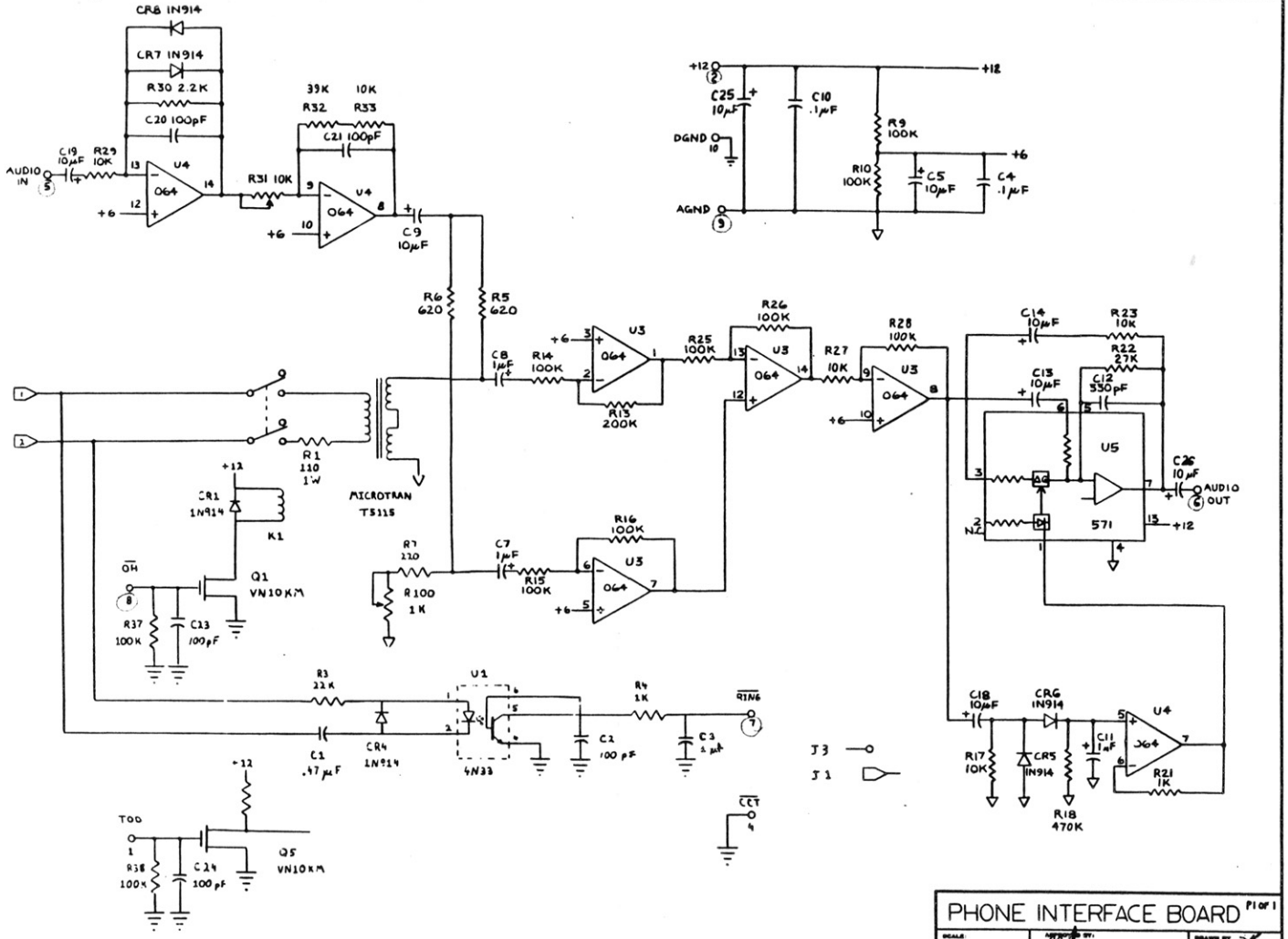
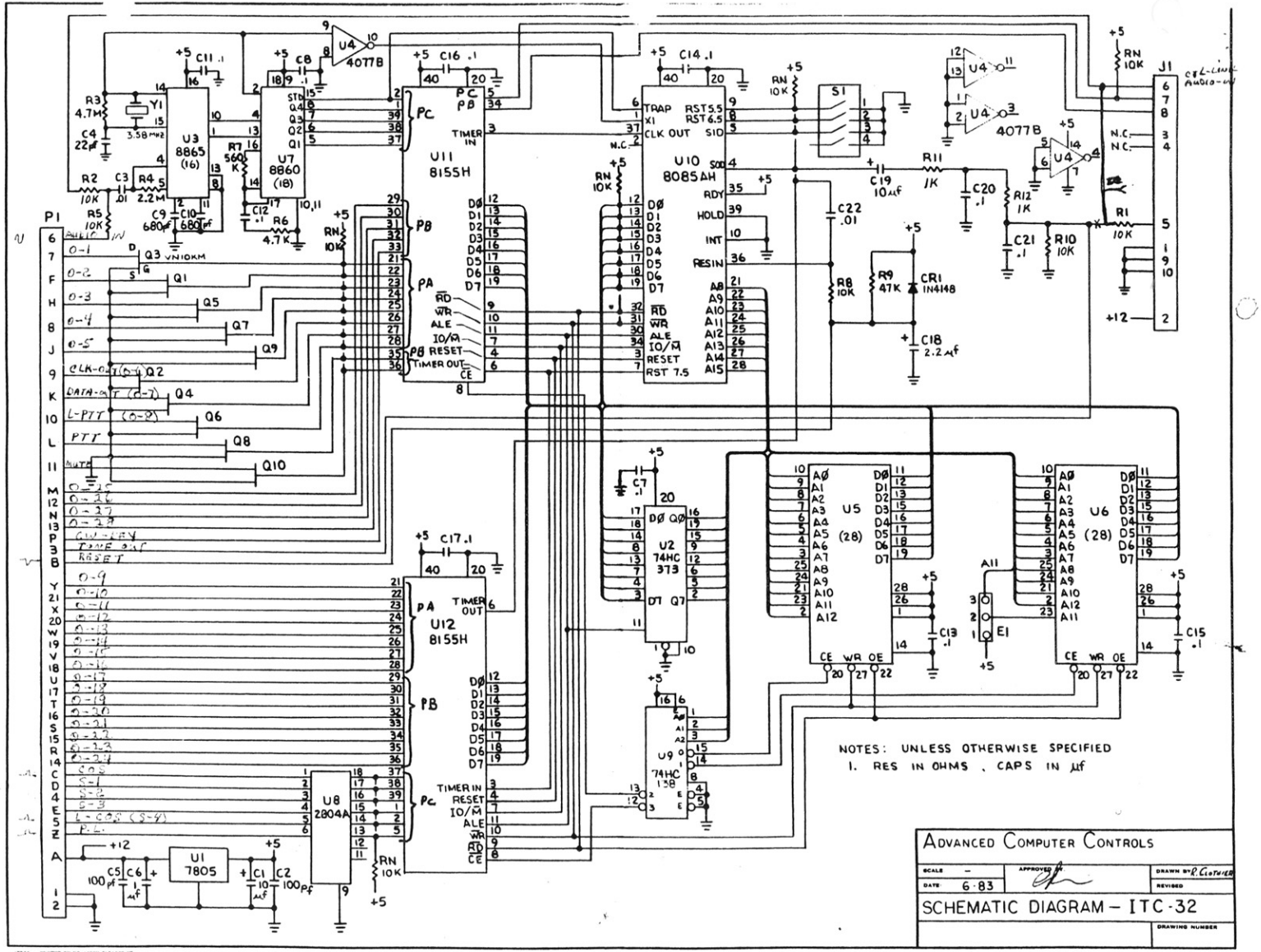
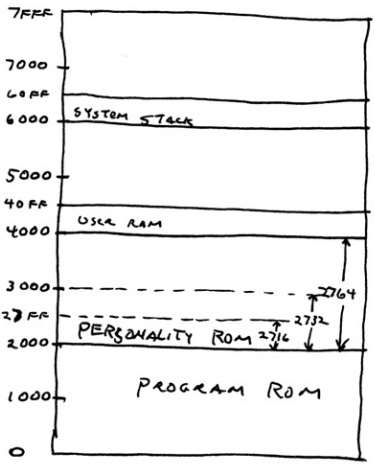
AC Coupled Trunks
CETC-32)



