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# Design of DSSS communication teaching assistant system

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# Design of DSSS communication teaching assistant system

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**Abstract.** Based on LabVIEW, the DSSS communication system under TCP/IP protocol is developed. It uses dual frequency USB wireless network card with a low price to build the wireless communication channel between PCS. The transmitter can generate spread spectrum signals with different time delays of different users' data which could be used to simulate the multipath propagation in mobile communication. The receiver uses different m sequences with different time delays to despread the received signal. The system can display the time domain waveform comparison and power spectrum comparison before and after processing, as well as the bit error rate under different parameters. They play a very good role in theoretical analysis and verification. The use of teaching assistant system is conducive to improve students' interest in study and design.

## 1. Introduction
Spread spectrum communication technology is widely used in military and civil communication fields[1][2] because of its outstanding anti-interference ability and communication concealment. As an important teaching content of mobile communication, IoT communication and other courses, spread spectrum technology is explained by means of system principle block diagram and static simulation waveform diagram. In this traditional way of teaching, students' participation is relatively low. If the real-time dynamic simulation experiments of spread spectrum communication can be introduced into the classroom, it can not only attract students' attention, but also make the theory intuitive and concrete, which is conducive to students' understanding and mastery[8]. The experimental systems of DSSS communication mentioned in literature [9] intuitively demonstrates its structural features and characteristics, which is a pure software simulation. The other mentioned in Literature [10] is a semi-physical experiment system which combines programmable PC communication simulation software and software radio platform. The former lacks engineering support, while the latter combines model building with hardware engineering effectively, but the equipment is expensive. It's not affordable for students.

In this paper, the DSSS communication teaching system has been developed with LabVIEW graphical platform. Its high-speed wireless data transmission path between multiple PCS is established by dual-frequency USB wireless network card which is portable, plug and play. More importantly, it is affordable and suitable for students who are interested in design.

## 2. Principle of DSSS communication
The bandwidth $B$ of the digital baseband signal is inversely proportional to the code element width $T_b$. Take the bi-polar non-zero digital baseband signal as an example, $B$=1/$T_b$. If each code element is replaced by a sequence composed of $N$ chips, the chip width of the new digital baseband signal will be $T_c$=$T_b$/$N$, therefore the bandwidth will be extended to $N$ times of the original signal, which will be sent out as a broadband signal, that is, spectrum spread. Pseudo-random sequence is a kind of sequence that

has some statistical properties similar to random sequence and can be produced repeatedly. The process of using pseudo-random sequence to spread spectrum is called spread spectrum in DSSS communication. The receiver can efficiently restore the received broadband signal to narrow band according to the self-correlation and cross-correlation characteristics of the pseudo-random sequence, that is, despread. Then the original digital baseband signal is recovered by integration, sampling and decision. There are many kinds of pseudo-noise sequences. The most basic and commonly used one is the longest linear feedback shift register sequence, also known as m sequence, which is generated by $n$-level shifter with linear feedback, and the period length is $N=2^n$. M sequence has sharp two-value self-correlation, and its cross-correlation value will be closer to 0 with the increase of $N$, so that the anti-multipath and anti-narrowband interference performance of DSSS communication system will be enhanced with the increase of $N$.

## 3. Design of teaching assistant system

The DSSS communication teaching assistant system is composed of wireless communication module, transmit module and receive module. The overall design process is shown in Figure 1.

