A Design and Simulation of Compact 16-Psk Modulator with Low Phase Imbalance for Wireless Communication Applications

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Abstract: In this paper, 16-Phase Shift Keying modulator is designed, by using various PSK modulation schemes which is designed for the wireless communication systems using MIC techniques. Sixteen-Phase Shift Keying (16-PSK) designed at the S-band that allows achieving a very high accuracy in phase with very low power consumption. The isolation between the carrier input port and the output port is very high and the phase error is less than 1º. The substrate used for the PSK modulator is FR-4 and the specification for substrate is dielectric thickness (h) =0.08mm, conductor thickness (t) =0.035mm, dielectric constant (ε) =4.4 and tangent loss=0.001.

Keywords: Microwave integrated circuit, 8-Phase shift keying modulator, 16-Phase shift keying modulator, Quadri-phase shift keying modulator, Microstrip, Power combiner, Branch line coupler, Rat-race (Hybrid rings) coupler.

1. INTRODUCTION

There is always a demand of high quality, high data rate and high spectral efficiency in communication systems. Moving to higher modulation techniques, the number of discrete signal allows, increases the amount of information per symbols although greater energy is required to maintain the same distance between signals vectors. The reduction of weight and cost due to quasi absence tuning is the key feature of PSK modulator. Moreover it provides good reproducibility and high reliability. These modulation scheme permits high amount of information to be carried within the same bandwidth with little additional complexity. There are two types of modulators, which are categorized on the basis of fabrication techniques namely balanced modulator and path-length modulator. In the balanced type modulator the path length is same, so no variation in signal is present and hence no circulator is required. The path length modulators are divided into two types reflection type modulator and transmission type modulator. The Transmission- type modulators use two microstrip lines with different lengths. The reflection type modulators have been constructed by MIC 3-dB branch line hybrid coupler. The microwave integrated circuit modulator has been fabricated for use in digital and wireless communication which requires some additional features and circuitries. General block diagram of various PSK modulators are shown in Fig.1.

The modulator proposed in this paper has the following advantages:

- The modulator provides high isolation between the carrier input port and output port.
- This modulator can be extended to the millimeter-wave band.
- The amplitude and phase variation are very less.

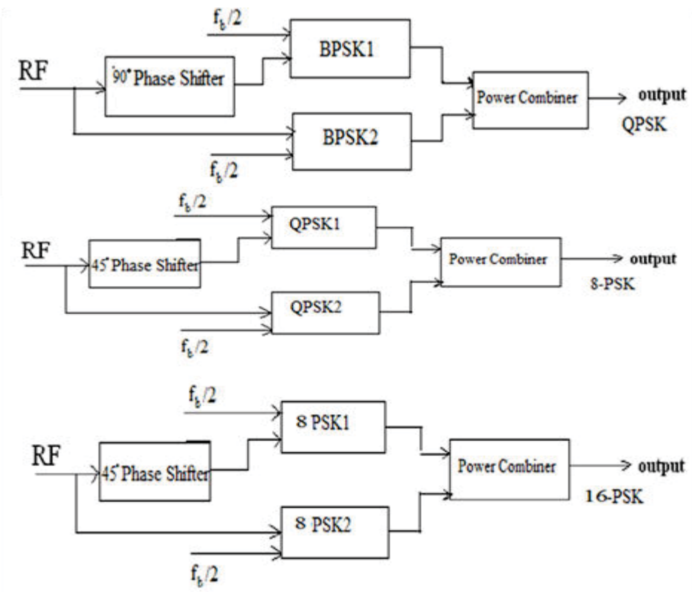

Figure 1: Block diagram of 16-PSK modulator

2. FORMULAS FOR DESIGNING 16-PSK MODULATOR

Effective Dielectric Constant

When $\left(\frac{W}{H}\right) < 1$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[\left(1 \Big/ \sqrt{1 + 12\left(H/W\right)}\right) + 0.04\sqrt{\left(1 - \left(W/H\right)\right)}\right]$$