PHONE INTERFACE BOARD	P1 of 1
SCALE:	DRAWN BY: JK
DATE: 7/7/82	REVISED: B
ADVANCED COMPUTER CONTROLS	
	DRAWING NUMBER: R43003


U10 8085AH
U11 8155H
U12 8155H
U3 8865 (16)
U7 8860 (18)
U8 2804A
U1 7805
U2 74HC 373
U5 (28)
U6 (28)
U9 74HC 138
U4 4077B
P1
J1
S1
Y1 3.58 MHz
CR1 IN4148
NOTES: UNLESS OTHERWISE SPECIFIED
1. RES IN OHMS , CAPS IN µf
ADVANCED COMPUTER CONTROLS
SCALE –
DATE 6-83
APPROVED
DRAWN BY P. COUTURIER
REVISED
SCHEMATIC DIAGRAM – ITC-32
DRAWING NUMBER

ADDRESS MAP



74C138 ADDRESS DECODE

	A15 A14 A13	
PGM ROM	0 0 0	0 → 1FFF
PERSON ROM	0 0 1	2K → 3FFF
USART #1	0 1 0	4K → 5FFF
USART #2	0 1 1	6K → 7FFF

40FF
403F] INITIALIZED TO = 0

PORT MAP

USART #1 256 BY 8 RAM - USER RAM.

	ADDR		
OUTPUT	40	COMMAND ~~STATUS~~ REG	= C0 +03 INITIALIZES PORTS A, B, & C, DEFINES TIMER
INPUT	40	READ TIMER STATUS	
OUTPUT	41	PORT A INPUT OR OUTPUT	SEE COMMAND
OUTPUT	42	PORT B " "	SEE COMMAND
IN/OUT	43	PORT C " "	SEE COMMAND READS DTMR 0-4 5 OH
IN/OUT	44	LOW 8 BITS OF TIME COUNT	INITIAL = FF
IN/OUT	45	HI 6 BITS & TIMER MODE	INITIAL = 7F

USART #2 256 BY 8 RAM USER STACK.

OUTPUT	60	COMMAND REGISTER.	INITIAL = C3
INPUT	60	STATUS	
OUTPUT	61	PORT A	
OUTPUT	62	PORT B	
INPUT	63	PORT C	4 ALARMS & PL & COS
IN/OUT	64	LO 8 BITS OF TIMER	INITIAL = C8
IN/OUT	65	H 6 BITS & TIMER MODE	INITIAL = 72

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7/83 REV 1.2

TABLE OF CONTENTS

SCHEMATICS AND COMMAND CODES SUPPLIED WITH BOARD

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SCHEMATICS AND COMMAND CODES SUPPLIED WITH BOARD

1. INTRODUCTION

The Advanced Computer Controls 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 remotely using standard Touch-Tone signalling over a radio link or a dial up telephone line. Unique 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.

In addition to the ITC-32 control 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 frequency synthesized remote base, or radio linking applications.

The characteristics of the ITC-32 are field programmable through a "Personality PROM", which may optionally customize many of the characteristics of the control board. The format of the Personality PROM is fully documented in this manual to allow the user to make changes to his system independant of the factory (factory support also available).

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 ITC-32 control 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.

