ITC-32

Intelligent Touch-Tone Control Board

Owner's Manual

Firmware Version 1.31

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About This Manual . . .

This manual provides operation and interfacing information for the ITC-32 Intelligent Touch-Tone Control Board.

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Chapter 1
Introduction

Description

The Advanced Computer Controls, Inc. ITC-32 Intelligent Touch-Tone Control Board offers low cost, compact, high performance remote control and status monitoring capability. Microcomputer control provides a level of capability and flexibility not possible in discrete logic designs.

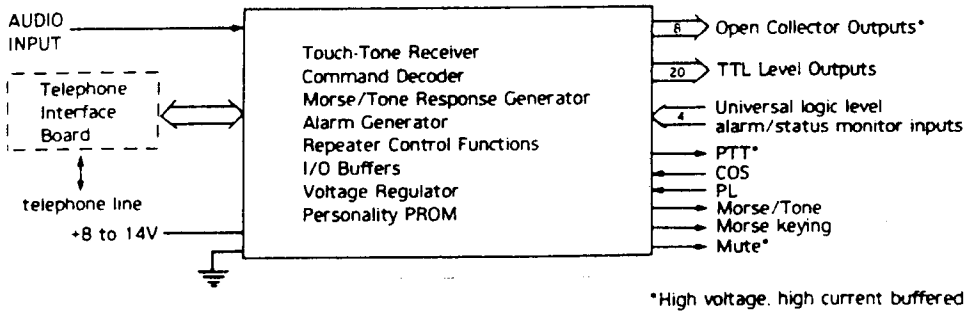
The ITC-32 control board provides 28 remote control logic outputs which may be commanded using standard Touch-Tone signalling over a radio link or a dial-up telephone line. Unique Morse code or tone response messages for each command verify correct command entry and allow interrogation of logic output states without changing them. Logic sense inputs may be interrogated remotely as well. Alarm inputs may cause the control board to key a radio transmitter and send a tone encoded alarm message or autodial out over the telephone line to one or more prestored telephone numbers (with the Telephone Interface option).

In addition to the board's remote control and monitoring capabilities, several additional specialized functions are provided including a basic two-way radio repeater COR, identifier, and timer function, plus support for a frequency synthesized remote base transciever.

The characteristics of the ITC-32 are optionally field programmable through a user developed "Personality PROM". The format of the Personality PROM is fully documented in this manual to allow the user to make changes to his system independent of the factory.

The ITC-32 control board uses a state-of-the art CMOS digital DTMF tone decoder for fast, reliable decoding with virtually no falsing. The logic I/O is designed for simplest interface to a variety of equipment and sensors. The board is well suited for use in industrial control and monitoring applications such as utilities, pipelines, irrigation systems, and cable TV operations. Security applications include remote site alarm reporting, such as valve and pump station, agricultural systems, computer rooms, and cold storage facilities. Additional applications include commercial and amateur repeater and remote base station control.

Block Diagram



*High voltage, high current buffered

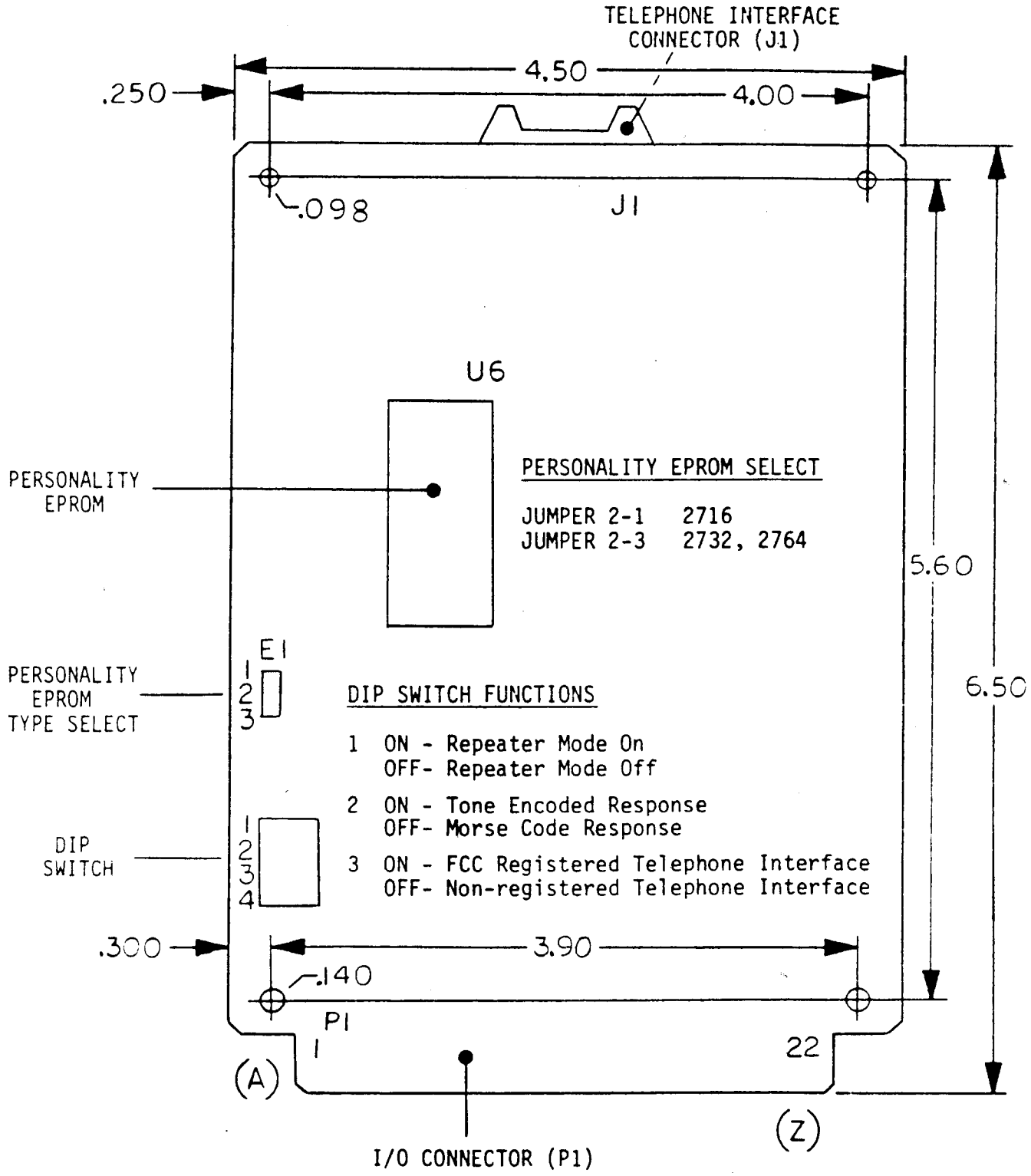
Features

- Microcomputer controlled
- State-of-the-art tone decoding
- Easy to interface
- 28 remotely commandable outputs, high/low/pulse
- 4 remote sense / alarm inputs
- Control and monitor over radio or telephone
- Telephone auto-answer and alarm autodial (with Telephone Interface)
- Morse code or tone encoded response messages
- Support for off-board speech chips for voice response messages
- Repeater COR/ID/Timer functions, remote base frequency control
- Personality PROM Option (user developed)
  - Fully documented for user reprogramming in the field
  - Offers custom command codes for each function
  - Custom response messages
  - Custom alarm autodial telephone numbers
  - Repeater ID message, timer values
  - Compatible with 2716, 2732, 2764 EPROMs
- Telephone Interface Board option for direct interface to telephone line

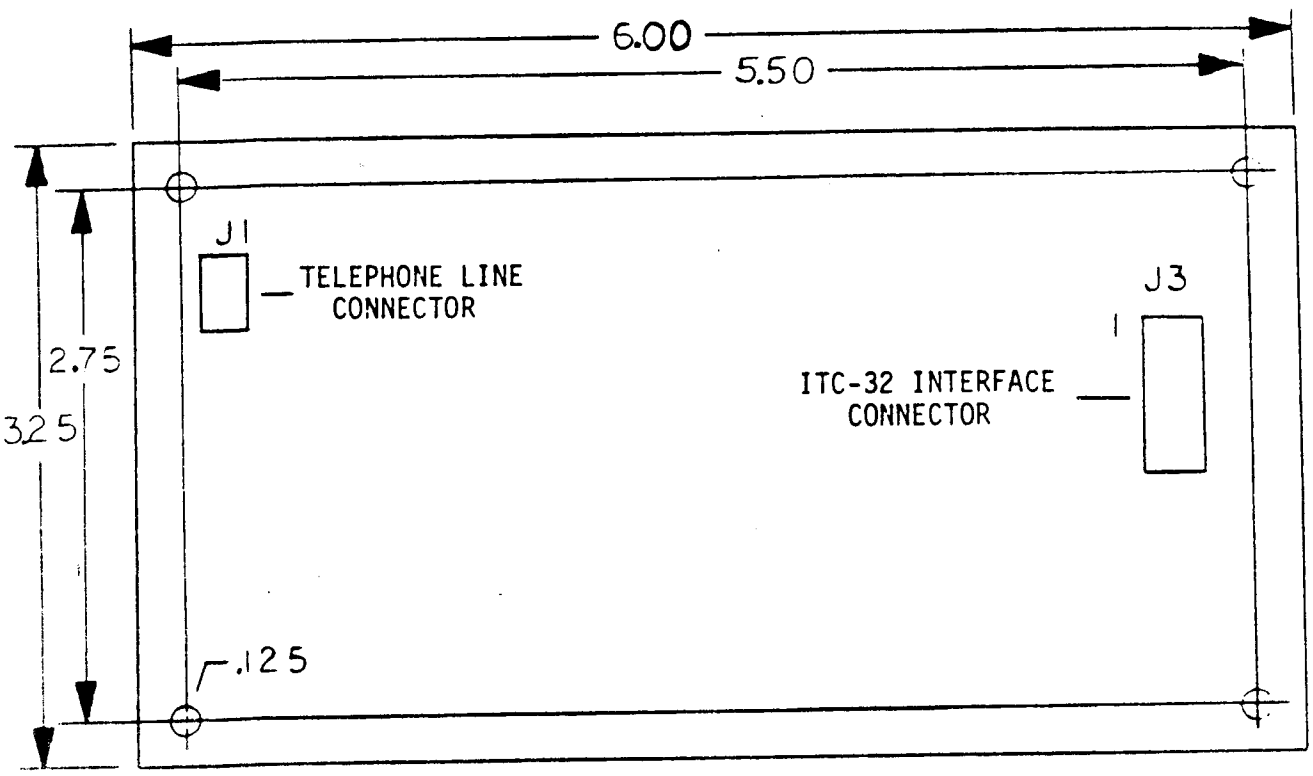
Specifications

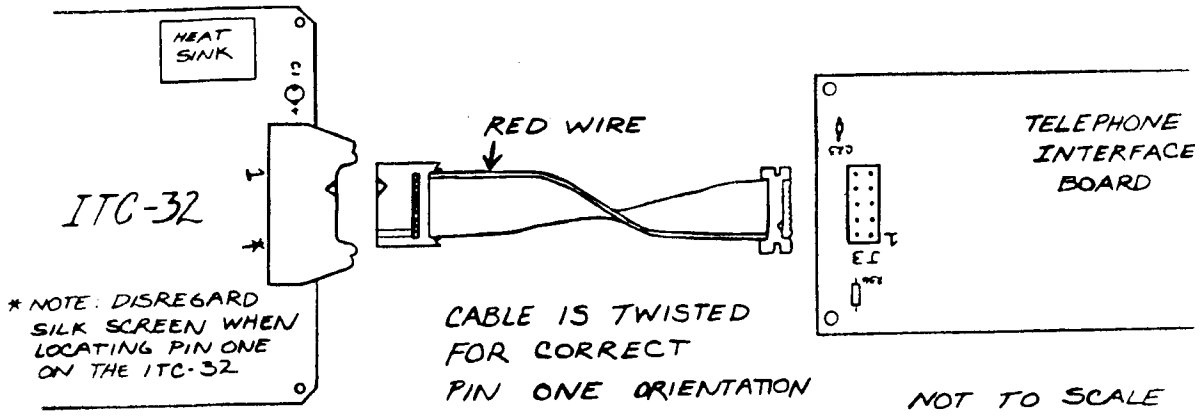
- Touch-Tone Receiver - Mitel MT8860/8865, full 16 digit
- Audio Input - Impedance = 100K, Level = 70 mV to 2.5 V peak-to-peak
- Logic Outputs
  - 8 remote control, buffered
  - 20 remote control, unbuffered
  - Push-to-Talk (for responses and repeater functions, buffered)
  - Mute (during Touch-Tone transmission, buffered)
  - Morse Code keying
- Logic Output Characteristics
  - Buffered - 100 mA, 60V, open "collector" VMOS
  - TTL Level - Low = .8 volt max @ 2.0 mA, High = 2.4 volt min @ -400 uA
- Logic Inputs
  - 4 remote status monitor / alarm
  - Carrier Operated Switch (repeater function)
  - PL (repeater function)
- Logic Input Characteristics
  - 10K input impedance
  - Low = .8 volts max., High = 2.4 volts min.
  - Compatible with TTL, 5/12 volt CMOS, etc.
- Morse Code / Tone Output - 1 volt p-p, 20K output impedance
- Command Codes - Configurable up to 15 digit
- Alarm Generation
  - Autodial phone numbers (up to 20 digit including pauses), or transmitter keying with alarm messages
- Power - +8 to +14 volts DC, 250 mA typical, 400 mA max
- Operating Temperature Range - 0 - 70 degrees C
- Size - 4.5" x 6.5"
- Connector: 44 pin dual row .156" (Vector R644 or equiv.)

