ECGR 6264

Final Project

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12/1/2121

1. You must submit 1 copy of your report by email
2. You must submit 1 hardcopy of your report
3. Signature sheet must be signed in all 4 places
4. One report per group
5. Report is due at scheduled final exam time
6. You must adhere to this format
7. Late or missing reports will result in U grade for course

Instructor Signature Sheet

You must demonstrate laboratory measurements to the instructor, and have the instructor sign below.
Your group will not receive any credit whatsoever for the following sections of the project, if you fail to
obtain the instructor signature for each section:

1. Sec. 1.1 Amplifier S-parameters.   Instructor Signature: _____

2. Sec. 1.2 IF Filter S-parameters.   Instructor Signature: _____

3. Sec. 1.3 Amplifier Intercept Point.   Instructor Signature: _____

4. Sec. 1.4 Downconverter.   Instructor Signature: _____

Any section above not signed by the instructor will receive a grade of zero.

Attendance for all of the laboratory class sessions is required, and **20% will be deducted for each class
missed**. Any make-up opportunity is entirely at the discretion of the instructor, and may not be possible near
the end of the semester.

Organize into groups of 3, and submit a single report per group.

For any problems, follow problem resolution guidelines on the website.

Executive summary

Edit the following to describe any issues that you could not resolve.

In Part 1 of this project, various RF devices were measured. The following experiments were performed:

1. Section 1.1 Amplifier S-parameters.
2. Section 1.2 IF Filter S-parameters.
3. Section 1.3 Amplifier Intercept Point.
4. Section 1.4 Downconverter.

The only unresolved problem was in a 0.023 volt DC error remained in the s-parameters of the MAR1. We were not able to resolve the problem. No other issues remained unresolved.

In Part 2 of this project, a radio receiver was designed. No issues remained unresolved in Part 2.

Part 1

Measurement Results

1.1 Amplifier S-parameters

Choose one of the two amplifiers (MAR1 or ERA5) to measure s-parameters. The s-parameters of the amplifier are to be measured from 10 MHz to 6 GHz. In this, a marker at 200 MHz must be used to display values at 200 MHz.

Chosen Amplifier: MAR1/ERA5???
DC Conditions: 10 V DC @ ???? mA

Equipment Setup: Use the Agilent 8753E network analyzer to make the measurements. Turn the instrument on, and press the instrument "Preset" key. Press the "Save/recall" key, and Save/Recall>>SelectDisk>>internalMemory and load the "tw_10_6" instrument state (to load the calibration data and setup for your measurement). Then, insert a floppy disk, and Save/Recall>>SelectDisk>>Internal. Press "Measure" and s11 or s21, etc. Press format, and select logMagnitude (you may wish to experiment with Smith). Once you have the data that you wish to store, use Save/Recll>>SaveFileFormats>>saveFile. (Make sure that the SaveFile format is reverse metafile and graphic.) When you save your first file, check the jpg file on a PC or Sun to make sure that it is readable for your report. *Make sure that the marker is set to 200 MHz to display data at that frequency.*

Measurements: Replace the images below with your measurements of:
1. S21 logMag from 10 MHz to 6 GHz
2. S11 logMag from 10 MHz to 6 GHz
3. S21 logMag from 10 MHz to 6 GHz
4. S22 logMag from 10 MHz to 6 GHz
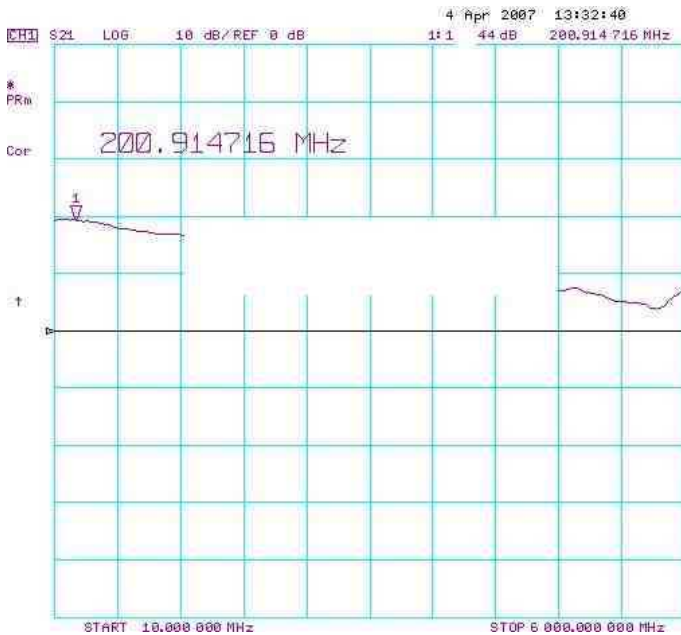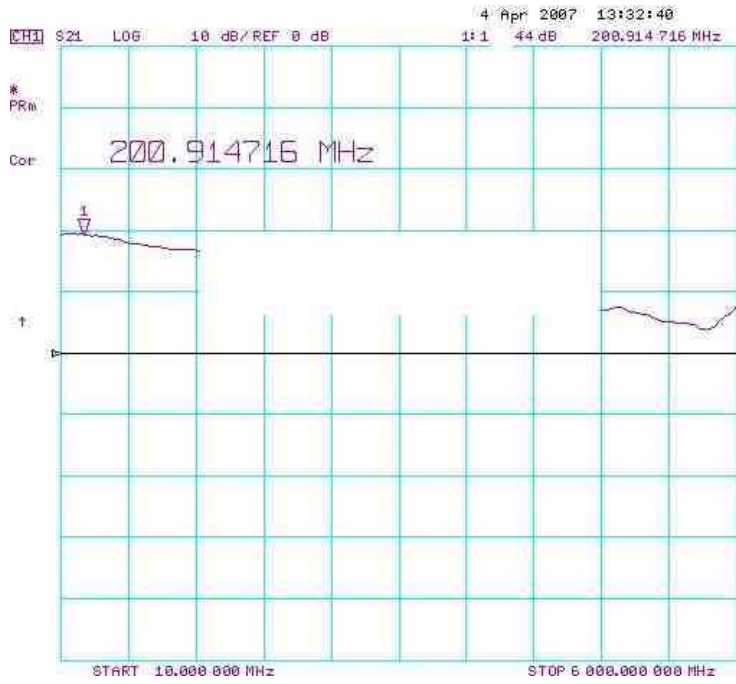5. S11 Smith from 10 MHz to 6 GHz

Fig. 1.1.1. MAR1/ERA5??? S21.

