CMR INSTITUTE OF TECHNOLOGY

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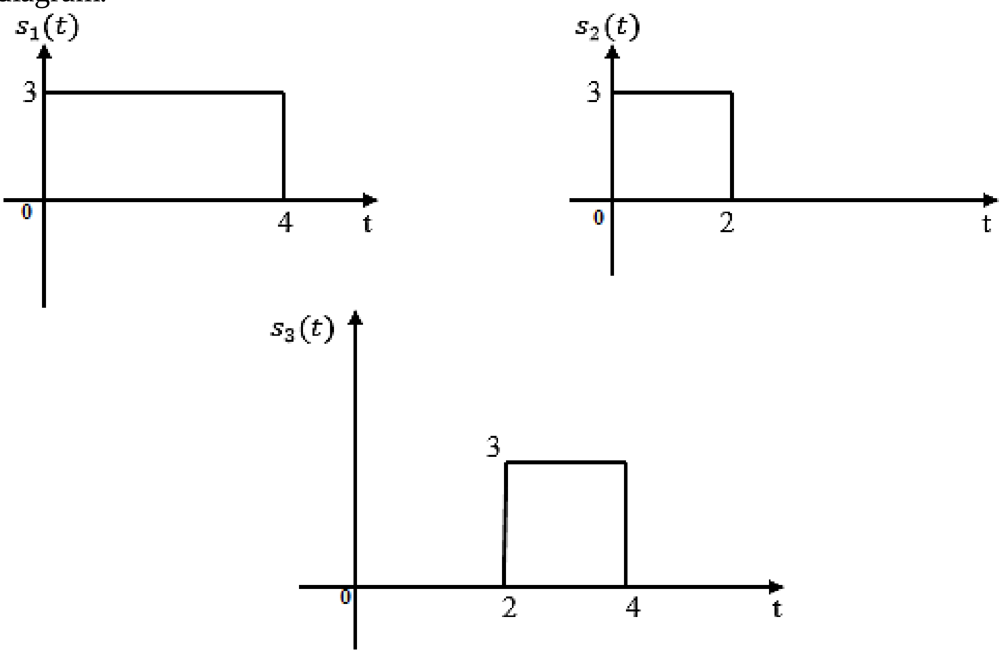
Internal Assesment Test - I

Sub:	DIGITAL COMMUNICATION							Code:	10EC/TE61
Date:	27 / 03 / 2017	Duration:	90 mins	Max Marks:	50	Sem:	VI	Branch:	ECE(D)/TCE(B)
Answer Any FIVE FULL Questions									

Q.	Question	Marks	OBE CO	OBE RBT
1(a)	With a neat block diagram, explain the conceptualized model of digital communication system.	[05]	CO1	L2
(b)	Consider the signal $x(t) = a_1\phi_1(t) + a_2\phi_2(t), 0 \leq t \leq T$, where $\phi_1(t), \phi_2(t)$ are basis functions and a_1, a_2 are the coordinates. Derive an expression for the energy of $x(t)$ in terms of a_1, a_2.	[05]	CO1	L3
2	Apply Gram-Schmidt orthogonalization procedure to obtain a set of orthonormal basis functions for the following set of signals. Express the signals as a linear combination of basis functions. Draw the constellation diagram.	[10]	CO1	L3



Q.	Question	Marks	OBE CO	OBE RBT
3	Show that the process of uniformly sampling the signal in the time domain results in a periodic spectrum with a period equal to sampling rate. Derive interpolation formula for the reconstruction of the original analog signal from its samples taken at Nyquist rate.	[10]	CO1	L3
4(a)	Show that the shifted *sinc* functions $sinc(2Wt - n)$ and $sinc(2Wt - m)$, where $n \neq m$, used in the reconstruction of the original analog signal from its samples are mutually orthogonal.	[05]	CO1	L3
(b)	If E denotes the energy of a strictly band limited signal $x(t)$, then prove that $$E = \frac{1}{2W}\sum_{n=-\infty}^{n=\infty}\left|x\left(\frac{n}{2W}\right)\right|^2$$ where W is the highest frequency component of $x(t)$.	[05]	CO1	L3

