Experiment -7

THE DOUBLE – BALANCED MODULATOR

Prelab Exercise

1. Draw a block diagram and explain the principle of operation of the double balanced modulator .

Required Equipment :

Function / Arbitrary Waveform Generator	33120A 15 MHz	- 2
Spectrum Analyzer	ESA –L1500 A	- 1
Oscilloscope	54600 B	- 1
50Ω " T " Adapter	455 – 832	- 2
MIXER	ZAD – 6	- 1
CABEL	RG-58	- 3
RESISTORS : 50 Ω , 100 Ω ,470Ω , 1 k Ω		- 4
RESISTOR 100 k		- 1

EXPERIMENT PROCEDURE

The experimental circuit is composted of an Mixer, Function Generator and Spectrum Analyzer as shown in figure 1.

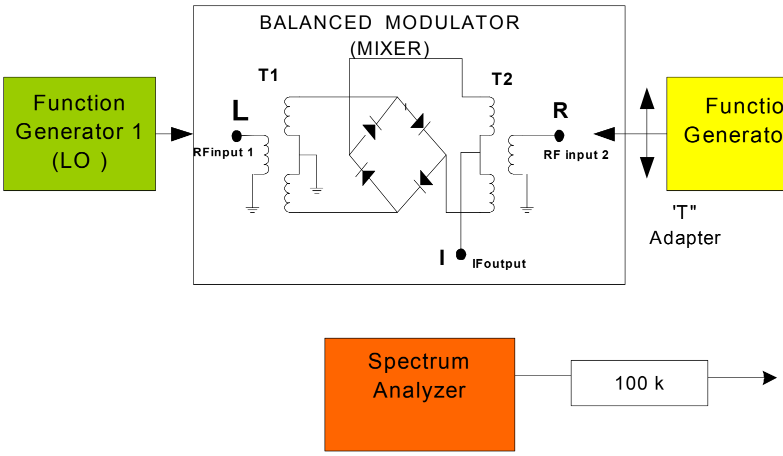


Figure. 1

1. RATIO OF INPUT RF VOLTAGE TO OUTPUT IF VOLTAGE IN THE BALANCED MODULATOR

In this section we shall examine the ratio of the RF input voltage to the IF output voltage , while the LO (Local oscillator) voltage remains constant .

Set the frequency of the Function Gen .1 (LO) to 450 kHz and its amplitude $V_{RF\ input\ 1}$ to 250 mV_{rms}.

Set Function Gen. 2 to 550 kHz and vary its amplitude $V_{RF\ input\ 2}$ from 50 mV to 400 mV_{rms} (According to table 1) .Measure voltage V_{RF} input 2 and IF output (100kHz or 1 MHz) using an Spectrum Analyzer - cabel RG – 58 and serial resistor 100 k .

Table 1

$F_{Gen\ 1\ (LO)}$ = 450 kHz , V_{LO} = 250 mV $_{rms}$, $F_{Gen.\ 2}$ = 550 kHz									
$V_{RF,}$ Gen. 2 mV_{rms}	50	80	100	150	200	250	300	350	400
V_{RF} input 2 μV_{rms}									
$V_{IF\ out,}$ μV_{rms}									

2. LOSS AS A FUNCTION OF THE LOAD

In this section we shall measure the input power and output power . By changing the load and calculating the power through it in each case , we shall be able to find the output impedance of the balanced modulator and conversion loss as a function of the load . The input resistance of an mixer $R_{mixer} = 50\Omega$.

Set amplitude of the Function Gen .2 (RF) to 100 mV_{rms} .

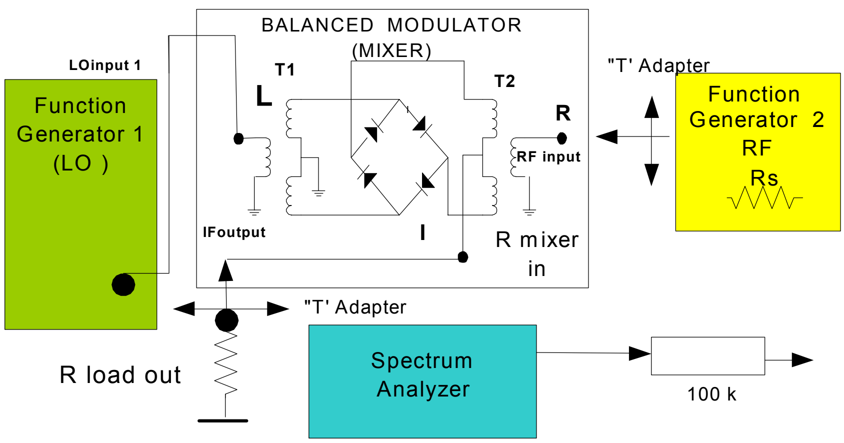
(Measure and calculate voltage $V_{RFinput2} = V_{RFinput2,\mu V} \times 2000$

