EXPERIMENT 1.f

SPREAD SPECTRUM – DSSS MODULATION & DEMODULATION

INTRODUCTION:

Recall that when a sinusoidal carrier is DSBSC modulated by a message, the two signals are multiplied together. Recall also that the resulting DSBSC signal consists of two sets of sidebands but no carrier.

When the DSBSC signal is demodulated using product detection, both sidebands re multiplied with a local carrier that must be synchronized to the transmitter's carrier that is , it has the same frequency and phase. Doing so produces two messages that are in phase with each other and so add to form a single bigger message.

Direct sequence spread spectrum is a variation of DSBSC modulation scheme with a pulse train for the carrier instead of a simple sinewave. This may sound radical until you remember that pulse trans are actually made up of a theoretically infinite number of sinewaves. That being the cse, spread spectrum is really the DSBSC modulation of a theoretically infinite number of sinusoidal carrier signals. The result is a theoretically infinite number of pairs of tiny sidebands about a suppressed carrier.

In practice, not all of these sidebands have any energy of significance. However, the fact that the message information is distributed across so many of them makes spread spectrum signals difficult to deliberately interfere with "jam". To do so , you have to upset a significant number of the sidebands which is difficult considering their number .

Spread spectrum signals are demodulated in the same way as DSBSC signals using a product detector. Importantly, the product detectors local carrier signal must contain all the sinewaves that m ake up transmitter's pulse train at the same frequency and phase. If this is not done, the tiny demodulated signals will be at the wrong frequency and phase and so they wont add up to reproduce the original message. Instead, they'll produce a garbage signal that looks like noise.

The only way to obtain the right number of sinewaves at the right frequency and phase at the receiver is to use a pulse train with an identical sequence to that used by the transmitter. Moreover, it must be synchronized. This issue gives spread spectrum another of its advantages over other modulation schemes. The transmitted signal is effectively encrypted.

Of course, with trial and error its possible for an unauthorized person to guess the correct PN sequence to use for their receiver. However, this can be made difficult by making the sequence longer before it repeats itself. Longer sequences can produce more combinations of unique codes which would take longer to guess using a trial and error approach. To illustrate this point , an 8 bit code has 256 combinations while a 20 bit code has 1048575 combinations. A 256 bit code has $1.1579*10^{77}$ combinations.

Increasing the sequence’s chip-length has another advantage. To explain, the total energy in a spread spectrum signal is distributed between all of the tiny DSBSC that make it up. A mathematical technique called Fourier Analysis shows that the greater the number of chips in a sequence before repeating, the greater the number of sinewaves of significance needed to make it.

That being the case, using more chips in the transmitter’s PN sequence products more DSBSC signals and so the signal’s total energy is distributed more thinly between them. This in turn means that the individual signals are many and extremely small. Infact , if the PN sequence is long enough, all of these DSBSC signals are smaller than the background electrical noise that’s always present in free space. This fact gives spread spectrum yet another important advantage. The signal is difficult to detect.

Spread spectrum finds use in several digital applications including: CDMA mobile phone technology, cordless phones. The global positioning system and two of the 805.11 Wi-fi standards

OBJECTIVE:

In this experiment you’ll use the Emona Telecoms-Telecoms-trainer 101 generate a DSSS signal by implementing its mathematical model. You’ll then use a product detector (with a stolen carrier) to reproduce the message. Once done, you’ll examine the importance of using the correct PN sequence for the local carrier and difficulty of jamming DSSS signals.

Equipment

1. Emona Telecoms Trainer 101 (plus power pack
2. Dual channel 20 MHz oscilloscope
3. Two Emona Telecoms Trainer 101 oscilloscope leads
4. Assorted Emona Telecoms Trainer 101 patch leads.