ITC-32 Board Layout

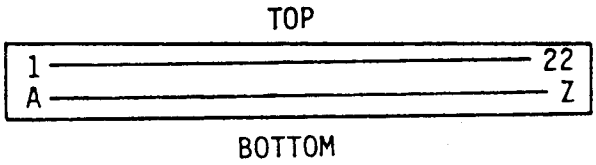


Telephone Interface Board Layout



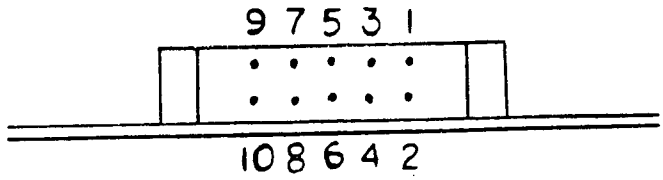


ITC-32 Board Connector Pinout (P1)



FUNCTION	PIN	FUNCTION	PIN
+8 TO 14 V	A	OUT 9	Y
GROUND	1,2	OUT 10	21
AUDIO IN	6	OUT 11	X
RESET	B	OUT 12	20
		OUT 13	W
PTT	L	OUT 14	19
COS	C	OUT 15	V
PL	Z	OUT 16	18
MUTE	11		
MORSE KEYING	P	OUT 17	U
MORSE/TONE	3	OUT 18	17
		OUT 19	T
ALARM/SENSE 1	D	OUT 20	16
ALARM/SENSE 2	4	OUT 21	S
ALARM/SENSE 3	E	OUT 22	15
ALARM/SENSE 4	5	OUT 23	R
		OUT 24	14
OUT 1	7		
OUT 2	F	OUT 25	M
OUT 3	H	OUT 26	12
OUT 4	8	OUT 27	N
OUT 5	J	OUT 28	13
OUT 6	9		
OUT 7	K	NO CONNECT	22
OUT 8	10		

Telephone Interface Board Connector Pinout



FUNCTION	PIN
GROUND	1, 9, 10
+12V	2
AUDIO TO PHONE	5
AUDIO FROM PHONE	6
RING	7
OFFHOOK	8
NO CONNECT	3,4

Chapter 2
Installation

Power

The ITC-32 control board operates from a single dc power supply which may range from +8 to +14 volts. An on-board voltage regulator supplies the regulated 5 volts required for the microcomputer, logic, and Touch-Tone receiver. Current drain is 400 mA maximum and 250 mA typical. The positive supply connects to pin A and ground connects to pins 1 and 2.

Audio Input

Audio may be applied to the control board from a radio receiver or other audio source. The audio level should be in the range of 75 mv to 2.5 volts peak-to-peak. Optimum Touch-Tone level is approximately one volt peak-to-peak. It is applied to connector pin 6 with ground to pins 1 and 2.

Telephone Line

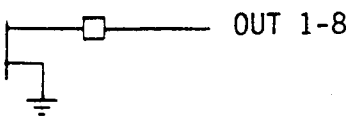
The ITC-32 control board may be optionally connected to a telephone line for control, monitoring, and alarm functions over the phone through use of the Telephone Interface Board. Connection is made through a 10 conductor ribbon cable from J1 of the ITC-32 control board to J3 of the Telephone Interface Board. The cable must be installed so that pin1 orientations match.

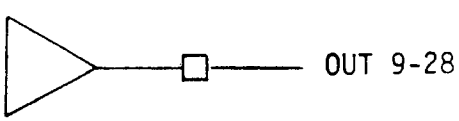
Connector J1 of the Telephone Interface Board may connect directly to tip and ring of the phone line.

The ITC-32 control board in conjunction with the Telephone Interface Board provides auto-answer for control and monitoring over the phone and autodial on alarm condition for alarm generation over the phone.

Remote Control Logic Outputs

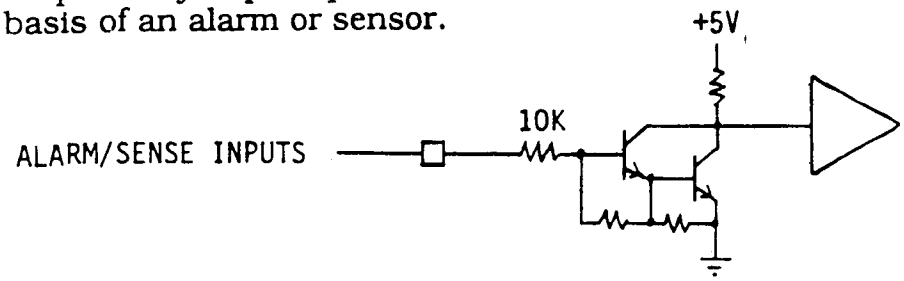
The ITC-32 control board provides 28 remotely controllable logic outputs. Eight of the outputs are buffered for high-current high-voltage drive with power FETs. These outputs (OUT1-OUT8) may drive high current loads, such as relay coils, keying lines, etc., directly. The TTL logic level outputs (OUT9-OUT28) may interface to other logic or TTL compatible equipment, or may be externally buffered for high current drive.





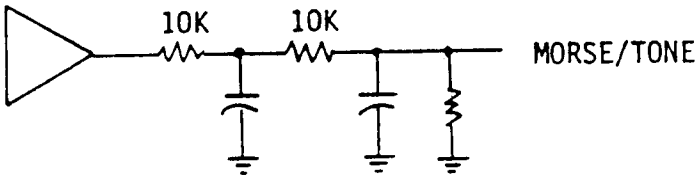
Alarm/Sense Inputs

The alarm/sense inputs accept TTL and CMOS type logic levels in the range of 0 to approximately 15 volts. The logic inputs are internally pulled low to a logic 0 so a contact closure to a 5 or 12 volt supply could also drive the logic inputs. Optionally, a pullup resistor with a contact closure to ground could be the basis of an alarm or sensor.



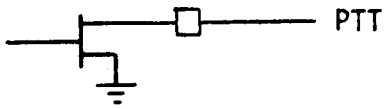
Morse / Tone Output

Morse code or tone encoded response and alarm messages are available for driving a radio transmitter's audio input. The output from the control board is approximately 1 volt peak-to-peak, at 20K output impedance, and may be injected into the transmitter at an appropriate point.



Push-to-Talk

A Push-to-Talk (PTT), or transmitter keying signal, is available to turn on the transmitter during a response or alarm message. The PTT logic output is buffered for high-current high-voltage drive and provides a solid-state "contact closure" to ground during a message. The output may typically be paralleled with the primary keying line to the transmitter, in a "wired-or" configuration, to ensure that the transmitter is held up during a response message.



Reset Switch

An optional switch to reset the microcomputer may be connected between the Reset pin and ground. The board contains an automatic power-on-reset circuit and a watchdog timer for automatic reset in case of soft error; however, in some systems it is desirable to have a front panel reset button. Reset restores all buffered outputs to their off state and the unbuffered outputs to their low states except as modified by the Personality PROM.

Repeater / Remote Base Functions

Various repeater and remote base functions are supported, using the PTT output, COS input, Morse code audio output, etc. Chapter 5, *Repeater Operation*, describes these functions in detail, including installation.

Chapter 3
Operation

Overview

The ITC-32 control board constantly monitors audio at its input for Touch-Tone signals. Touch-Tone digits are collected in a buffer in memory and are evaluated at the Command Evaluaton point (as defined below).

The telephone ring signal from the Telephone Interface Board causes the board to answer the phone after an answer delay period (nominally 1-2 rings, configurable in the Personality PROM) and provide a tone prompt to the calling party. The board can then receive Touch-Tone commands entered over the phone for controlling functions of the board. The board automatically hangs up if a period of one minute elapses after a valid command entry.

The alarm logic inputs, when activated, either cause the transmitter to be keyed with a tone or Morse code message or cause an autodial over the phone to one or more pre-stored phone numbers (stored in the Personality PROM). The board may continue to call the pre-stored numbers periodically until the alarm status is cleared with a Touch-Tone command.

Command Decoder

Touch-Tone digits received are stored until a Command Evaluation occurs. The Command Evaluation is performed

1) After receipt of a "*" key (may be re-configured to another key using the Personality PROM), **OR**
2) 500 ms after the trailing edge of the COS (carrier-operated-switch) logic input.

For example, commands entered over the phone should be terminated with the * key to cause a command evaluation. Commands entered over a radio receiver may be entered without a terminating * if the board's COS logic input is connected to the receiver's carrier-operated-switch (or squelch) logic signal. If the COS signal is not readily available from the receiver, the * key may again be used to force a command evaluation at the end of each command entered over the radio receiver. If it is desirable to use the * key as part of command code sequences, the Command Evaluation key may be redefined to be any Touch-Tone value using the Personality PROM.

A command which has been partially entered incorrectly may be cancelled using the "#" key. The Touch-Tone digits sent prior to the # are cancelled and only those following the # are evaluated at the Command Evaluation point. The Cancel Key may be redefined using the Personality PROM to be other than the # key, in case it is desirable to use the # as part of command code sequences.

The Command Decoder is implemented as an algorithm in software and is carefully designed to provide reliable decoding of valid commands while ignoring invalid ones. It inherently provides "wrong digit reset", "wrong digit lockout", "wrong digit reject", etc. An interdigit timer disqualifies a command if greater than 3 seconds elapses between digits.

Command Structure

Commands consist of a command code prefix unique to each ITC-32 board followed by predefined "root" codes which define the particular function to be performed. Command root codes exist for commanding each logic output high, low, or pulse, setting output groups to particular values, and for interrogating the state of sense inputs, control outputs, and output group values. A "lock" command may cause the board to ignore all commands until an "unlock" command is received to enhance the security of the system. Alarms may be cleared and disabled, and other miscellaneous internal functions may be performed.

The addition of a Personality PROM allows the user to customize each of the command codes independently. Short codes may be assigned to some functions, while longer, more secure commands may be assigned to more critical functions.

Remote Control Logic Outputs

Each remote control output may be commanded individually for on/off type controls, A/B select, valve open/close, etc. When commanded, the control board responds with a high or a low beep, indicating on/off or high/low logic state, followed by the logic output number in Morse code or tone encoded response. Function number tone encoding (an alternative to Morse code) is

_	0	.....	5
.	1	_.	6
..	2	_..	7
...	3	_...	8
....	4	_....	9

High/low beep encoding is defined below.

BUFFERED OUTPUTS	
On	High Beep
Off	Low Beep
Pulse (off/on/off)	Low/High/Low Beep

UNBUFFERED OUTPUTS AND SENSE INPUTS	
High	High Beep
Low	Low Beep
Pulse (l/h/l)	Low/High/Low Beep

For example, commanding function 19 high results in a response of "high tone" followed by ". _...." .

The state of the control outputs may be interrogated as well, without affecting the output state, with a similar readback.

Outputs may also be commanded in groups, as defined below.

Outputs which form "Group"	
16 15 14 13 12 11 10 9	GROUP 1 (8 bits, 0-255)
21 20 19 18 17	GROUP 2 (5 bits, 0-31)
25 24 23 22	GROUP 3 (4 bits, 0-15)
28 27 26	GROUP 4 (3 bits, 0-7)

Response to group command or group interrogate consists of a Morse or tone encoded message conveying the value of the group.

Using the Personality PROM, response messages for the high and low states of each individual output may be customized as Morse code or speech messages indicating the meaning of the output state. In the Personality PROM selectable "Speech" mode, the control board drives off-board Digitalker speech synthesizer chips with the function number or group value in speech, or a custom message as defined in the Personality PROM.

Alarm / Status Monitor Inputs

The four alarm / status monitor inputs may function either as remotely sensed inputs or as alarms which may key the transmitter or autodial out over the phone line to several prestored phone numbers. Alarm autodial requires a Personality PROM for storage of phone numbers. Without a Personality PROM, the functions of the alarm / sense inputs are defined below.

LOGIC INPUT	FUNCTION
ALARM/SENSE 1	ALARM, TRANSMITTER
ALARM/SENSE 2	ALARM, TRANSMITTER
ALARM/SENSE 3	SENSE (INTERROGATE H/L)
ALARM/SENSE 4	SENSE (INTERROGATE H/L)

With a Personality PROM, each input may be defined as a sense input, or as an alarm with transmitter keyup or autodial. The sense response messages and alarm messages may also be customized with the Personality PROM.

Over-the-air alarms cause the transmitter to be keyed approximately every 10 seconds with the message stored in the Personality PROM or with a default Morse code "AL1" through "AL4" message. The alarm state may be cleared by the "Alarm Clear" command.

Telephone autodial alarms require storage of one or two phone numbers for each alarm in the Personality PROM. On alarm condition, the board dials each number and announces the alarm condition several times for approximately one minute. The phone numbers are then redialed at five minute intervals until the alarm condition is cleared. Any Touch-Tone command while the board is connected to the phone (including simply the Command Evaluation key) cancels the alarm.

Reset

A reset signal is applied to the microcomputer briefly on powerup or when the "Reset" pin at P1 is grounded. While the reset signal is applied, the buffered remote control logic outputs are in their on, or grounded state. The unbuffered outputs float and so their state is dependent on what type of circuitry they are connected to. Immediately after the reset signal is removed, the buffered logic outputs are initialized to the off state and the unbuffered outputs to the low state.

The output states which follow a reset may be redefined using the optional Personality PROM.

Repeater Control Functions

The operation of the ITC-32 control board's repeater and remote base functions are described in Chapter 5, *Repeater Operation and Interfacing.*

Personality PROM

The optional Personality PROM allows the user to customize many of the aspects of the controller board without the need to modify the microcomputer firmware. Such characteristics as command codes for each function, reponse messages, alarm autodial numbers, and certain timer values may be modified from their default values defined in the firmware. The Personality PROM allows field reprogrammability and customization of the control board for the user's particular application. Appendix I defines the format for the Personality PROM.

Control Over the Telephone

The ITC-32 control board may be controlled over the telephone when used with ACC's Telephone Interface Board. The control board detects ring, and after a delay of 15 seconds, answers the phone. The caller may enter Touch-Tone commands (terminated with the Command Evaluation key *) and command internal and external functions of the board.

When the phone is answered, the caller must enter a valid command within 10 seconds to prevent the board from hanging up. After the first command has been entered, additional commands must be entered within one minute of each other to prevent automatic hangup.

The board may be commanded to hang up manually with the # key followed by the Command Evaluation key (i.e. #*).

Chapter 4
Interfacing

Remote Control

The applications of remote control of equipment using Touch-Tone signalling over radio or telephone links are wide ranging. This section describes some interfacing examples for the remote control outputs to the real world.

Eight of the 28 remote control outputs are buffered on-board with high-voltage high-current transistors. When the output is commanded "on", the transistor conducts, providing a dc path to ground. The outputs can drive relay coils, solenoids, and opto-couplers directly. They can also drive power transistors for switching heavy dc loads.

Figure 4.1 illustrates the ITC-32 control board buffered outputs driving various types of loads for remote control applications. Relay coils may be driven directly, assuming the current and voltage requirements are within the 100 mA / 60 volt limitations of the buffered outputs. A diode should be connected across the relay coil as shown to protect the driver transistor from inductive kickback voltage spikes when switching. The relay can be commanded to either state remotely with Touch-Tone commands.

A latching relay can be driven by two of the control board's outputs. Latching relays have the advantage of "remembering" magnetically the last state requested. They require no power to drive the coil except when commanded to change state so that they consume less power than non-latching relays. The latching relays may be commanded using the "pulse" Touch-Tone commands.

The control board can drive loads which need to be electrically isolated because of grounding considerations, level translation, or transient protection. Opto-couplers consist of an LED and photo-transistor in a single package, electrically isolated from each other. The control board can directly drive the LED in the coupler, and the photo-transistor, which is completely isolated from the control board, may interface to other circuitry.

