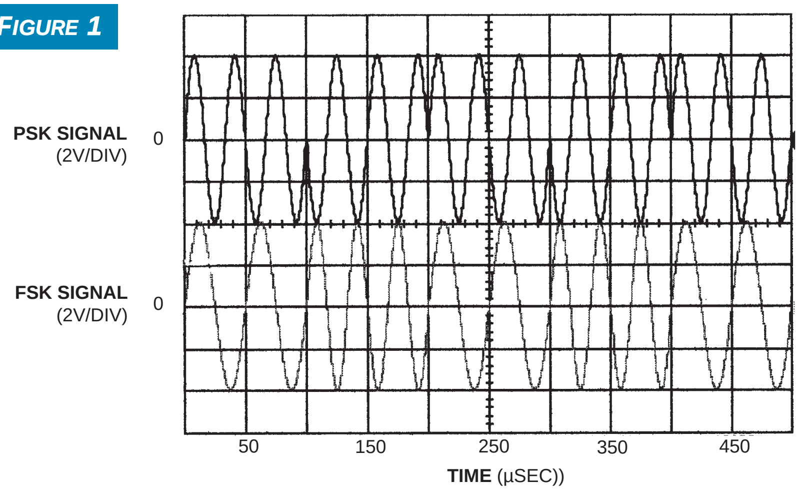
Spice generates PSK and FSK signals

DEBRA HORVITZ, GALAHAD SYSTEMS, LAGUNA HILLS, CA

Creating generators for amplitude-, frequency-, and phase-modulated signals can greatly simplify communication-system simulation. Although Spice includes a basic set of waveform generators, it includes no built-in support for many types of signals. You must create these signals from combinations of elements, and you can create variations of these built-in generators using Spice 2-dependent sources. However, using dependent sources to generate complex waveforms can require fairly complex Spice subcircuits.

Fortunately, the nonlinear, arbitrary dependent source—the B element—in Berkeley Spice 3 and IsSpice4 (Intusoft, San Pedro, CA) provides a quantum leap in capability over Spice 2-dependent sources. The B element is more versatile and easier to use. For example, **Listing 1** is the IsSpice4 subcircuit for a parameterized phase-shift-keying (PSK) source; **Listing 2** is the subcircuit of a parameterized frequency-shift-keying (FSK) source. **Figure 1** shows the resultant output signals of each subcircuit generator.

FIGURE 1



The behavioral and mathematical capabilities of Spice 3 and IsSpice 4 make it easy to create PSK and FSK signals.

The PSK subcircuit produces a coherent binary PSK signal according to the following equations:

$$s_1(t) = \sqrt{\frac{2 \bullet EB}{TB}} \bullet \sin(2\pi f t),$$

$$s_2(t) = -\sqrt{\frac{2 \bullet EB}{TB}} \bullet \sin(2\pi f t),$$

where EB is the transmitted energy per bit, TB is the bit duration, and f is the transmission frequency equal to NC/TB. (NC is an integer constant, and the period is 2×TB; thus, the duty cycle equals 50%.) In **Listing 1**, the input voltage source, VSIG, produces the polar form of the input signal. Using the B1 element, the subcircuit multiplies this input by the local oscillator voltage, VLO1, to produce the PSK output signal.

The subcircuit, FSK, produces a coherent binary FSK signal according to the following equations:

$$s_1(t) = \sqrt{\frac{2 \bullet EB}{TB}} \bullet \sin(2\pi f_1 t),$$

$$s_2(t) = \sqrt{\frac{2 \bullet EB}{TB}} \bullet \sin(2\pi f_2 t).$$

where f_1 is the high-bit transmission frequency, and f_2 is the low-bit transmission frequency. The frequency, f_1, is equal to NC+1/TB. The frequency, f_2, is equal to NC+2/TB. For simplicity, two pulse generators, VSIG and VSIGN, produce the input signal, m(t), and the inverse of the message signal, M(t), respectively. Again, using the B1 element, the subcircuit code multiplies these signals by the appropriate frequency generator: VLO1 for logic high and VLO2 for logic low. The sum of the resultant signals produces the FSK output signal. (DI #2173)

EDN

LISTING 1—ISSPICE4 SUBCIRCUIT FOR PSK SOURCE

```
.SUBCKT PSK  3   ; Signal Generator for PSK
VSIG 2 0  PULSE  {-(EB)^2}  {(EB)^2}  {TD}  {TR}  {TF}
+ {50/100*(2*TB-TR-TF)}  {2*TB}
B1 3 0 V = V(1) * V(2)
VLO1 1 0  SIN 0 {(2/EB)^2}  {(NC)/TB}
.ENDS
```

LISTING 2—SUBCIRCUIT FOR FSK SOURCE

```
.SUBCKT FSK  5 ; Signal Generator for FSK
VSIG 3 0  PULSE  0  {(EB)^2}  {TD}  {TR}  {TF}
 {50/100*(2*TB-TR-TF)}  {2*TB}
VSIGN 4 0  PULSE  {(EB)^2}  0  {TD}  {TR}  {TF}
 {50/100*(2*TB-TR-TF)}  {2*TB}
B1 5 0 V = (V(1) * V(3)) + (V(2) * V(4))
VLO1 1 0  SIN  0  {(2/EB)^2}  {(NC+1)/TB}
VLO2 2 0  SIN  0  {(2/EB)^2}  {(NC+2)/TB}
.ENDS
```