Procedure :

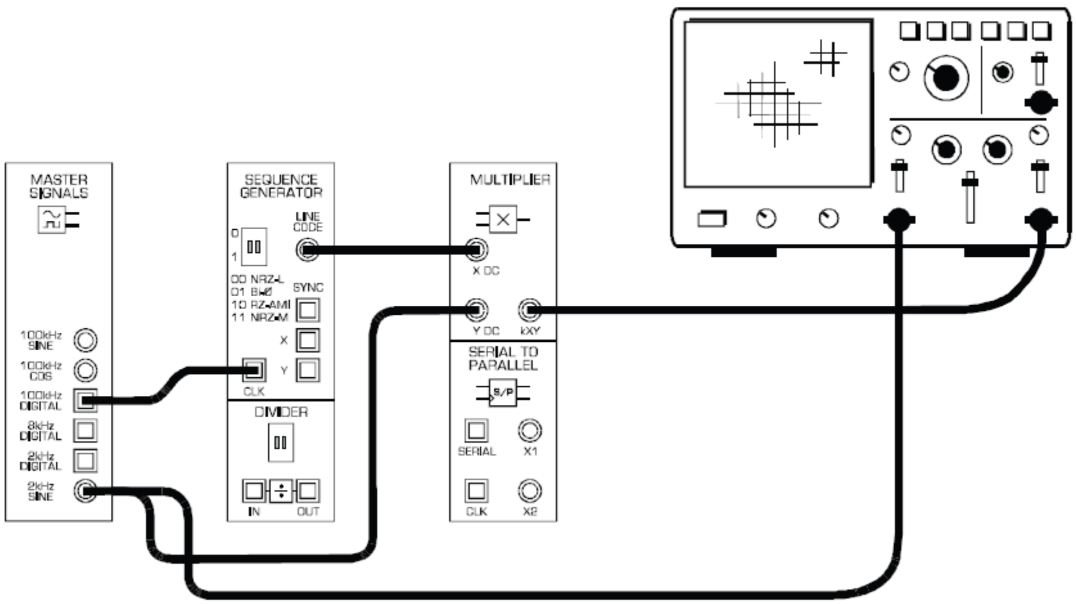
Part A

As DSSS is basically just DSBSC with a pulse train for the carrier instead of a simple sinusoid, it can be generated by implementing the mathematical model for DSBSC.

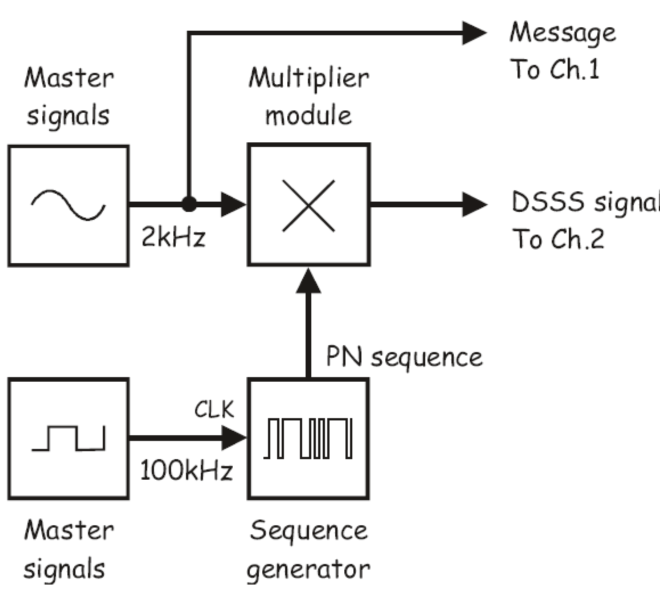
1. Gather a set of the equipment listed on the previous page.
2. Set up the scope per the instructions in experiment 1.
    a. The Trigger source control is set to the CHI position
    b. The Moe control is set to the CHI position.
3. Set the scope’s Trigger source coupling control the t he HF REJ position.
4. Locate the sequence Generator module and set its dip-switches to 00

   a. To do this, push both switches up.

5. Connect the set-up shown in Figure 1 below.
   a. Note : Insert the black plugs of the oscilloscope leads into a ground (GND) socket.



The set up i*N FIG 1* can be represented by the block diagram in Fig 2 below. It multiplies the 2 kHz sinewave message with a PN sequence modeled by the sequence Generator's 32 bit pulse train output.