AC power loads may be controlled using solid state relays, such as those available from Magnecraft and others, which may be driven directly by the ITC-32 buffered outputs.

Finally, the buffered outputs may interface to TTL or CMOS logic inputs directly with the addition of a pullup resistor to define a logic high voltage compatible with the logic input's requirements.

The remaining 20 TTL compatible level remote control outputs may interface to TTL or CMOS logic, digital-to-analog converters, etc. Figure 4.2 illustrates interface of the TTL level outputs to a variety of circuitry.

The interface to TTL is direct with no other components required. Fanout is one TTL load or four Low Power Schottky loads. Interface to 5 volt CMOS requires only a pullup resistor to 5 volts to guarantee a valid logic high level. Twelve volt CMOS requires level translation through a device such as the 4504B IC.

The control board's group outputs can drive digital-to-analog converters directly which allows easy remote control of analog levels. This capability is useful for controlling rotator direction, audio levels, squelch settings, or power levels.

The group outputs also allow easy "one-of-n" selection of functions with a one-of-n logic decoder, such as a 74LS138 one-of-eight or a 74LS154 one-of-sixteen decoder. In this way, the number of outputs controllable by one ITC-32 control board can be expanded into the hundreds.

Figure 4.1 Buffered Logic Output Interface

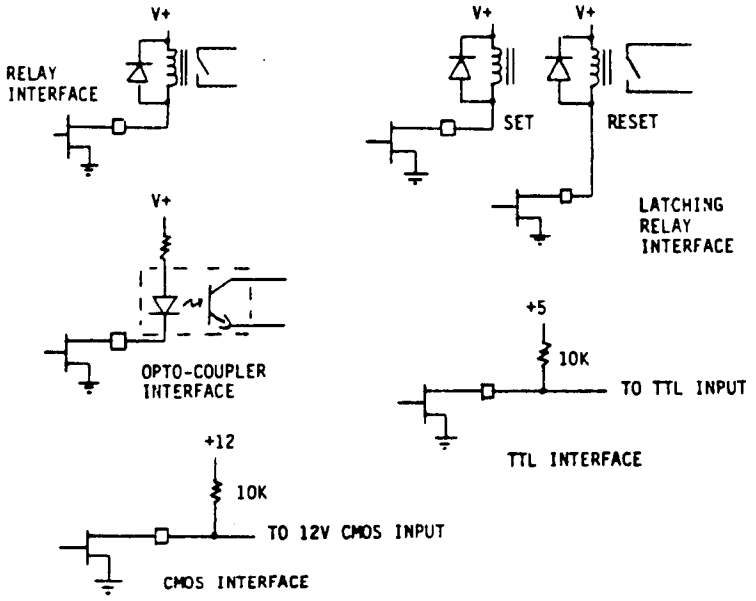
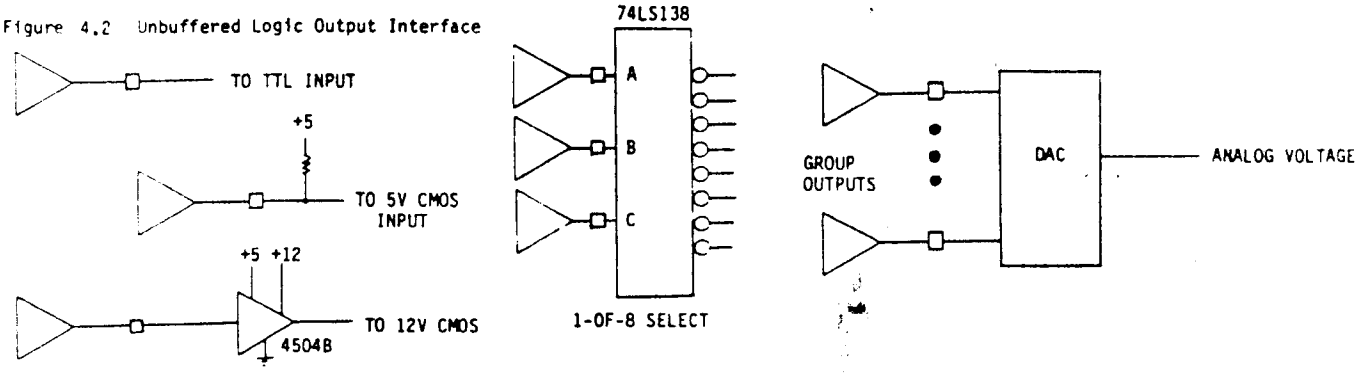


Figure 4.2 Unbuffered Logic Output Interface

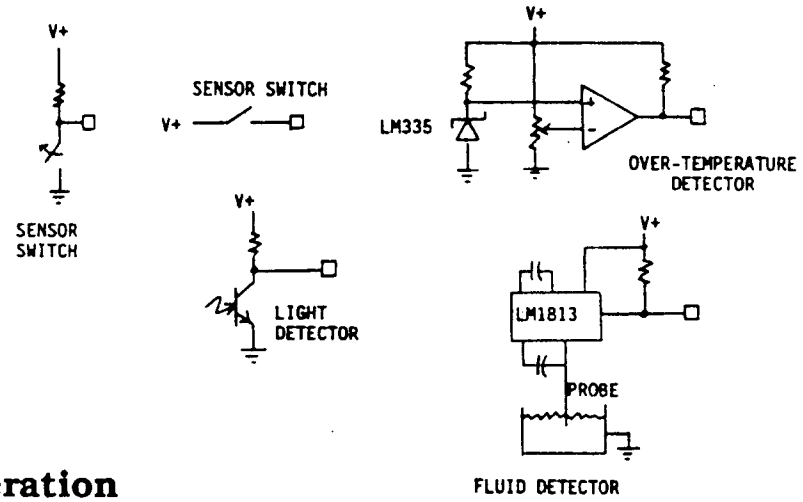


Remote Status Monitoring

The ITC-32 control board's four status logic inputs allow remote interrogation of conditions at a remote site. For example, sensors could provide information on tank level, indicate if there is snow on the ground, or if lights are on in a building. Interrogating the board with Touch-Tone commands causes a readback indicating the logic state at the status inputs.

The status logic inputs are compatible with TTL and 5/12 volt CMOS levels, pull-up resistors with contact closures to ground, etc. Various types of sensors which may be deployed at a remote site include temperature, fluid level, smoke detector, pressure, and light. Figure 4.3 illustrates some interfacing examples with typical sensors for status monitoring.

Figure 4.3 Sensor Interfacing



Alarm Generation

Many of the sensors suitable for alarm generation are similar to those described in the previous section. Alarm capability is particularly valuable for events such as intrusion, overtemperature, undervoltage, water on the floor, and fire.

Logic inputs defined as alarms are activated by a low to high logic level transition. The high level is debounced by the board to prevent false triggering and is latched, activating the alarm. For example, a limit switch activating momentarily on intrusion will generate a latched alarm condition in the ITC-32 control board with the autodial out or keyed transmitter alarm generation until cleared with a Touch-Tone command.

Touch-Tone Audio Input

Since the ITC-32 control board is controlled using Touch-Tone signalling, it's important to apply the audio source correctly for reliable operation. The following section describes telephone interfacing while this section assumes audio is derived from a radio receiver or similar source. The Touch-Tone receiver has a wide dynamic range, but for most reliable results, the audio level should be roughly in the one volt peak-to-peak range. It is important that the frequency response of the audio path be fairly flat since a significant difference between low tone and high tone levels makes Touch-Tone

difficult to decode. The distortion through the path should also be minimized since distortion causes harmonic and intermodulation distortion which can confuse the decoder.

Telephone Line Interface

Interface through the telephone line is handled directly by the Telephone Interface Board (either the FCC registered or non-registered board). The ITC-32 / Telephone Interface Board combination detects phone ring and auto-answers and can dial out on alarm condition.

If the control board is used with both telephone interface and radio receiver audio input, the receiver audio is mixed with the telephone audio into the Touch-Tone receiver after the board auto-answers. Commands from the telephone can be decoded only if the receiver is squelched because the audio is mixed into the decoder.

Morse Code / Tone Audio Output

The Morse / tone audio generated by the control board may be injected into a transmitter audio input stage for sending response and alarm messages over the radio link. Coupling to the phone line is automatically handled by the Telephone Interface Board.

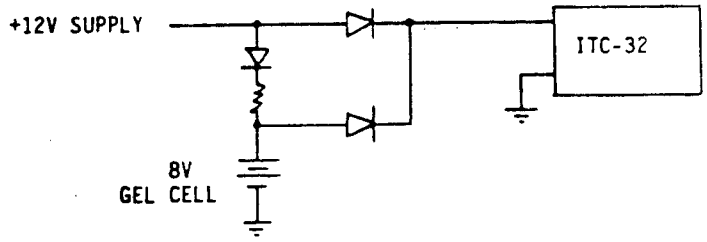
The audio characteristics of the tone output are approximately 20K impedance with a level of about one volt peak-to-peak. The level can be reduced with a resistor from the audio output to ground. The signal should drive a relatively high impedance input to the transmitter audio stage.

Mute Output

The Mute output from the control board provides a solid-state contact closure to ground during the time that Touch-Tone signalling is being sent to the board (unless the telephone is off-hook). The output may be used to mute audio retransmitted over a duplex radio link for code security. The output may connect through a capacitor to a fairly high impedance point in the transmitter audio stage.

Battery Backup

In case of failure of the main supply and since the power requirements of the ITC-32 control board are modest, an 8 or 12 volt Gel-Cell can provide many hours of operation. Use the simple circuit shown below which includes trickle charge of the battery.



Synthesized Speech Readback

Interface of the Digitalker speech synthesizer chip set to the ITC-32 control board is detailed in Appendix II.

Chapter 5
Repeater Operation and Interface

Overview

The ITC-32 control board can provide the basic control functions for simple repeaters, including the COR, IDer, courtesy tone, hang timer, and timeout timer functions. The control operator can also select carrier or PL access and repeater enable/disable remotely.

The board also provides a synthesized remote base capability consisting of a remote base transceiver COS input and PTT output and BCD frequency programming information supplied in response to Touch-Tone commands.

Audio mixing functions must be handled externally. An autopatch is not provided. The Telephone Interface Board is configured for telephone line remote control - not an autopatch. To implement a patch, a remote control output may be connected to the offhook relay of an existing patch.

The repeater functions are in addition to the board's remote control, status monitoring, and alarm capabilities, but the repeater mode "uses up" some of the board's inputs and outputs. The repeater mode is selected by DIP switch 1 "On".

In the Repeater Mode, certain I/O functions are redefined:

OUT 8	Remote Base PTT (active low)
ALARM/SENSE 4	Remote Base COS (active high)
ALARM/SENSE 2	ID Select (low=ID1, high=ID2)
OUT 13-28	Remote Base Frequency (parallel mode)
OUT 6,7	Remote Base Frequency (serial mode)

Several of the repeater's parameters may be changed from their default values through the optional Personality PROM, including ID message, timer values, and tone pitch.

COR Timing

The PTT output is keyed (low) in response to an active (high) COS input. When the COS signal goes away (returns low), a courtesy tone is generated and the PTT remains keyed for the hang time period. The delay to the courtesy tone is nominally .6 second and the hang time is 4 seconds.

ID Timing

The board ID's within 10 seconds of a new COS signal after a period of inactivity. It continues to ID periodically during normal activity and will ID after the last activity is complete.

The board attempts to ID at the end of the hang time if given the opportunity. If not, it tries between user transmissions and finally forces an ID on top of a user transmission if necessary within 10 minutes of the last ID.

Operation Modes

Control Operator level Touch-Tone commands allow selection of repeater enable/disable, remote base enable/disable, carrier or PL access, timer enable/disable, and short or long timer select. See Appendix III for command codes.

Repeater disable inhibits repeater and remote base transmitter operation. Remote base disable inhibits the remote base transmitter and remote base user level commands. Carrier or PL access selects between the COS input or the PL input as the signal which activates the repeater. As a Personality PROM selectable option, OUT5 may indicate the current selection (carrier high, PL low). The repeater timeout timer may be inhibited with the timer disable command and the timer value may be selected as short (45 seconds) or long (3 minutes).

A command is available to "unmute" the next transmission to allow passing tones through the repeater system. Muting is then restored.

Remote Base Function

User level Touch-Tone commands allow enabling or disabling a remote base function which causes the the repeater transmitter to be keyed when a signal is received on the remote base receiver and the remote base transmitter to be keyed when a signal is received on the repeater receiver. The remote base may be a half duplex synthesized transceiver, a full duplex link transceiver, or another repeater at the site, allowing a variety of linking possibilities.

In addition to enabling or disabling the remote base function with Touch-Tone commands, the frequency of a synthesized transceiver may be programmed, with the BCD frequency value present at the control board's outputs, in parallel or serial format. The BCD outputs may interface to the transceiver's frequency synthesizer to allow remote control of its transmit and receive frequency. Readback of the frequency entered by the user verifies correct command entry. When the remote base is in the transmit mode, the courtesy tone is split into two pieces to warn the user.

The *parallel format* (Personality PROM required for parallel format) provides all 16 freqency bits (3 BCD digits plus offset and on/off bits) directly at logic outputs.

The *serial format* conserves remote control outputs by serially shifting information out of two logic outputs as shown in Figure 5.1. External shift registers capture the data shifted out of the board and at the same time may perform any level translation required in interfacing to a particular radio.

A clock signal and data signal are present at OUT 6 and OUT 7, freeing up OUT 13 through OUT 28 for remote control functions.

Figure 5.2 shows circuitry suitable for capturing the serial frequency data for interface to an ICOM IC-22U two meter transceiver as a synthesized remote base. ACC offers a frequency control board (FC-1) which is designed to interface the ITC-32 to the ICOM IC2/3/4AT transceivers.

Interface Signals (REPEATER MODE - SWITCH 1 ON)

Repeater Signals

Repeater Function	Signal Name	Connector Pin
PTT (active low)	PTT	L
COS (active high)	COS	C
PL (active high)	PL	Z
Remote Base PTT (active low)	OUT 8	10
Remote Base COS (active high)	ALARM/SENSE 4	5

Remote Base Frequency, Offset and Control Signals

Parallel Mode

Note: Personality PROM required for this mode selection.

