plot of VCO turning sensitivity is shown in figure ….

Question 11

Comment on VCO stability

Question 12

Part c:

If we assume that frequency from VSG is Fsg and that of VCO to be Fco then the expected intermodulation products are at Fsg ± |Fsg - Fco| while for Harmonics we expect the first harmonic of each frequency to 2F and the following will be at integer multiples of the fundamental frequency.