Diale Number Detection

EXERCISE OBJECTIVE

When you have completed this exercise, you will be familiar with the detection of telephone numbers produced using either pulse or tone dialing. You will learn that the way the central office detects telephone numbers dialed on a telephone set depends on whether pulse or tone dialing is used.

DISCUSSION

Introduction

Dialing is the means used by a subscriber to transmit to the call processor of the central office, the telephone number that he, or she, wishes to call. There are two techniques of dialing: pulse dialing which is the older, slower technique, and dual-tone multiple frequency (DTMF) dialing which is the newer, faster technique.

In both techniques, dialing signals enter the central office via the analog line interface. However, the way the telephone number dialed by the subscriber is detected in the central office depends on the dialing technique used.

Dial Number Detection (Pulse dialing)

Pulse dialing originates from older telephone sets provided with a rotary dial. On these telephone sets, a spring-loaded dial is rotated and released for each digit of the telephone number. As the dial returns to the rest position, a switch in the dial mechanism briefly interrupts the current flowing through the telephone line (loop current) several successive times to transmit the dialed digit to the central office as a series of short current pulses. The number of momentary loop current interruptions produced depends on the digit dialed: one interruption for the digit 1, two interruptions for the digit 2, and so on up to the digit 0 which results in 10 interruptions. Figure 1-6 shows an example of the loop current interruptions when various digits are dialed. Each loop current interruption causes the corresponding hook status signal to go to logic state 0 momentarily.

Time-multiplexed pulse dialing (hook status) signals are routed, via the hook status lines, to the hook status demultiplexing and storage circuit of the signaling circuit where they are demultiplexed and stored in memory. The call processor continually monitors the hook status signal related to each telephone set connected to the central office by reading the memory at regular intervals.
Dial Number Detection

A: DIAL PULSE PERIOD (100 ms)
B: LOOP CURRENT INTERRUPTION
   (NORTH AMERICA: 60 ms, OTHER COUNTRIES: ~ 67 ms)
C: CURRENT PULSE DURATION
   (NORTH AMERICA: 40 ms, OTHER COUNTRIES: ~ 33 ms)
D: INTER-DIGIT INTERVAL (>300 ms, NORTH AMERICA: ~700 ms)

Figure 1-6. Loop current pulses produced when the digits 1, 2, and 4 are dialed successively.

A pulse dialing detector in the call processor detects a dialed digit by counting the number of times the hook status bit, stored in the memory, goes from logic state 1 to logic state 0 between each inter-digit interval. To prevent the counter from being triggered by electrical disturbances or glitches, the pulse dialing detector takes no action until the hook status bit remains at logic state 0 for approximately 60 ms. The counter is reset to zero at each inter-digit interval. To ensure reliable number detection, the call processor reads the hook status buffer memory at a rate that is usually greater than 100 Hz (<10-ms period). Since the loop current interruption in a dial pulse period (100 ms) ranges between 60 and 67 ms, the call processor reads the hook status at least 6 times per dial pulse period. This ensures the detection of every zero pulses that occur in the hook status signal when a digit is dialed on a pulse dialing telephone set.

In the Telephony Training System software, the content of the HOOK STATUS BUFFER MEMORY is refreshed at a rate that is fast enough to show that the hook status bit associated with the calling telephone alternates between logic states 0 and 1 whenever a digit is dialed. Furthermore, the DETECTED DIGITS displays indicate the digits detected by the PULSE DIALING DETECTOR of the CALL PROCESSOR.

Dial Number Detection (Tone dialing)

Today, most analog telephone sets are of the electronic type and use audio tones for dialing telephone numbers. On such telephone sets, dialing is performed through a standard 12-key pad. A specific frequency is associated with each row and column of the keypad. When a key is depressed, a dual-tone audio signal consisting of the frequencies associated with the corresponding row and column is output to the telephone line. When a complete telephone number is dialed, dual-tone audio signals are produced successively. This series of signals is often referred to as dual-tone multiple frequency (DTMF) dialing signals.
Dialed Number Detection

In the analog line interfaces, the DTMF dialing signals pass through the SLIC, are converted to digital form (PCM codes) and multiplexed in time (TDM) by the CODEC and TSAC, and thus, are available on the TX line to which the line interface is connected. In other words, DTMF dialing signals enter the central office via the same path as voice signals coming from the telephone set. This is illustrated in Figure 1-7.