Function	Name	Pin	Function	Name	Pin
MHz 8	OUT 28	13	10KHz 8	OUT 20	16
MHz 4	OUT 27	N	10KHz 4	OUT 19	T
MHz 2	OUT 26	12	10KHz 2	OUT 18	17
MHz 1	OUT 25	M	10KHz 1	OUT 17	U
100KHz 8	OUT 24	14	ON(H)/OFF(L)	OUT 16	18
100KHz 4	OUT 23	R	5(H)/0(L) KHz	OUT 15	V
100KHz 2	OUT 22	15	SIM(H)/DUP(L)	OUT 14	19
100KHz 1	OUT 21	S	+(H)/-(L) OFFST	OUT 13	W

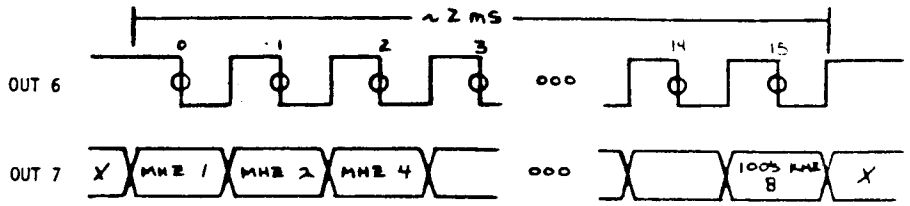
Note: The ON/OFF bit is high when a user has turned the remote base on, and remains low when the remote base is off. The signal may be used to gate remote base receiver squelched audio into the transmitter.

Serial Mode

Note: This is the default mode.

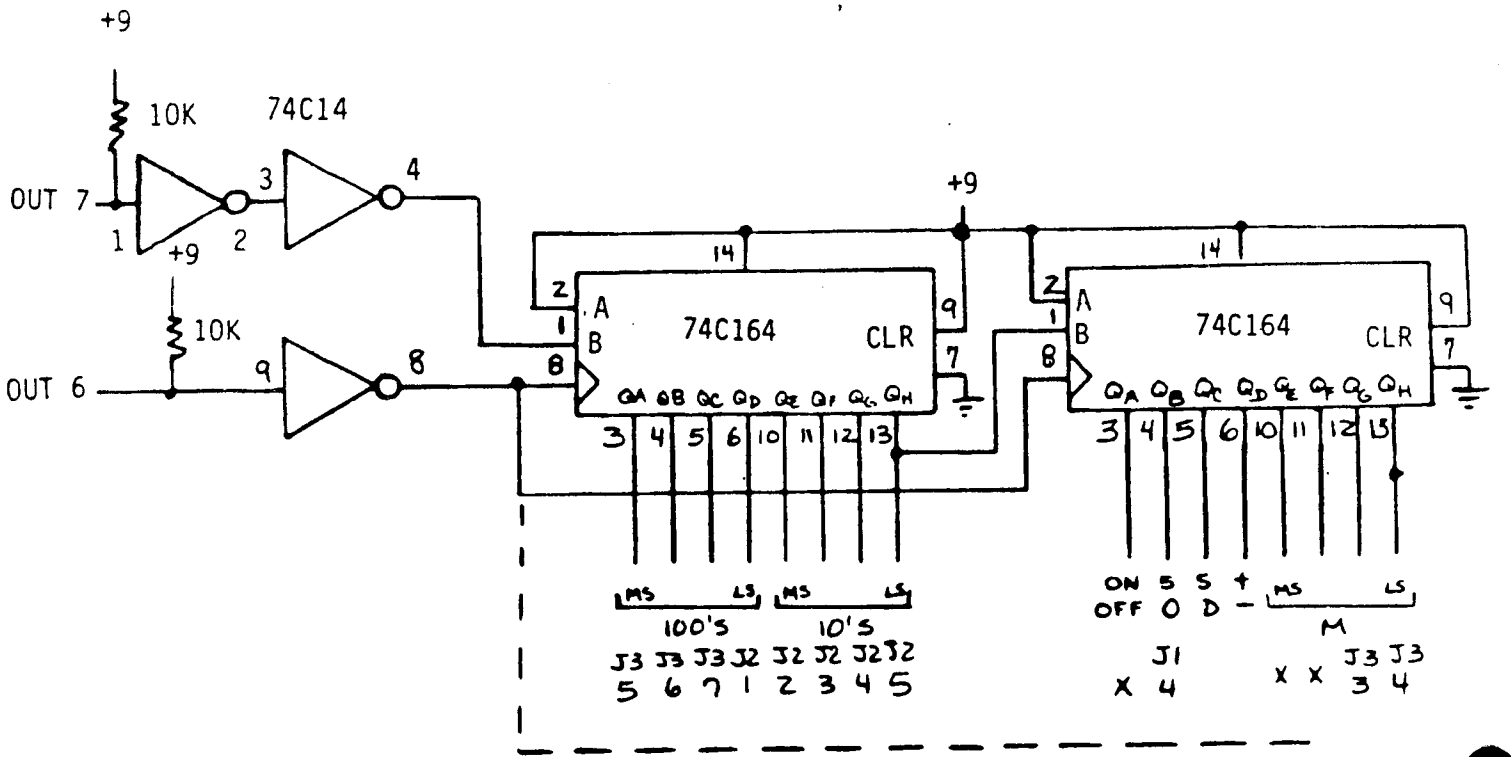
Function	Name	Pin
DATA	OUT 7	K
CLOCK	OUT 6	9

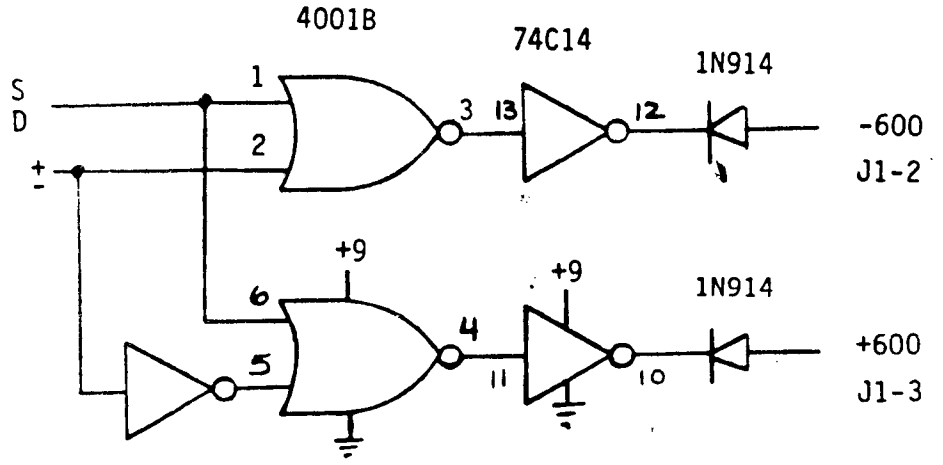
FIGURE 5.1 SYNTHESIZER INFO TIMING (SERIAL MODE)



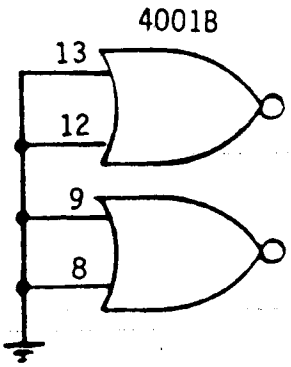
0	MHz	1	8	10's KHz	1
1	MHz	2	9	10's KHz	2
2	MHz	4	10	10's KHz	4
3	MHz	8	11	10's KHz	8
4	PLUS/MINUS		12	100's KHz	1
5	SIMPLEX/DUPLEX		13	100's KHz	2
6	5/0 KHz		14	100's KHz	4
7	ON/OFF		15	100's KHz	8

FIGURE 5.2 - IC-22U INTERFACE





IC's must be CMOS not TTL



J2 - 6 = +9V
DUP = OPEN
SEND = PTT

Chapter 6
Principles of Operation

ITC-32 Control Board

The ITC-32 control board is based on an 8085AH microprocessor, in conjunction with two 8155H I/O and RAM chips, and up to two EPROMs. The 8085 CPU clock signal is derived from the Touch-Tone receiver chip 3.58 MHz crystal oscillator. The CPU's multiplexed address/data bus is de-multiplexed by a 74HC373 octal latch which recovers the low half of the address bus. A 74HC138 decoder provides address decoding and generates chip select signals for the 8155's and the EPROMs.

The 8155 I/O and RAM chips provide the board's control outputs and alarm/sense inputs. Eight of the control outputs are buffered with VMOS power transistors for direct high-current high-voltage drive capability. The alarm / sense inputs are buffered with an integrated transistor array. The two 8155's provide 512 bytes of RAM for program temporary storage and stack usage. On-chip programmable timers develop a periodic interrupt signal to the CPU which forms the basis of the operating system and a much longer period signal for use as a watchdog timer. In the event that the program fails to periodically clear the watchdog timer, it times out, resetting the CPU and causing a recovery from soft error.

The EPROM devices may range from 2K to 8K byte devices (2716, 2732, or 2764). Each is decoded into an 8K byte location in the microcomputer's memory map.

Morse code or tone encoded audio is generated by software at the CPU's SOD output and is filtered to remove harmonic content.

Touch-Tone audio is applied to the Touch-Tone receiver chip set input. The MT8865 filter chip separates the Touch-Tone signal into its low tone and high tone components and squares up the audio signal for presentation to the MT8860 digital decoder chip. The filter also removes 60 Hz, dial tone, and CTCSS audio components. The digital decoder analyzes the high and low group tones and decides when valid Touch-Tone audio is present. Valid Touch-Tone causes an interrupt to the CPU which causes the program to read the input port connected to the Touch-Tone receiver binary outputs.

A voltage regulator IC accepts +8 to +14 volts at the input to the board and converts it to the +5 volts required by the circuitry for proper operation.

Telephone Interface Board

The Telephone Interface Board provides the interface between the circuitry on the ITC-32 control board and the telephone line. The interface consists of isolation for protection from hazardous voltages and transients, impedance matching, on/off hook control, and ring detect. In addition, the Telephone Interface Board provides a received audio agc, and an electronic hybrid (not used in this application).

The FCC registered interface board uses a Novation Phone Line Interface Module to achieve FCC registration of the board. This permits legal direct connect to the U.S. telephone network. The non-registered board replaces the Novation module with a discrete transformer, relay, and opto-coupler to provide the identical function at a lower cost, but without the FCC registration feature.

Chapter 7
Troubleshooting

General Maintenance

The ITC-32 control board is fully solid-state with no electro-mechanical or moving parts. As such, no maintenance should be required over the life of the board.

As with all electronic equipment, temperature extremes should be avoided to lengthen the life of the solid-state circuitry on the board. The board should be protected from moisture and dirty or corrosive environments.

In Case of Difficulty

The ITC-32 control board is based on an 8085 microprocessor. Although microprocessor based, the ITC-32 control board contains vastly fewer components than less capable discrete logic designs. Therefore, the reliability will equal or exceed that of conventional Touch-Tone decoder boards and systems.

A failure in a microcomputer based system such as this is extremely rare, but would generally fall into one of two categories - one which causes the microcomputer itself to not function (i.e., not execute its program) or one where peripheral circuitry is damaged and so does not perform certain of the board's I/O functions.

If the board appears to operate with the exception of certain input or output functions, check the buffer devices or the 8155 I/O devices. Also check for good quality Touch-Tone signals, proper command entry, and proper Personality PROM contents if used.

If the board is totally non-functional, check for presence of the input power supply and the regulated 5 volts on the board. Check for the 3.58 MHz oscillator signal from the Touch-Tone receiver chip set. Look for microcomputer bus activity and for activity at the CPU's ALE pin (pin 30). Check also for unusually hot components or IC's not properly seated in their sockets.

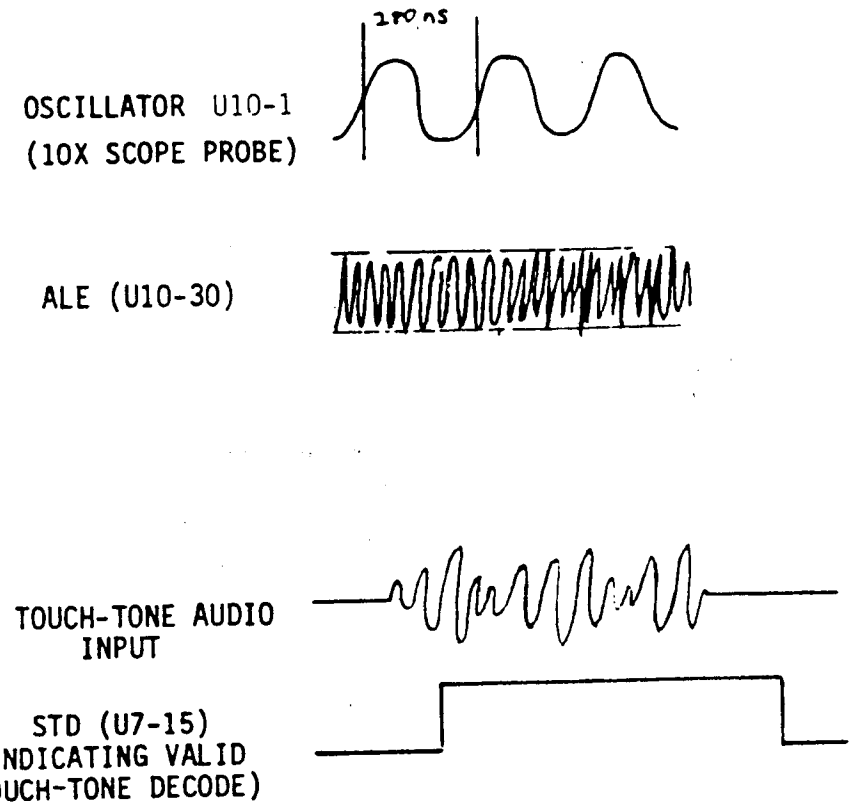
RF Generation

Since the ITC-32 control board uses a microcomputer, digital signals are present on the board which contain harmonic components which extend into the VHF range. In most installations, since the receiver is typically well shielded and the board is located far from the receiving antenna, no interference will result.

In cases where interference to radio reception does occur, the following hints should be helpful.

- Place the board in a metal enclosure.
- Shield the wires carrying power and control signals.
- Wrap the bundle of wires around a toroid core.
- If interference results with the receiver's antenna disconnected, rf may be entering through the receiver audio or COS path. Add a small choke (around 10 uH) at each signal entry to the receiver.

Waveforms



Appendix I
Personality PROM Specification

The Personality PROM option allows the user to customize many of the parameters of the ITC-32 control board without the need to modify the firmware. Changes can be made in the field independent of the factory. Equipment required for field programming of the Personality PROM is any EPROM programmer capable of programming single supply (Intel pinout) 2716, 2732, or 2764 EPROMs, and a UV eraser. The format of the Personality PROM is defined below.

About Hex

Hexadecimal is a numbering system in base 16. This means that the decimal numbers zero through fifteen are each represented by a single digit 0-9, A, B, C, D, E, and F. For example, the decimal number 14 is represented in hexadecimal by the letter E.

