UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, SECOND SEMESTER MAY 2011

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	COMMUNICATION SYSTEMS
COURSE CODE:	E410
TIME ALLOWED:	THREE HOURS

Candidates' Examination Number ....

INSTRUCTIONS:

1. **Write your Examination number in the space provided above.**
2. **Answer all questions. Marks for different questions are indicated at the beginning of each question.**
3. **Write your answers in the space provided on the question paper. If you need more space to complete your answer you may use the space at the back of the question paper or you may use the examination Answer Book. In either case you must mention where using "continued at the back" or "continued in the Answer Book".**
4. **At the end of the Examination put the question paper inside your Answer Book and submit both.**
5. **Rough work may be done in the answer Book and crossed through.**

THIS PAPER SHOULD NOT BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

THIS PAPER CONTAINS TWENTY ONE (21) PAGES

Question 1: Solve the following questions (57 marks):

A message signal $m(t) = 2\cos(2\pi * 400t)$ **is used to modulate a carrier** $c(t) = 4\cos(2\pi * 10^4 t)$.

1) If DSB-SC amplitude modulation was used to modulate the message signal

a) Draw the spectrum of the message signal.

b) Draw the spectrum of the modulated signal.

c) Calculate the power content in the DSB-SC amplitude modulated carrier.

d) What is the bandwidth of the DSB-SC amplitude modulated carrier?

2) If single side band amplitude modulation (SSB-AM) was used to modulate a carrier to obtain the lower side band in the previous case: $m(t) = 2\cos(2\pi * 400t)$, $c(t) = 4\cos(2\pi * 10^4 t)$.

a) **Given that the Hilbert transform of** $\cos(2\pi f_m t)$ **is** $\sin(2\pi f_m t)$, **write the expression for modulated carrier u(t).**

b) **Draw the spectrum of the SSB amplitude modulated signal (lower side band).**

c) **What is the bandwidth of the SSB amplitude modulated carrier?**

3) If a conventional amplitude modulation according to the expression $u(t) = (A_c + m(t))\cos(2\pi f_c t) = (1 + \frac{1}{A_c} m(t)) A_c \cos(2\pi f_c t)$ **was used to modulate a carrier in the previous case:** $m(t) = 2\cos(2\pi * 400t)$**,** $c(t) = 4\cos(2\pi * 10^4 t)$**.**

(Note: you can consider $m_{new}(t) = \frac{1}{A_c} m(t)$ **).**

a) Draw the spectrum of the conventional amplitude modulated signal.

b) Calculate the total power in the conventional amplitude modulated signal.

c) What is the modulation index?

d) Show how you can demodulate the received conventional AM carrier.

4) If the message signal is used to frequency modulate a carrier with $k_f = 400$ in the previous case: $m(t) = 2\cos(2\pi * 400t)$, $c(t) = 4\cos(2\pi * 10^4 t)$.

a) **Calculate the modulation index β.**

b) **Give expression for the frequency modulated modulated signal.**

c) **Calculate the effective bandwidth of the angle modulated signal.**

d) **Calculate the frequency deviation Δf.**

e) **Calculate the number of harmonics in the frequency modulated signal.**

f) **Referring to the table of Bessel function values, expand the frequency modulated signal in terms of its harmonics components up to** $n = \pm(\beta + 1)$

g) **Hence, draw the spectrum of the frequency modulated signal (in positive frequency region).**

n	$\beta = 1$	$\beta = 2$	$\beta = 5$	$\beta = 8$	$\beta = 1$[illegible]
0	0.765	0.224	−0.178	0.172	−0.24[illegible]
1	0.440	0.577	−0.328	0.235	0.04[illegible]
2	0.115	0.353	0.047	−0.113	0.25[illegible]
3	0.020	0.129	0.365	−0.291	0.05[illegible]
4	0.002	0.034	0.391	−0.105	−0.22[illegible]
5		0.007	0.261	0.186	−0.23[illegible]
6		0.001	0.131	0.338	−0.0[illegible]
7			0.053	0.321	0.2[illegible]
8			0.018	0.223	0.3[illegible]
9			0.006	0.126	0.2[illegible]
10			0.001	0.061	0.2[illegible]
11				0.026	0.1[illegible]
12				0.010	0.0[illegible]
13				0.003	0.0[illegible]
14				0.001	0.0[illegible]
15					0.0[illegible]
16					0.0[illegible]

h) Calculate the power content of the frequency modulated signal.

