Section 6
ZR340 Advanced Interconnect Repeater Controller

Overview

This section describes the basic operation, system configurations, and theory of operation for the ZR340 Advanced Interconnect Repeater Controller.

Basic Operation

The Zetron ZR340 is a multi-mode, easy to use telephone interconnect. Simplex VOX, simplex sampling, intelligent sampling, and half duplex modes are supported. Digital voice delay is an available option to enhance simplex operation.

Multi-digit DTMF access codes and toll restrict digits are selectable to eliminate unauthorized use of the phone line. The ZR340 allows mobile DTMF or regenerated pulse dialing. Repeat audio processing and transmitter control are included.

The ZR340 includes factory defaults for all programmable settings so that it will function on any system straight out of the box, or may be customized easily using a Touch-tone telephone or DTMF equipped radio.

Phone To Mobile Calls

When the telephone line rings, the ZR340 will wait the number of programmed rings to answer before ringing out on the channel. This is to allow a parallel phone to be manually answered before the ZR340 begins ringing on the radio channel. If the phone continues to ring, and the channel is not in use, the ZR340 will begin ringing out on the radio channel until the connect code is entered by a mobile. The ZR340 may be installed to ring either once and wait up to 1 minute for an answer, or ring each time the phone rings for up to 1 minute. If a mobile has not answered within this time, the call is terminated. Once a mobile answers, the ZR340 will take the phone off hook and allow the call to progress.

After 10 rings past the number of programmed rings to answer, the phone is answered and the user can enter the program access code to remotely program the ZR340.

Pressing the **Connect** button on the front panel while the ZR340 is on-hook causes it to go off-hook and enter into the conversation mode.

Mobile Originated Calls

To place a call, a mobile user enters the DTMF Access Code (sign-on sequence) and unkeys. Once the Access Code has been started, each additional digit must be transmitted within 1 second of the last without dropping carrier between digits, or the sign-on attempt will be ignored. The ZR340 takes the phone off-hook and sends dial tone (phone audio) to the transmitter. For simplex installations, the transmitter is keyed for 2 seconds, then unkeyed to receive mobile dialing digits. The ZR340 will pass the mobile DTMF to the phone or provide conversion from DTMF to pulse dialing until there is a 5-second gap in the entered digits. The radio timeout and call limit timers are started as soon as the telephone is taken off-hook. During dialing, if the mobile's first digit matches a digit in the first digit toll restricted string, the ZR340 will terminate the call.

The same applies for the second digit toll restrict string.

The user may enter the program access code to gain access to remote programming.

Once A Call Is In Progress

Once a call has been connected, the call may be terminated in one of five ways:

Deaccess Code

A mobile may disconnect the call by sending the Deaccess Code. The call is terminated immediately and 5 fast beeps are sent to the mobile indicating that the call is over. Once the Deaccess Code sequence has been started, each additional digit must be transmitted within 1 second of the last without dropping carrier between digits, or the sign-off attempt will be ignored.

Busy Disconnect

If a busy tone is detected by the ZR340 during the first 20 seconds of a mobile-originated call, the ZR340 will disconnect and send 3 fast busy tones to the transmitter when it detects a busy signal. The Busy Disconnect feature can be disabled.

Mobile Activity

The mobile must transmit at least once during the radio timeout interval. If no transmission occurs during that time, the call is terminated and 5 fast beeps are

sent to the mobile. During the conversation, a single beep is sent to the phone and the mobile every 3 seconds starting 12 seconds before the mobile activity timer expires. This beep serves as a warning to both the telephone user and the mobile user.

Call Limit

Each call is limited in length. Once the Call Limit timer has expired, the call is terminated and 5 fast beeps are sent to the mobile. Double warning beeps are sent to the telephone and mobile every 3 seconds starting 15 seconds before the call limit timer expires. If programmed to do so, the user may allow the mobile to extend the Call Limit time by pressing the '*' key.