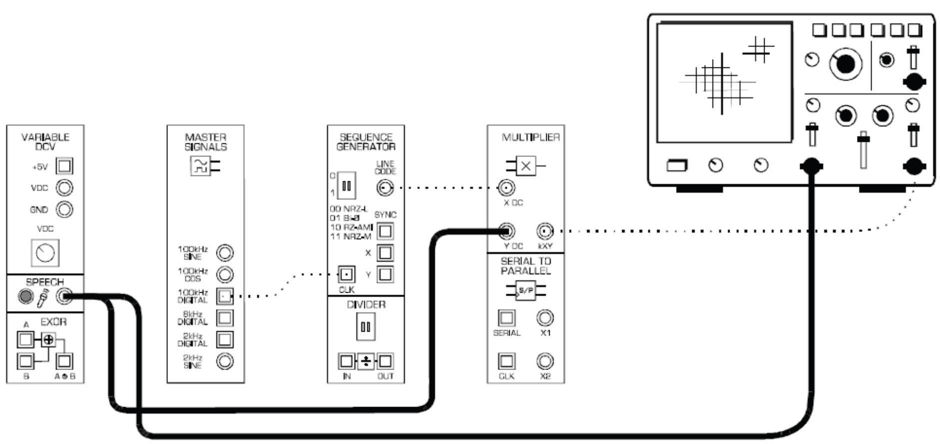


6. Adjust the scope's Time base control to view two or more cycles of the Master signals modules 2 kHz sine output.
7. Set the scope's Mode control to the DUAL position to view the DSSS signal out of the Multiplier Module as well as the message signal.
8. Adjust the scope's Vertical Attenuations controls to the appropriate settings for the signals.
9. Draw the two waveforms to scale in the space provided on the next page leaving room to draw a third waveform.
    a. Tip: Draw the message signal in the upper third of the graph and DSSS signal in the middle third.
10. Use the scope's channel 1 Vertical position control to overlay the message with the DSSS signal's envelope's and compare them.

Part B – Generating a DSSS signal using speech.

So far , this experiment has generated a DSSS signal using a sinewave for the message. The next part of the experiment lets you see what a DSSS signal looks like when modulated by speech.

11. Disconnect the plugs to the Master signals module's 2kHz sine output.
12. Connect them to the speech module's output as shown in fig 3 below.
    a. Remember Dotted lines sow leads already in place.

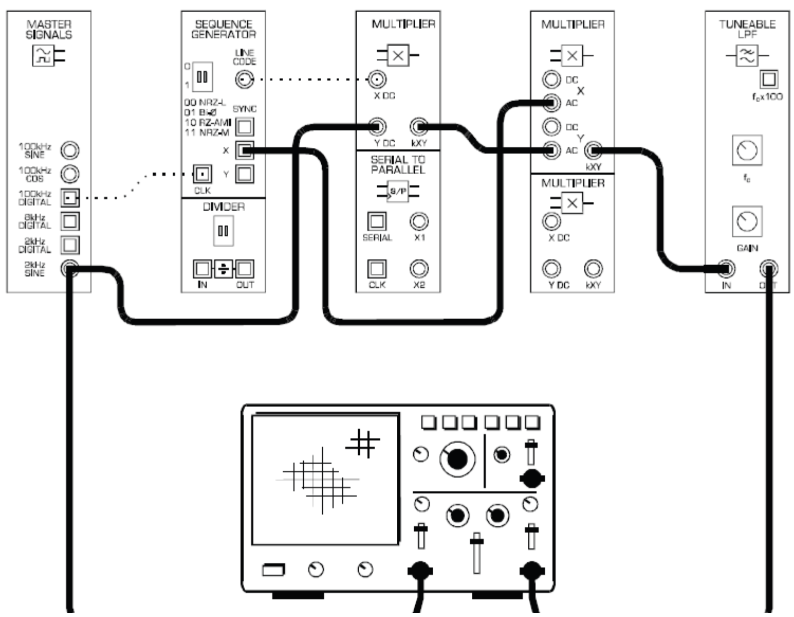


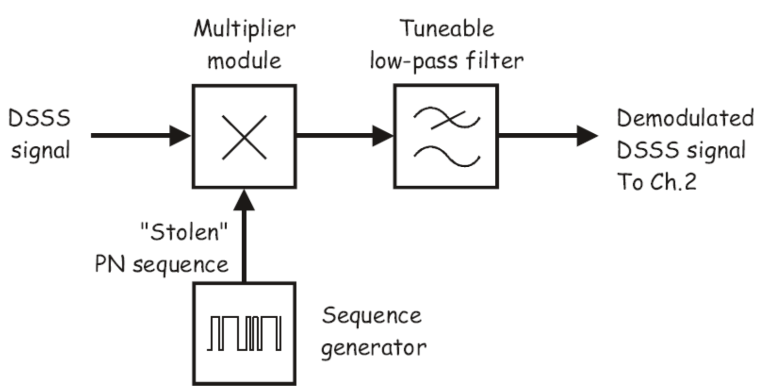
13. Set the scope's time base control to the 2ms/div position.
14. Talk, sing or hum while watching the scope's display.