The multiplexed digitized DTMF dialing signals on the TX line are then routed, via the switching circuit, to one of the service circuits in the signaling circuit of the central office as shown in Figure 1-7. The switching circuit consists of a digital space-division switch whose operation will be explained in detail in the next unit of this manual.

There are several service circuits in a signaling circuit. Each of them has a CODEC and a TSAC, like those in the analog line interfaces, to demultiplex and convert to analog form the multiplexed digitized DTMF dialing signals coming from the analog line interfaces. As the analog line interfaces, the service circuits are grouped in banks, each bank having a TX line and an RX line.
Diale Number Detection

Once the digitized DTMF dialing signals are demultiplexed and converted to analog form, the resulting signal is sent to a DTMF detector in the service circuit. The DTMF detector analyses each analog DTMF dialing signal, determines the frequency components in the DTMF dialing signal, and translates these components into the corresponding digit. The detected digit is then sent as a binary number to the call processor which recovers the telephone number and performs the connection requested.

In the Telephony Training System software, the digit detected by the DTMF DETECTOR in a SERVICE CIRCUIT is indicated by a DETECTED DIGIT display.

Note that as soon as the handset of a telephone set is lifted off the cradle, a service request is detected in the central office which immediately reacts by connecting the TX line of the corresponding line interface to the RX line of a bank of service circuits via the switching circuit. The connection is made to any unoccupied service circuit in the bank, and is released as soon as the call processor detects that pulse dialing is used, the subscriber hangs up, or the subscriber has dialed a complete telephone number.

Dynamic connection of service circuits to the TX lines of line interface bank, is preferred to hard-wired connection of a certain number of service circuits to each of these TX lines. Dynamic connection, via the switching circuit of the central office, provides additional flexibility that increases the capacity of the system to process a large number of service requests (from subscribers) occurring at a same time.

Figure 1-8 shows a comparison between hard-wired and dynamically-connected service circuits in a central office. In each implementation, there are 30 service circuits for 240 subscribers. In the hard-wired implementation, as soon as 4 subscribers in a same analog line interface bank require service, one of them is blocked (no service circuit is available to process the request). The probability of this to occur with dynamic connection of the same total number (30) of service circuits is greatly decreased. This increases the service quality (decreases the blocking probability) which can be provided with a certain number of service circuits.
Dialed Number Detection

![Diagram of service circuits](image)

(a) Hard-wired service circuits  
(b) Dynamically-connected service circuits

**Figure 1-8.** Comparison between hard-wired and dynamically-connected service circuits.

**Procedure summary**

In the first part of the exercise, you will set up a central office with the Telephony Training System (TTS).

In the second part of the exercise, you will study the operation of the Central Office circuitry that is involved in the detection of telephone numbers produced with pulse dialing.

In the third part of the exercise, you will study the operation of the Central Office circuitry that is involved in the detection of telephone numbers produced with tone dialing.

In the fourth part of the exercise, you will determine how the DTMF dialing signals produced by a telephone set are routed to the DTMF DETECTOR of a SERVICE CIRCUIT in the SIGNALING CIRCUIT of the Central Office.

In the last part of the exercise, you will observe how the TSAC and CODEC of a SERVICE CIRCUIT demultiplex the multiplexed digitized DTMF dialing signals.
EQUIPMENT REQUIRED

Refer to Appendix A of this manual to obtain the list of equipment required to perform this exercise.

PROCEDURE

Setting Up the Central Office

1. Make sure that the Reconfigurable Training Module, Model 9431, is connected to the TTS Power Supply, Model 9408.

Make sure that there is a network connection between the Reconfigurable Training Module and the host computer.