2. FEATURES AND SPECIFICATIONS

2.1 Standard Features

* Microcomputer controlled
* State-of-the-art tone decoding
* Easy to interface
* 28 remotely commandable outputs, high/low/pulse
* 4 remote sense / alarm inputs
* Command outputs individually or in groups
* Control and monitor over radio or telephone
* Telephone auto-answer (with Telephone Interface Board)
* Morse or tone encoded response messages
* Support for off-board speech synthesizer for voice response messages
* Repeater COR/ID/Timer functions, remote base frequency programming

2.2 Personality PROM

* Optionally available from factory or user programmable
* Fully documented for user reprogramming in the field
* 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

2.3 Telephone Interface Board

* Direct interface to telephone line
* Ring detect, offhook control, audio in/out
* Received audio agc, electronic hybrid

2.4 Specifications

Touch-Tone Receiver:
- Mitel MT8860/65
- 16 digit (standard 2 of 8)
- Dynamic Range - 30 db
- Twist - +-10 dB
- Acceptable S/N - 12 dB
- Decode Time - 40 ms
- Excellent voice talkoff

Audio Input:
- Impedance - 100K
- Level - 70 mV to 2.5 V peak to peak

Telephone Interface (optional):
- Via ACC's FCC registered or non-registered Telephone Interface Board

Logic Outputs:
- 8 remote control, buffered
- 20 remote control, unbuffered
- Push-to-Talk (for response messages 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 at 2.0 mA
  high = 2.4 volt min at -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

Personality PROM (optional):
- Available from factory
- Fully documented for user reprogramming
- Compatible with 2716, 2732, 2764 EPROM devices
- Individual custom command codes for each function
- Customized response and alarm messages
- Alarm autodial phone numbers
- Repeater ID messages
- Repeater timer values

Repeater Control Functions:
- COR, ID, courtesy tone, hang timer, timeout timer, carrier/PL operation, repeater on/off

Remote Base Functions:
- Remote Base on/off, receive only / transmit / off
- 3 digit BCD logic outputs plus offset bits for frequency synthesizer

Alarm Generation:
- Autodial phone numbers (up to 20 digit including pauses), or transmitter keying with alarm messages

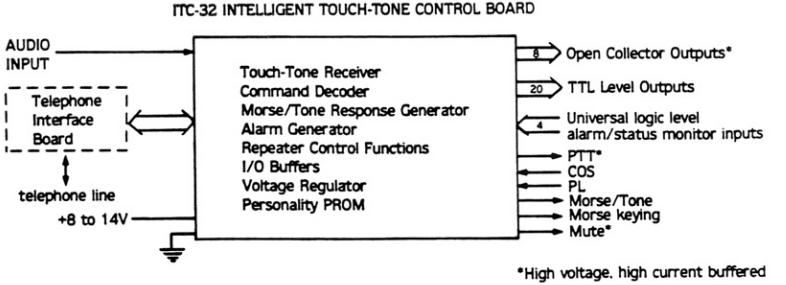
Power: +8 to +14 volts DC, 250 mA typical, 400 mA max (low current version available for special applications)

Operating Temperature Range:
- 0 - 70 degrees C (-40 to +85 degree range available)

Size: 4.5" x 6.5"