Fig. 1.1.2. MAR1/ERA5??? S11.
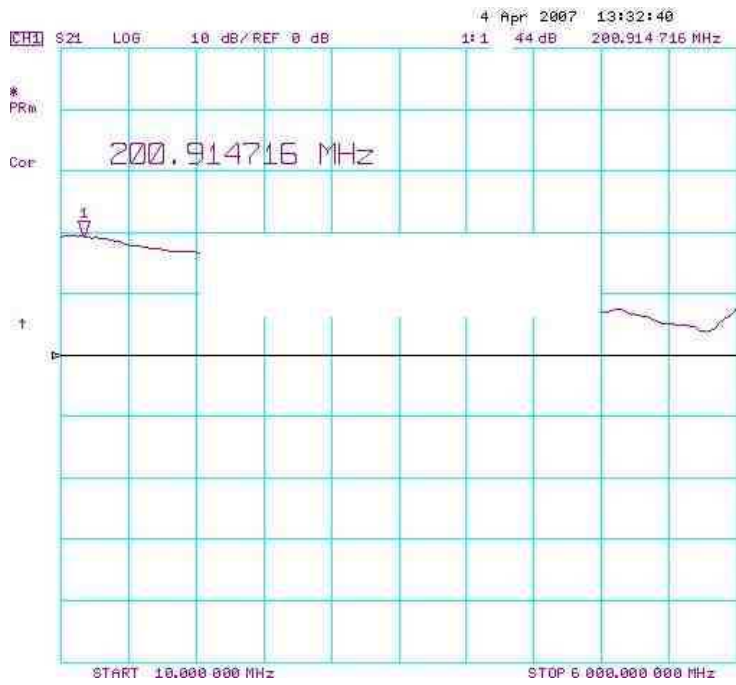

Fig. 1.1.3. MAR1/ERA5??? S12.
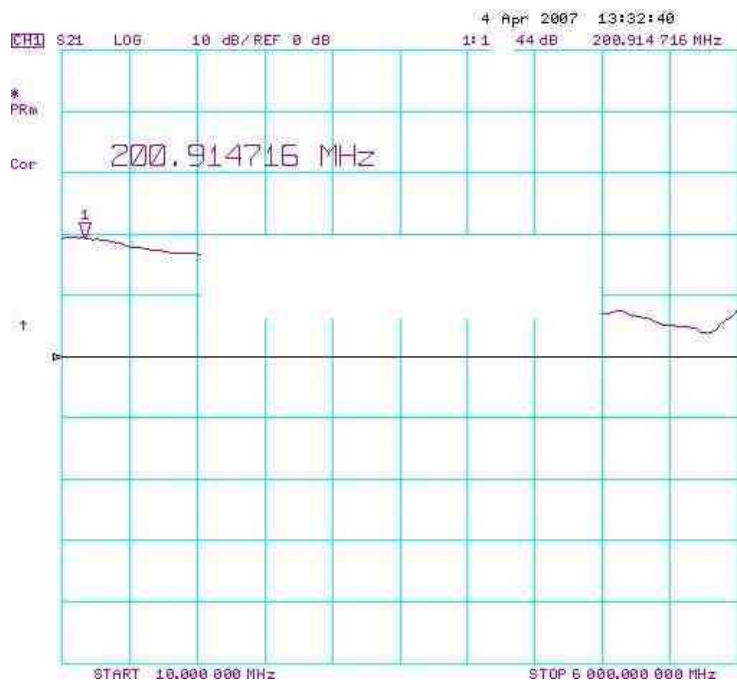
Fig. 1.1.4. MAR1/ERA5??? S22.
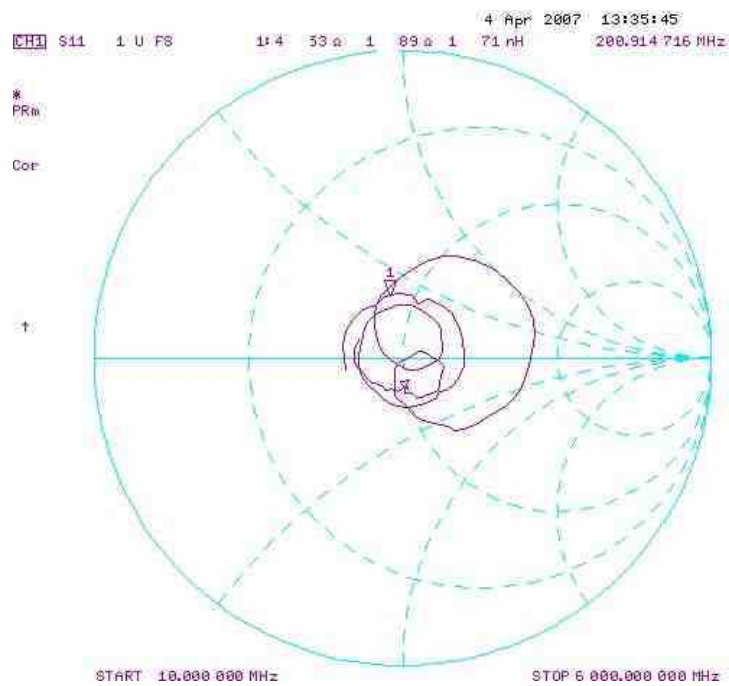

Fig. 1.1.5. MAR1/ERA5???, Smith chart.

1.2 IF Filter S-parameters

The s-parameters of the IF filter are to be measured from 5 MHz to 15 MHz. In this, a marker at 10.7 MHz will be used to display values at 10.7 MHz. Finally, S21 is re-measured from 10-11 MHz to observe the details of the frequency response near 10.7 MHz.

Equipment Setup: Use the Agilent 8753E network analyzer to make the measurements. Turn the instrument on, and press the instrument "Preset" key. There is *no need* to load any calibration data for your measurement. Press "start," and enter 5 MHz. Press "stop," and enter 15 MHz. Then, insert a floppy disk and Save/Recall>>SelectDisk>>Internal. Press "Measure" and s11 or s21, etc. Press format, and select logMagnitude (you may wish to experiment with Smith). Once you have the data you wish to store, use Save/Recll>>SaveFileFormats>>saveFile. (Make sure that the SaveFile format is reverse metafile and graphic.) When you save your first file, check the jpg file on a PC or Sun to make sure it is readable for your report.