5(a)	The signal $g(t) = 10\cos(20\pi t)\cos(200\pi t)$ is sampled at the rate of 250 samples per second. Determine the spectrum of the resulting sampled signal. What is the Nyquist rate for $g(t)$?	[05]	CO1	L3
(b)	A low pass signal has the spectrum given by $$G(f) = \begin{cases} 1 - \frac{\|f\|}{200}, & for\ \|f\| \le 200, \\ 0, & otherwise \end{cases}$$ Assuming that $g(t)$ is sampled at 300 Hz, plot the spectrum of the resulting signal.	[05]	CO1	L3
6	Explain quadrature sampling of band pass signals with related block diagram, spectra and equations.	[10]	CO1	L2

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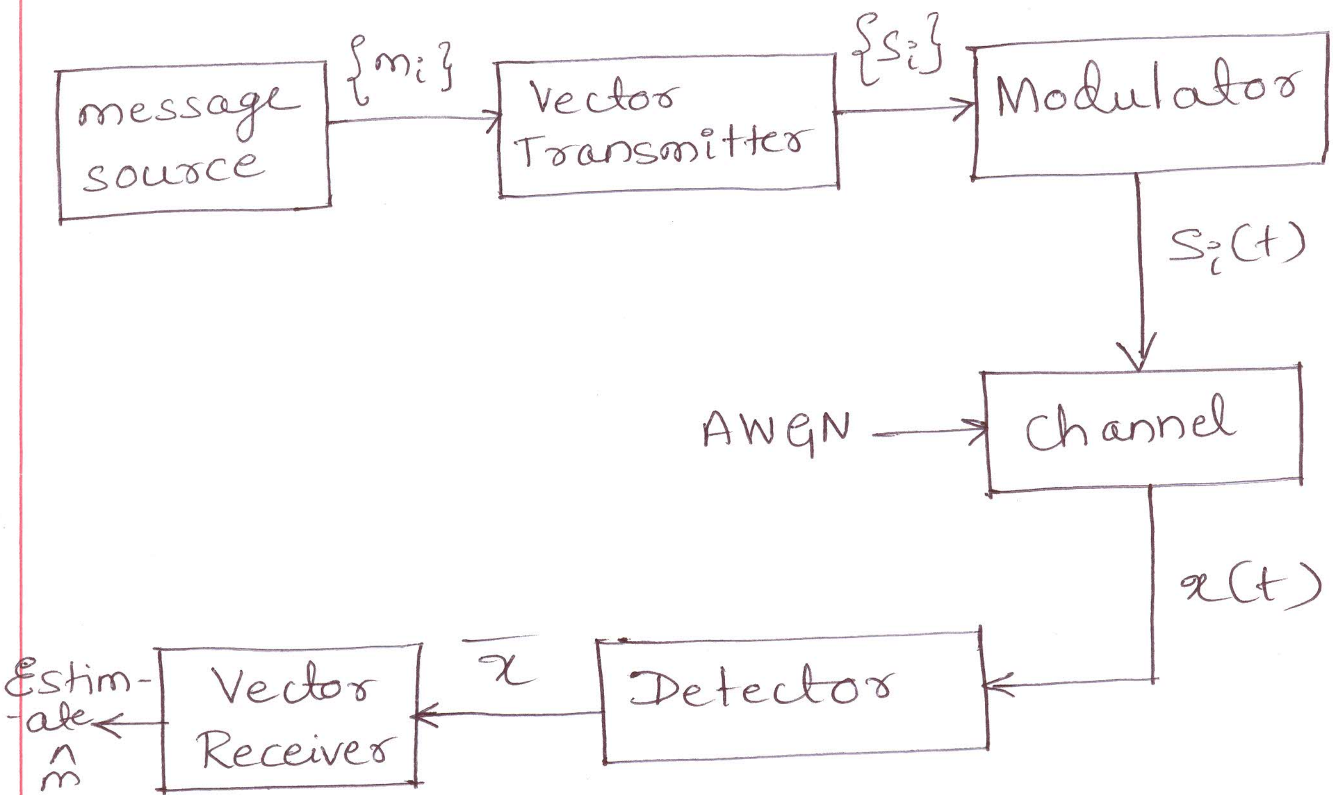
Course Outcomes		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1:	Explain the basic building blocks of digital communication systems and discuss the practical aspects of A2D conversion	3	3	3	3	3	-	-	-	-	-	3	3
CO2:	Explain the waveform coding techniques and design of maximum likelihood receivers	3	3	3	3	3	-	-	-	-	-	3	3
CO3:	Describe and analyze different digital modulation techniques	3	3	3	3	3	-	-	-	-	-	3	3
CO4:	Explain different spread spectrum modulation techniques	3	3	3	3	3	-	-	-	-	-	3	3