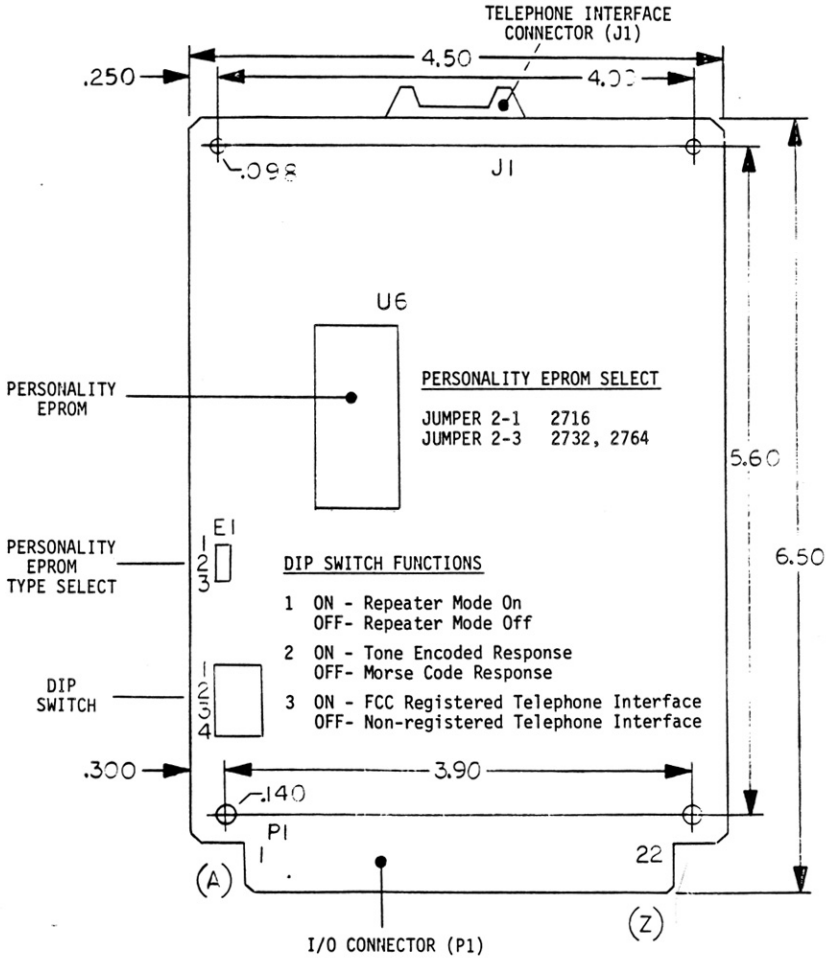
Connector: 44 pin dual row .156" (Vector R644 or equiv.)

2.5 Block Diagram

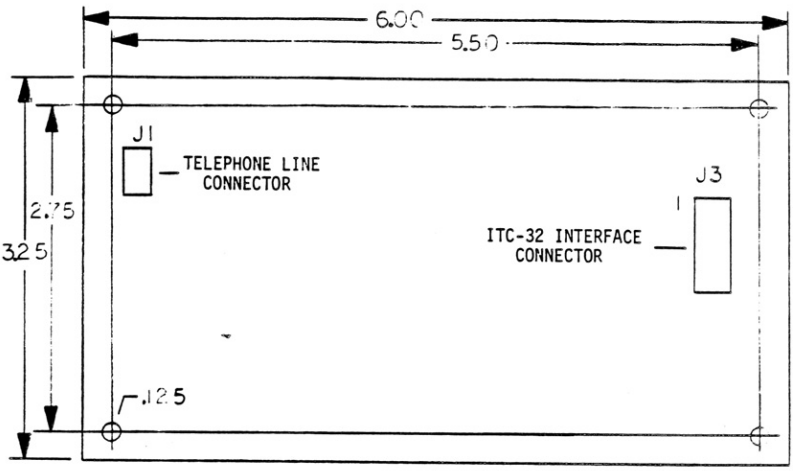


3. PHYSICAL CHARACTERISTICS

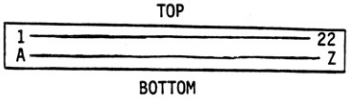
3.1 ITC-32 Board Layout



3.2 Telephone Interface Board Layout



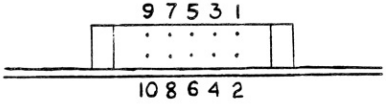
3.3 I/O Connector Pinout (P1)



FUNCTION	PIN
+8 TO 14 V	A
GROUND	1,2
AUDIO IN	6
RESET	B
PTT	L
COS	C
PL	Z
MUTE	11
MORSE KEYING	P
MORSE/TONE	3
ALARM/SENSE 1	D
ALARM/SENSE 2	4
ALARM/SENSE 3	E
ALARM/SENSE 4	5
OUT 1	7
OUT 2	F
OUT 3	H
OUT 4	8
OUT 5	J
OUT 6	9
OUT 7	K
OUT 8	10

FUNCTION	PIN
OUT 9	Y
OUT 10	21
OUT 11	X
OUT 12	20
OUT 13	W
OUT 14	19
OUT 15	V
OUT 16	18
OUT 17	U
OUT 18	17
OUT 19	T
OUT 20	16
OUT 21	S
OUT 22	15
OUT 23	R
OUT 24	14
OUT 25	M
OUT 26	12
OUT 27	N
OUT 28	13
NO CONNECT	22