Install the Dual Analog Line Interface, Model 9475, into one of the analog/digital (A/D) slots of the Reconfigurable Training Module.

Connect two analog telephone sets to the Dual Analog Line Interface. Select the tone dialing mode on analog telephone set A. Select the pulse dialing mode on analog telephone set B.

CAUTION!

High voltages are present on the standard telephone connectors of the Dual Analog Line Interface. Do not connect or disconnect the analog telephone sets when the Reconfigurable Training Module is turned on.

Connect the AC/DC power converter supplied with each analog telephone set to one of the AC power outlets on the TTS Power Supply. Connect the DC power output jack of each AC/DC power converter to the DC power input connector on either of the analog telephone sets.

Note: The analog telephone set requires an auxiliary DC power source for the digital display to be operative.

2. Turn on the host computer.

Turn on the TTS Power Supply, then the Reconfigurable Training Module.

3. On the host computer, start the Telephony Training System software, then download the CO program to the Reconfigurable Training Module. The CO program configures the Reconfigurable Training Module so that it operates as a central office.
Dialled Number Detection

Note: If the host computer is unable to download the CO program to the Reconfigurable Training Module, it may not be using the proper IP address. Have your instructor check if the computer is using the proper IP address to communicate with the Reconfigurable Training Module.

☐ 4. On the host computer, set the address of the TSAC in ANALOG LINE INTERFACE A to 03.

Detection of Telephone Numbers Produced with Pulse Dialing

☐ 5. On the host computer, zoom in on the SIGNALING CIRCUIT of the Central Office, then zoom in on SERVICE CIRCUITs 1 and 2.

Locate the DETECTED DIGIT displays next to the DTMF DETECTOR of each SERVICE CIRCUIT.

While observing both DETECTED DIGIT displays, lift off the handset of telephone set B and slowly dial the number of telephone set A. Replace the handset of telephone set B on the cradle.

Did the dialed digits appear on either of the DETECTED DIGIT displays? Why?

☐ 6. Adjust the view so as to display the HOOK STATUS DEMULTIPLEXING AND STORAGE CIRCUIT, as well as the CALL PROCESSOR of the Central Office.

In the left-hand section of the CALL PROCESSOR, locate the two DETECTED DIGITS displays of the PULSE DIALING DETECTOR.

While observing these displays, lift off the handset of telephone set B and slowly dial the number of telephone set A. Replace the handset of telephone set B on the cradle.

Did the dialed digits appear on either of the displays? Explain.
Dialled Number Detection

□ 7. Which device of the Central Office detects telephone numbers that are produced with a telephone set that uses pulse dialing?

□ 8. In the HOOK STATUS DEMULTIPLEXING AND STORAGE CIRCUIT of the SIGNALING CIRCUIT, display the contents of the HOOK STATUS BUFFER MEMORY.

While observing the status of the bits in column D0 of the memory, lift off the handset of telephone set B and slowly dial the number of telephone set A. Replace the handset of telephone set B on the cradle.

Describe below what you observed.

□ 9. From the observations you have made up to this point, explain how the digits of the telephone number dialed on telephone set B are detected by the CALL PROCESSOR.

Close the window that shows the contents of the HOOK STATUS BUFFER MEMORY.

Detection of Telephone Numbers Produced with Tone Dialing

□ 10. Open a second window in LVTTS to display SERVICE CIRCUITs 1 and 2 of the SIGNALING CIRCUIT.

Adjust the view of each window in order to be able to simultaneously observe the two DETECTED DIGIT displays of SERVICE CIRCUITs 1 and 2 in the SIGNALING CIRCUIT, and the two DETECTED DIGIT displays of the PULSE DIALING DETECTOR in the CALL PROCESSOR. While observing these displays, lift off the handset of telephone set A and slowly dial the number of telephone set B. Replace the handset of telephone set A on the cradle.
Dangled Number Detection

Which device of the Central Office detected the digits dialed on telephone set A? Explain.