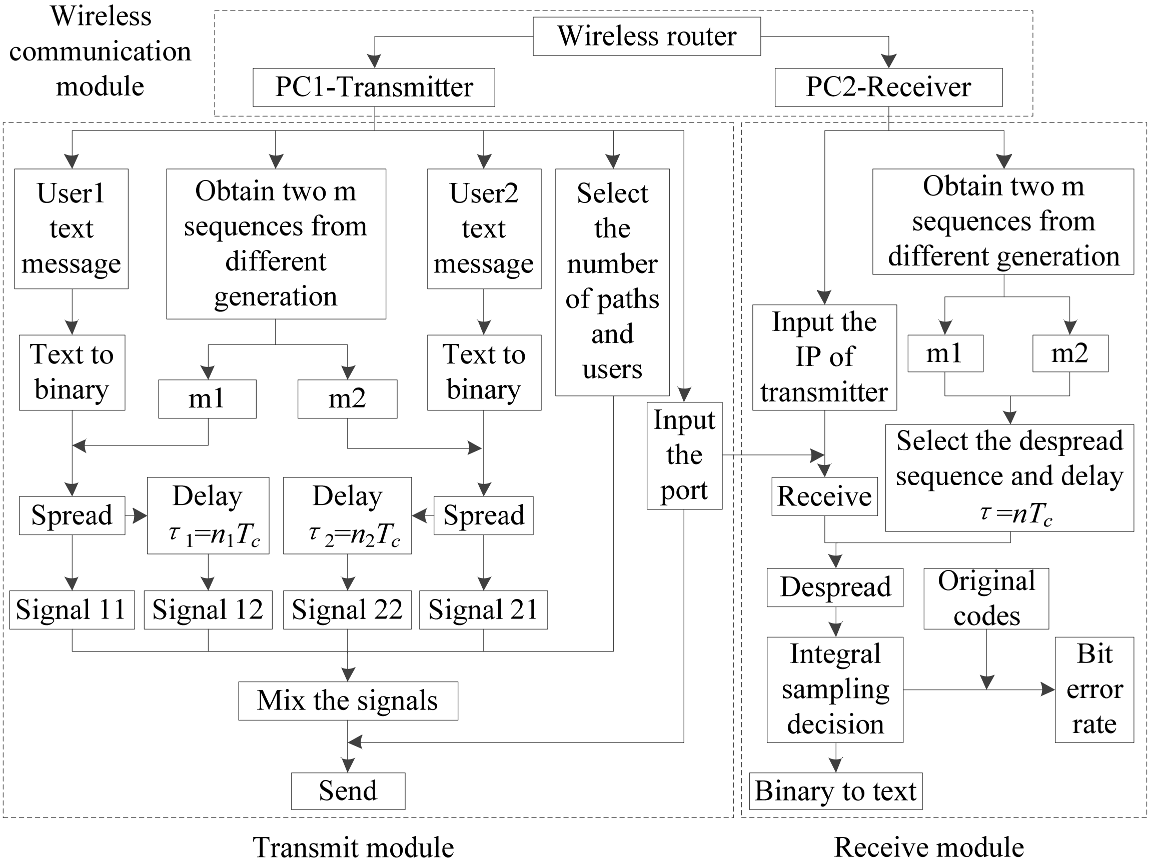
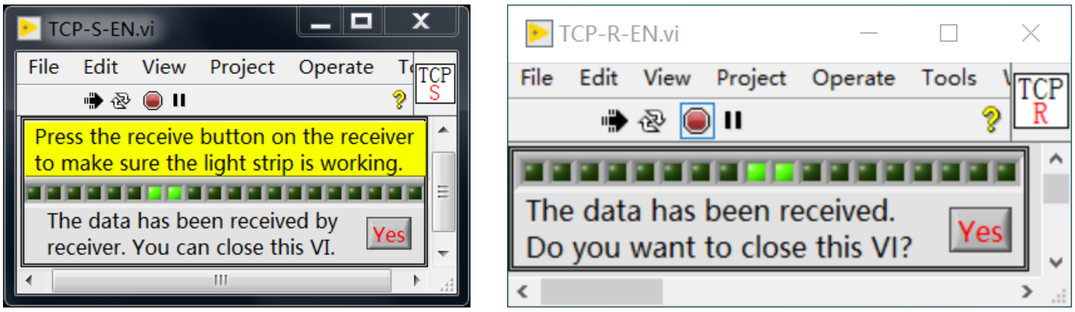



Figure 1. Design flow chart of the DSSS communication teaching assistant system

### *3.1. Wireless communication module*

TP-Link TL-WDN5200H drive free version 650M dual-frequency USB wireless network card is selected as the wireless router. In combination with data sending and receiving terminal VI under the TCP/IP protocol as shown in Figure 2, the wireless communication function between PC1 and PC2 is realized.