Cognitive level	**KEYWORDS**
L1	List, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where, etc.
L2	summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend
L3	Apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover.
L4	Analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer.
L5	Assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize.

PO1 - *Engineering knowledge*; PO2 - *Problem analysis*; PO3 - *Design/development of solutions*; PO4 - *Conduct investigations of complex problems*; PO5 - *Modern tool usage*; PO6 - *The Engineer and society*; PO7- *Environment and sustainability*; PO8 – *Ethics*; PO9 - *Individual and team work*; PO10 - *Communication*; PO11 - *Project management and finance*; PO12 - *Life-long learning*

Solutions to IAT I

1 a



1 b

$$E = \int_0^T |x(t)|^2 dt$$

$$= \int_0^T x(t)\, x^*(t)\, dt$$

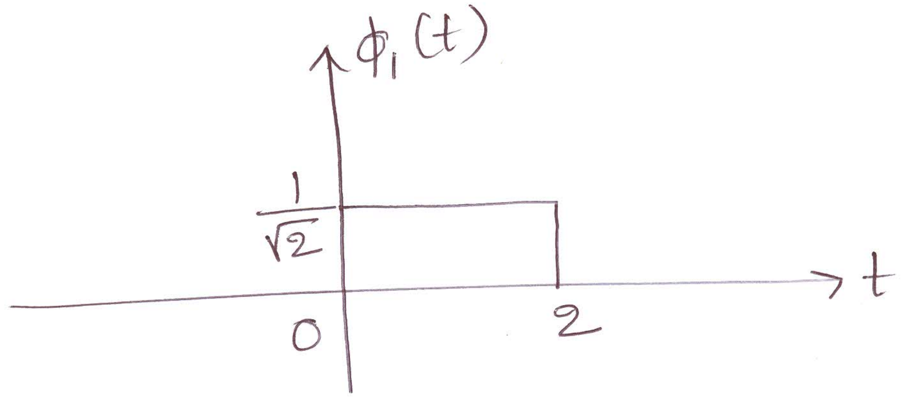
$$= \int_0^T [a_1 \phi_1(t) + a_2 \phi_2(t)]\,[a_1^* \phi_1^*(t) + a_2^* \phi_2^*(t)]\, dt$$

$$= \int_0^T |a_1|^2 |\phi_1(t)|^2 dt + \int_0^T |a_2|^2 |\phi_2(t)|^2 dt$$

$$= |a_1|^2 + |a_2|^2$$

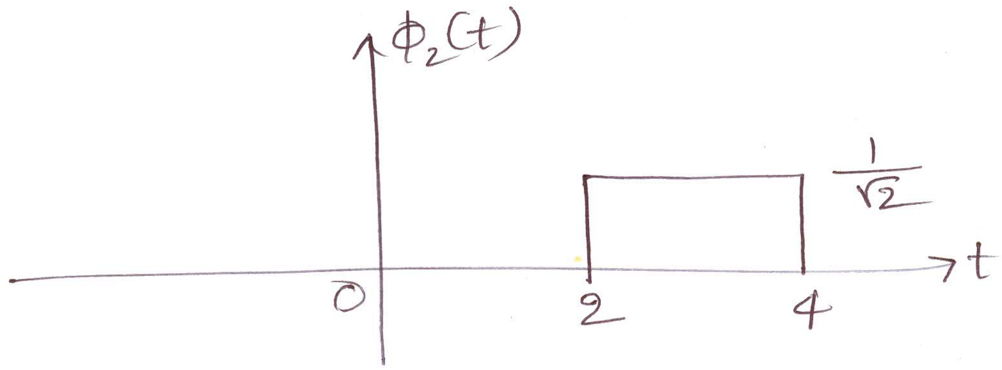
2 Energy of $s_2(t) = \int_0^2 9\,dt = 18$