3.4 Telephone Interface Connector Pinout (J1)

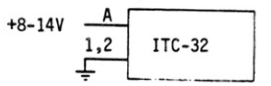


FUNCTION	PIN
GROUND	1, 9, 10
+12V	2
AUDIO TO PHONE	5
AUDIO FROM PHONE	6
RING	7
OFFHOOK	8
NO CONNECT	3,4

4. INSTALLATION

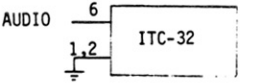
4.1 Power

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. A version of the ITC-32 control board with CMOS microcomputer and I/O devices is available for low power applications (contact factory).



4.2 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.

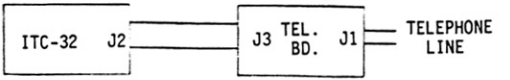


4.3 Telephone Line

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 pin 1 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 out on alarm condition for alarm generation over the phone.

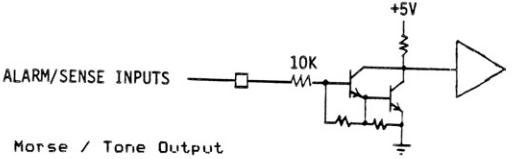


4.4 Remote Control Logic Outputs

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 VFETs. These outputs (OUT1-OUT8) may drive high current loads, such as relay coils, keying lines, etc., directly. The other 20 outputs (OUT9-OUT28) are TTL logic levels and may interface to other logic or TTL compatible equipment.

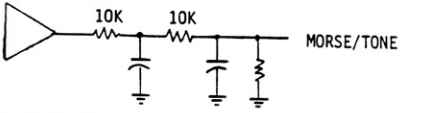
4.5 Alarm/Sense Inputs

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 down 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.



4.6 Morse / Tone Output

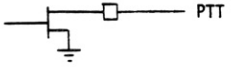
Morse code or tone encoded response and alarm messages are available for driving a radio transmitter's audio input. The output from the control board is approximately 1 volt peak to peak, at 20K output impedance, and may be injected into the transmitter at an appropriate point.



4.7 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.

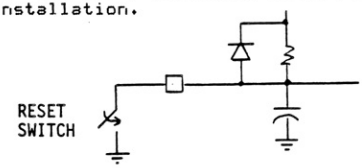


4.8 Reset Switch

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 many 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 defined in the Personality PROM.

4.9 Repeater / Remote Base Functions

Various repeater and remote base functions are supported, using the PTT output, COS input, Morse code audio output, etc. Chapter 7 describes these functions in detail, including installation.



5. OPERATION

5.1 Overview

The ITC-32 control board constantly monitors audio at its input for Touch-Tone signals sent to the board. Touch-Tone digits are collected in a buffer in memory, and are evaluated at the Command Evaluation point (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 causes an autodial out over the phone to one or more pre-stored phone numbers (stored in Personality PROM). The board may continue to call the pre-stored phone numbers periodically until the alarm status is cleared.

5.2 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) On 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 * by connecting the board's COS logic input to the receiver's carrier-operated switch (or squelch open) 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 a 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. The Cancel

Key may be redefined using the Personality PROM to be other than the # key, in case it is desired to use the # as part of command code sequences.

The Command Decoder is 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, nominally 3 seconds, disqualifies a command if greater than 3 seconds elapses between digits.

5.3 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, group outputs 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 independantly. Short codes may be assigned to some functions, while longer, more secure commands may be assigned to more critical functions.