Measurements: Replace the images below with your measurements of:
1. S21 logMag from 5 to 15 MHz
2. S11 logMag from 5 to 15 MHz
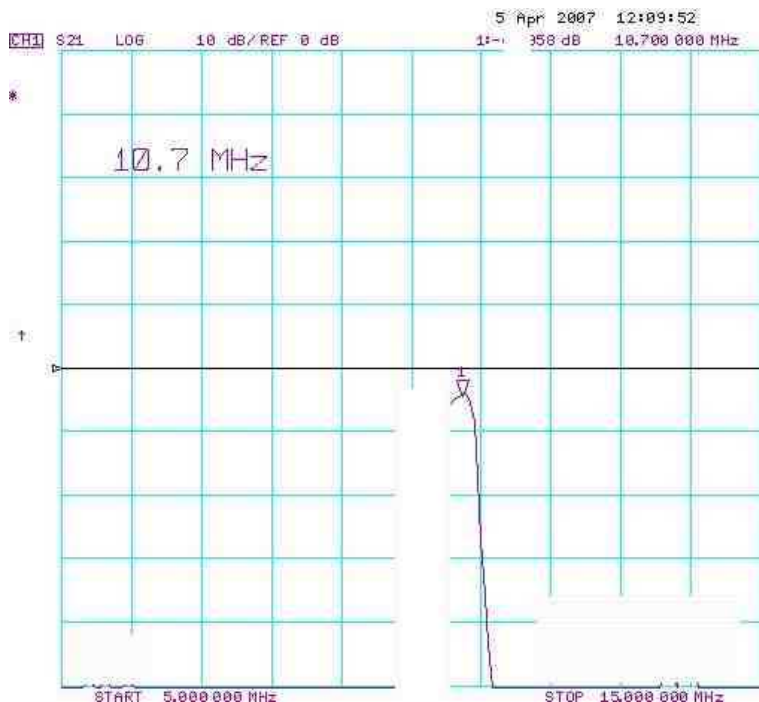3. S21 logMag from 10 to 11 MHz
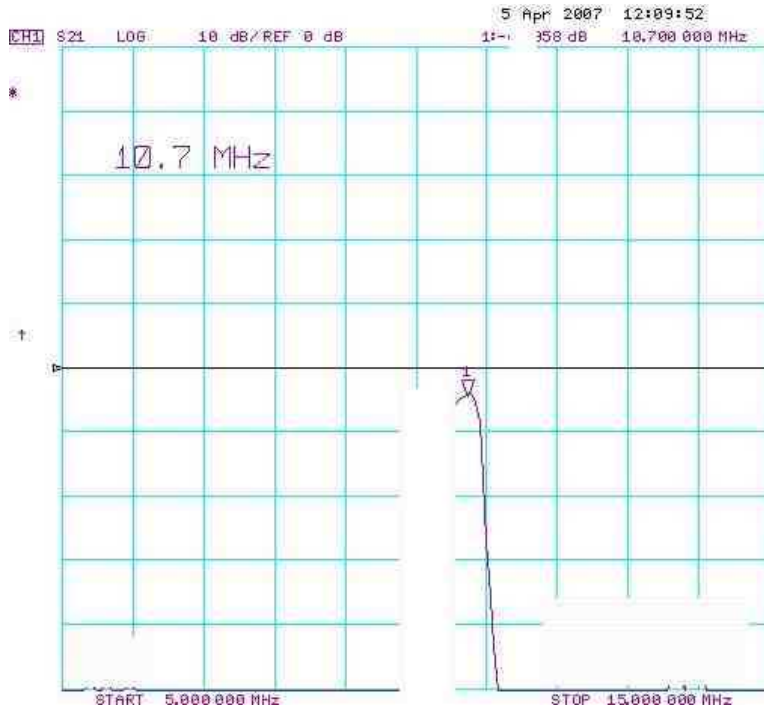

Fig. 1.2.1. IF Filter S21, 5–15 MHz..
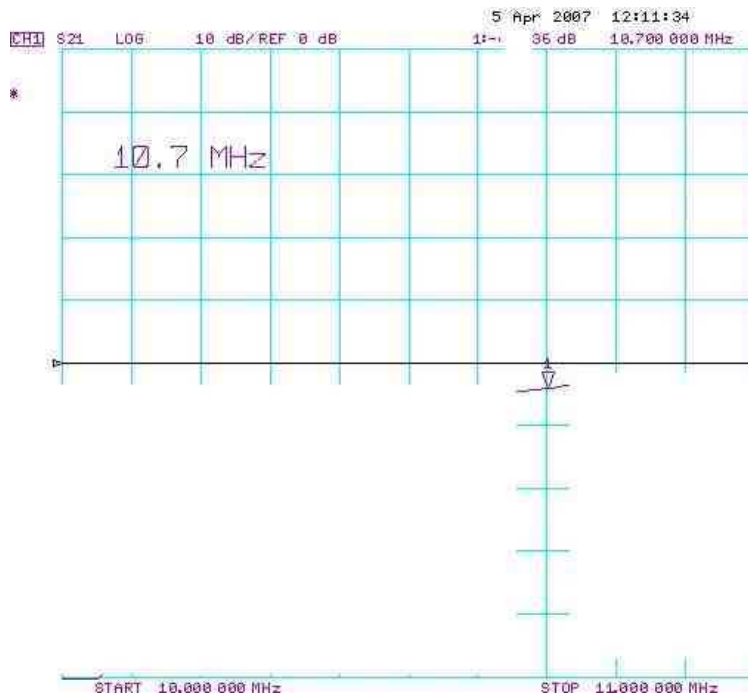
Fig. 1.2.2. IF Filter S11, 5–15 MHz.

Fig. 1.2.3. IF Filter S21, 10–11 MHz.

1.3 Amplifier Intercept Point

Choose one of the two amplifiers (MAR1 or ERA5) to measure the third order output intercept using 2 tones (sinusoids) at 199.5 and 200.5 MHz. In this, markers at 199.5 and 200.5 MHz will be used to display the measured values.