i) Classify each of the following approaches listed in the table according if it will be used for

- **Frequency modulation**
- **Amplitude modulation**
- **Frequency demodulation**
- **Amplitude demodulation**

Approach	Used for
Phase locked loop	
Envelope detector	
Multiplier	
Voltage Controlled Oscillator	
Differentiator followed by AM demodulator	
Balanced discriminator	
NBFM followed by frequency multiplier	
Varactor diode	
FMFB	

j) Describe one approach for implementing a frequency modulator.

k) Describe one approach for implementing a frequency demodulator.

5) If the message signal is used to phase modulate a carrier with $k_p = 2$ in the previous case: $m(t) = 2\cos(2\pi * 400t)$, $c(t) = 4\cos(2\pi * 10^4 t)$.

a) **Calculate the modulation index β.**

b) **Give expression for the phase modulated signal.**

c) **Calculate the effective bandwidth of the angle modulated signal.**

6) **If the message signal in the previous case** $m(t) = 2\cos(2\pi * 400t)$ **is ideally sampled, where the sampled signal is given by** $m_\delta(t) = \sum_{n=-\infty}^{\infty} m(nT_s)\delta(t - nT_s)$.

a) **What should be the Nyquist rate for sampling the signal?**

b) **Give an expression for the Fourier transform of sampled message signal** $M_\delta(f)$**, assuming the signal is sampled at the nyquist rate.**

c) **Draw the spectrum of the sampled signal, assuming the signal is sampled at the nyquist rate.**

d) What should be the specification of a reconstruction filter (i.e., what is the type of the filter? and what is the pass band of the filter?)?

e) If the message signal was not band limited, what should be done prior to sampling?

f) If the message signal was transmitted using pulse amplitude modulation, by instantaneous sampling of message signal every Ts sec and lengthening the duration of sample to some constant T sec, what is will be the main effect upon recovering the message signal at the receiver?, and what can be the correction for that effect?

Question 2: Answer the following questions (30 marks):

1) **In pulse code modulation, the signal bandwidth is 4 KHz, and 8 bits code word is used to encode each sample. The maximum amplitude of the signal is 4 and the minimum amplitude of the signal is -4.**

    a) **How many quantization levels are available for quantizing the signal?**

    b) **What is the Nyquist rate for sampling the signal?**

    c) **What is the bit rate of the transmitted signal when pulse code modulation is used?**

    d) **Calculate the quantization step.**

    e) **To which binary code word should be encoded a sample having quantization level index=8?**

f) Estimate the value of the sample having quantization level index= 8, assuming the codebook starts from min(m(t)) + Δ which corresponds to quantization level index=0?

g) If a quantized sample was encoded to the code word 01001001 before transmission, to which quantization level index should the receiver decode this code word.

h) Assuming the message signal was sinusoidal signal; calculate the signal to quantization noise ratio?

i) What will be the final bit rate if 32 signals from 32 sources, each with bandwidth of 4 KHZ and 8 bit encoded are multiplexed and transmitted in one channel?

2) Draw the block diagram for time division multiplexing.

3) **Answer the following regarding the pulse code modulation**
   a) **Draw the block diagram for pulse code modulation and indicate in the following table which element will do the corresponding function.**