Connect Button

Pressing the **Connect** Button while the ZR340 is off-hook terminates the call in progress and forces the ZR340 back into the on-hook idle mode.

ZR340 Features

Access Code

The Access Code may be up to 9 digits in length, and may include any combination of digits 0-9 and '*.' This code is used to gain access to the telephone line.

Deaccess Code

The mobile Deaccess Code may be to up to 9 digits in length, and may include any combination of digits 0-9 and #. This code is used by a mobile radio to terminate a call in progress.

Telephone Disconnect Code

The telephone user may terminate a call in progress by dialing the code '#0' from a DTMF telephone.

Toll Restrict 1

If set for Toll Restrict 1, the ZR340 does not allow a mobile to dial a telephone number whose first digit is in the 1st digit toll restrict table. This table usually contains 0 and 1 so that long distance and operator calls cannot be made. Up to four digits may be restricted as the first dialed digit.

Toll Restrict 2

This feature operates in the same way as Toll Restrict 1, but acts based on the second digit of a telephone number that a mobile dials.

Call Limit

The Call Limit is a timer which determines the maximum time that a call may last before being terminated. The Call Limit timer may be reset using a DTMF '*' if programmed to do so. Double warning beeps are sent to the telephone and mobile every 3 seconds, starting 15 seconds before the call is terminated.

Radio Timeout

The Radio Timeout, or mobile activity time, is the amount of time that may elapse without the ZR340 detecting a mobile transmission before a call is terminated. The timer assures that if a mobile gets out of range (loses control of the interconnect) the conversation will be terminated even though the mobile cannot manually terminate the call. Single warning beeps are sent to the telephone and mobile every 3 seconds, starting twelve seconds before the call is terminated. The Radio Timeout is programmable to 30, 45, or 60 seconds.

Courtesy Tone

The Courtesy Tone is a short 50 millisecond beep that prompts the phone party to begin speaking. This feature is especially useful since phone callers are not usually aware that they must wait for the mobile to unkey before speaking.

Carrier Repeat

When enabled, the ZR340 will repeat audio any time the receive radio generates a COR signal. After the receive COR signal ends (the mobile unkeys), the transmitter is held up for the programmable repeater transmit hang time.

Tx Hang Time

The Tx (transmit) Hang Time is the time that the transmitter will stay keyed after the mobile unkeys during repeat operation. It is programmable to 0, 1, 3, or 5 seconds.

Privacy Mode

Privacy Mode is intended to discourage casual eavesdropping. During a call with the Privacy Mode disabled, the mobile audio is routed to the transmitter (repeated). With Privacy Mode enabled, a disturbing tone is sent to the transmitter while the mobile speaks. This masks the mobile's half of the conversation to other listening mobiles or scanners.

Toll Restrict

The Toll Restrict is a code which allows "privileged" users to get around the toll restriction when making calls. This code must be used in place of the Access Code.

Rings to Answer

The ZR340 may be programmed to ring in two ways: on the channel one time and wait for 1 minute for an answer from a mobile, or continue ringing for up to 1 minute while waiting for an answer. In either case, if

the mobile does not answer within the 1 minute time-out time, the call is terminated.

Disconnect On Busy

The ZR340 has the ability to automatically disconnect the call when a busy tone is detected. The busy tone detection is only enabled during the first 20 seconds of a mobile-originated telephone call. This feature may be disabled if desired.

> **NOTE**
> Some dial-up services will read back numbers using computer generated voice. These often "sound like" a busy tone to the ZR340.

Simplex Operation

There are five simplex modes:

Simplex VOX

Simplex VOX is the standard simplex mode that keys the transmitter using phone voice (VOX) detection. When neither party is talking, the ZR340 is watching for either VOX or COR indication. When the ZR340 detects VOX, it will key the transmitter and allow telephone audio to pass to the transmitter. When VOX drops and the VOX hold timer expires, the transmitter is dropped and the ZR340 goes back to waiting. When the ZR340 detects COR, it allows mobile audio to pass to the telephone. When the mobile unkeys and the COR hold timer expires, the ZR340 once again returns to waiting.