Equipment Setup: Use the Agilent E4438C Vector Signal Generator to create a 2-tone signal for measurement of OIP3. Press "Preset." Press "Frequency" 200 MHz. Press Mode>More>Multitone>InitializeTable, and select NumberTones=2, FreqSpacing=1MHz, Phase=Fixed, Seed=fixed. Press "Mod" on, press "RF" on. Press "Amplitude" -20 dBm, "Frequency" 200 MHz, and Mode>more>multitone>mutitoneOn.

Connect the Signal Generator to the spectrum analyzer. Using an ESA analyzer such as Agilent E4402B, Press "Frequency"=200MHz, "span"=10MHz, "Amplitude"=10dBm. You should see two tones at 199.5 and 200.5 MHz and at -23 dBm (total power is 20 dBm). Press "Marker," and "PeakSearch," and Marker>more>markerTableOn. Add a second marker. To save a file, use the file menu. Using a CSA analyzer such as Agilent N1996A, follow similar menu buttons. When you save your first file, check the jpg file on a PC or Sun to make sure it is readable for your report.

Measurements: Replace the images below with your measurements of:
1. Amplifier OIP3 spectrum logMag from 195 to 205 MHz at -20 dBm input
2. Tabular data
3. Plot of OIP3 tabular data
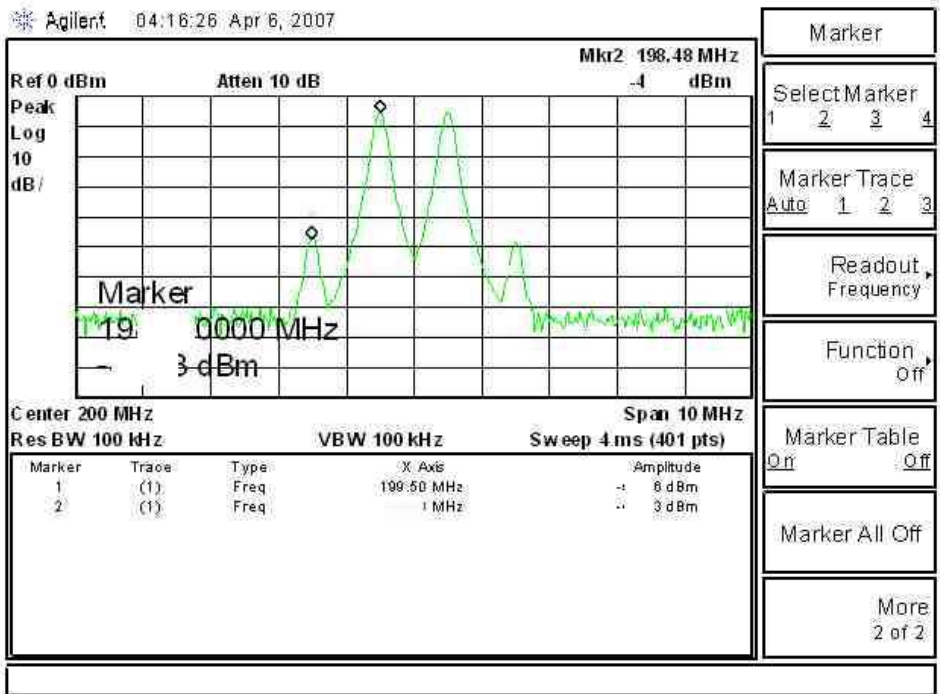
Fig. 1.3.1. Measured Spectrum of MAR1/ERA5???   at -20 dBm input (-23 per tone).

In the tables below, enter measured data for the OIP3 output spectrum for the amplifier.

MAR1/ERA5??? **OIP3 data**

Sig Gen Amplitude	Sig Gen Power per tone	Linear Output Power @199.5 MHz	3rd Order Output Power @198.5 MHz	Calculated Linear Gain in dB	Calculated OIP3 in dBm
-25 dBm	-28 dBm	?? dBm	?? dBm	?? dB	?? dBm
-20 dBm	-23 dBm				
-15 dBm	-18 dBm				
-10 dBm	-13 dBm				
-5 dBm	-8 dBm				
0 dBm	-3 dBm				

In the graph below, plot measured data for the OIP3 output spectrum for the amplifier.

MAR1/ERA5??? OIP3 Plot
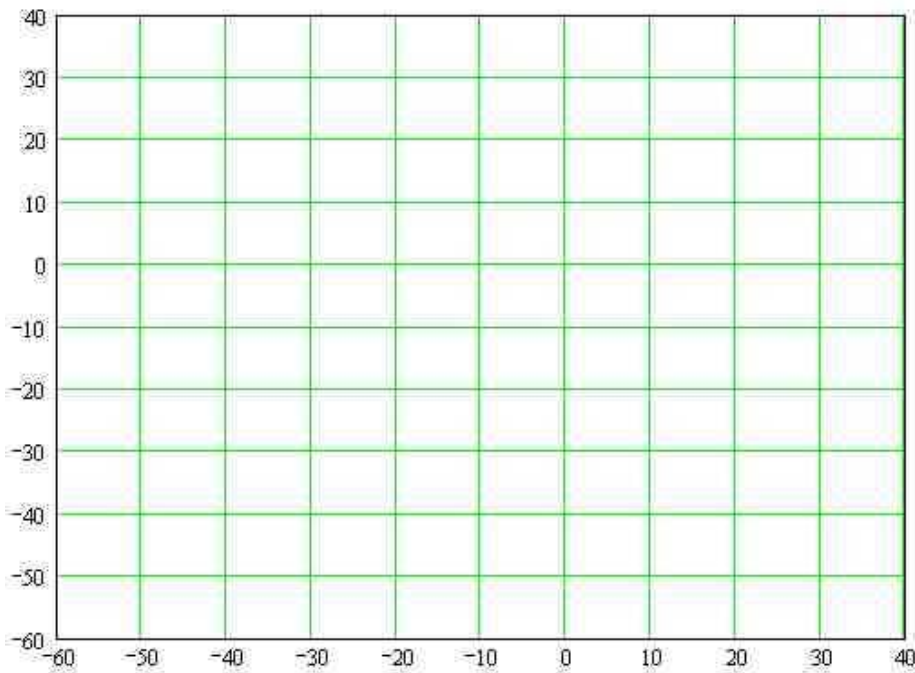
1.4 Downconverter

A downconverter is comprised of a Minicircuits mixer followed by a 10.7 MHz IF filter (same as above). The conversion loss is to be measured with LO=100MHz and RF=110.7 MHz. The response to the image frequency is also to be measured.