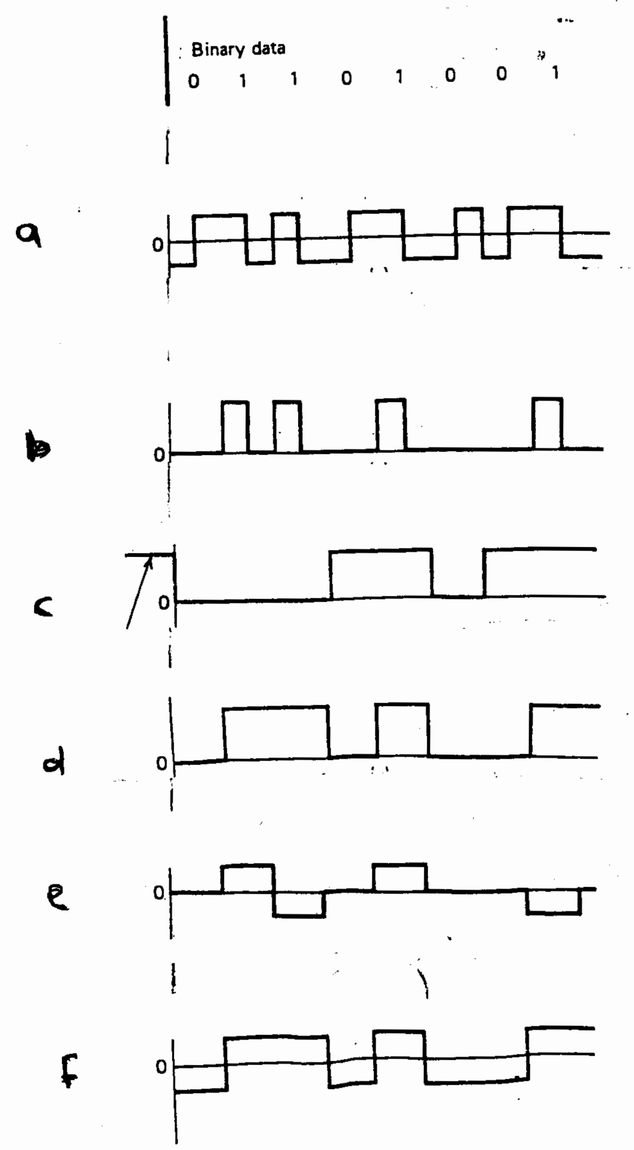
Function	Carried by
Recover the message signal by passing the decoder output through low pass filter.	
Regroup the received pulses into code words and decode them into quantized PAM signal.	
To synchronize the transmitter and receiver clocks by putting a code element at the end of frame.	
Translate the discrete set of sample values to more appropriate form of signal which is code word.	
The message signal sampled with train of narrow rectangular pulses.	
Transmission of a number of independent message sources within time division group.	
Transforming the sample amplitude of message signal into discrete amplitude taken at finite set of possible amplitudes.	
Filter that is used to exclude frequencies greater than W before sampling.	
Controlling the noise and distortion of the PCM signal by reconstructing the PCM signal along the transmission route	

b) In pulse code modulation, talk about the main functions of the regenerative repeater?

c) What is the main function of the compounder in pulse code modulation?

d) **In pulse code modulation, indicate which of the given figures (a,b,c,d,e,f) represents any of the following encoding methods.**

Method of encoding	Graph
Non return to zero signaling	
Differential encoding:	
Return to zero signaling:	
Bipolar return to zero signaling	
On-off signaling	
Manchester code	



Question 3: Complete the missing information about broadcasting with referrence to the attached block diagram for TV broadcasting (13 marks):

Image is scanned by electron beam that produces output .... proportional to .... of the picture.

Scanning of electron beam is controlled by two voltages applied across .... and .... plates. To reduce flicker, the image signal is transmitted in interlaced manner. Interlaced pattern consists of two .... and each consists of 252.5 lines and each transmitted in .... sec.

.... scanned in ....sec. The beam has ....sec to move to the next line. During that interval .... is inserted to avoid appearance of retrace line across TV receiver. A .... sec is added to provide synchronization for .... circuit at receiver

After transmission of one interlaced field, ... waveform applied to .... plates to reset to zero. The retrace interval of .... allows the beam to move from bottom to top of pictures.

.... is inserted during the interval to avoid appearance of retrace lines at receiver.