The digital voice delay option board may be installed to enhance the Simplex VOX mode (contact Zetron Inc. to order--refer to page iv). Since the ZR340 uses the voice detector to know when to key the transmitter, the first syllable is typically lost while the transmitter (and associated repeater or links) comes up on channel. TPL/DPL decoding will also contribute to the lost syllables. By adding the digital voice delay board, the phone audio is delayed so that the transmitter will have plenty of time to get "on line" before the phone audio is passed to the mobile.

Simplex VOX with Prekey

Simplex VOX with Prekey mode is identical to the Simplex VOX mode, with one exception: When COR ceases, it is assumed that the telephone user wants to begin talking, so the ZR340 will "prekey" the transmitter. Prekeying the transmitter reduces the chance of lost syllables while the transmitter is coming up to full power. If the phone party does not begin speaking before the VOX hold time expires (typically one second), the transmitter will unkey. The ZR340 then begins watching for either VOX or COR activity.

Simplex Sampling

When the ZR340 is connected to a radio that switches very quickly between transmit and receive (and is not working through a repeater) the Simplex Sampling mode may be used. Two parameters affect the sampling modes: the sample rate and the sample width times. The Simplex Sampling mode begins with the transmitter keyed up and audio passing from the telco to the mobile. When the sample rate timer expires, the transmitter unkeys and the sample width timer starts. When the sample width timer expires, the ZR340 looks for a COR signal. If COR is not present, the transmitter re-keys and the cycle starts again. If COR is present, telco to mobile audio shuts down and mobile to telco audio opens. Audio is passed from the mobile to the telco until COR drops and the COR hold timer expires; the cycle starts again.

Simplex Sampling with VOX to Extend Sample Interval

This mode is identical to Simplex Sampling, but the ZR340 looks for VOX indication, as well as for COR detection. When VOX is up, the sample rate is extended to 4 times the normal sampling time. When the ZR340 detects VOX, the telephone user is speaking, and therefore sampling only needs to happen 1/4 as often.

Intelligent Simplex Mode

When the ZR340 is not working through a repeater (not connected to a control station), the Intelligent Simplex Mode will provide the best possible operation. This mode uses VOX, the sample width timer and the audio delay to provide premium simplex operation. As long as VOX is detected, the transmitter keys and audio passes from the telco to the mobile. When VOX drops for the sample width time (or longer), the ZR340 allows the rest of the audio (still trapped in the delay) to go out the transmitter. Once the audio is out and silence (gap) is detected, the transmitter unkeys. Just before the end of the gap reaches the transmitter, COR is checked. If COR is present, the mobile takes over the call. If COR is not present, the transmitter keys again and the remaining audio in the delay is allowed out the transmitter. Using the delay and timing the gap, the ZR340 is capable of sampling between words without the loss of telephone audio.

> **NOTE**
> This feature is available only when the optional simplex delay has been installed.

VOX Hang Time

VOX Hang Time sets the time that VOX detection must be gone before the telco side of the conversation is assumed to be finished. This time should be set to the minimum required as it slows down the conversation, but a time too short will cause the conversation to flip to the mobile side prematurely. This timer only affects the VOX simplex modes. VOX Hang Time is programmable to 0.5, 0.8, 1.0, 1.3, or 1.5 seconds.

COR Hang Time

The COR Hang Time can be added to the receive carrier detector in simplex mode to reduce the effects of "picket fencing." When mobiles operate in fringe areas, or through multi-path zones, the carrier can momentarily drop. When it does, the patch assumes that the mobile has unkeyed and keys the transmitter to allow the phone party to begin speaking. The COR Hang Time allows the receive audio to be muted to the phone party, but it won't assume the mobile has unkeyed until the COR Hang Time expires. COR Hang Time is programmable to 0, 100, 300, or 500 msec.

