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Development of a DSP Prototype for 16-Bit QAM Modulator Using Code Composer Studio for Application in Mobile Communication Systems

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Abstract

As step by step there is increment in mobile telephone users, the bandwidth capacity prerequisite for every user is commonly expanding. Because of this, there is spectral blockage brought about and exceptional upgrades have been taken in the field of mobile communications. Quadrature amplitude modulation (QAM) multilevel modulation can offer an alluring answer for current transmission bandwidth confinement in microcellular systems. The conservative technique of QAM synthesis is analog. This paper is an effort that has been engaged for the untried synthesis of 16-Bit QAM by means of the principle of direct digital synthesis (DDS) with the help of digital signal processor (DSP) TMS320C6713. The synthesized QAM signal has been produced by writing a program in the C-source file of code composer studio (CCS) integrated development environment (IDE). Experimental results for 16-bit QAM modulating sequence are comprised.

Keywords: CCS, DDS, DPS, IDE, QAM

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INTRODUCTION

Direct digital synthesis (DDS) is a technique of constructing an analog waveform, typically a sine wave by producing a time varying signal in digital form and then execution a Digital-to-analog (DAC) conversion. As the processes within a device are digital it can proposal fast switching between frequencies which delivers better optimization, resolution, and operation over a broad spectrum of frequencies.[1,2] Code composer studio (CCS) is used to write necessary C-language and Assembly level programs. CCS delivers all of the host tools and runtime software support for TMS320C6713 DSP-based real-time embedded applications.[3] ASK, PSK and FSK are popular modulation techniques used for Digital Communication. On the basis of modulating sequence, as we vary the amplitude and phase simultaneously, we can have the combination of ASK and PSK which results in quadrature amplitude modulation (QAM). DDS-based sinusoid generation and ASK implementation on Texas Instruments TMS320C6713 is well discussed in refs.[4,5] In this present work, we have experimentally generated a QAM signal on digital signal processor (DSP) by writing program in C and Assembly level language using the principle of look-up table (LUT)-based DDS. The experimentally generated QAM signals have been recorded on Digital Oscilloscope and also been included in the result. This QAM signal may be used for realizing high capacity land mobile communication systems.[6] This work has been developed as a prototype model in the laboratory, which has its own limitation in term of speed, however the same work as required by the application can be implemented on a compatible processor with high speed DAC and other required peripherals for setting up practical mobile communication systems.

BLOCK DIAGRAM

16-bit QAM in-phase component is directly proportional to the quadrature phase component, there are 16-bits per symbol are transmitted as an input signal. These 16-bits are fed into serial in and parallel out converter. The upper eight bits are multiplied with sine table consisting of 48 samples which results in Quadrature phase or q-phase and the lower eight bits are multiplied with cosine table which results in in-phase. This results when 16-bits per symbols are processed it come out as 4-bits i.e., 0000, 0001, 0010, 0011, 0010, 0101, 0110, 0111, 1000, 1001, 1010, 1011, 1100, 1101, 1110, 1111, etc. and thus outputting Quadrature amplitude modulator. The addition of quadrature phase and the in-phase component gives the 16-bit quadrature amplitude modulator. There is no exact phase shift keying in QAM, below shown the block diagram of 16-bit QAM signal.

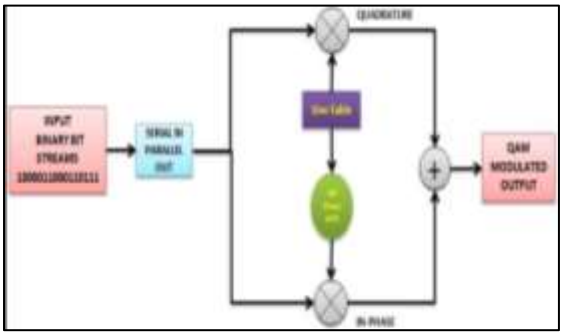

Fig. 1. *The Block Diagram of 16-Bit QAM Signal.*

LOOK-UP TABLE BY USING FLOATING POINT NUMBERS

There are 48 samples over a period to form an angle of 7.5° which will result in sine and cosine values in floating point numbers. The sampling technique is used in the programming to form a multiplier and this multiplier again gives the values in floating point numbers and by using the DSP (TMS320C6713), these floating point numbers will be converted into two's complement form where the device Texas Instrument can download the data.