Equipment Setup: Use the Agilent E4438C Vector Signal Generator to create the RF signal. Press "Preset." Press "Frequency" 110.7 MHz. Press "Mod" off, press "RF" on. Press "Amplitude" -10 dBm.

Use a second Agilent signal generator for the 100 MHz LO. Press "Preset." Press "Frequency" 100 MHz. Press "Mod" off, press "RF" on. Press "Amplitude" 7 dBm.

Connect the IF output to the spectrum analyzer. Using an ESA analyzer such as Agilent E4402B, Press "Frequency"=10.7MHz, "span"=10MHz, "Amplitude"=10dBm. You should see one tone at 10.7 MHz. Press "Marker," and "PeakSearch". To save a file, use the file menu. Using a CSA analyzer such as Agilent N1996A, follow similar menu buttons. When you save your first file, check the jpg file on a PC or Sun to make sure it is readable for your report.

Measurements:

1. Replace the image below with your measurements of IF spectrum logMag from 5.7 to 15.7 MHz at -10 dBm RF input

2. **Measured Conversion Loss at RF 110.7 MHz =** ??? dB

3. **Measured Conversion Loss at RF 111 MHz =** ??? dB

4. **Image Frequency =** ??? MHz

5. **Measured Conversion Loss at Image Frequency =** ??? dB
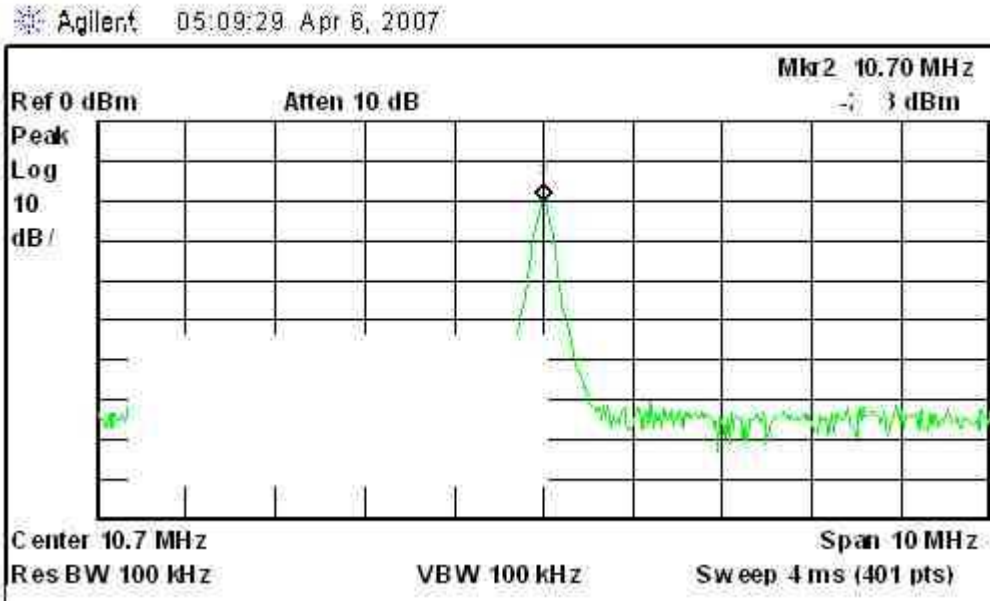
Fig. 1.4.1. Measured Spectrum of IF output.

Part 2

Receiver Design

Using parts from the attached data sheets, **design the receiver only** for a full duplex (FDD, Freq. Division Duplex) IS-95 CDMA radio in the PCS 1900 bandwidth with the following performance.

(Only design the receiver up to, but not including, the demodulator, and include a duplexer as the preselector).

Receiver Design Specifications

1. Frequency band:
   Transmit: 1850-1910 MHz, Receive: 1930-1990 MHz
   Set the LO for 1960 receive

2. Channel Bandwidth: 1.25 MHz

3. Alternate channel rejection (at Fc +/- 2.5 MHz): 50 dB

4. Receiver noise figure: 10 dB

5. Spur-free Dynamic range: 40 dB

6. Receiver output level: 0 dBm at minimum receiver input signal power
   (i.e., at receiver sensitivity). This output is at the final IF frequency.
   A demodulator is NOT required. You may assume 10 dB signal/noise for
   receiver sensitivity.

6. Transmitter : you need not design the transmitter, but you must include a duplexer

Hint: to achieve SFDR, use more amplification after the IF filter.

2.1 Receiver Block Diagram

Draw the block diagram of your receiver below, showing each amplifier, mixer, etc., and including the part number and manufacturer.