In general, to distinguish hexadecimal representations from decimal, the hex number is followed by the letter H. For example, fifteen in decimal would be written as EH. Often, leading zero digits are added to fill out a certain number of columns. When representing decimal address fifteen in a memory chip, it is often written as 000EH. It is also common to require a leading zero digit before a first alpha character in a hex number. For example, hexadecimal FFFF would be written as 0FFFFH.

Addresses shown below are the hexadecimal representation of the Personality PROM location for each function.

About EPROMs

When an EPROM is erased, every data location is set to 0FFH (all ones). In addition, if no Personality PROM is plugged into the socket on the ITC-32 board, the "phantom" locations are read as 0FFH, since the data bus is pulled high with resistors. Therefore, all Personality PROM locations which you are not specifically modifying should be left in the erased state of 0FFH. Only enter data into those locations where you intend to make changes to the board's default operation.

Summary

To summarize the format of the information below, the left hand column indicates the *starting address* (in Hex) for the data to be stored in the EPROM. Data consists of strings, or sequences of bytes, in the case of messages and command code prefixes. Such data is stored beginning at the starting address and continuing in sequential locations. In other cases, the data consists of one or two bytes, representing timer values, initialization parameters, or "flag bytes" which tell the software of a selected option.

MODE SELECTIONS

0010H Set to 00H indicates Digitalker Speech installed

0011H Remote Base Frequency Information
- Parallel ("uses up" OUT 13-28) — 00H
- Serial ("uses up" OUT 6, 7) — FFH

0012H Alarm/Status 1
0013H Alarm/Status 2
0014H Alarm/Status 3
0015H Alarm/Status 4

{ Alarm — 00H
  Status — 01H
  Default — FFH
  (see section 3.5) }

0016H Command Evaluation Key — TOUCH-TONE KEY

0017H Cancel Key — TOUCH-TONE KEY

(see "Touch-Tone Digit Representation In Hex" in this Appendix)

0019H When set to 00H, OUT 5 is redefined to indicate "Carrier" mode (high) or "PL" mode (low)

REMOTE BASE FREQUENCY INITIALIZATION

001AH Frequency MHz
001BH Frequency hundreds kHz
001CH Frequency tens kHz
001DH Offset bits
Bit 0 - 1=plus, 0=minus
Bit 1 - 1=simplex, 0=duplex
Bit 2 - 1=5 kHz, 0=0 kHz
Bit 3 - 1="on", 0="off" (controls logic output suitable for power and/or audio switching)
Bits 4-7 - 0

Example: 6.520 MHz simplex
001AH=06H,05H,02H,0AH

MORSE / TONE PARAMETERS

0020H Morse Speed (10,15,20,25WPM) — WORDS PER MINUTE
Example 15 WPM
15=0FH
Address 0020H=0FH

0023H,0024H Courtesy Tone Duration — # CYCLES OF TONE BURST
Example 100 ms at 440 Hz
440 Hz = 2.27 ms,
100 ms = 44 cycles
44=002CH
Address 0023H=2CH (low byte), 0024H=00H (high byte)

0025H,0026H Repeater Courtesy Tone Pitch — PITCH

0027H,0028H Link Courtesy Tone Pitch — PITCH

PITCH = 2 x ((PERIOD(us) - 108us) / 26.8us)

TIMERS

0030H	Interdigit Example 5 seconds 5=05H Address 0030H=05H	SECONDS
0031H	Repeater Hang Time Example 4 seconds 4=04H Address 0031H=04H	SECONDS
0032H,0033H	Repeater Timeout Time (Long) Example 180 seconds (3 minutes) 180=00B4H Address 0032H=B4H, 0033H=00H	SECONDS
0034H,0035H	Repeater Timeout Time (Short) Example 45 seconds 45=002DH Address 0034H=2DH, 0035H=00H	SECONDS
0036H,0037H	Delay to Courtesy Tone Example 600 ms 600=0258H Address 0034H=58H, 0035H=02H	MILLISECONDS
0038H	Phone Answer Delay Time	SECONDS
003DH	Alarm over-the-air announcement delay	SECONDS

INITIALIZATION PARAMETERS

		MS LS	
0040H	OUT 1-8	8 7 6 5 4 3 2 1	0=on, 1=off
0041H	OUT 9-16	16 15 14 13 12 11 10 9	0=high, 1=low
0042H	OUT 17-24	24 23 22 21 20 19 18 17	" "
0043H	OUT 25-28	xx xx xx xx 28 27 26 25	" "

0049H	Alarm 1	/	00H=Disable
004AH	Alarm 2	\	FFH=Enable
004BH	Alarm 3		
004CH	Alarm 4		

Note: The following apply to Repeater Mode only.

0044H	Repeater Enable	
	Enable	FFH
	Disable	00H
0045H	Remote Base Enable	
	Enable	FFH
	Disable	00H
0046H	Carrier / PL Operation	
	Carrier	FFH
	PL	00H
0047H	Repeater Timer Enable	
	Enable	FFH
	Disable	00H
0048H	Repeater Timer Select	
	Long Timer	FFH
	Short Timer	00H

RESPONSE MESSAGES

FORMAT: (PREFIX) (CHARACTER/WORD STRING) (TERMINATOR)

PREFIX = 00H (MORSE CODE)
01H (SPEECH)
02H (DTMF, with external DTMF encoder wired to OUT21-28)

STRING = LIST OF CODES FROM MORSE CODE ASCII HEX VALUES OR SPEECH MASTER WORD LIST (APPENDIX II)

TERMINATOR = FFH

Example Morse "HI PWR"
00H,48H,49H,20H,50H,57H,52H,FFH

Example Speech "Control up"
01H,4BH,8DH,FFH

0080H REPEATER ID #1 (AL3 LOW)
0090H REPEATER ID #2 (AL3 HIGH)
00A0H REPEATER FORCED CW ID
0100H OUT 1 OFF
0108H OUT 1 ON
0110H OUT 2 OFF
0118H OUT 2 ON
0120H OUT 3 OFF
0128H OUT 3 ON
0130H OUT 4 OFF
0138H OUT 4 ON
0140H OUT 5 OFF
0148H OUT 5 ON
0150H OUT 6 OFF
0158H OUT 6 ON
0160H OUT 7 OFF
0168H OUT 7 ON
0170H OUT 8 OFF
0178H OUT 8 ON
0180H OUT 9 LOW
0188H OUT 9 HIGH
0190H OUT 10 LOW
0198H OUT 10 HIGH
01A0H OUT 11 LOW
01A8H OUT 11 HIGH
01B0H OUT 12 LOW
01B8H OUT 12 HIGH
01C0H OUT 13 LOW
01C8H OUT 13 HIGH
01D0H OUT 14 LOW
01D8H OUT 14 HIGH
01E0H OUT 15 LOW
01E8H OUT 15 HIGH
01F0H OUT 16 LOW
01F8H OUT 16 HIGH

0200H OUT 17 LOW
0208H OUT 17 HIGH
0210H OUT 18 LOW
0218H OUT 18 HIGH
0220H OUT 19 LOW
0228H OUT 19 HIGH
0230H OUT 20 LOW
0238H OUT 20 HIGH
0240H OUT 21 LOW
0248H OUT 22 HIGH
0250H OUT 22 LOW
0258H OUT 22 HIGH
0260H OUT 23 LOW
0268H OUT 23 HIGH
0270H OUT 24 LOW
0278H OUT 24 HIGH
0280H OUT 25 LOW
0288H OUT 25 HIGH
0290H OUT 26 LOW
0298H OUT 26 HIGH
02A0H OUT 27 LOW
02A8H OUT 27 HIGH
02B0H OUT 28 LOW
02B8H OUT 28 HIGH

02C0H STATUS 1 LOW / ALARM 1 CLEAR
02C8H STATUS 1 HIGH / ALARM 1 ACTIVATED
02D0H STATUS 2 LOW / ALARM 2 CLEAR
02D8H STATUS 2 HIGH / ALARM 2 ACTIVATED
02E0H STATUS 3 LOW / ALARM 3 CLEAR
02E8H STATUS 3 HIGH / ALARM 3 ACTIVATED
02F0H STATUS 4 LOW / ALARM 4 CLEAR
02F8H STATUS 4 HIGH / ALARM 4 ACTIVATED

COMMAND CODE PREFIXES

FORMAT: (COMMAND CODE STRING) (TERMINATOR)

STRING = LIST OF TOUCH-TONE HEX REPRESENTATION OF PREFIX
TERMINATOR = FFH

Example 3A7...
03H,0DH,07H,FFH (starting at the specified address)

0300H OUT 1
0310H OUT 2
0320H OUT 3
0330H OUT 4
0340H OUT 5
0350H OUT 6
0360H OUT 7
0370H OUT 8
0380H OUT 9
0390H OUT 10
03A0H OUT 11
03B0H OUT 12
03C0H OUT 13
03D0H OUT 14
03E0H OUT 15
03F0H OUT 16
0400H OUT 17
0410H OUT 18
0420H OUT 19
0430H OUT 20
0440H OUT 21
0450H OUT 22
0460H OUT 23
0470H OUT 24
0480H OUT 25
0490H OUT 26
04A0H OUT 27
04B0H OUT 28

04C0H GROUP 1
04D0H GROUP 2
04E0H GROUP 3
04F0H GROUP 4

0500H STATUS 1
0510H STATUS 2
0520H STATUS 3
0530H STATUS 4

0540H ALARM

0550H REPEATER CONTROL OPERATOR
0560H REPEATER REMOTE BASE

0570H LOCK / UNLOCK

0580H INITIALIZE

NOTE: PRESENCE OF ANY PP COMMAND CODE PREFIX CANCELS FIRMWARE DEFINED PREFIX FOR ALL COMMANDS - PREFIXES MUST BE DEFINED FOR ALL FUNCTIONS TO BE USED.

ALARM AUTODIAL PHONE NUMBERS

0600H ALARM 1 #1
0620H ALARM 1 #2
0640H ALARM 2 #1
0660H ALARM 2 #2
0680H ALARM 3 #1
06A0H ALARM 3 #2
06C0H ALARM 4 #1
06E0H ALARM 4 #2

FORMAT: (PHONE NUMBER STRING) (TERMINATOR)

STRING = TOUCH-TONE HEX REPRESENTATION
(PAUSE = 0BH)
TERMINATOR = FFH

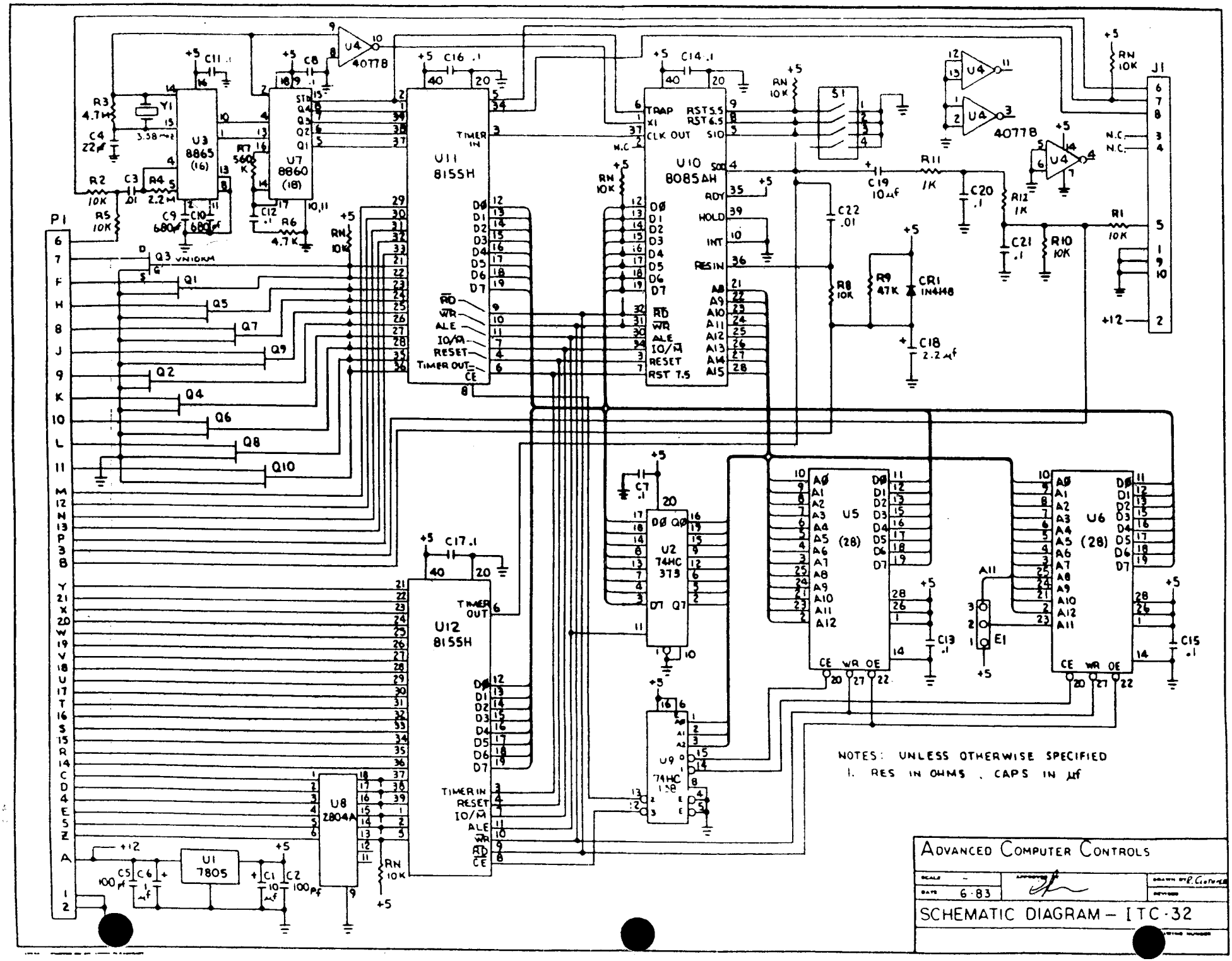
Example Alarm 2 phone #1 = 253-8085, phone #2 not used
Address 0640H=02H,05H,03H,08H,00H,08H,05H,FFH
Address 0660H=FFH

Morse Code Character ASCII HEX Values

A	41	0	30
B	42	1	31
C	43	2	32
D	44	3	33
E	45	4	34
F	46	5	35
G	47	6	36
H	48	7	37
I	49	8	38
J	4A	9	39
K	4B		
L	4C		
M	4D		
N	4E		
O	4F	WORD SPACE	20
P	50	WAIT (AS)	22
Q	51	END OF MSG (AR)	24
R	52	END OF LINE (SK)	25
S	53	PARENTHESIS	28
T	54	COMMA (,)	2C
U	55	DASH (-)	2D
V	56	PERIOD (.)	2E
W	57	SLANT BAR (/)	2F
X	58	COLON (:)	3A
Y	59	SEMICOLON (;)	3B
Z	5A	QUESTION (?)	3F