Sample Rate

The Sample Rate is the rate at which the ZR340 will sample for carrier. This is **not** the amount of time that it looks for carrier, but how often it looks. The sample rate timer is used for Simplex Sampling and Simplex Sampling with VOX. The Sample Rate is programmable to 0.5, 1.0, or 1.5 seconds.

NOTE
Simplex Intelligent mode does **not** use this timer.

Auto Sample Setup

This command allows the simplex sample window duration to be set automatically for any radio. Once the command is executed, the ZR340 will key the radio for 2 seconds allowing time to generate a DTMF digit into the receiver using a DTMF equipped radio. The ZR340 will unkey the transmitter and time how long it takes to decode the DTMF. This is saved as the sample width time. Commands are available to increment and decrement the sample window for fine tuning in 10-millisecond increments.

Theory of Operation

Microprocessor

To ensure a proper power-up sequence to the microprocessor, U7, the active low reset signal, is held low until the 12 Vdc supply and crystal Y1 have stabilized. The reset signal is also asserted whenever the supply dips below 8 Vdc. Zener diode CR8, R24, and R53 set the threshold, with R54 and C36 setting the delay until reset is allowed to become active.

VR1 provides a regulated 5 Vdc for the digital circuitry and 5 Vdc (labeled +A) for the analog circuitry. U2D provides a regulated 2 Vdc for an analog bias voltage.

The microprocessor, U7, controls operation of the ZR340 by executing the instructions stored in its internal program memory. The microprocessor also contains data memory for temporary data storage. User programmed values are stored in EEPROMs U4 and U5 which retain their values even when power is lost.

The microprocessor generates DTMF and progress tones which are converted to analog signals by RP1 and U2B. This audio may then be routed by the microprocessor to the transmit radio via U10C and to the telephone interface via U11A.

Radio Interface

Receiver audio can be scaled by R86 to set the proper level at the output of the buffer U12D. This audio may be routed to three destinations under control of the microprocessor. It may be gated to the transmit radio via U10A, to the DTMF decoder via U11B and to the telephone interface via Q7 and Q8. The transmit audio is amplified by U2A and may be scaled by R87 for a GM300 radio. Unscaled audio is available to the accessory connector.

Telephone Interface

The ring detect circuit triggers when sufficient voltage is sensed across R20. This causes C29 to be discharged, resulting in a ring signal being sent to the microprocessor.

The telephone line is taken off-hook under microprocessor control by K1. The line is coupled to the circuit by T1. Received telephone audio may be routed to two destinations or gated on and off by U11C. One path is to the DTMF decoder via U11B and the other is to the transmit radio via U10B. If the VOX delay card is installed in J2 the audio is delayed when routed to the transmit radio.

The received telephone audio also passes through the VOX detect circuit. The level at which the VOX triggers may be set with R75. The audio is low-pass filtered by U13D and compared to a threshold by U12C. U8A converts the level to 5 V logic to the microprocessor.

The transmitted telephone audio is generated by U2C which sums the receive radio audio with any internally generated tones. The transmitted audio can be muted by the audio limiter circuit consisting of U13A, U13B, and U13C. The limiter compares the audio with a threshold at U13B which causes C53 to charge. When this level exceeds the threshold at U13C the limiter turns on Q9.

DTMF Decoding

U9 performs the DTMF decoding of either the receive radio audio or the telephone audio depending upon the state of U11B. When a digit is decoded, the value is sent to an input port of the microprocessor.

Carrier Squelch Detect

JP7, JP8, and JP9 are used to route the proper inputs for COR and PL/DPL depending upon whether 8 or 16 channel radios are used with the ZR340. JP9 is used to direct the COR input from the transmit radio to U1C. JP8 directs the COR input from the receive radio to U1C which sends an active COR signal to the microprocessor if either transmit or receive is active. JP7 routes the PL/DPL input to the microprocessor for 16 channel radios, and routes the receive radio's COR input for 8 channel radios.