M1
Mini-
circuits
MAR1

**Add/remove amplifiers
and parts as needed**

F1
K91
G88

A1
Mini-
circuits
MAR1

O1
Mini-
Circuits
POS-25

F3
Sawtek
855
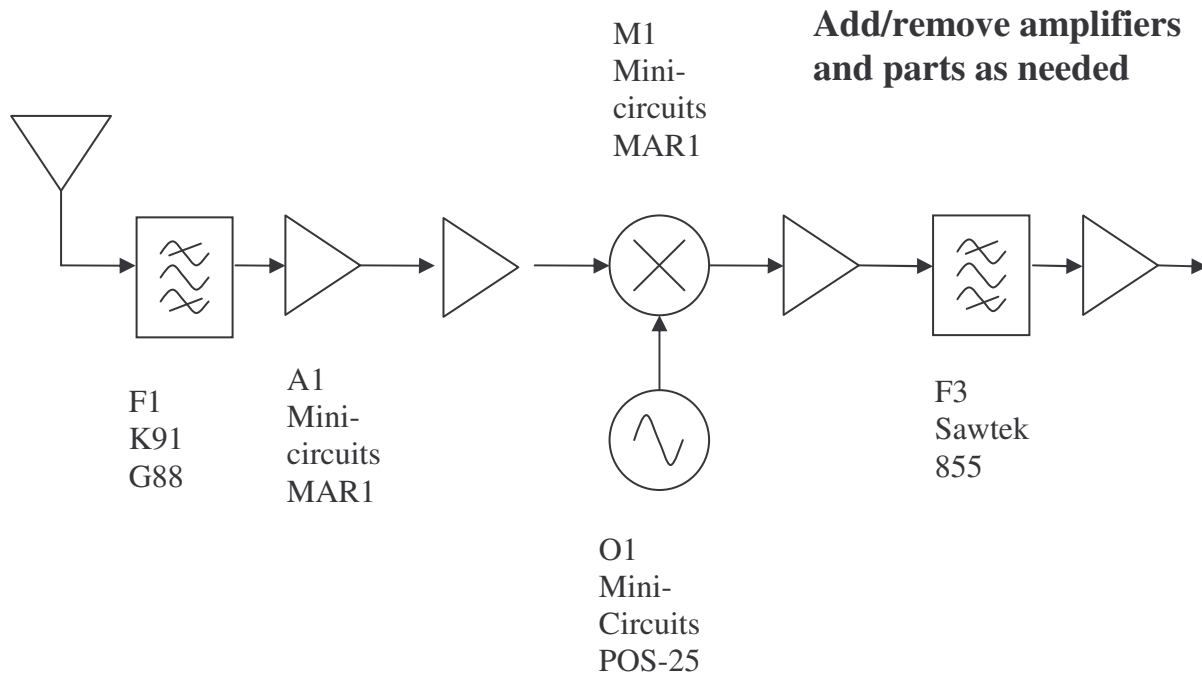
2.2 Receiver Cascade Analysis

Below, fill in the table with your receiver analysis.

STAGE	Duplexer	Amp1						
	K91G88							
gain,dB								
nf,dB								
ip3out, dBm								
1dBout, dBm								
TOTAL								
gain,dB								
nf,dB								
ip3out,dB								
1dBout, dB								

2.3 Receiver Performance Calculations

After designing the radio, fill in the following.

1. Receiver sensitivity in dBm at 10 dB S/N

    Your answer here:_____

2. Receiver image rejection

    Your answer here:_____

3. Alternate channel selectivity/rejection

    Your answer here:_____

4. Receiver Spur-free dynamic range

    Your answer here:_____

2.4 Receiver ADS Schematic

After designing the radio, enter the design in ADS and show the schematic below.

Fig. 2.4.1. Receiver schematic in ADS.
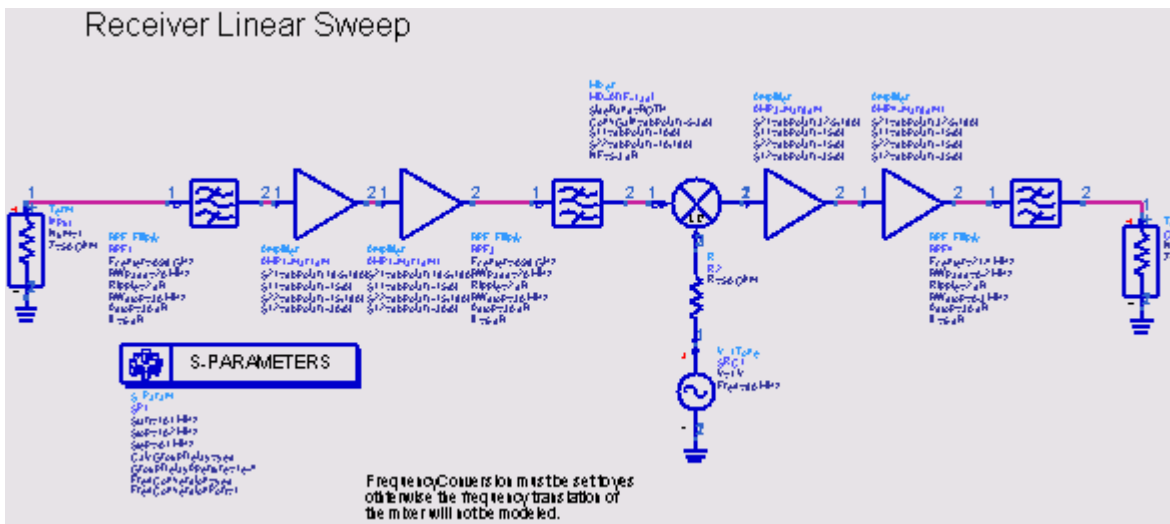
2.5 Receiver ADS Simulation

After designing the radio, plot the desired frequency response and image frequency response +/5 Mhz around the center frequency. Also plot a wideband frequency response of the receiver from 1.5 to 2.5 GHz
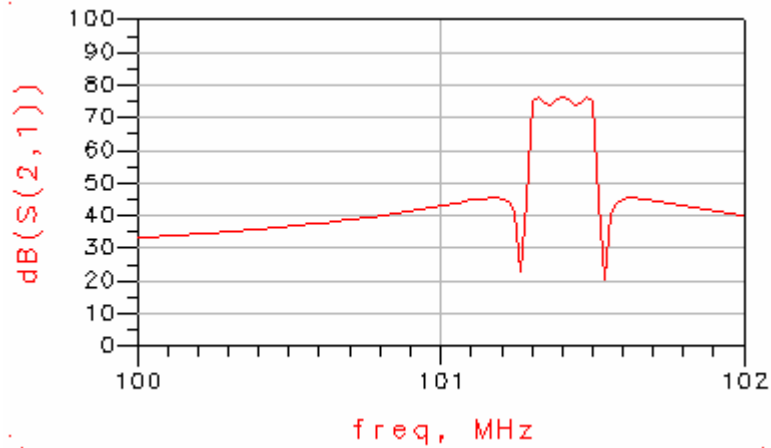