Touch-Tone Digit Representation In Hex

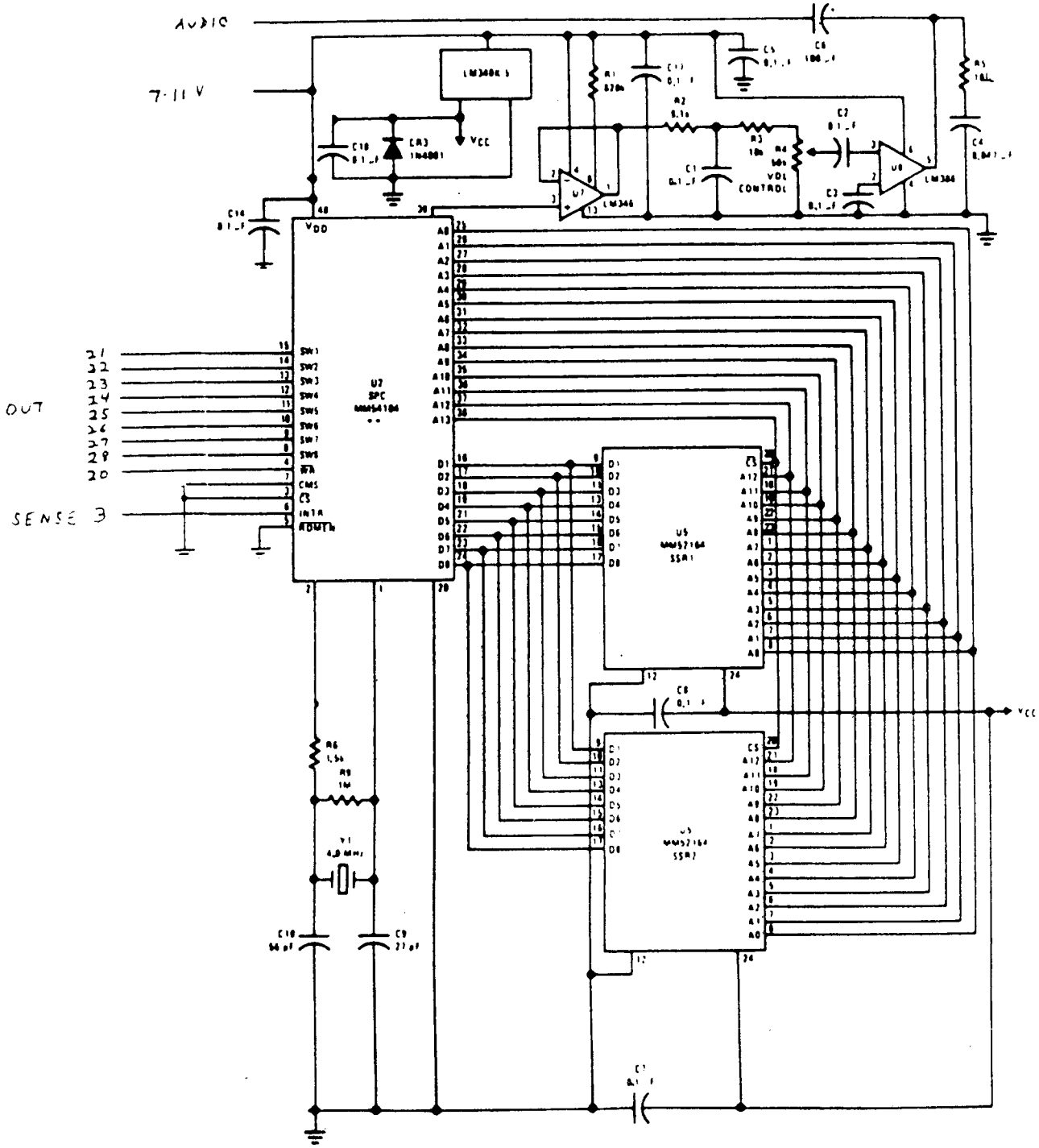
0	00	8	08
1	01	9	09
2	02	*	0B
3	03	#	0C
4	04	A	0D
5	05	B	0E
6	06	C	0F
7	07	D	0A



P1
J1
U1 7805
U2 74HC 373
U3 8865 (16)
U4 4077B
U5 (28)
U6 (28)
U7 8860 (18)
U8 2804A
U9 74HC 138
U10 8085AH
U11 8155H
U12 8155H
S1
CR1 1N4148
E1
NOTES: UNLESS OTHERWISE SPECIFIED
1. RES IN OHMS, CAPS IN µf
ADVANCED COMPUTER CONTROLS
SCALE -
DATE 6-83
SCHEMATIC DIAGRAM – ITC-32

Appendix IV
Schematic

Appendix II
Speech Synthesizer Interface



MASTER WORD LIST

	DEC	HEX	BINARY
ZERO	000	00	00000000
ONE	001	01	00000001
TWO	002	02	00000010
THREE	003	03	00000011
FOUR	004	04	00000100
FIVE	005	05	00000101
SIX	006	06	00000110
SEVEN	007	07	00000111
EIGHT	008	08	00001000
NINE	009	09	00001001
TEN	010	0A	00001010
ELEVEN	011	0B	00001011
TWELVE	012	0C	00001100
THIRTEEN	013	0D	00001101
FOURTEEN	014	0E	00001110
FIFTEEN	015	0F	00001111
SIXTEEN	016	10	00010000
SEVENTEEN	017	11	00010001
EIGHTEEN	018	12	00010010
NINETEEN	019	13	00010011
TWENTY	020	14	00010100
THIRTY	021	15	00010101
FORTY	022	16	00010110
FIFTY	023	17	00010111
SIXTY	024	18	00011000
SEVENTY	025	19	00011001
EIGHTY	026	1A	00011010
NINETY	027	1B	00011011
HUNDRED	028	1C	00011100
THOUSAND	029	1D	00011101
MILLION	030	1E	00011110
A	032	20	00100000
B	033	21	00100001
C	034	22	00100010
D	035	23	00100011
E	036	24	00100100
F	037	25	00100101
G	038	26	00100110
H	039	27	00100111
I	040	28	00101000
J	041	29	00101001
K	042	2A	00101010
L	043	2B	00101011
M	044	2C	00101100
N	045	2D	00101101
O	046	2E	00101110
P	047	2F	00101111
Q	048	30	00110000
R	049	31	00110001
S	050	32	00110010
T	051	33	00110011
U	052	34	00110100
V	053	35	00110101

	DEC	HEX	BINARY
W	054	36	00110110
X	055	37	00110111
Y	056	38	00111000
Z	057	39	00111001
AGAIN	058	3A	00111010
AMPERE	059	3B	00111011
AND	060	3C	00111100
AT	061	3D	00111101
CANCEL	062	3E	00111110
CASE	063	3F	00111111
CENT	064	40	01000000
400HERTZ TONE	065	41	01000001
80HERTZ TONE	066	42	01000010
20MS SILENCE	067	43	01000011
40MS SILENCE	068	44	01000100
80MS SILENCE	069	45	01000101
160MS SILENCE	070	46	01000110
320MS SILENCE	071	47	01000111
CENTI	072	48	01001000
CHECK	073	49	01001001
COMMA	074	4A	01001010
CONTROL	075	4B	01001011
DANGER	076	4C	01001100
DEGREE	077	4D	01001101
DOLLAR	078	4E	01001110
DOWN	079	4F	01001111
EQUAL	080	50	01010000
ERROR	081	51	01010001
FEET	082	52	01010010
FLOW	083	53	01010011
FUEL	084	54	01010100
GALLON	085	55	01010101
GO	086	56	01010110
GRAM	087	57	01010111
GREAT	088	58	01011000
GREATER	089	59	01011001
HAVE	090	5A	01011010
HIGH	091	5B	01011011
HIGHER	092	5C	01011100
HOUR	093	5D	01011101
IN	094	5E	01011110
INCHES	095	5F	01011111
IS	096	60	01100000
IT	097	61	01100001
KILO	098	62	01100010
LEFT	099	63	01100011
LESS	100	64	01100100
LESSER	101	65	01100101
LIMIT	102	66	01100110
LOW	103	67	01100111
LOWER	104	68	01101000
MARK	105	69	01101001
METER	106	6A	01101010
MILE	107	6B	01101011

	DEC	HEX	BINARY
MILLI	108	6C	01101100
MINUS	109	6D	01101101
MINUTE	110	6E	01101110
NEAR	111	6F	01101111
NUMBER	112	70	01110000
OF	113	71	01110001
OFF	114	72	01110010
ON	115	73	01110011
OUT	116	74	01110100
OVER	117	75	01110101
PARENTHESIS	118	76	01110110
PERCENT	119	77	01110111
PLEASE	120	78	01111000
PLUS	121	79	01111001
POINT	122	7A	01111010
POUND	123	7B	01111011
PULSES	124	7C	01111100
RATE	125	7D	01111101
RE	126	7E	01111110
READY	127	7F	01111111
RIGHT	128	80	10000000
SS (Note 1)	129	81	10000001
SECOND	130	82	10000010
SET	131	83	10000011
SPACE	132	84	10000100
SPEED	133	85	10000101
STAR	134	86	10000110
START	135	87	10000111
STOP	136	88	10001000
THAN	137	89	10001001
THE	138	8A	10001010
TIME	139	8B	10001011
TRY	140	8C	10001100
UP	141	8D	10001101
VOLT	142	8E	10001110
WEIGHT (Note 2)	143	8F	10001111

Note 1: "SS" makes any singular word plural

Note 2: Address 143 is the last legal address in this particular word list. Exceeding address 143 in an external processor application will produce pieces of unintelligible invalid speech data

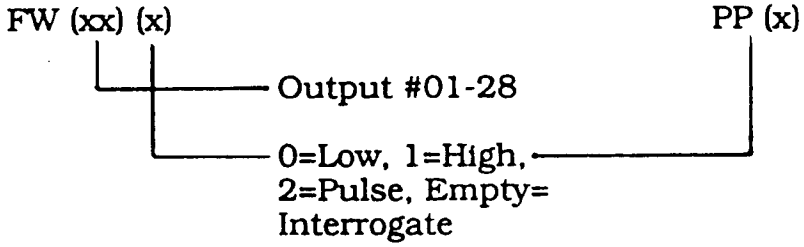
* Digitalker IC's available from Jameco Electronics, (415) 592=8097, or any National Semiconductor distributor.
* Voice Response mode defined in Personality PROM status byte.
* OUT 20 - OUT 28, and ALARM/SENSE 3 redefined in Voice Response mode to support speech hardware.

Appendix III
Command Codes

Command codes may consist of a prefix defined in the firmware common to all codes followed by "root codes" or the prefixes may be customized using the Personality PROM. The codes below show two columns for each function. The "FW" code identifies the command based on a firmware defined prefix which applies to all codes. The PP column indicates the command if codes are customized through the Personality PROM.

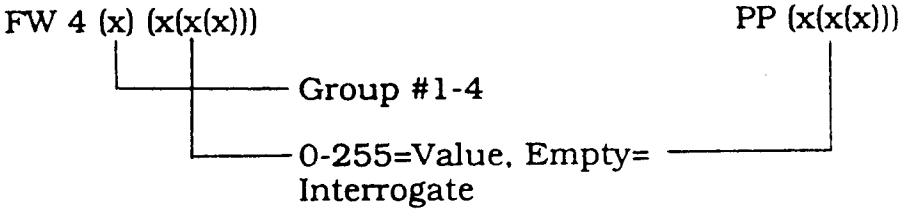
FW = Firmware supplied Command Code Prefix.
PP = Personality PROM defined Command Code Prefix.
*** Personality PROM codes override Firmware codes ***
*** Any Command Code Prefix defined in Personality PROM CANCELS Firmware Prefix for ALL commands ***

INDIVIDUAL OUTPUT FORCE / INTERROGATE



Example:
Firmware defined prefix = 123. Command output 1 high. "123011"
Personality PROM defined prefix = 834. Command output 1 high. "8341"

GROUP OUTPUT FORCE / INTERROGATE



Example:
Firmware defined prefix = 123. Command group 1 to value 7. "123417"
Pers. PROM defined prefix = 658. Command group 1 to value 7. "6587"

STATUS INPUT INTERROGATE

FW 3 (x) PP

Input #1-4

Example:

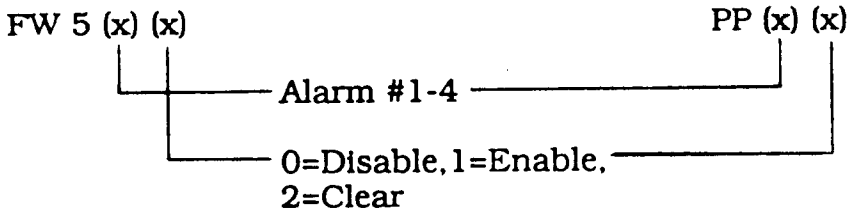
Firmware defined prefix = 123. Interrogate input 2. "12332"
Pers. PROM defined prefix = 94. Interrogate input 2. "94"

ALARM

FW 5 (x) (x) PP (x) (x)

Alarm #1-4

0=Disable, 1=Enable,
2=Clear



(Any command over phone cancels dial out alarm - i.e. "*", assuming * is command evaluation key.)

REPEATER CONTROL OPERATOR

FW 6 1 4 (x) PP (x)

0 Repeater Enable
1 Repeater Disable
2 Remote Base Enable
3 Remote Base Disable
4 Carrier Access
5 PL Access
6 Repeater Timer Enable
7 Repeater Timer Disable
8 Long Repeater Timer
9 Short Repeater Timer

Example:

Firmware defined prefix = 123. Enable repeater. "1236140"
Pers. PROM defined prefix = 2990. Enable repeater. "29900"

REMOTE BASE

FW 7 (x) ... PP (x)

1 Receive Only
2 Transmit
3 Off

4 Unmute Touch-Tone during next transmission. Mute is restored following the next transmission.

FW 7 (MHTOF) ... PP (MHTOF)

M Megahertz
H Hundreds MHz
T Tens MHz
O Ones MHz (0/5)
F Transmit Offset
  1 Minus
  2 Simplex
  3 Plus

LOCK / UNLOCK

PP (x)

0=Unlock, 1=Lock ("Lock" causes ITC-32 to ignore all further commands until "Unlocked".)

INITIALIZE

PP

(Clears board to powerup state).