$$\phi_1(t) = \frac{s_2(t)}{\sqrt{18}} = \frac{s_2(t)}{3\sqrt{2}}$$



Energy of $s_3(t) = 18$

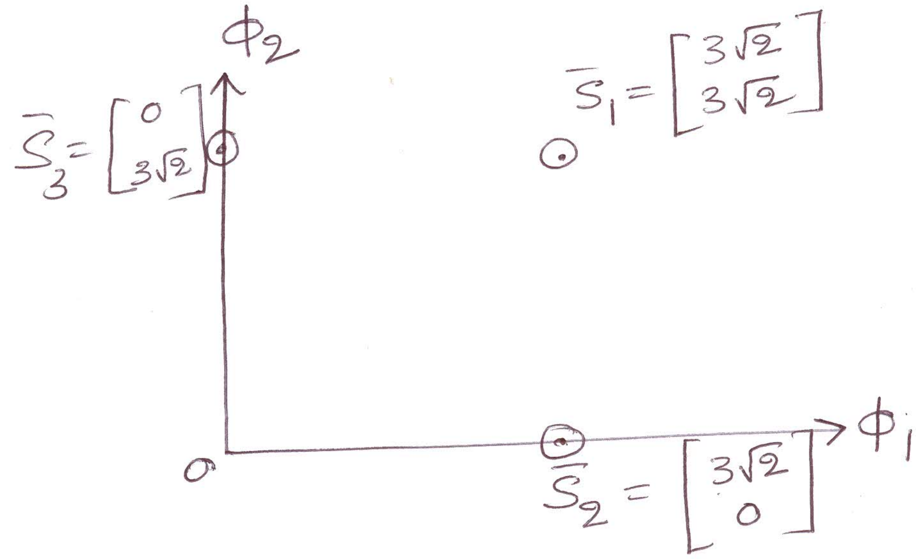
$$\phi_2(t) = \frac{s_3(t)}{\sqrt{18}} = \frac{s_3(t)}{3\sqrt{2}}$$



$s_1(t) = 3\sqrt{2}\,\phi_1(t) + 3\sqrt{2}\,\phi_2(t)$

$s_2(t) = 3\sqrt{2}\,\phi_1(t) + 0\,\phi_2(t)$

$s_3(t) = 0\,\phi_1(t) + 3\sqrt{2}\,\phi_2(t)$



3

$$x_\delta(t) = x(t) \sum_{n=-\infty}^{\infty} \delta(t - nT_s)$$

$$X_\delta(f) = X(f) * \sum_{k=-\infty}^{\infty} \frac{1}{T_s} \delta(f - kf_s)$$

$$= f_s \sum_{k=-\infty}^{\infty} X(f - kf_s)$$

$$x_\delta(t) = \sum_{n=-\infty}^{\infty} x(nT_s)\, \delta(t - nT_s)$$

$$X_\delta(f) = \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f nT_s}.$$

$$x(t) = \int_{-W}^{W} X_\delta(f)\, e^{j2\pi f t}\, df$$

$$= \int_{-W}^{W} \sum_{n=-\infty}^{\infty} x(nT_s)\, e^{-j2\pi f nT_s}\, e^{j2\pi f t}\, df$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) \int_{-W}^{W} e^{j2\pi f(t - nT_s)}\, df$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s)\,\text{sinc}(2Wt - n)$$