Table 1. *Look-Up Tables for Sine and Cosine Values.*

Sample	Angle (A)	Sine (A) Values	Cosine (A) Values
0	0	0.000	1.000
1	7.5	0.1305	0.9914
2	15	0.2588	0.9659
3	22.5	0.3827	0.9238
4	30	0.5	0.8660
5	37.5	0.6087	0.7933
6	45	0.7071	0.7071
7	52.5	0.7933	0.6087
8	60	0.8680	0.5000
9	67.5	0.9238	0.3827
10	75	0.9659	0.2588
11	82.5	0.9914	0.1305
12	90	1.000	0.000
13	97.5	0.9914	–0.1305
14	105	0.9659	–0.2588
15	112.5	0.9238	–0.3827
16	120	0.8660	–0.5
17	127.5	0.7933	–0.6087
18	135	0.7071	–0.7071
19	142.5	0.6087	–0.7933
20	150	0.5000	–0.8660
21	157.5	0.3827	–0.9238
22	165	0.2588	–0.9659
23	172.5	0.1308	–0.9914
24	180	0.000	–1.000
25	187.5	–0.1305	–0.9914
26	195	–0.2588	–0.9659
27	202.5	–0.3827	–0.9238
28	210	–0.5	–0.8660
29	217.5	–0.6087	–0.7933
30	225	–0.7071	–0.7071
31	232.5	–0.7933	–0.6087
32	240	–0.8680	–0.5000
33	247.5	–0.9238	–0.3827
34	255	–0.9659	–0.2788
35	262.5	–0.9914	–0.1305
36	270	–1.0000	0.000
37	277.5	–0.9914	0.1305
38	285	–0.9659	0.2588
39	292.5	–0.9238	0.3827
40	300	–0.8660	0.5000
41	307.5	–0.7933	0,6087
42	315	–0.7071	0.7071
43	322.5	–0.6087	0.7933
44	330	–0.5	0.8680
45	337.5	–0.3827	0.9233
46	345	–0.2588	0.9659
47	352.5	–0.1305	0.9914

ADVANTAGES

The move to digital modulation provides more information capacity, compatibility with digital data services, higher data security, better quality communications, and quicker system availability. Developers of communications systems face these constraints: Available bandwidth, Permissible power, Inherent noise level of the system. The RF spectrum must be shared, yet every day there are more users for that spectrum as demand for communications services increases. Digital modulation schemes have greater capacity to convey large amounts of information than analog modulation schemes.

DISADVANTAGES

(1) Required higher order degree filtering.
(2) As the data rate increases the error in the signal increases.
(3) Noise effects.