Part C

Using the product detector to recover the message.

15. Return the scope's Time base control to its original position.
16. Locate the Tunable low pass filter module and set its Gain control to about the middle of its travel.
17. Turn the tunable low pass filter modules cut-off frequency adjust control fully anti-clockwise.
18. Disconnect the plugs to the speech module's output and modify the set-up as shown in Fig 4 below



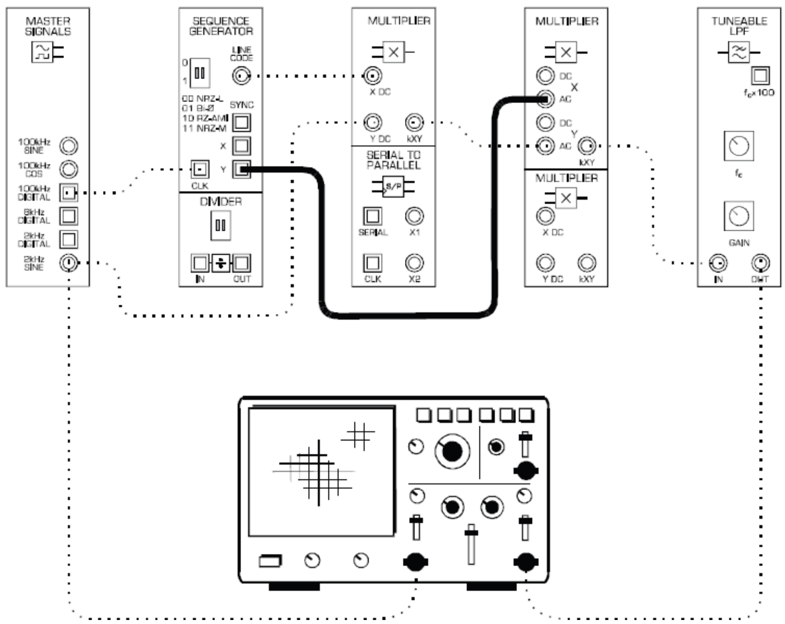


19. Slowly turn the Tunable low-pass Filter module's cut – off Frequency control clockwise while watching the scope's display and stop when it's at about half its travel.

20. Draw the demodulated DSSS signal to scale in the space that you left on the graph paper.

Recall that the message can only be recovered by the product detector if an identical PN sequence to the DSSS modulator's carrier is used. The next part of the experiment demonstrates. This.

21. Modify the setup as shown in Fig 7 below to make the demodulator's local carrier a different PN sequence to the transmitter's carrier.



22. Compare the message with the product detector's new output.

Part D

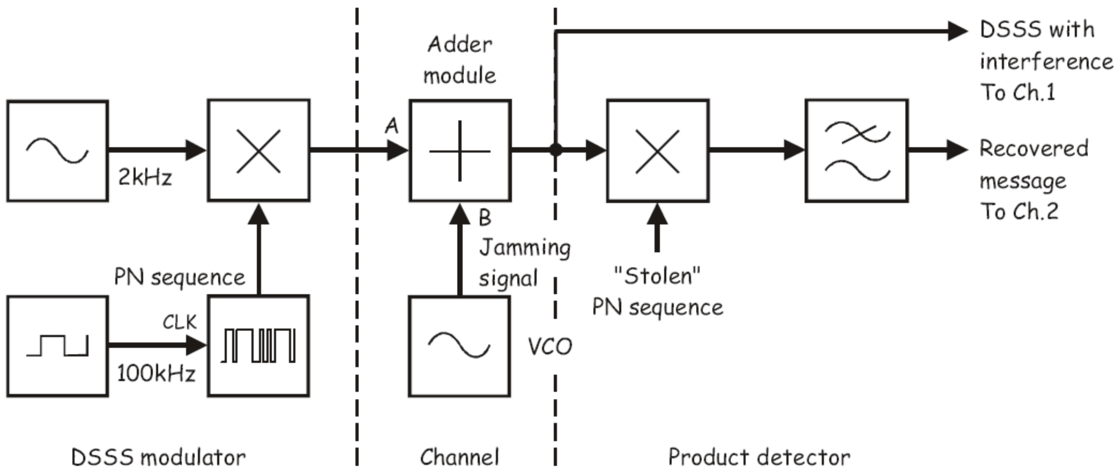
DSSS and deliberate interference (Jamming)