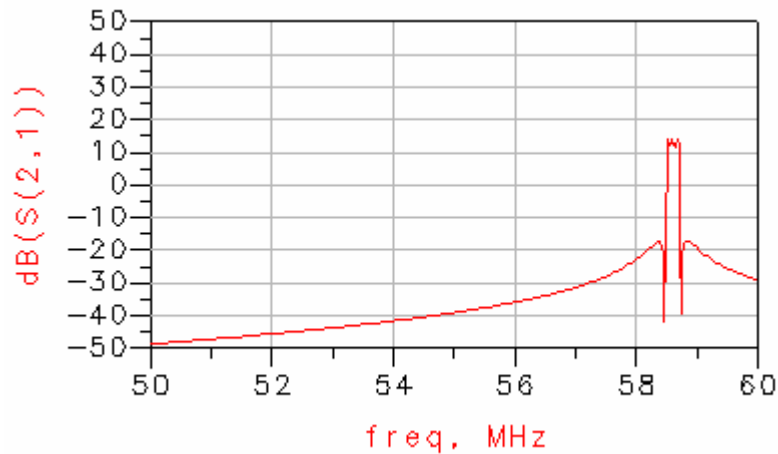Fig. 2.5.1. Receiver desired signal channel response.
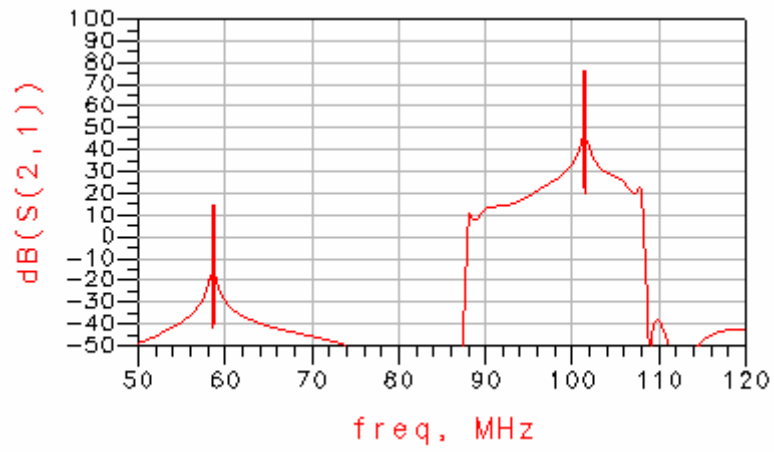

Fig. 2.5.2. Receiver image response.

Fig. 2.5.3. Receiver frequency sweep, 1.5-2.5 GHz.

MODEL◆ NO.	FREQ.✪ (MHz)	GAIN (dB) Typical at MHz				MAXIMUM POWER (dBm)		DYNAMIC RANGE		VSWR (:1) Typ.	
		100	1000	2000	Note 1 Min.	Output (1 dB Comp.) Typ.	Input (no damage)	NF (dB) Typ.	IP3 (dBm) Typ.	In	Out
MAR-1SM	DC-1000	18.5	15.5	—	13.0	+1.5	+13	5.5	+14.0	1.3	1.2
MAR-2SM	DC-2000	12.5	12.0	11.0	8.5	+4.5	+13	6.5	+17.0	1.5	1.4
MAR-3SM	DC-2000	12.5	12.0	10.5	8.0	+10.0	+13	6.0	+23.0	1.5	1.7
MAR-4SM	DC-1000	8.3	8.0	—	7.0	+12.5	+13	7.0	+25.5	1.5	1.9
MAR-6SM	DC-2000	20.0	16.0	11.0	9.0	+2.0	+13	3.0	+14.5	1.7	1.7
MAR-7SM	DC-2000	13.5	12.5	11.0	8.5	+5.5	+13	5.0	+19.0	1.7	1.7
/ MAR-8ASM	DC-1000	31.5	25	—	20.0	+12.5	+13	3.1	+25.0	1.4	1.8
MAR-8SM	DC-1000	32.5	22.5	—	19.0	+12.5	+13	3.3	+27.0	#	#

+7 dBm LO, up to +1 dBm RF

ADE/ADEX

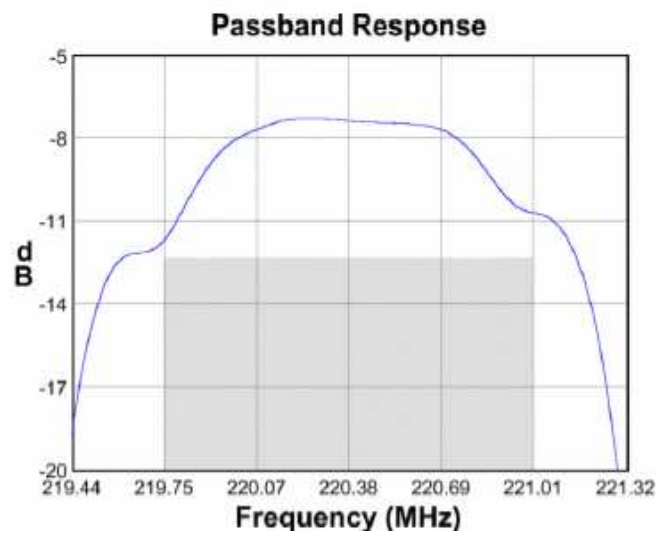| ◆ MODEL NO.	FREQUENCY MHz		CONVERSION LOSS dB				LO-RF ISOLATION dB						LO-IF ISOLATION dB						IP3@ center band Typ. (dBm)
	LO/RF f_L-f_U	IF	Mid-Band			Total Range Max.	L		M		U		L		M		U		
			–	σ	Max.		Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	
ADE-1**	0.5-500	DC-500	5.0	.10	6.5	7.8	70	50	55	35	45	30	65	45	40	25	30	20	15
ADE-1ASK**	2-600	DC-600	5.3	.10	6.5	7.5	55	45	50	30	40	25	50	40	45	24	35	18	16
ADE-2ASK**	1-1000	DC-1000	5.4	.10	6.8	9.5	55	45	45	30	36	20	50	40	32	22	22	12	12
ADE-2	5-1000	DC-1000	6.67	0.26	8.0	9.5	60	40	47	25	32	22	62	35	45	25	32	20	20
ADE-3G**	2300-2700	DC-400	5.6	.10	—	7.0	36 (typ.)		25 (min.)				26 (typ.)		17 (min.)				13
ADE-3GL**	2100-2600	DC-600	6.0	.25	—	8.8	34 (typ.)		25 (min.)				20 (typ.)		7 (min.)				17
ADE-4**	200-1000	DC-800	6.8	.10	8.5	8.5	60	45	53	40	45	30	45	30	40	22	35	20	15
ADE-5**	5-1500	DC-1000	6.6	.10	7.5	9.3	50	40	40	25	33	23	50	40	30	20	20	10	15
ADE-6**	0.05-250	DC-200	4.6	.05	7.0	8.4	62	49	40	30	40	20	58	44	45	24	25	15	10
ADE-11X**	10-2000	5-1000	7.1	.10	8.2	9.8	62	45	36	20	27	18	60	45	37	20	38	20	9