The bandwidth of image is 485 rows * .... Columns, so we have .... Pixels per frame transmitted in 1/30 sec. That equivalent to sampling rate 10.5 MHz, which can represent a signal as large as .... MHz. In commercial TV broadcasting the bandwidth of video signal is limited to .... MHz.

If we employ three filters one with .... filter and one with .... filter and one with .... filter and transmit the three electrical signals which generated by the three color cameras that view the image, the received signals can be combined to produce replica of original image.

.... is the best alternative to modulate the video signal. The NTSC standard transmit mixture of three primary color signals
$m_L(t) = 0.11m_b(t) + 0.59m_g(t) + 0.3m_r(t)$, $m_I(t) = -0.32m_b(t) - 0.28m_g(t) + 0.6m_r(t)$
$m_Q(t) = 0.31m_b(t) - .52m_g(t) + 0.21m_r(t)$

m_L: Called luminance signal. It is assigned bandwidth of.................................... and transmitted via .... m_I, m_Q: Called chrominance signals. They are related to rue and saturation of colors. m_I is limited in bandwidth to ....and m_Q limited to .... prior to transmission. These two signals are .... multiplexed on subcarrier f_{sc} = ...

The signal m_I is passed through VSB filter which removes upper side band that above 4.2 M Hz. The signal m_Q is transmitted via DSB-SC. So the composite video signal $m = m_L(t) + m_Q(t)\sin(2\pi f_{sc}t) + m_I(t)\cos(2\pi f_{sc}t) + \hat{m}_I(t)\sin(2\pi f_{sc}t)$. The composite signal is transmitted in .... in 6 MHz bandwidth. Horizontal and vertical synchronization pulses are added to m(t) at transmitter. In addition, eight cycles of color subcarrier $A_c \cos(2\pi f_{sc}t)$ called color bursts are superimposed at trailing end of blanking pulses to provide a signal for subcarrier phase synchronization at receiver.

The full upper side band .... MHz of video signal transmitted along with portion 1.25 MHz of video signal from fc to .... transmitted without attenuation and frequencies from .... to fc-1.25 MHz attenuated and the frequency components below blocked .

The audio portion of TV signal transmitted by ....modulating carrier at............. MHz. The audio signal bandwidth is limited to W=..................... The frequency deviation in FM modulated signal 25 MHz and the FM signal bandwidth is 70 KHz. The total channel bandwidth to transmit the audio and video signal is ....

At receiver, there are two separate tuners one for .... band and the other for...................................band. The TV signals in ....band are brought down to .... band by .... mixer. Thus we can use one amplifier for the two frequency bands. Then the video signal selected by tuner translated to common .... band at 41-47 MHz. The output of .... is..................................to produce baseband signal.

Low pass signal with bandwidth .... MHz used to recover luminance signal m_L. Chrominance signals stripped off by band pass filtering and .... by .... using the output of VCO that phase locked to received color carrier burst. The chrominance signals are low pass filtered and a long with luminance signal passed to .... that reconstruct $m_b(t), m_g(t), m_r(t)$. The resulting signals control three electron guns that strike corresponding .... elements in picture tube. The synchronizing pulse in the received video signal separated and applied to .... and .... sweep generators

The audio portion of signal centered at .... MHz filtered out and amplified via .... and passed to .... Audio signal is then amplified by .... and the output drives ....

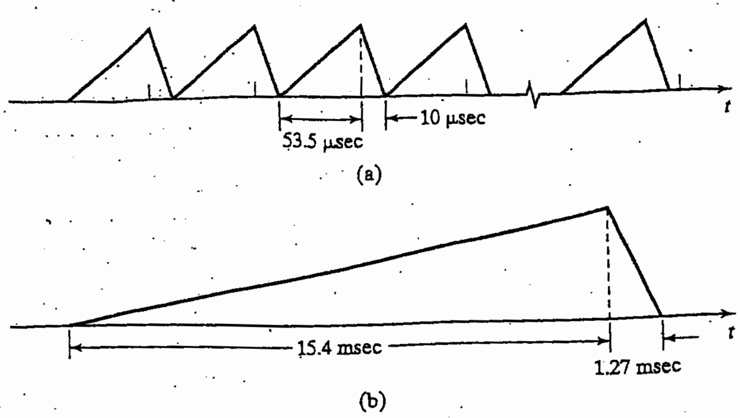


Figure 4.19 Signal waveforms applied to horizontal and vertical deflection plates.