(a)Sending terminal VI (b)Receiving terminal VI

Figure 2. Wireless communication VI under the TCP/IP protocol

### *3.2. Transmit module*

It can be seen from the design flow chart of transmit module in Figure 1 that the transmit module mainly consists of 4 parts, which are 3 or 5 level m sequence generation, text-to-binary conversion, spread spectrum and sending. Its operation effect is shown in Figure 3. The transmit module can generate multiple spread spectrum signals with m1 or m2 sequence according to the number of signal paths and the delay parameters of two users, and then simulate multipath propagation in mobile communication through the superposition and transmission of signals. The "Spread spectrum" button is used to perform spread spectrum calculations, meanwhile the "TCPS-T&F.vi" is dynamically called. As shown in Figure 4, the spread spectrum operation broadens the bandwidth of digital baseband signals. By reading the frequency value of the first spectral zero, the relationship between the bandwidth of signals before and after spread spectrum and the periodic length $N$ of m sequence can be verified.

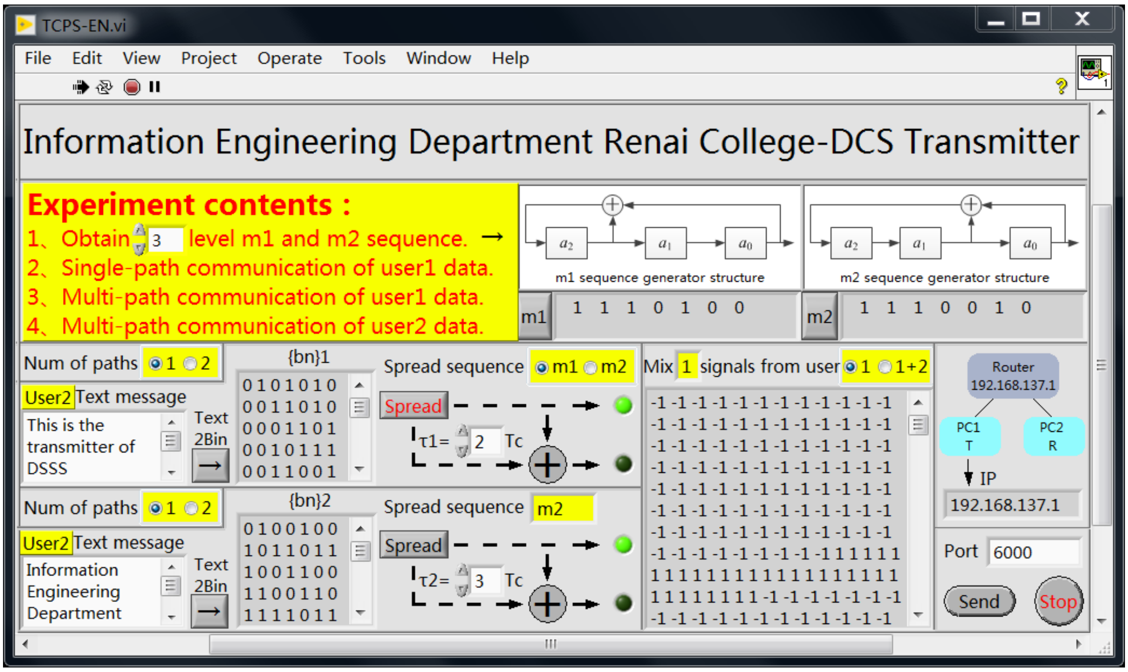