Close the window that displays the HOOK STATUS DEMULTIPLEXING AND STORAGE CIRCUIT and the PULSE DIALING DETECTOR in the CALL PROCESSOR.

11. Connect Oscilloscope Probes 1, 2, and 4 to TP4 (SLIC TXA output), TP6 (TX0 line), and TP17 (FRAME SYNC. signal) of ANALOG LINE INTERFACE A, respectively.

Connect Oscilloscope Probe 3 to TP6 (CODEC demultiplexed PCM output) of the SIGNALING CIRCUIT.

12. Start the Oscilloscope:

Make the following settings on the Oscilloscope:

<table>
<thead>
<tr>
<th>Channel</th>
<th>Mode</th>
<th>Sensitivity</th>
<th>Input Coupling</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal</td>
<td>1 V/div</td>
<td>DC</td>
</tr>
<tr>
<td>2</td>
<td>Normal</td>
<td>5 V/div</td>
<td>DC</td>
</tr>
<tr>
<td>3</td>
<td>Normal</td>
<td>5 V/div</td>
<td>DC</td>
</tr>
<tr>
<td>4</td>
<td>Normal</td>
<td>5 V/div</td>
<td>DC</td>
</tr>
</tbody>
</table>

Time Base: 2 µs/div

Trigger

<table>
<thead>
<tr>
<th>Source</th>
<th>Level</th>
<th>Slope</th>
<th>Display Refresh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ch 4</td>
<td>2.0 V</td>
<td>positive (+)</td>
<td>Continuous</td>
</tr>
</tbody>
</table>

13. While observing the signals displayed on the Oscilloscope screen, lift off the handset of telephone set A and slowly dial the number of telephone set B.
Observe that, whenever a digit is dialed, the PCM signal at TP6 of SERVICE CIRCUIT 1 is identical to the PCM signal in time slot 3 at TP6 of ANALOG LINE INTERFACE A. What does this indicate?

**Note:** It is normal that some pulses appear in the PCM signal on the TX0 line during time slot 3 even when no DTMF signal is produced. These pulses are due to the presence of residual noise on the line.

Replace the handset of telephone set A on the cradle.

☐ 14. Disconnect Oscilloscope Probe 4 from TP17 of ANALOG LINE INTERFACE A then connect it to TP7 (CODEC analog output) of the SIGNALING CIRCUIT.

Make the following settings on the Oscilloscope:

- **Channel 4**
  - Sensitivity: 1 V/div
  - Time Base: 0.5 ms/div
  - Trigger: Source: Ch 1, Level: 0.2 V

☐ 15. While observing the signals displayed on the Oscilloscope screen, lift off the handset of telephone set A and slowly dial the number of telephone set B.

Observe that, whenever a digit is dialed, the analog signal at TP7 of the SIGNALING CIRCUIT is identical to the analog signal at TP4 of ANALOG LINE INTERFACE A. What does this indicate?

Replace the handset of telephone set A on the cradle.
Dialled Number Detection

☐ 16. What happens to the analog DTMF dialing signals once they have been recovered at the analog output of the CODEC in SERVICE CIRCUIT 1? Explain.

Select the manual display refresh mode on the Oscilloscope.

Routing of the DTMF Dialing Signals from a Telephone Set to the DTMF Detector of a SERVICE CIRCUIT

☐ 17. On the host computer, adjust the view in order to be able to simultaneously observe the TIME SLOT NUMBER displays of ANALOG LINE INTERFACE A and SERVICE CIRCUIT 1 in the SIGNALING CIRCUIT.

Open a second window in LVTTS to display the SPACE-DIVISION SWITCH and the TIME SLOT SELECTOR of the SWITCHING CIRCUIT.

Set the TIME SLOT SELECTOR of the SWITCHING CIRCUIT to 03. This will enable display of the connections made by the SPACE-DIVISION SWITCH during time slot 3.