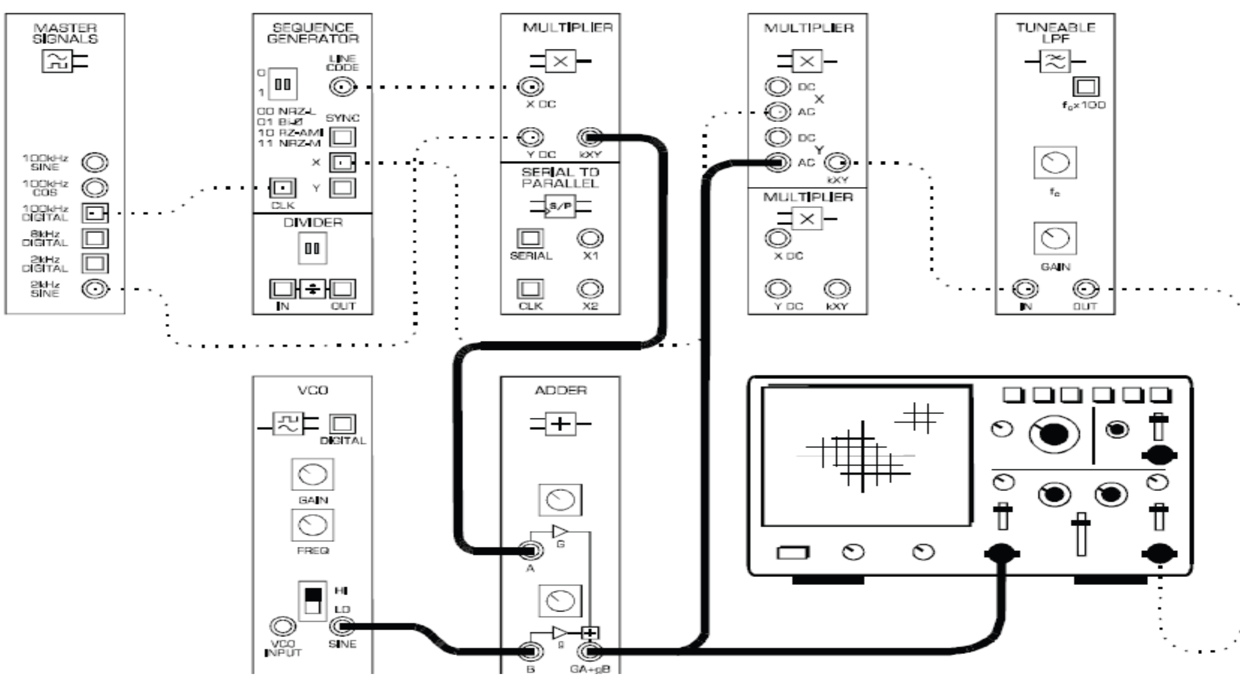
Interferences occurs when an unwanted electrical signal gets added to the transmitted signal and changes it enough to change the recovered message. Electrical noise is a significant source of unintentional interference.

However, sometimes noise is deliberately added to the transmitted signal for the purpose of interfering or Jamming it. The next part of the experiment models deliberate interference to show how spread spectrum signals are highly resistant to it.

23. Move the patch lead from the sequence Generator's Y output back to its X output.
   a. Note : The product detector should now be recovering the message again.
24. Locate the VCO module and set its Range control the HI position.
25. Set the VCO modules Frequency Adjust control to about the middle of its travel.
26. Locate the Adder Module and turn its g control fully anti clockwise.