4a $$\int_{-\infty}^{\infty} x_1(t)\, x_2^*(t)\, dt = \int_{-\infty}^{\infty} X_1(f) X_2^*(f)\, df$$

$$= \frac{1}{2W}\frac{1}{2W}\int_{-W}^{W} e^{-j2\pi f\left(\frac{n-m}{2W}\right)}\, df$$

$$= \frac{1}{2W}\,\text{sinc}(m-n)$$

$$= \begin{cases} \frac{1}{2W}, & m = n \\ 0, & m \neq n \end{cases}$$

4b $$E = \int_{-\infty}^{\infty} |x(t)|^2\, dt$$

$$= \int_{-\infty}^{\infty} \sum_{n=-\infty}^{\infty} x(nT_s)\,\text{sinc}(2Wt-n) \sum_{m=-\infty}^{\infty} x^*(mT_s)\,\text{sinc}(2Wt-m)\, dt$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) \sum_{m=-\infty}^{\infty} x^*(mT_s) \int_{-\infty} \text{sinc}(2Wt-n)\,\text{sinc}(2Wt-m)\, dt$$

$$= \frac{1}{2W}\sum_{n=-\infty}^{\infty} |x(nT_s)|^2$$

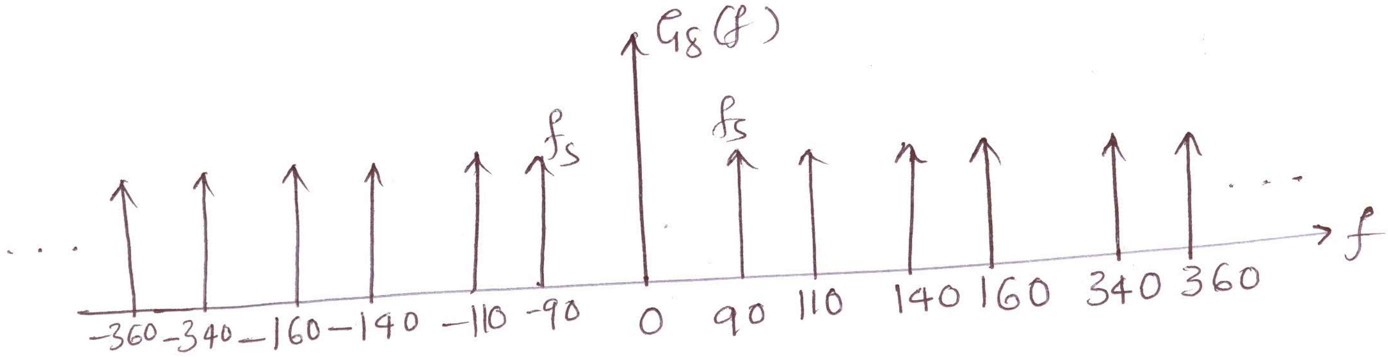
5a $g(t) = 10\cos(20\pi t)\cos(200\pi t)$

$= 5\cos(220\pi t) + 5\cos(180\pi t)$

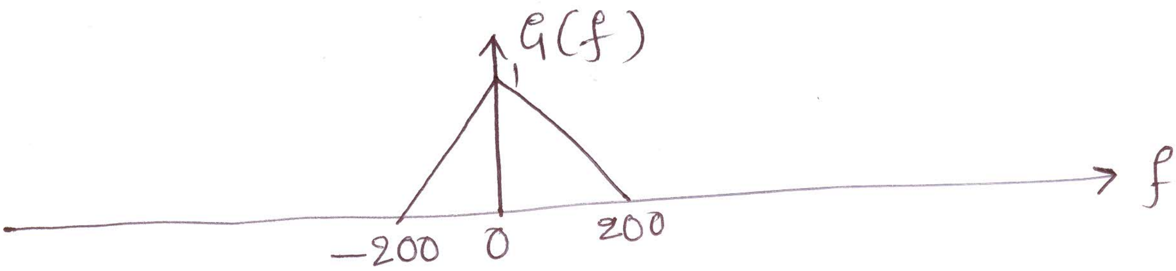
$$G(f) = \frac{5}{2}\left[\delta(f-110) + \delta(f+110) + \delta(f-90) + \delta(f+90)\right]$$