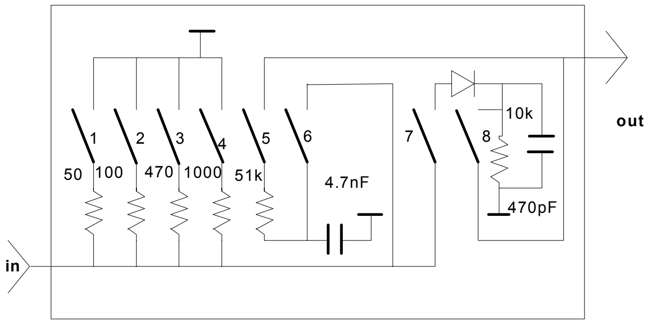
using an Spectrum Analyzer - cabel RG – 58 and serial resistor 100 k).

The input power of the mixer can be calculated :

$$P_{in} = \frac{V^2_{RFinput}}{R_{mixerIN}}$$

Connect $R_{Load\ out} = 50\ \Omega$ to the balanced modulator as shown in figure2.





R load

Figure 2

The output power can be calculated by measuring the voltage drop $V_{IF\ output}$ on resistor $R_{Load\ out}$. (Measure and calculate voltage $V_{IFioutput} = V_{IFoutputt,\mu V} \times 2000$ using an Spectrum Analyzer - cabel RG – 58 and serial resistor 100 k).

$$P_{out} = \frac{V_{IFoutput}^2}{R_{Load}}$$

Repeat these measurements for each load resistance and calculate the input power P_{in} and output power P_{out}.
The conversion loss is calculated from the following formula :

$$Conversion \quad Loss \quad (dB) = 10\log \frac{P_{in}}{P_{out}}$$

The measurements should be carried out for the following values of load resistance : 50 Ω ,1 00 Ω ,4 70 Ω , 1 k Ω .

Table 2

R_{Load}, Ω	50	100	470	1000
$V_{IF\ output\ ,rms}$				
P_{in}				
P_{out}				
dB =10 log P_{in} / P_{out}				

3.SPURIOUS RESPONSES OF THE BALANCED MODULATOR

In this section we shall check the response of the balanced modulator to harmonics of the fundamental frequencies . We shall use the circuit shown in figure 3 (R_{Load} = 50 Ω) ..

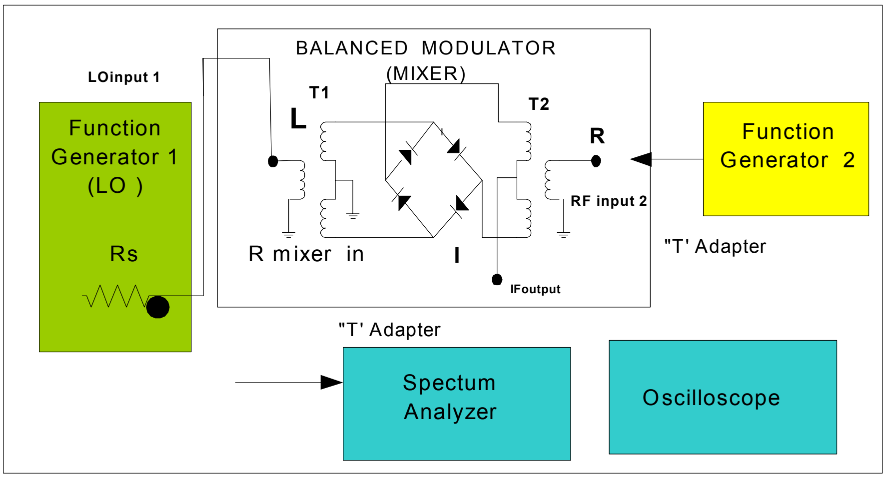


Figure 3

Set amplitude of the Function Gen .1 (LO) to 40 mV_{rms} and amplitude of the Function Gen .2 (RF) to 40 mV_{rms} .

Use a spectrum analyzer to measure the voltages and the frequencies of the IF signal .

Connect the Spectrum Analyzer to IF output of the mixer .

Observe the spectrum of the signal and measure the amplitudes of the signal IF and spurious responses and record the amplitude of the IF signal for each value .Print the results .

Set amplitude of the Function Gen .1 (LO) to 60 mV_{rms} and amplitude of the Function Gen .2 (RF) to 60 mV_{rms} .

Observe the spectrum of the signal and measure the amplitudes of the signal IF and spurious responses and record the amplitude (dBm) of the IF signal for each value .Print the results .

Final Report

- From the results of section 1 draw a graph of the balanced modulator output IF voltage as function of the input RF voltage .
- From the results of section 2 draw the following graphs :
  The output IF power as function of the input RF power , with constant LO power .
  The conversion loss as a function of the load (R_L) .
- To explain the results of the section 3