HANGUP PHONE

(*)

(*)

Appendix I
Personality PROM Specification

The Personality PROM option allows the user to customize many of the paameters of the ITC-32 control board without the need to modify the firmware. Changes can be made in the field independent of the factory. Equipment required for field programming of the Personality PROM is any EPROM programmer capable of programming single supply (Intel pinout) 2716, 2732, or 2764 EPROMs, and a UV eraser. The format of the Personality PROM is defined below.

About Hex

Hexadecimal is a numbering system in base 16. That means that the decimal numbers zero through fifteen are each represented by a single digit 0-9, A, B, C, D, E, and F. For example, the decimal number 14 is represented in hexadecimal by the letter E.

In general, to distinguish hexadecimal representations from decimal, the hex number is followed by the letter H. For example, fifteen in decimal would be written as FH. Often, leading zero digits are added to fill out a certain number of columns. When representing decimal address fifteen in a memory chip, it is often written as 000EH. It is also common to require a leading zero digit before a first alpha character in a hex number. For example, hexadecimal FFFF would be written as 0FFFFH.

Addresses shown below are the hexadecimal representation of the Personality PROM location for each function.

About EPROMs

When an EPROM is erased, every data location is set to 0FFH (all ones). In addition, if no Personality PROM is plugged into the socket on the ITC-32 board, the "phantom" locations are read as 0FFH, since the data bus is pulled high with resistors. Therefore, all Personality PROM locations which you are not specifically modifying should be left in the erased state of 0FFH. Only enter data into those locations where you intend to make changes to the board's default operation.

DECIMAL	HEX	DECIMAL	HEX	DECIMAL	HEX
1	01	12	0C	23	17
2	02	13	0D	24	18
3	03	14	0E	25	19
4	04	15	0F	26	1A
5	05	16	10	27	1B
6	06	17	11	28	1C
7	07	18	12	29	1D
8	08	19	13	30	1E
9	09	20	14	31	1F
10	0A	21	15	32	20
11	0B	22	16	33	21

MODE SELECTIONS

0010H	Set to 00H indicates Digitalker Speech installed	
0011H	Remote Base Frequency Information	
	Parallel ("uses up" OUT 13-28)	00H
	Serial ("uses up" OUT 6, 7)	FFH
0012H	Alarm/Status 1 } Alarm	00H
0013H	Alarm/Status 2 } Status	01H
0014H	Alarm/Status 3 } Default	FFH
0015H	Alarm/Status 4 } (see section 3.5)	
0016H	Command Evaluation Key	TOUCH-TONE KEY
0017H	Cancel Key	TOUCH-TONE KEY

(see "Touch-Tone Digit Representation In Hex" in this Appendix)

0018H When set to 00H, outputs 21-28 are redefined to drive a DTMF encoder chip for DTMF response messages. This may not be used in conjunction with Digitalker.

0019H When set to 00H, OUT 5 is redefined to indicate "Carrier" mode (high) or "PL" mode (low)

REMOTE BASE FREQUENCY INITIALIZATION

001AH Frequency MHz

001BH Frequency hundreds kHz

001CH Frequency tens kHz

001DH Offset bits

Bit 0 - 1=plus, 0=minus

Bit 1 - 1=simplex, 0=duplex

Bit 2 - 1=5 kHz, 0=0 kHz

Bit 3 - 1="on", 0="off" (controls logic output suitable for power and/or audio switching)

Bits 4-7 - 0

Example: 6.520 MHz simplex
001AH=06H,05H,02H,0AH

MORSE / TONE PARAMETERS

0020H Morse Speed (10,15,20,25WPM) WORDS PER MINUTE

Example 15 WPM
15=0FH
Address 0020H=0FH

0023H,0024H Courtesy Tone Duration # CYCLES OF TONE BURST

Example 100 ms at 440 Hz
440 Hz = 2.27 ms,
100 ms = 44 cycles
44=002CH
Address 0023H=2CH (low byte), 0024H=00H (high byte)

0025H,0026H Repeater Courtesy Tone Pitch — PITCH
0027H,0028H Link Courtesy Tone Pitch — PITCH
PITCH = 2 x ((PERIOD(us) - 108us) / 26.8us)

TIMERS

0030H Interdigit — SECONDS
Example 5 seconds
5=05H
Address 0030H=05H

0031H Repeater Hang Time — SECONDS
Example 4 seconds
4=04H
Address 0031H=04H

0032H,0033H Repeater Timeout Time (Long) — SECONDS
Example 180 seconds (3 minutes)
180=00B4H
Address 0032H=B4H, 0033H=00H

0034H,0035H Repeater Timeout Time (Short) — SECONDS
Example 45 seconds
45=002DH
Address 0034H=2DH, 0035H=00H

0036H,0037H Delay to Courtesy Tone — MILLISECONDS
Example 600 ms
600=0258H
Address 0036H=58H, 0037H=02H

0038H Phone Answer Delay Time — SECONDS
003DH Alarm over-the-air announcement delay — SECONDS

INITIALIZATION PARAMETERS

		MS 1 0 1 1 0 1 0 LS	
0040H	OUT 1-8	8 7 6 5 4 3 2 1	0=on, 1=off
0041H	OUT 9-16	16 15 14 13 12 11 10 9	0=high, 1=low
0042H	OUT 17-24	24 23 22 21 20 19 18 17	
0043H	OUT 25-28	xx xx xx xx 28 27 26 25	
		0 0 0 0 1 0 1 0	

0049H Alarm 1 / 00H=Disable
004AH Alarm 2 \ FFH=Enable
004BH Alarm 3
004CH Alarm 4

Note: The following apply to Repeater Mode only.
0044H Repeater Enable

Enable	FFH
Disable	00H

0045H	Remote Base Enable	
	Enable	FFH
	Disable	00H
0046H	Carrier / PL Operation	
	Carrier	FFH
	PL	00H
0047H	Repeater Timer Enable	
	Enable	FFH
	Disable	00H
0048H	Repeater Timer Select	
	Long Timer	FFH
	Short Timer	00H

RESPONSE MESSAGES

FORMAT: (PREFIX) (CHARACTER/WORD STRING) (TERMINATOR)

PREFIX = 00H (MORSE CODE)
01H (SPEECH)
02H (DTMF, with external DTMF encoder wired to OUT21-28)

STRING = LIST OF CODES FROM MORSE CODE ASCII HEX VALUES
OR SPEECH MASTER WORD LIST (APPENDIX II)

TERMINATOR = FFH

Example Morse "HI PWR"
00H,48H,49H,20H,50H,57H,52H,FFH

Example Speech "Control up"
01H,4BH,8DH,FFH

0080H REPEATER ID #1 (AL2 LOW)
0090H REPEATER ID #2 (AL2 HIGH)
00A0H REPEATER FORCED CW ID
0100H OUT 1 OFF
0108H OUT 1 ON
0110H OUT 2 OFF
0118H OUT 2 ON
0120H OUT 3 OFF
0128H OUT 3 ON
0130H OUT 4 OFF
0138H OUT 4 ON
0140H OUT 5 OFF
0148H OUT 5 ON
0150H OUT 6 OFF
0158H OUT 6 ON
0160H OUT 7 OFF
0168H OUT 7 ON
0170H OUT 8 OFF
0178H OUT 8 ON
0180H OUT 9 LOW
0188H OUT 9 HIGH
0190H OUT 10 LOW
0198H OUT 10 HIGH
01A0H OUT 11 LOW
01A8H OUT 11 HIGH
01B0H OUT 12 LOW
01B8H OUT 12 HIGH
01C0H OUT 13 LOW
01C8H OUT 13 HIGH
01D0H OUT 14 LOW
01D8H OUT 14 HIGH
01E0H OUT 15 LOW
01E8H OUT 15 HIGH
01F0H OUT 16 LOW
01F8H OUT 16 HIGH

0200H OUT 17 LOW
0208H OUT 17 HIGH
0210H OUT 18 LOW
0218H OUT 18 HIGH
0220H OUT 19 LOW
0228H OUT 19 HIGH
0230H OUT 20 LOW
0238H OUT 20 HIGH
0240H OUT 21 LOW
0248H OUT 21 HIGH
0250H OUT 22 LOW
0258H OUT 22 HIGH
0260H OUT 23 LOW
0268H OUT 23 HIGH
0270H OUT 24 LOW
0278H OUT 24 HIGH
0280H OUT 25 LOW
0288H OUT 25 HIGH
0290H OUT 26 LOW
0298H OUT 26 HIGH
02A0H OUT 27 LOW
02A8H OUT 27 HIGH
02B0H OUT 28 LOW
02B8H OUT 28 HIGH

02C0H STATUS 1 LOW / ALARM 1 CLEAR
02C8H STATUS 1 HIGH / ALARM 1 ACTIVATED
02D0H STATUS 2 LOW / ALARM 2 CLEAR
02D8H STATUS 2 HIGH / ALARM 2 ACTIVATED
02E0H STATUS 3 LOW / ALARM 3 CLEAR
02E8H STATUS 3 HIGH / ALARM 3 ACTIVATED
02F0H STATUS 4 LOW / ALARM 4 CLEAR
02F8H STATUS 4 HIGH / ALARM 4 ACTIVATED

COMMAND CODE PREFIXES

FORMAT: (COMMAND CODE STRING) (TERMINATOR)

STRING = LIST OF TOUCH-TONE HEX REPRESENTATION OF PREFIX
→ TERMINATOR = FFH

Example 3A7...
03H,0DH,07H,FFH (starting at the specified address)

0300H OUT 1
0310H OUT 2
0320H OUT 3
0330H OUT 4
0340H OUT 5
0350H OUT 6
0360H OUT 7
0370H OUT 8
0380H OUT 9
0390H OUT 10
03A0H OUT 11
03B0H OUT 12
03C0H OUT 13
03D0H OUT 14
03E0H OUT 15
03F0H OUT 16
0400H OUT 17
0410H OUT 18
0420H OUT 19
0430H OUT 20
0440H OUT 21
0450H OUT 22
0460H OUT 23
0470H OUT 24
0480H OUT 25
0490H OUT 26
04A0H OUT 27
04B0H OUT 28

04C0H GROUP 1
04D0H GROUP 2
04E0H GROUP 3
04F0H GROUP 4

0500H STATUS 1
0510H STATUS 2
0520H STATUS 3
0530H STATUS 4

0540H ALARM

0550H REPEATER CONTROL OPERATOR
0560H REPEATER REMOTE BASE

0570H LOCK / UNLOCK

0580H INITIALIZE

NOTE: PRESENCE OF ANY PP COMMAND CODE PREFIX CANCELS FIRMWARE DEFINED PREFIX FOR ALL COMMANDS - PREFIXES MUST BE DEFINED FOR ALL FUNCTIONS TO BE USED.

ALARM AUTODIAL PHONE NUMBERS

0600H ALARM 1 #1
0620H ALARM 1 #2
0640H ALARM 2 #1
0660H ALARM 2 #2
0680H ALARM 3 #1
06A0H ALARM 3 #2
06C0H ALARM 4 #1
06E0H ALARM 4 #2

FORMAT: (PHONE NUMBER STRING) (TERMINATOR)

- STRING = TOUCH-TONE HEX REPRESENTATION (PAUSE = 0BH)
- TERMINATOR = FFH

Example Alarm 2 phone #1 = 253-8085, phone #2 not used
Address 0640H=02H,05H,03H,08H,00H,08H,05H,FFH
Address 0660H=FFH

COMMAND CODE PREFIXES

FORMAT: (COMMAND CODE STRING) (TERMINATOR)

STRING = LIST OF TOUCH-TONE HEX REPRESENTATION OF PREFIX
→ TERMINATOR = FFH

Example 3A7...
03H,0DH,07H,FFH (starting at the specified address)

0300H OUT 1
0310H OUT 2
0320H OUT 3
0330H OUT 4
0340H OUT 5
0350H OUT 6
0360H OUT 7
0370H OUT 8
0380H OUT 9
0390H OUT 10
03A0H OUT 11
03B0H OUT 12
03C0H OUT 13
03D0H OUT 14
03E0H OUT 15
03F0H OUT 16
0400H OUT 17
0410H OUT 18
0420H OUT 19
0430H OUT 20
0440H OUT 21
0450H OUT 22
0460H OUT 23
0470H OUT 24
0480H OUT 25
0490H OUT 26
04A0H OUT 27
04B0H OUT 28

04C0H GROUP 1
04D0H GROUP 2
04E0H GROUP 3
04F0H GROUP 4

0500H STATUS 1
0510H STATUS 2
0520H STATUS 3
0530H STATUS 4

0540H ALARM

0550H REPEATER CONTROL OPERATOR
0560H REPEATER REMOTE BASE

* 0570H LOCK / UNLOCK

0580H INITIALIZE

NOTE: PRESENCE OF ANY PP COMMAND CODE PREFIX CANCELS FIRMWARE DEFINED PREFIX FOR ALL COMMANDS - PREFIXES MUST BE DEFINED FOR ALL FUNCTIONS TO BE USED.