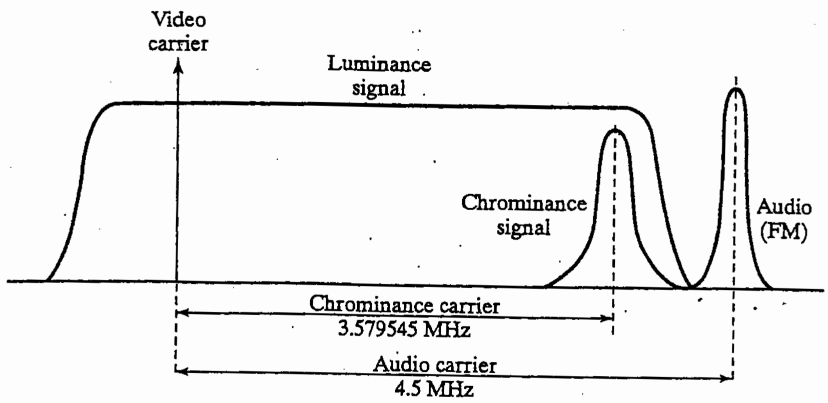


Figure 4.26 Spectral characteristics of color TV signal.

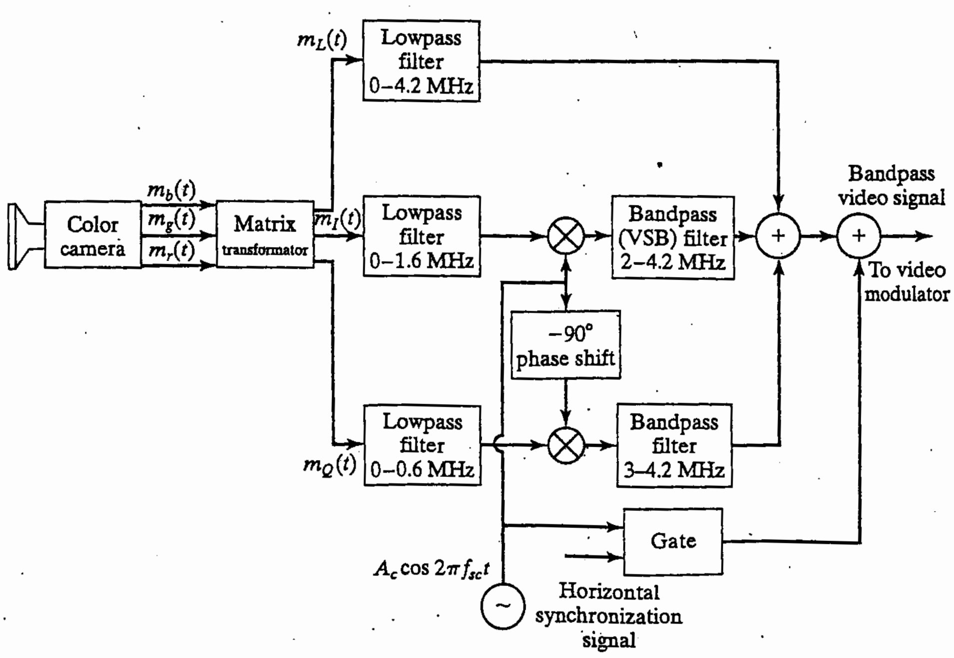


Figure 4.25 Transmission of primary color signals and multiplexing of chrominance and luminance signals.