5.4 Remote Control Logic Outputs

The 28 logic outputs may be commanded remotely using Touch-Tone commands. Each 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 encoding. Function number tone encoding (an alternative to Morse code) is defined below:

_	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:

```
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.

Response messages for the high and low states of each individual output may be customized as a Morse code or speech message indicating the meaning of the output state, using the Personality PROM. 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.

5.5 Alarm / Status Monitor Inputs

The 4 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. Autodial out requires a Personality PROM for storage of phone numbers. Without a Personality PROM, the functions of the alarm / sense inputs are defined below:

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 alarm with transmitter key or autodial. The response 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 a default "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 pulse dials each number, announcing 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 over the phone (including simply the Command Evaluation key) cancels the alarm.

5.6 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 dependant 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.

5.7 Repeater Control Functions

The operation of the ITC-32 control board's repeater and remote base functions are described in Chapter 7.

5.8 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, response 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.

5.9 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 nominal 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. #*).

6. INTERFACING

6.1 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 6.1 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 transistors against inductive kick-back voltage spikes when switching. The relay can be commanded to either state remotely with Touch-Tone commands which latch the commanded state.

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.

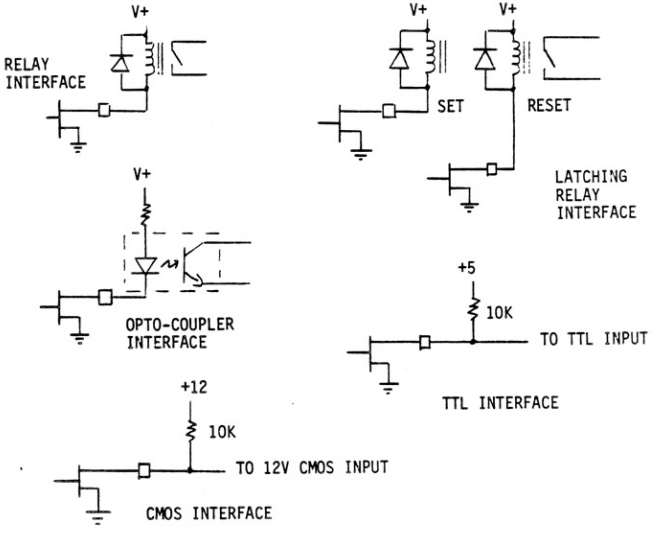
The control board can drive loads which need to be electrically isolated because of grounding considerations, level translation, or transient protection. Opto-couplers consist of an LED and photo-transistor in a single package, electrically isolated from each other. The control board can directly drive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

logic input's requirements.

Figure 6.1. Buffered Logic Output Interface



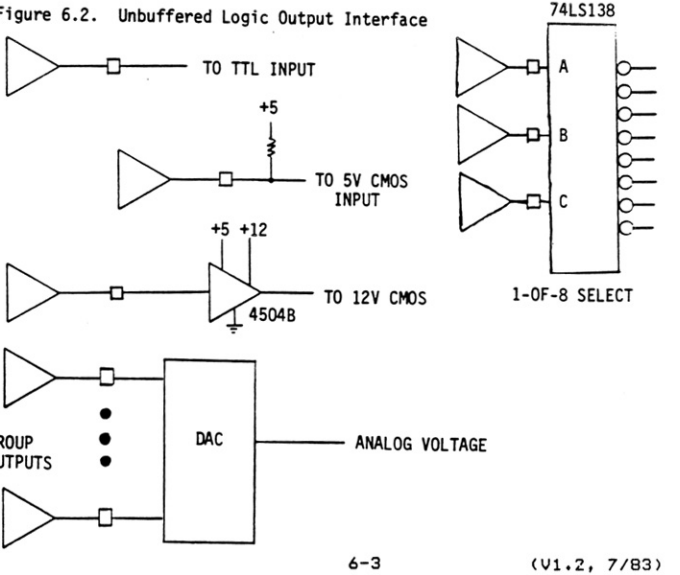
The remaining 20 TTL compatible level remote control outputs may interface to TTL or CMOS logic, digital-to-analog converters, etc. Figure 6.2 illustrates interface of the TTL level outputs to a variety of circuitry.

The interface to TTL is direct, with no other components required. Fanout is one TTL load, or 4 Low Power Schottky loads. Interface to 5 volt CMOS requires only a pullup resistor to 5 volts to guarantee a valid logic one 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. Control of analog levels 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-8 or a 74LS154 one-of-16 decoder. In this way, the number of outputs controllable by one ITC-32 control board can be expanded into the hundreds.

Figure 6.2. Unbuffered Logic Output Interface

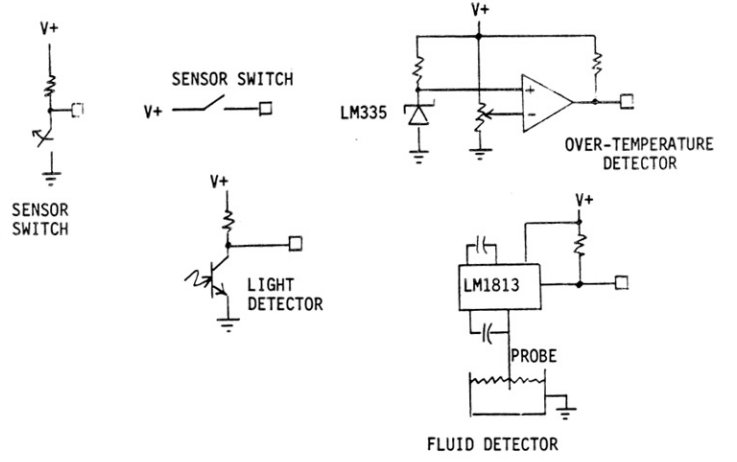


6.2 Remote Status Monitoring