ALARM AUTODIAL PHONE NUMBERS

0600H ALARM 1 #1
0620H ALARM 1 #2
0640H ALARM 2 #1
0660H ALARM 2 #2
0680H ALARM 3 #1
06A0H ALARM 3 #2
06C0H ALARM 4 #1
06E0H ALARM 4 #2

FORMAT: (PHONE NUMBER STRING) (TERMINATOR)

* STRING = TOUCH-TONE HEX REPRESENTATION
(PAUSE = 0BH)
* TERMINATOR = FFH

Example Alarm 2 phone #1 = 253-8085, phone #2 not used
Address 0640H=02H,05H,03H,08H,00H,08H,05H,FFH
Address 0660H=FFH

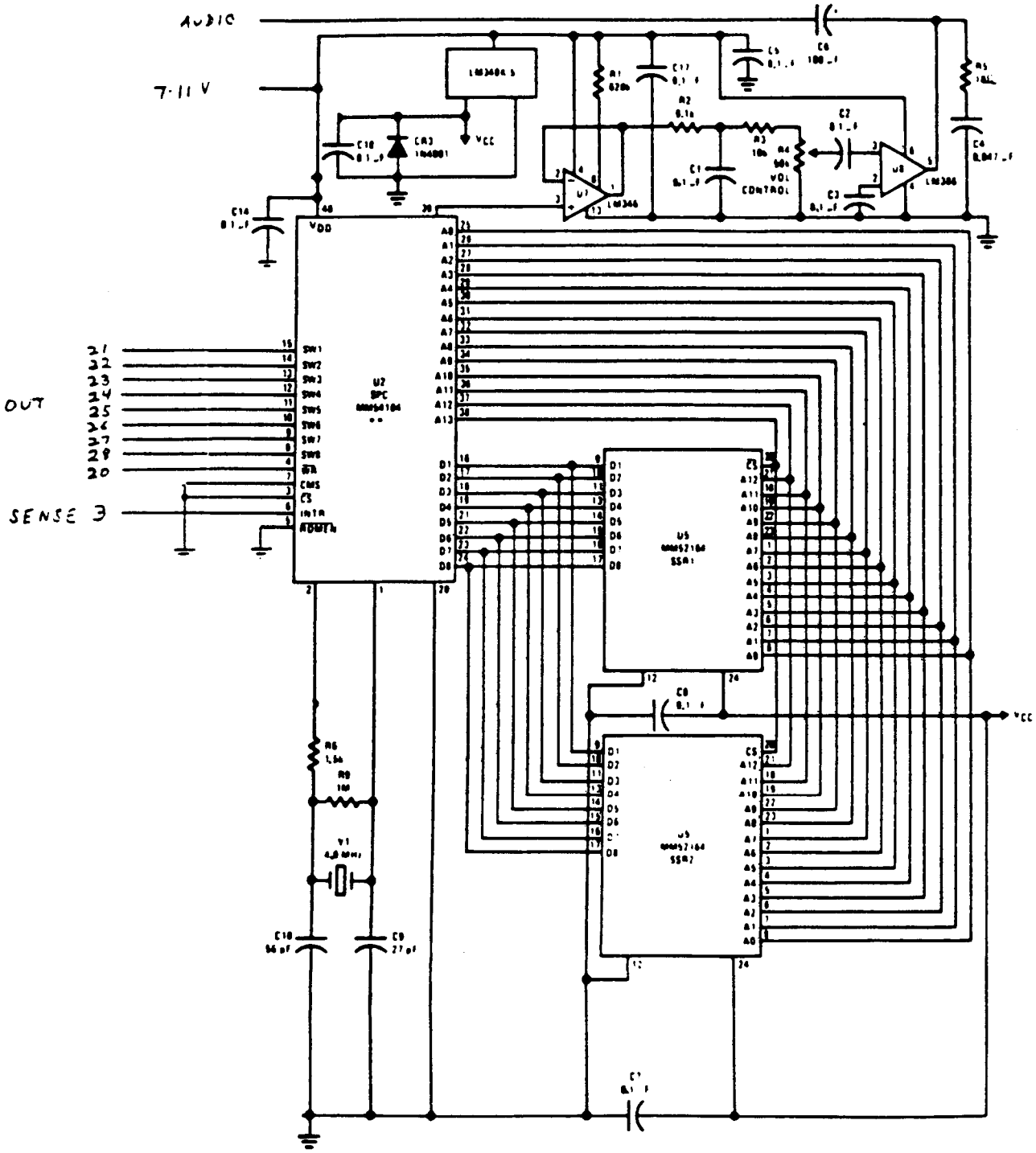
Morse Code Character ASCII HEX Values

A	41	0	30
B	42	1	31
C	43	2	32
D	44	3	33
E	45	4	34
F	46	5	35
G	47	6	36
H	48	7	37
I	49	8	38
J	4A	9	39
K	4B		
L	4C		
M	4D		
N	4E		
O	4F	WORD SPACE	20
P	50	WAIT (AS)	22
Q	51	END OF MSG (AR)	24
R	52	END OF LINE (SK)	25
S	53	PARENTHESIS	28
T	54	COMMA (,)	2C
U	55	DASH (-)	2D
V	56	PERIOD (.)	2E
W	57	SLANT BAR (/)	2F
X	58	COLON (:)	3A
Y	59	SEMICOLON (;)	3B
Z	5A	QUESTION (?)	3F

Touch-Tone Digit Representation In Hex

0	00	8	08
1	01	9	09
2	02	*	0B
3	03	#	0C
4	04	A	0D
5	05	B	0E
6	06	C	0F
7	07	D	0A

Appendix II
Speech Synthesizer Interface



MASTER WORD LIST

	DEC	HEX	BINARY
ZERO	000	00	00000000
ONE	001	01	00000001
TWO	002	02	00000010
THREE	003	03	00000011
FOUR	004	04	00000100
FIVE	005	05	00000101
SIX	006	06	00000110
SEVEN	007	07	00000111
EIGHT	008	08	00001000
NINE	009	09	00001001
TEN	010	0A	00001010
ELEVEN	011	0B	00001011
TWELVE	012	0C	00001100
THIRTEEN	013	0D	00001101
FOURTEEN	014	0E	00001110
FIFTEEN	015	0F	00001111
SIXTEEN	016	10	00010000
SEVENTEEN	017	11	00010001
EIGHTEEN	018	12	00010010
NINETEEN	019	13	00010011
TWENTY	020	14	00010100
THIRTY	021	15	00010101
FORTY	022	16	00010110
FIFTY	023	17	00010111
SIXTY	024	18	00011000
SEVENTY	025	19	00011001
EIGHTY	026	1A	00011010
NINETY	027	1B	00011011
HUNDRED	028	1C	00011100
THOUSAND	029	1D	00011101
MILLION	030	1E	00011110
A	032	20	00100000
B	033	21	00100001
C	034	22	00100010
D	035	23	00100011
E	036	24	00100100
F	037	25	00100101
G	038	26	00100110
H	039	27	00100111
I	040	28	00101000
J	041	29	00101001
K	042	2A	00101010
L	043	2B	00101011
M	044	2C	00101100
N	045	2D	00101101
O	046	2E	00101110
P	047	2F	00101111
Q	048	30	00110000
R	049	31	00110001
S	050	32	00110010
T	051	33	00110011
U	052	34	00110100
V	053	35	00110101

	DEC	HEX	BINARY
W	054	36	00110110
X	055	37	00110111
Y	056	38	00111000
Z	057	39	00111001
AGAIN	058	3A	00111010
AMPERE	059	3B	00111011
AND	060	3C	00111100
AT	061	3D	00111101
CANCEL	062	3E	00111110
CASE	063	3F	00111111
CENT	064	40	01000000
400HERTZ TONE	065	41	01000001
80HERTZ TONE	066	42	01000010
20MS SILENCE	067	43	01000011
40MS SILENCE	068	44	01000100
80MS SILENCE	069	45	01000101
160MS SILENCE	070	46	01000110
320MS SILENCE	071	47	01000111
CENTI	072	48	01001000
CHECK	073	49	01001001
COMMA	074	4A	01001010
CONTROL	075	4B	01001011
DANGER	076	4C	01001100
DEGREE	077	4D	01001101
DOLLAR	078	4E	01001110
DOWN	079	4F	01001111
EQUAL	080	50	01010000
ERROR	081	51	01010001
FEET	082	52	01010010
FLOW	083	53	01010011
FUEL	084	54	01010100
GALLON	085	55	01010101
GO	086	56	01010110
GRAM	087	57	01010111
GREAT	088	58	01011000
GREATER	089	59	01011001
HAVE	090	5A	01011010
HIGH	091	5B	01011011
HIGHER	092	5C	01011100
HOUR	093	5D	01011101
IN	094	5E	01011110
INCHES	095	5F	01011111
IS	096	60	01100000
IT	097	61	01100001
KILO	098	62	01100010
LEFT	099	63	01100011
LESS	100	64	01100100
LESSER	101	65	01100101
LIMIT	102	66	01100110
LOW	103	67	01100111
LOWER	104	68	01101000
MARK	105	69	01101001
METER	106	6A	01101010
MILE	107	6B	01101011

	DEC	HEX	BINARY
MILLI	108	6C	01101100
MINUS	109	6D	01101101
MINUTE	110	6E	01101110
NEAR	111	6F	01101111
NUMBER	112	70	01110000
OF	113	71	01110001
OFF	114	72	01110010
ON	115	73	01110011
OUT	116	74	01110100
OVER	117	75	01110101
PARENTHESIS	118	76	01110110
PERCENT	119	77	01110111
PLEASE	120	78	01111000
PLUS	121	79	01111001
POINT	122	7A	01111010
POUND	123	7B	01111011
PULSES	124	7C	01111100
RATE	125	7D	01111101
RE	126	7E	01111110
READY	127	7F	01111111
RIGHT	128	80	10000000
SS (Note 1)	129	81	10000001
SECOND	130	82	10000010
SET	131	83	10000011
SPACE	132	84	10000100
SPEED	133	85	10000101
STAR	134	86	10000110
START	135	87	10000111
STOP	136	88	10001000
THAN	137	89	10001001
THE	138	8A	10001010
TIME	139	8B	10001011
TRY	140	8C	10001100
UP	141	8D	10001101
VOLT	142	8E	10001110
WEIGHT (Note 2)	143	8F	10001111

Note 1: "SS" makes any singular word plural

Note 2: Address 143 is the last legal address in this particular word list Exceeding address 143 in an external processor application will produce pieces of unintelligible invalid speech data

* Digitalker IC's available from Jameco Electronics, (415) 592=8097, or any National Semiconductor distributor.
* Voice Response mode defined in Personality PROM status byte.
* OUT 20 - OUT 28, and ALARM/SENSE 3 redefined in Voice Response mode to support speech hardware.

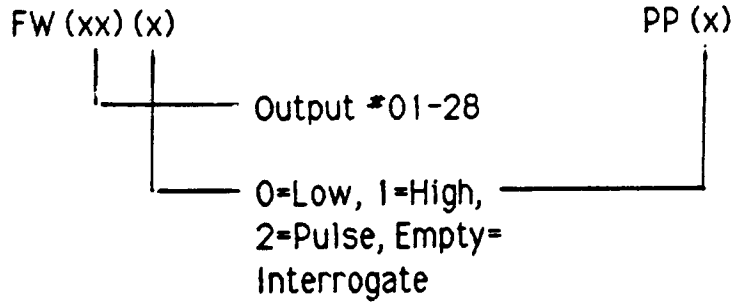
Appendix III

Command Codes

Command codes may consist of a prefix defined in the firmware common to all codes followed by "root codes", or the prefixes may be customized using the Personality PROM. The codes below show two columns for each function. The "FW" code identifies the command based on a firmware defined prefix which applies to all codes. The PP column indicates the command if codes are customized through the Personality PROM.

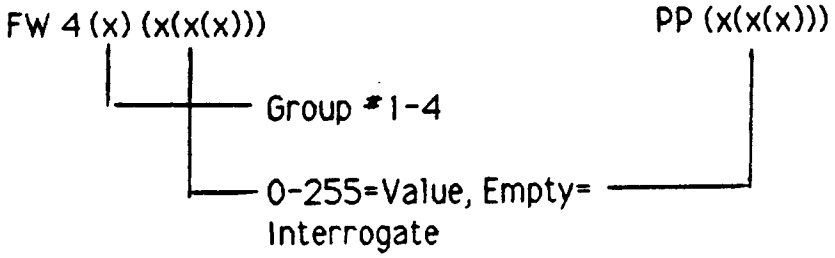
FW = Firmware supplied Command Code Prefix.
PP = Personality PROM defined Command Code Prefix.
*** Personality PROM codes override Firmware codes ***
*** Any Command Code Prefix defined in Personality PROM CANCELS Firmware Prefix for ALL commands ***

INDIVIDUAL OUTPUT FORCE / INTERROGATE



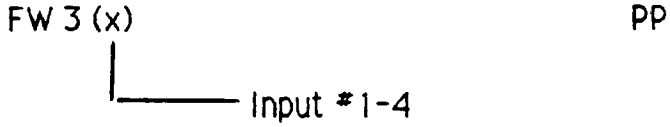
Example:
Firmware defined prefix = 123. Command output 1 high. "123011"
Personality PROM defined prefix = 834. Command output 1 high. "8341"

GROUP OUTPUT FORCE / INTERROGATE



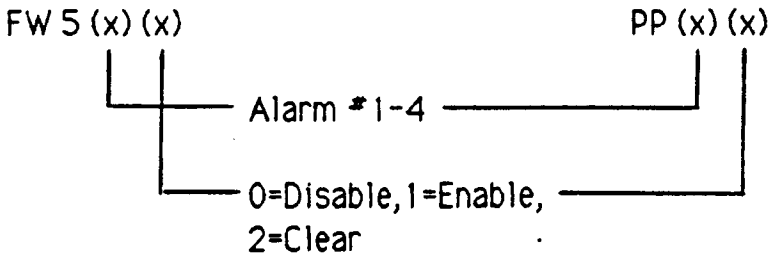
Example:
Firmware defined prefix = 123. Command group 1 to value 7. "123417"
Pers. PROM defined prefix = 658. Command group 1 to value 7. "6587"

STATUS INPUT INTERROGATE



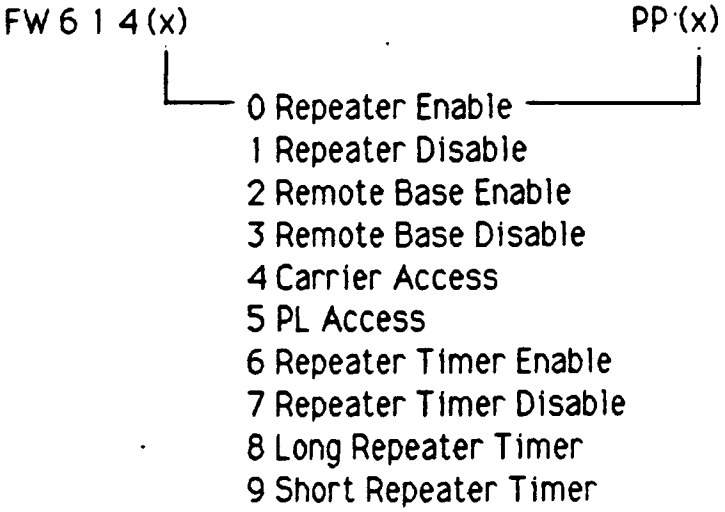
Example:
Firmware defined prefix = 123. Interrogate input 2. "12332"
Pers. PROM defined prefix = 94. Interrogate input 2. "94"

ALARM



(Any command over phone cancels dial out alarm -
i.e. "*", assuming * is command evaluation key.)

REPEATER CONTROL OPERATOR



Example:
Firmware defined prefix = 123. Enable repeater. "1236140"
Pers. PROM defined prefix = 2990. Enable repeater. "29900"

REMOTE BASE

FW 7 (x) — PP (x)

1 Receive Only
2 Transmit
3 Off

4 Unmute Touch-Tone during next transmission. Mute is restored following the next transmission.

FW 7 (MHTOF) — PP (MHTOF)

M Megahertz
H Hundreds MHz
T Tens MHz
O Ones MHz (0/5)
F Transmit Offset
1 Minus
2 Simplex
3 Plus

LOCK / UNLOCK

PP (x)

0=Unlock, 1=Lock ("Lock" causes ITC-32 to ignore all further commands until "Unlocked".)

INITIALIZE

PP

(Clears board to powerup state).

HANGUP PHONE

* (*)

* (*)