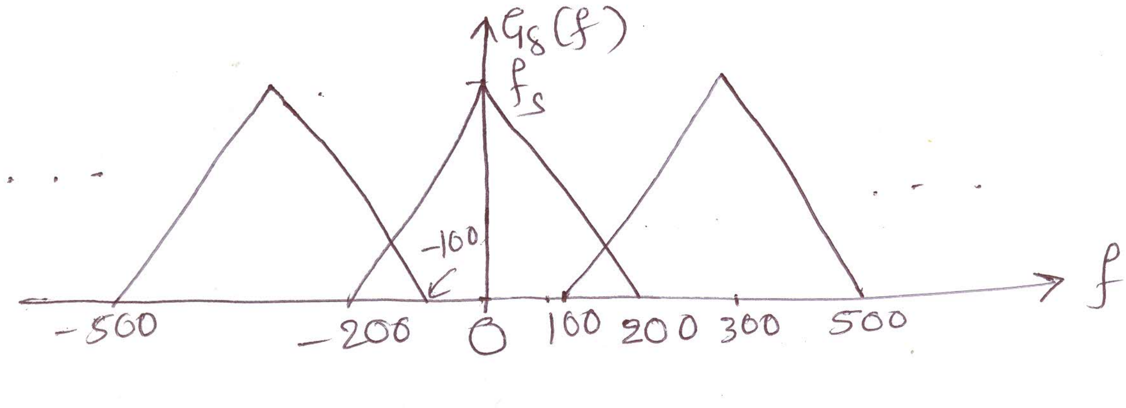
$$G_\delta(f) = f_s \sum_{k=-\infty}^{\infty} G(f - kf_s)$$

$f_s = 250$



5b





6 $$s(t) = s_i(t)\cos(2\pi f_c t) - s_q(t)\sin(2\pi f_c t)$$ 6/6

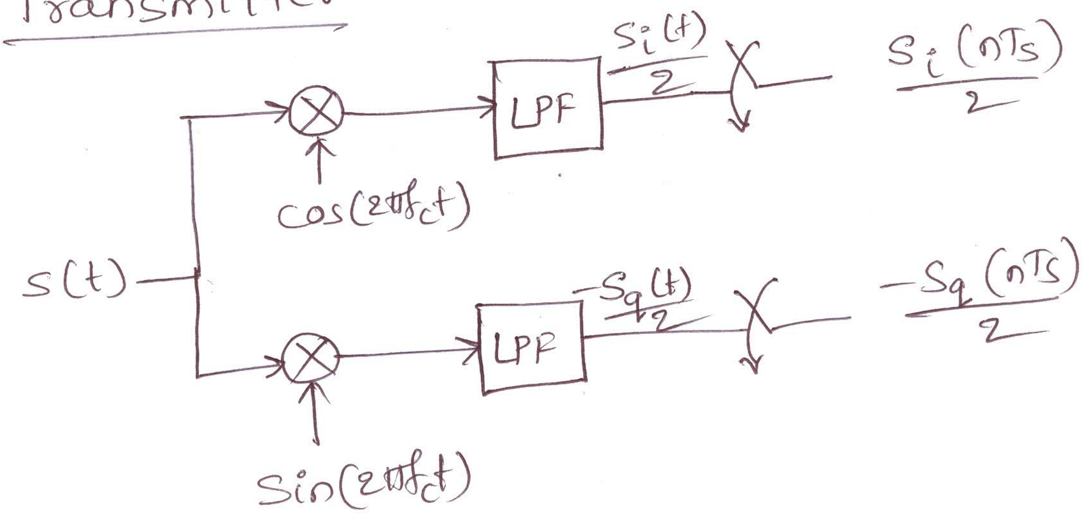
$$s(t)\cos(2\pi f_c t) = s_i(t)\cos^2(2\pi f_c t) - s_q(t)\sin(2\pi f_c t)\cos(2\pi f_c t)$$

$$= \frac{s_i(t)}{2} + \frac{s_i(t)}{2}\cos(4\pi f_c t) - \frac{s_q(t)}{2}\sin(4\pi f_c t)$$

$$s(t)\sin(2\pi f_c t) = s_i(t)\cos(2\pi f_c t)\sin(2\pi f_c t) - s_q(t)\sin^2(2\pi f_c t)$$

$$= \frac{s_i(t)}{2}\sin(4\pi f_c t) - \frac{s_q(t)}{2} + \frac{s_q(t)}{2}\cos(4\pi f_c t)$$

Transmitter



Receiver