Figure 3. Operation effect of the transmit module

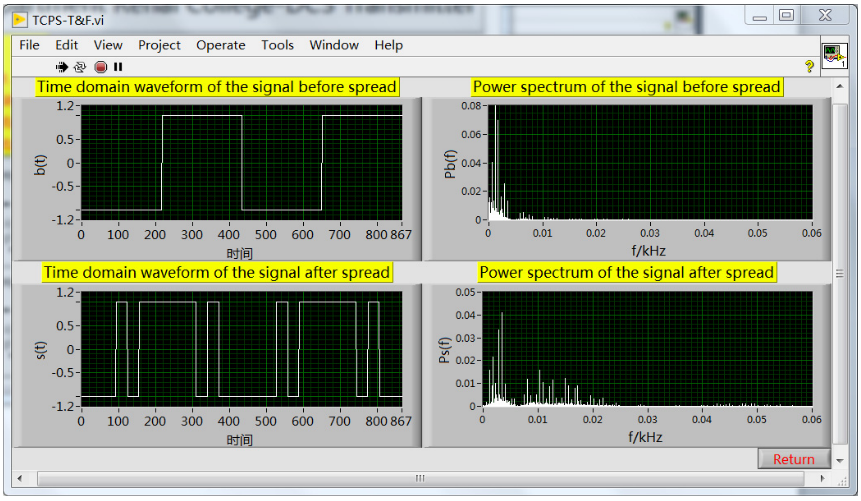



Figure 4. Comparison of the signals before and after spread spectrum

### 3.3. *Receive module*

It can be seen from the design flow chart of receive module in Figure 1 that the receive module mainly consists of 5 parts, which are signal receiving, 3 or 5 level m sequence generation, despread, integration and sampling decision, and binary-to-text conversion. Its operation effect is shown in Figure 5. The "Despread" button is used to perform despread calculations with m sequence, meanwhile the "TCPR-T&F.vi" is dynamically called to compare the signals between before and after despread as shown in Figure 6. The "Integral→Sampling→Decision" button is used to restore the binary codes, meanwhile the "TCPR-Tb-Integral.vi" is dynamically called to display the time domain waveform of integral signal as shown in Figure 7. The bit error rate is calculated between the recovered binary codes and the binary codes obtained by user's text conversion such as {bn}1 and {bn}2 in Figure 3. At the same time, the text message is recovered by binary codes to text conversion.