☐ 18. Lift off the handset of telephone set A and slowly dial the number of telephone set B. While doing this, observe the TSAC TX TIME SLOT NUMBER display of ANALOG LINE INTERFACE A, the connection made by the SPACE-DIVISION SWITCH of the SWITCHING CIRCUIT, and the TSAC RX TIME SLOT NUMBER display of SERVICE CIRCUIT 1.

Replace the handset of telephone set A on the cradle.

Based on your observations, which time slot is assigned to ANALOG LINE INTERFACE A for transmission of the digitized DTMF dialing signals? Explain.
What connection is made by the SPACE-DIVISION SWITCH during time slot 3? Why? When is this connection released?

Which time slot is assigned to SERVICE CIRCUIT 1 of the SIGNALING CIRCUIT for reception of the digitized DTMF dialing signals? Why?

☐ 19. In the window used to observe the TIME SLOT NUMBER displays of ANALOG LINE INTERFACE A and SERVICE CIRCUIT 1 in the SIGNALING CIRCUIT, modify the view so as to display both SERVICE CIRCUITs 1 and 2.

Lift off the handset of telephone set A and slowly dial the number of telephone set B. While doing this, observe the DETECTED DIGIT display of SERVICE CIRCUIT 2. Replace the handset of telephone set A on the cradle.

Explain why SERVICE CIRCUIT 2 of the SIGNALING CIRCUIT did not detect the digitized DTMF dialing signals present on line RX1 during time slot 3.
Diale Number Detection

20. From the observations you have made up to this point, explain how the analog DTMF dia
ing signals produced by a telephone set are routed to the DTMF DETECTOR of a SERVICE CIRCUIT in the SIGNALING CIRCUIT of the Central Office.

Note: The operation of the SPACE-DIVISION SWITCH in the SWITCHING CIRCUIT will be covered in detail in Exercise 2-2.

21. Select the **tone** dialing mode on analog telephone set B.

Telephone sets A and B are now both in the tone dialing mode.

22. Lift off the handset of telephone set A and depress a number key on the keypad. Observe that the dialed digit is detected by SERVICE CIRCUIT 1. Do not hang up.

Lift off the handset of telephone set B and depress a number key on the keypad. Observe that the dialed digit is detected by SERVICE CIRCUIT 2, since SERVICE CIRCUIT 1 is currently occupied.

Replace the handsets of telephone sets A and B on their cradle.

23. Now lift off the handset of telephone set B and depress a number key on the keypad. Observe that the dialed digit is detected by SERVICE CIRCUIT 1. Do not hang up.

Lift off the handset of telephone set A and depress a number key on the keypad. Observe that the dialed digit is detected by SERVICE CIRCUIT 2, since SERVICE CIRCUIT 1 is currently occupied. Replace the handsets of telephone sets A and B on their cradle.

From your observations, is each SERVICE CIRCUIT of the SIGNALING CIRCUIT dedicated to serve a specific ANALOG LINE INTERFACE? Explain.
Dialled Number Detection

☐ 24. Select the **pulse** dialing mode on analog telephone set **B**.

☐ 25. In the **SWITCHING CIRCUIT** of the Central Office, set the TIME SLOT SELECTOR in the **SWITCHING CIRCUIT** to 02. This will enable display of the connections made by the SPACE-DIVISION SWITCH during time slot 2.

☐ 26. While observing the SPACE-DIVISION SWITCH, lift off the handset of telephone set **B**.

You should observe that, as soon as the handset is lifted, the SPACE-DIVISION SWITCH establishes a connection between transmit line TX0 and receive line RX1 of the **SIGNALING CIRCUIT** during time slot 2.

While observing this connection, depress a number key on telephone set **B**. Replace the handset of telephone set **B** on the cradle.

Is the connection released as soon as the key is depressed? Why?

________________________________________________________________________

________________________________________________________________________

Close the window that displays the SPACE-DIVISION SWITCH and the TIME SLOT SELECTOR in the **SWITCHING CIRCUIT**.