Pass Band (Rx)

Spurious (Rx)
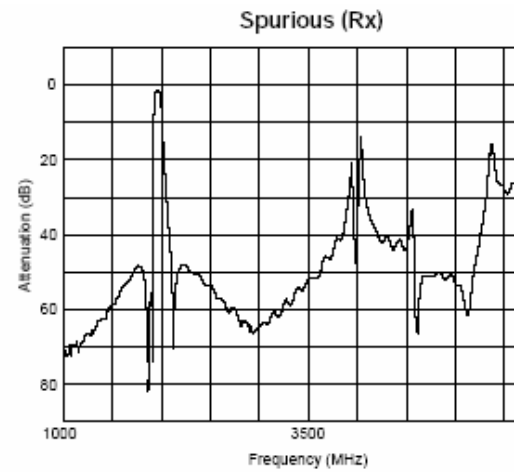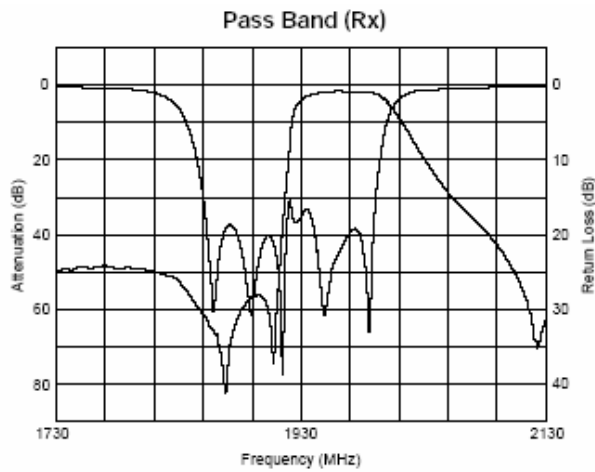
Part Number	fo (Tx) (MHz)	Bandwidth (Tx) (MHz)	IL at BW (dB max.)	Attenuation (dB min.)	fo (Rx) (MHz)	Bandwidth (Rx) (MHz)	IL at BW (dB max.)	Attenuation (dB min.)
K91G88LEHAB	1880	60	3.4	40 (1930 to 1990MHz)	1960	60	4.1	50 (1850 to 1910MHz) 0 to +35 degree C
K91G88LEHAC	1880	60	3.4	40 (1930 to 1990MHz)	1960	60	4.6	53 (1850 to 1910MHz) -35 to +85 degree C

SAWTEK
a *TriQuint* company

ta Sheet

220.38 MHz SAW Fi

Typical Performance (at +25°C)

Frequency Response

Passband Response
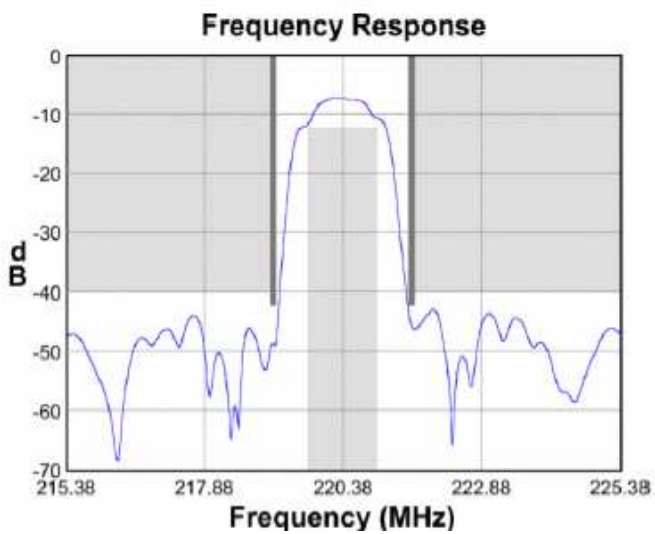
VOLTAGE CONTROLLED OSCILLATORS

LINEAR TUNING   15 to 2000 MHz

POS

MODEL NO.	FREQ. (MHz)		POWER OUTPUT (dBm)	TUNE VOLTAGE (V)		PHASE NOISE (dBc/Hz) SSB@ offset frequencies: Typ.				PULLING (MHz) pk-pk @12 dBr	PUSHING (MHz/V)	TUNING SENSITIVITY (MHz/V)	HARMONICS (dBc)		3 dB MOD. BANDWIDTH (kHz)
	Min.	Max.	Typ.	Min.	Max.	1 kHz	10 kHz	100 kHz	1 MHz	Typ.	Typ.	Typ.	Typ.	Max.	Typ.
POS-25	15-25		+7.0	1	11	-86	-105	-125	-145	0.06	0.04	1–4	-26	-15	60
POS-50	25-50		+8.5	1	16	-88	-110	-130	-150	0.06	0.04	2.0 –2.6	-19	-12	100
POS-75	37.5-75		+8.0	1	16	-87	-110	-130	-150	0.15	0.11	3.1–3.8	-27	-16	100
POS-100	50-100		+8.3	1	16	-83	-107	-130	-150	0.6	0.2	4.2 –4.8	-23	-18	100
POS-150	75-150		+9.5	1	16	-80	-103	-127	-147	0.8	0.3	5.8–6.7	-23	-17	100
POS-200	100-200		+10.0	1	16	-80	-102	-122	-142	1.0	0.2	7.1–8.6	-24	-20	100
POS-300	150-280		+10.0	1	16	-78	-100	-120	-140	1.8	0.3	9.5 –13	-30	-20	100
POS-400	200-380		+9.5	1	16	-76	-98	-120	-140	1.8	0.3	13.7–16.9	-28	-20	100
POS-535	300-525		+8.8	1	16	-70	-93	-116	-139	2.0	0.4	10.5–24	-26	-20	100
POS-765	485-765		+9.5	1	16	-61	-85	-108	-129	5.0	0.4	18–27	-21	-17	100
POS-1025	685-1025		+9.0	1	16	-65	-84	-104	-124	5.0	0.6	21–36	-23	-18	100
POS-1060	750-1060		+12.0	1	20	-65	-90	-112	-132	50	3.0	18–32	-11	—	1000