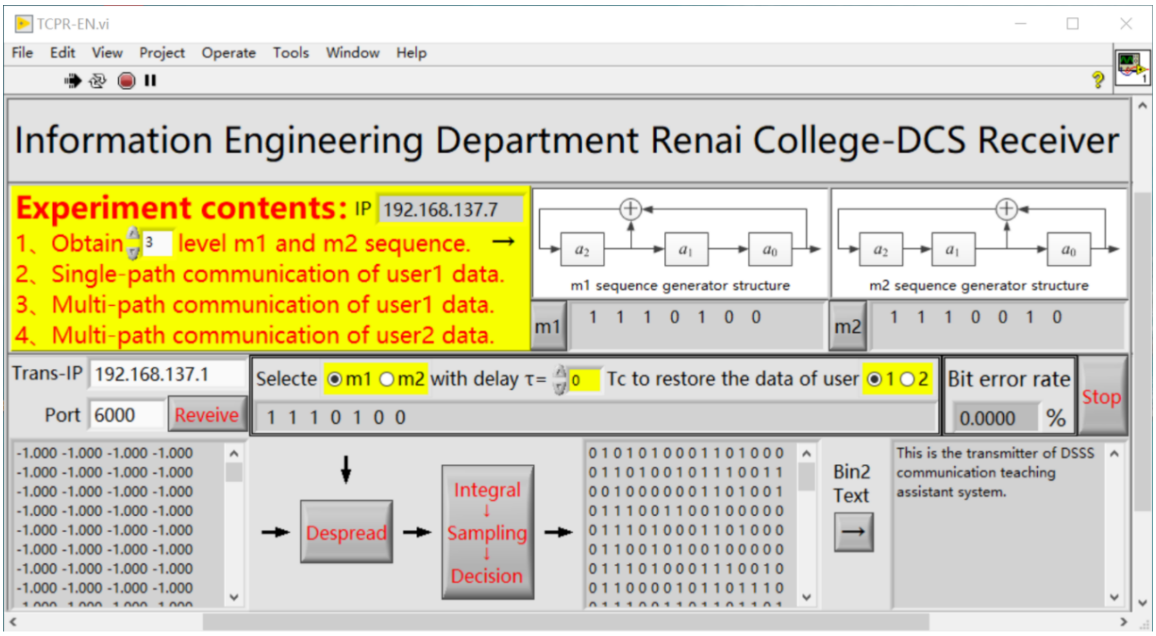



Figure 5. Operation effect of the transmit module

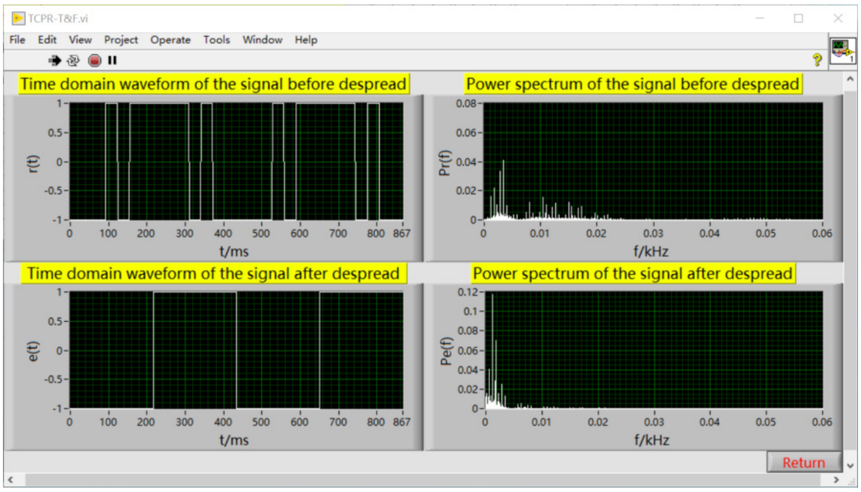



Figure 6. Comparison of the signals before and after despread

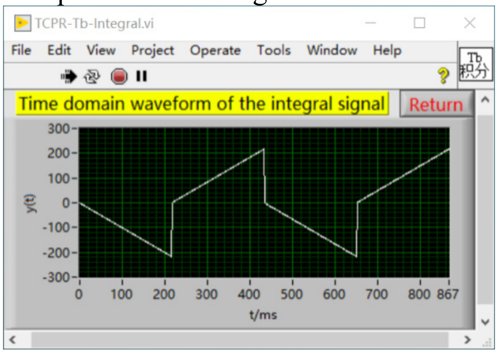



Figure 7. Time domain waveform of the integral signal

## 4. Simulation experiment data and analysis

The DSSS communication environment built by two PCS and a USB wireless network card is shown in Figure 8. The bit width Tb is 217ms. Communication experiments are conducted on user1 data under different number of paths, different delays and different despread sequences. The bit error rates under 3 and 5 level m sequences are recorded in Table 1 and Table 2 respectively.