Jumper Configurations

Table 6-1 lists the jumper settings for the transmit and receive radios when used with a Radius repeater and the ZR340 Advanced Interconnect Repeater Controller. Table 6-2 lists the jumper settings for the ZR340.

ZR340 Adjustments

The following steps should be performed with a service monitor, such as the Motorola R2000 series, connected to the antenna jack of the duplexer (or the transmitter, if applicable). Except for a simplex radio system, the service monitor must be operating in the duplex mode. Set the service monitor to monitor the frequency of the transmit radio while generating the duplex signal at the frequency of the receive radio. Refer to the operating instructions for your service monitor.

1. Connect the line cord from the repeater to a suitable 50/60 Hz ac source.
2. If the repeater is the GR300, turn on the power switch on the front panel of the power supply.
3. Turn on the two radios by rotating the volume controls clockwise. The front panels of the radios and the green **Power** LED of the ZR340 should illuminate.

Transmit Audio Level

1. Use a DTMF equipped radio to place the ZR340 in the programming mode (default programming access code is '12123').
2. Key in the DTMF command '92#' (Tx test). The ZR340 will generate a 1 kHz tone.
3. Adjust the **TX Setup** potentiometer for 70 percent of full rated system deviation (3.5 kHz for a 5 kHz system or 1.75 kHz for a 2.5 kHz system).
4. Press any DTMF digit to end the test.

Repeated Audio Level

1. Complete the "Transmit Audio Level" adjustment, described above, before continuing.
2. Modulate the duplex generator of the service monitor with a 1 kHz tone at 60 percent of full rated system deviation.
3. Key in the DTMF command '93#' (repeated audio test).
4. Adjust the **RX Setup** potentiometer for 60 percent of full rated system deviation of the transmit radio.
5. Press any DTMF digit to end the test.
6. Key in the DTMF command '99#' to exit the programming mode.

Table 6-1. Radio Jumper Settings (GM300 16-Channel Radios)

Radio Jumper	Receive Radio	Transmit Radio
JU551	B	X*
JU651	X*	A
JU701	X*	A

* either A or B

Table 6-2. ZR340 Jumper Settings

Jumper	Default	Notes
JP1	Open	Closed for simplex operation.
JP2	Open	Closed for simplex operation.
JP3	Open	Closed for simplex operation.
JP4	Open	Closed to activate emergency switch.
JP5	Closed	Open to use external speaker for transmit radio (cut trace).
JP6	Closed	Open to use external speaker for receive radio (cut trace).
JP7	B	A = M10, M120, M130 or an 8-channel GM300 receive radio. B = 16-channel GM300 receive radio.
JP8	B	A = M10, M120, M130 or an 8-channel GM300 receive radio. B = 16-channel GM300 receive radio.
JP9	B	A = M10, M120, M130 or an 8-channel GM300 transmit radio. B = 16-channel GM300 transmit radio.
JP10	Closed	Open when VOX delay card installed (cut trace).

Received Audio Level—Simplex Operation

The received audio level is properly set for a repeater with the two previously described adjustments. For a simplex (one radio) system, the received audio level is adjusted differently.

1. Remove the ZR340 from the GR Series repeater housing (follow the appropriate procedures outlined in this manual).
2. Remove the four 4-40 Phillips head machine screws that secure the top cover to the chassis of the ZR340.
3. Remove the top cover of the ZR340.
4. Connect an ac voltmeter or ocilloscope to pin 14 of U12D.
5. Place the service monitor in the Generate mode.
6. Apply an on channel signal at the frequency of the receiver of the radio.
7. Modulate the signal with a 1 kHz tone at 60 percent of full rated system deviation.
8. Adjust the **RX Setup** potentiometer for 353 mV rms on the ac voltmeter (or 1 V peak-to-peak on the oscilloscope).
9. Disconnect the ac voltmeter or oscilloscope.
10. Replace the top cover of the ZR340 and secure with the four 4-40 Phillips head machine screws that were removed in step 2.
11. Follow the procedures in this manual to remount the ZR340 in the GR Series repeater housing.