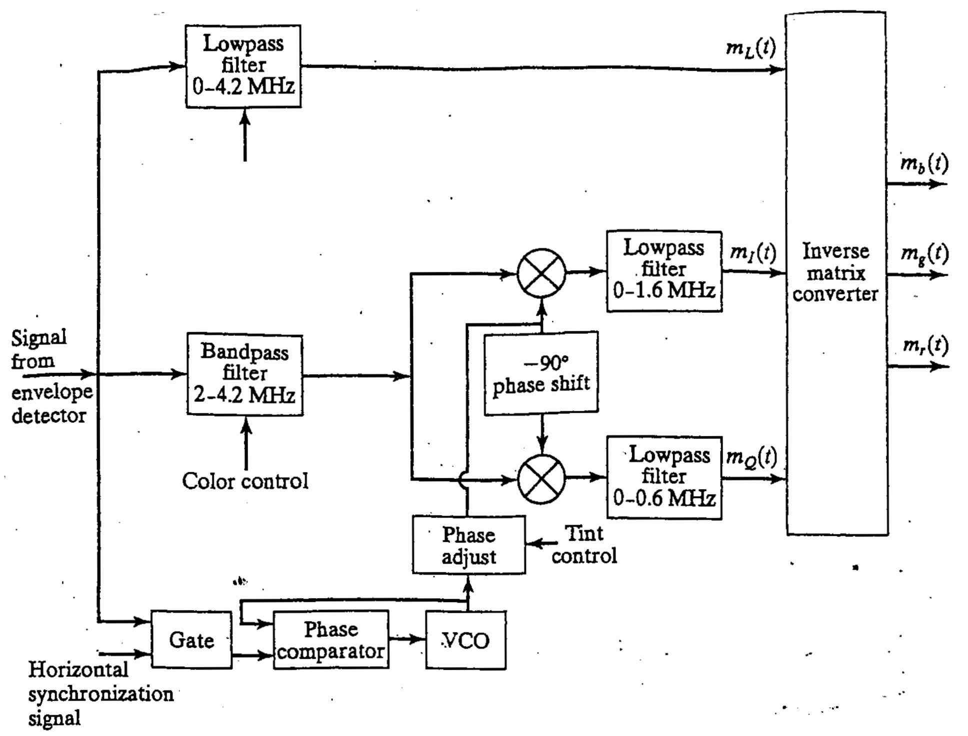


Figure 4.29 Demultiplexing and demodulation of luminance and chrominance signals in a color TV receiver.

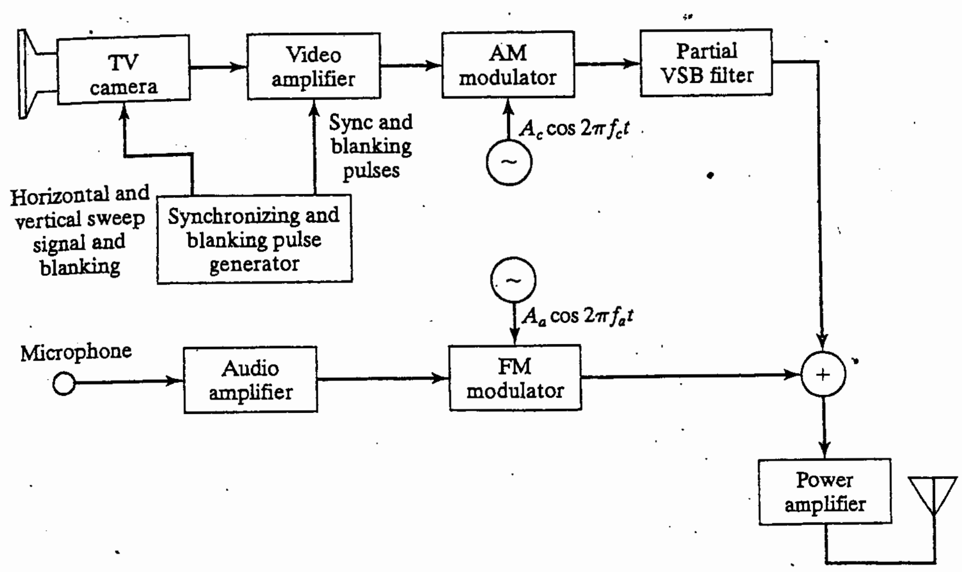


Figure 4.23 Block diagram of a black-and-white TV transmitter.