**Demultiplexing of the Digitized DTMF Dialing Signals on Line RX1**

☐ 27. Disconnect all the Oscilloscope Probes.

    Connect Oscilloscope Probes 1, 2, 3, and 4 to TP10 (TSAC RXE output), TP5 (RX1 line), TP6 (CODEC demultiplexed output), and TP30 (FRAME SYNC. signal) of the **SIGNALING CIRCUIT**, respectively.
Dialled Number Detection

Make the following settings on the Oscilloscope:

Channel 1
- Sensitivity: 5 V/div

Channel 4
- Sensitivity: 5 V/div
- Time Base: 50 µs/div
- Trigger
  - Source: Ch 4
  - Level: 2.0 V
  - Slope: positive (+)
- Display Refresh: Continuous
- Display Mode: Square

☐ 28. Lift off the handset of telephone set A. Observe that a pulse appears in the TSAC RXE signal (TP10) once every frame.

On the Oscilloscope, readjust the time base to 5 µs/div. Observe that the pulse in the TSAC RXE signal occurs in time slot 3, which corresponds to the time slot used by ANALOG LINE INTERFACE A for transmission of the digitized DTMF dialing signals. Is the duration of this pulse equal to that of one time slot? Explain.

Replace the handset of telephone set A on the cradle.

☐ 29. While observing the signals on the Oscilloscope screen, lift off the handset of telephone set A and slowly dial the number of telephone set B. Replace the handset of telephone set A on the cradle.

Does the pulse in the TSAC RXE signal (TP10) occur at the same time the digitized DTMF dialing signal from ANALOG LINE INTERFACE A appears on line RX1 (TP5)? Why?

☐ 30. On the host computer, close the Telephony Training System software.

Turn off the TTS Power Supply, as well as the host computer (if it is no longer required).

Disconnect the AC/DC power converters from the TTS Power Supply and the analog telephone sets.

Disconnect the analog telephone sets from the Dual Analog Line Interface.
Remove the Dual Analog Line Interface from the Reconfigurable Training Module.

CONCLUSION

In this exercise, you familiarized yourself with the detection of telephone numbers produced using either pulse or tone dialing. You learned that the way a central office detects the telephone numbers dialed on a telephone set depends on whether pulse or tone dialing is used.

You saw that, when the dialing signal is of the pulse type, the call processor detects the dialed digits by counting the number of times the corresponding hook status bit goes from logic state 1 to logic state 0 between each inter-digit interval of the pulse dialing signal.

You also saw that, when the dialing signal is of the DTMF type, the call processor detects the dialed digits by using a service circuit located in the signaling circuit of the central office. You learned that the service circuit demultiplexes the digitized DTMF dialing signals and converts them back into their original analog form. It then translates the frequency components in these analog signals into the corresponding digits. You also learned that the service circuits in the signaling circuit are grouped in banks, as the analog line interfaces are.

Finally, you saw that the switching circuit is used to connect the TX lines of the banks of line interfaces to the RX lines of the banks of service circuits in the signaling circuit of the central office. You saw that the switching circuit releases the connection between a line interface and a service circuit as soon as it detects that the dialing signal coming from the line interface is of the pulse type or the subscriber has dialed a complete telephone number.

REVIEW QUESTIONS

1. How does the call processor detect telephone numbers dialed with a telephone set that uses pulse dialing?

2. To detect telephone numbers dialed with a telephone set that uses pulse dialing, why must the call processor read the memory at a fast rate?
Dialled Number Detection

3. How does the call processor detect telephone numbers dialed with a telephone set that uses tone dialing?

4. Whenever a subscriber dials a telephone number on a telephone set, under which conditions will the TX-to-RX line connection between the corresponding bank of line interfaces and a bank of service circuits be released?

5. Why is dynamic connection (via the switching circuit of the central office) of the service circuits to the TX lines of line interface banks preferable to hard-wired connection of a certain number of service circuits to each of these TX lines?