When $\left(\frac{W}{H}\right) \geq 1$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 \Big/ \sqrt{\left(1 + 12\left(H/W\right)\right)}\right]$$

Characteristic Impedance

When $\left(\frac{W}{H}\right) < 1$

$$Z_0 = \frac{60}{\sqrt{\varepsilon_{eff}}} \ln\left(8\left(H/W\right) + 0.25\left(W/H\right)\right)\ \Omega$$

When $\left(\frac{W}{H}\right) \geq 1$

$$Z_0 = \frac{120\pi}{\sqrt{\varepsilon_{eff}}\left[\frac{W}{H} + 1.393 + \frac{2}{3}\ln\left(\frac{W}{H} + 1.444\right)\right]}\ \Omega$$

Guided wavelength, propagation constant, phase velocity and electrical length

$\lambda_g = \frac{\lambda_0}{\sqrt{\varepsilon_{re}}}$, $\beta = \frac{2\pi}{\lambda_g}$, $V_p = \frac{\omega}{\beta} = \frac{c}{\sqrt{\varepsilon_r}}$

($c = 3 * 10^8$ m/s) and $\theta = \beta l$.

3. DESIGN OF SIXTEEN-PHASE SHIFT KEYING MODULATOR

It is an M array encoding technique where M=16 therefore 16 different output phases possible. Four bits are sending at a time. Minimum bandwidth and baud equals to ¼ of the bit rate i.e. $f_b/4$. Angular separation between adjacent output phases is 22.5º. Phase shifts during transmission and still retains its integrity.

M-PSK is a method of modulating a carrier with a unique symbol. Each symbol consists of two or more bits. The number of unique data states is defined as M = 2", where *n* represents the number of bits which comprise the symbol. A 16-PSK scheme would utilize a symbol containing four data bits to shift the phase of a carrier, 16 distinct amounts. In 16PSK modulation, the alphabets $\{1, e^{\frac{j2\pi}{M}}, e^{\frac{j4\pi}{M}}, \ldots\ldots, e^{\frac{j2\pi(M-1)}{M}}\}$ is used, where M=16.

Table 1: Designing parameters for 16-PSK

$\sqrt{2}\,Z_0$ = 70.7106Ω	$\sqrt{2}\,Z_0$ = 70.7106Ω	Z_0 = 50Ω
βl = 90°	βl = 270°	βl = 90°
W = 0.76635mm	W = 0.76635mm	W = 1.4897mm
L = 17.7077mm	L = 53.1232 mm	L = 17.1900mm
R =16.9179mm	R = 16.918mm	-
Angle=60°	Angle=180°	-

By using above parameters 16-PSK modulator is designed on Agilent ADS software, and results are shown in table below.

Table 2: 16-PSK results at 2.4GHz

S. N	**BIT**	**MEASURE PHASE (Degree)**	**MEASURE PHASE + REFERENCE PHASE (Degree)**	**ERROR (Degree)**
1	0 0 0 0	-5.588	0	0
2	0 0 0 1	61.916	67.504	0.004
3	0 0 1 0	39.440	45.028	.028
4	0 0 1 1	106.944	112.532	.032
5	0 1 0 0	85.179	90.767	.767
6	0 1 0 1	152.670	158.258	.758
7	0 1 1 0	130.146	135.734	.734
8	0 1 1 1	-162.362	-156.774	.726
9	1 0 0 0	-95.487	-89.899	.101
10	1 0 0 1	-27.997	-22.408	.092
11	1 0 1 0	-50.520	-44.932	.068
12	1 0 1 1	16.971	+22.599	.099
13	1 1 0 0	175.215	180.803	.803
14	1 1 0 1	-117.281	-111.693	.807

15	1 1 1 0	-139.758	-134.17	.83
16	1 1 1 1	-72.253	-66.665	.835

4. CONCLUSION

The experimental result of the 16- PSK modulation scheme in S-band demonstrates the good performance for the wireless communication bands and larger applications such as Wi-Fi and WiMAX with least phase error of 1º. These PSK modulators transmit high power with less error in phase so the modulator can be extended for higher band of frequency.

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