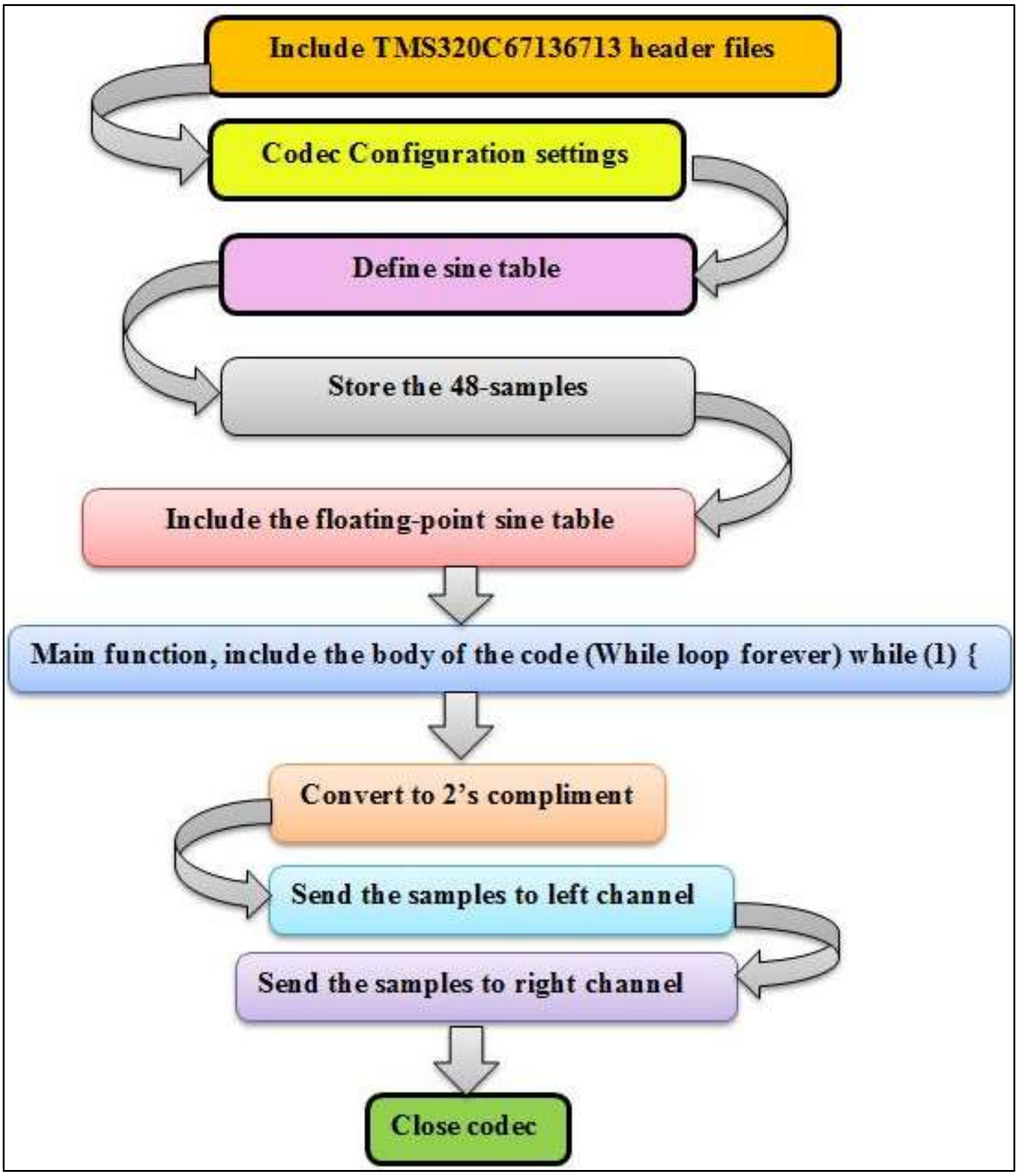

Fig. 2. *Code Structure for the Generation of 16-Bit QAM Signal.*

EXPERIEMENTAL SETUP AND RESULTS

To generate a 16-QAM modulated Signal the respective sample amplitudes were calculated, converted into floating point values and stored in the form of a Sine lookup table as shown in Table 1. The DSP TMS320C6713 is interfaced with a PC.

The CCS software package to operate the DSP kit is loaded on the PC. The C level program to implement the generation of 16-QAM Signal on the principle of DDS is written in a C-source file of CCS, from where the equivalent assembly file is generated.

The assembler then translates the assembly file into Common Object Format File (COFF) while the linker combines the COFF and library modules into a single executable COFF. A floating point values conversion utility is used to convert a COFF object into TI-tagged object formats.

The converted file can be downloaded to an EPROM programmer, of the DSP kit making the processor ready to execute the program. During the execution, the processor fetches the data of LUT and presents the same to DAC of the TMS320C6713.

The output of the DAC of DSK kit is connected to Pico-scope Technology which is the 2–channel Pico-Scope 4226 and 4227 are precision USB oscilloscope that are suitable for general, scientific and field-service use.

With 12-bit resolution (adjustable up to 16 bits in enhanced resolution mode) and 1% accuracy they also make an excellent choice for noise, vibration and mechanical analysis. This oscilloscope is used to store the data digitally.

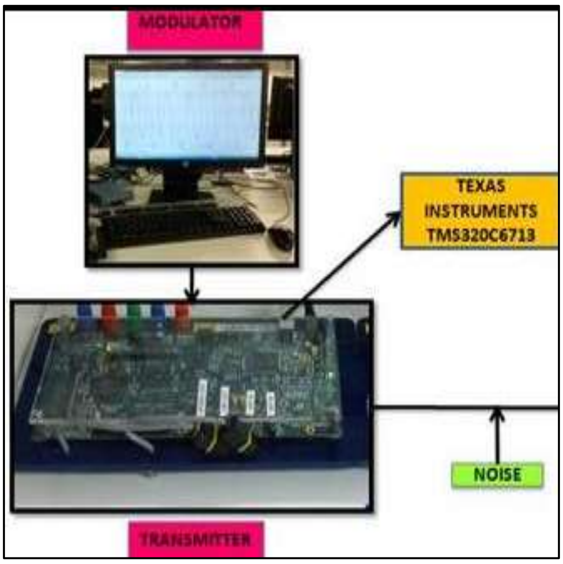

Fig. 3. *Shows the Experimental Setup of Texas Instrument (TMS320C6713).*

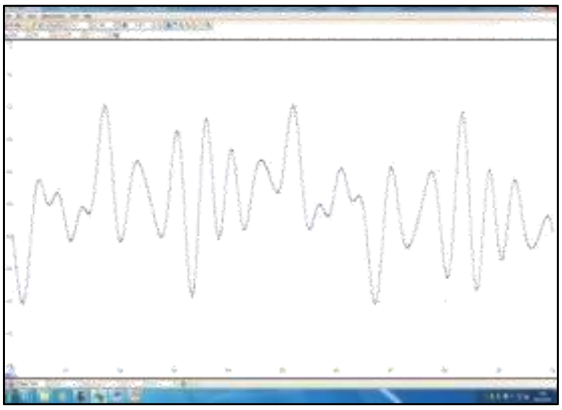

Fig. 4. *The 16-Bit QAM Modulated Data Output for Mobile Applications*.

CONCLUSION

A successful 16-bit QAM modulator was designed, implemented and practically tested. The results were evaluated by observing the modulated signal waveforms, frequency spectrum and recovering the original information data. This paper also validates the effect of noise by practically adding additional noise at the modulator. This makes it more applicable in mobile communication system.

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