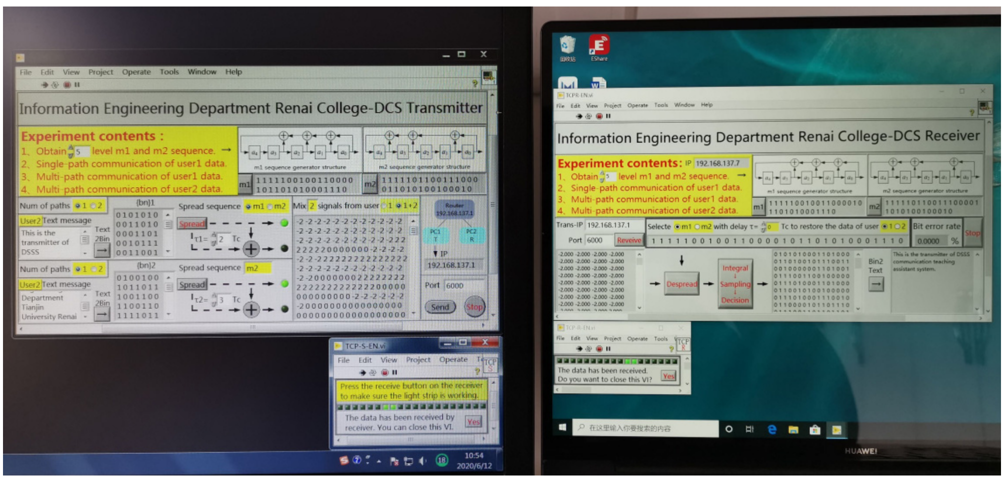



Figure 8. Operation effect of the DSSS communication teaching assistant system

Table 1. Bit error rate of user1 data communication with 3 level m sequence

| User(m sequence) | Multipath signals | | Bit error rate of user1 data communication(%) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of paths | Sending signal ($\tau_1$=2$T_c$, $\tau_2$=3$T_c$) | Despread with m1 | | | Despread with m2 | | |
| | | | $\tau$=0 | $\tau$=2$T_c$ | $\tau$=3$T_c$ | $\tau$=0 | $\tau$=2$T_c$ | $\tau$=3$T_c$ |
| User1(m1) | 1 | 11 | 0 | 41.049 | 41.049 | 0 | 0 | 41.049 |
| | 2 | 11+ 12 | 0 | 0 | 41.049 | 40.895 | 0 | 41.049 |
| User1(m1) + User2(m2) | 2 | 11+ 21 | 0 | 39.969 | 47.222 | 35.494 | 0 | 47.222 |
| | 3 | 11+12+21 | 0 | 0 | 41.049 | 41.667 | 0 | 41.049 |
| | | 11+21+22 | 0 | 40.586 | 41.667 | 35.494 | 0 | 41.667 |
| | 4 | 11+ 12+ 21+ 22 | 0 | 4.321 | 44.599 | 41.667 | 0 | 41.667 |

Table 2. Bit error rate of user1 data communication with 5 level m sequence

| User(m sequence) | Multipath signals | | Bit error rate of user1 data communication(%) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of paths | Sending signal ($\tau_1$=2$T_c$, $\tau_2$=3$T_c$) | Despread with m1 | | | Despread with m2 | | |
| | | | $\tau$=0 | $\tau$=2$T_c$ | $\tau$=3$T_c$ | $\tau$=0 | $\tau$=2$T_c$ | $\tau$=3$T_c$ |
| User1(m1) | 1 | 11 | 0 | 92.593 | 92.593 | 0 | 92.593 | 41.049 |
| | 2 | 11+ 12 | 0 | 0 | 92.593 | 0 | 92.593 | 0 |
| User1(m1) + User2(m2) | 2 | 11+ 21 | 0 | 49.074 | 75.309 | 35.494 | 92.593 | 47.222 |
| | 3 | 11+12+21 | 0 | 0 | 73.302 | 35.494 | 92.593 | 0 |
| | | 11+21+22 | 0 | 49.074 | 49.074 | 35.494 | 92.593 | 41.667 |
| | 4 | 11+ 12+ 21+ 22 | 0 | 0 | 49.074 | 35.494 | 81.944 | 35.494 |

Obviously, when the despread sequence and spread spectrum sequence are completely consistent, the receiver can recover the original data well. Meanwhile, the longer the periodic length of m sequence $N$ is, the better the anti-multipath interference performance of DSSS communication system will be.

## 5. Conclusion

With the aid of USB wireless network card, the teaching assistant system of DSSS communication can complete the simulation experiments by a single PC or between multiple PCS, according to the different teaching environment, and assist to complete the teaching of DSSS communication principle. The system selects TCP/IP protocol that students majoring in communication and electronics are familiar with and devices that are easy to get in touch with in daily life, so as to improve students' participation and enhance theoretical learning with the help of simulation design.

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