PSpice for Analog Communications Engineering

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ABSTRACT

In PSpice for Analog Communications Engineering we simulate the difficult principles of analog modulation using the superb free simulation software Cadence Orcad PSpice V10.5. While use is made of analog behavioral model parts (ABM), we use actual circuitry in most of the simulation circuits. For example, we use the 4-quadrant multiplier IC AD633 as a modulator and import real speech as the modulating source and look at the trapezoidal method for measuring the modulation index. Modulation is the process of relocating signals to different parts of the radio frequency spectrum by modifying certain parameters of the carrier in accordance with the modulating/information signals. In amplitude modulation, the modulating source changes the carrier amplitude, but in frequency modulation it causes the carrier frequency to change (and in phase modulation it's the carrier phase).

The digital equivalent of these modulation techniques are examined in *PSpice for Digital Communications Engineering*, where we look at QAM, FSK, PSK and variants. We examine a range of oscillators and plot Nyquist diagrams showing the marginal stability of these systems. The superhetrodyne principle, the backbone of modern receivers is simulated using discrete components followed by simulating complete AM and FM receivers. In this exercise we examine the problems of matching individual stages and the use of double-tuned RF circuits to accommodate the large FM signal bandwidth.

KEYWORDS

Amplitude modulation, frequency modulation, phase modulation, radio-frequency amplifiers, superhetrodyne receivers, phase lock loops, Nyquist plot, gain and phase margins.

I dedicate this book to my wife and friend, Marie and sons Lee, Roy, Scott and Keith and my parents (Eddie and Roseanne), sisters, Sylvia, Madeleine, Jean, and brother, Ted.

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Preface

In book 1, PSpice for Circuit Theory and Electronic Devices, we explained in detail the operational procedures for the new version of PSpice (10.5) but I include here a very quick explanation of the project management procedure that must be followed in order to carry out even a simple simulation task. Before each simulation session, it is necessary to create a project file by following the procedure as shown in Figure 1. This will not be mentioned in the text as it becomes tedious for the reader seeing the same statement "Create a project called Figure 1-008.opj etc" before each experiment. After selecting Capture CIS from the Windows start menu, select the small folded white sheet icon at the top left hand corner of the display as shown.

Enter a suitable name in the **Name** box and select **Analog or Mixed A/D** and specify a **Location** for the file. Press **OK** and a further menu will appear so tick **Create a blank project** as shown in Figure 2. In the project management area, expand the **DC_circuits** directory (or

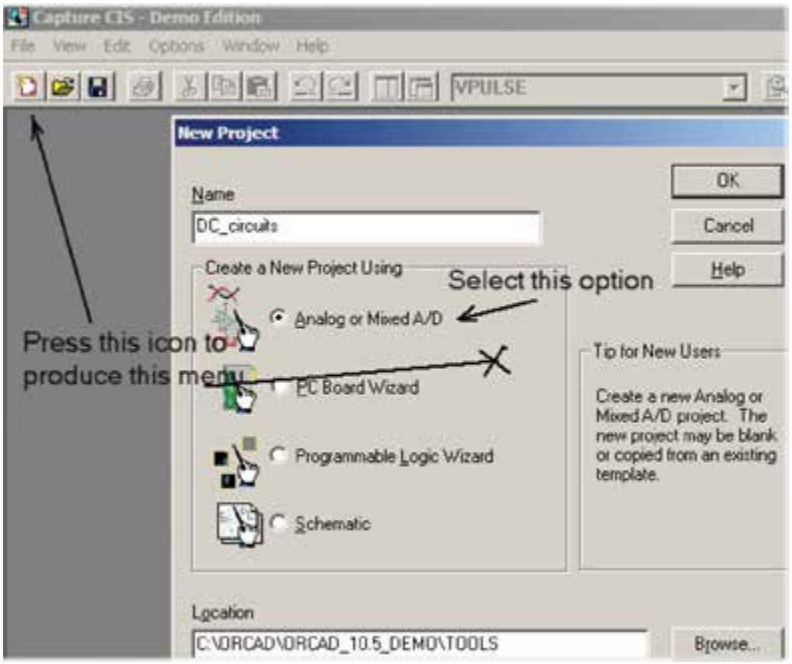

FIGURE 1: Creating new project file

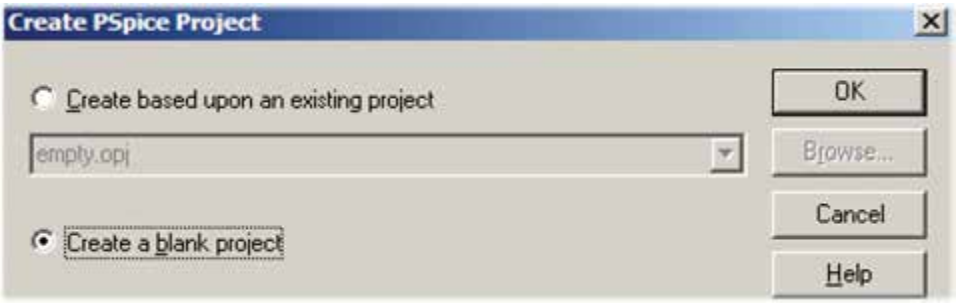

FIGURE 2: Create a blank project

whatever you called the project) to produce an empty schematic area called **Page 1** where components are placed. Libraries have to be added, (**Add library**) by selecting the little **AND** symbol from the right toolbar icons. The easiest method is to select all the libraries. However, if you select **Create based upon an existing project**, then all previously used libraries associated with that project will be loaded.

It is a sad fact that analog communications, over the last few years, has taken a back seat to digital communications. I suppose this is an inevitable step but still, the principles of analog communications have a lot of important concepts that will never go away. To this end, this book covers those important principles through the amazing teaching world of PSpice simulation. In Chapter 1 we look at various amplitude modulation methods. Here we import speech ASCII signals [ref 6] and look at the time and frequency domains signals. The transmission efficiency is considered by looking at the power signals and leads us to examine suppressed carriers methods in Chapter 2. In this chapter we select the correct choice of components for the detection circuit and the AGC circuit. Double sideband carrier suppressed techniques using the AD633 four-quadrant multiplier IC are investigated.

In Chapter 3, we examine a range of oscillators and include the important topic of stability by looking at gain and phase margins in a frequency response plot and a Nyquist plot for assessing stability. Chapter 4 deals with the AM superhetrodyne receiver and all the problems associated when you couple stages together. Here, we examine JFET and BJT mixers for producing the superhetrodyne effect and the associated problem of image frequency. Chapter 5 looks at frequency modulation principles and the phase lock loop for recovering the modulation signal. We generate an FM stereo signal using imported speech signals in order to examine the spectrum associated with stereo production. In Chapter 6 we look at an FM superhetrodyne receiver which uses double-tuned RF amplifiers to accommodate the larger bandwidth associated with FM transmission. Chapter 7 examines the important concept of noise and how we can import noise into circuits for assessment purposes.

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