27. Set the Adder module’s G control to about the middle of its travel.
28. Modify the setup as shown in Fig 8 below.



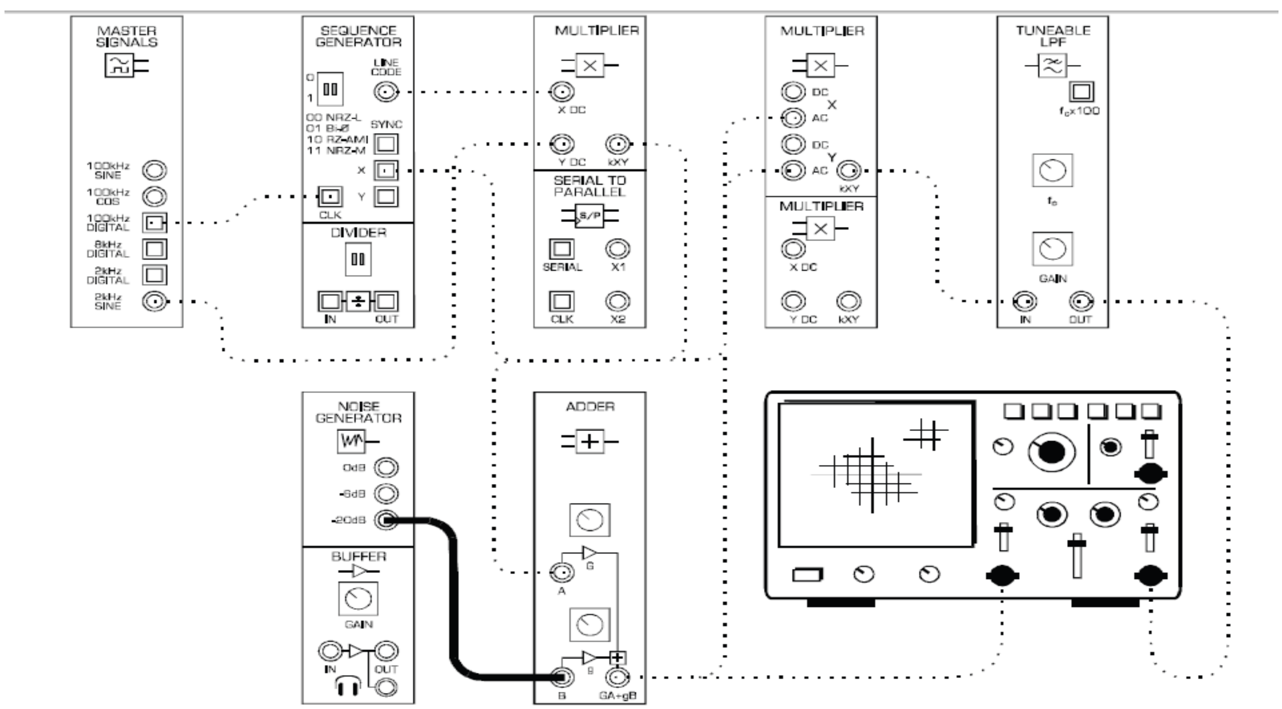


This modification forces the VCO module’s output to sweep continuously through a wide range of Frequencies.

29. compare the two signals. Notice that the DSSS signal with interference is very distorted but the recovered message is only mildly affected.

An even more sophisticated approach to jamming involves using jamming signals at once to increase the chances of upsetting the transmitted signal. The next part of the experiment let's you see how spread spectrum handles this.

30. Modify the setup shown in Fig 11 below. This modification uses the Noise generator module to model a jamming signal that consists of thousands of frequencies.
31. Compare the two signal. Notice that the DSSS signal with interference is distorted but the recovered message is only mildly affected.
32. Increase the strength of the broadband jamming signal by connecting the Adder.
33. Compare the DSSS signal and the recovered message.
34. Increase the strength of the broadband jamming signal even more by connecting the Adder module's B input to the Noise Generator module's 0dB output.
35. Compare the two signals. Notice how distorted DSSS signal is but how little the recovered message is affected.
36. Modify the Setup as shown.



Result:

Thus the Experiment was performed successfully.