The ITC-32 control board's 4 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 a high or low 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 6.3 illustrates some interfacing examples with typical sensors for status monitoring.

Figure 6.3. Sensor Interfacing



6.3 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, over-temperature, under-voltage, water on the floor, and fire.

Logic inputs defined as alarms are activated by a high level logic signal. The high level is debounced 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.

6.4 Touch-Tone Audio Input

Since the ITC-32 control board is controlled using Touch-Tone signalling, it's important to apply the source of audio correctly for reliable operation. Section 6.5 describes telephone interfacing, while this section assumes audio is derived exclusively 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 the 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.

6.5 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 (10 pulse per second dial pulse) on alarm condition.

If the control board is used with both telephone interface and radio receiver audio input, the nominal input audio voltage range rises to approximately two volts peak to peak. The receiver audio is mixed with the telephone audio into the Touch-Tone receiver, after the board auto-answers.

6.6 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 audio should drive a relatively high impedance input to the transmitter audio stage.

6.7 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 (while the telephone is on-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.

6.8 Battery Backup

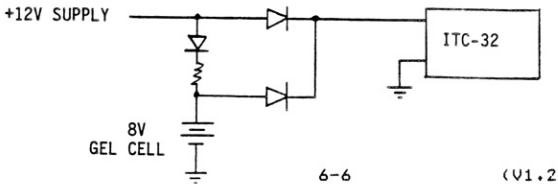
Since the power requirements of the ITC-32 control board are modest, an 8 or 12 volt Gel-Cell can provide many hours of operation in case of failure of the main supply. Figure 6.4 illustrates diode isolation for battery backup, with continuous trickle charging of the battery.

For special applications requiring extremely low power consumption, a low power version of the ITC-32 control board is available (contact factory).

6.9 Synthesized Speech Readback

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

Figure 6.4. Battery Backup



7. REPEATER / REMOTE BASE OPERATION AND INTERFACE

7.1 Overview

The ITC-32 control board can serve as a basic controller for simple repeaters, providing the COR, ID, courtesy tone, hang timer, and timeout timer functions. The control board can also select carrier or PL access, and repeater on/off. Audio mixing functions must be handled externally.

The control 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. These functions are in addition to the control board's remote control, status monitoring, and alarm capabilities, but "use 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 as described below:

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

Many 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.

7.2 COR Timing

The PTT output is keyed (active low) in response to an active (low) COS input. When the COS signal goes away, 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 5 seconds.

7.3 ID Timing

The control 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 control 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.

7.4 Operation Modes

Touch-Tone commands allow selection of repeater enable/disable, link (remote base) enable/disable, carrier or PL access, timer enable/disable, and short or long timer select.

7.5 Link Function

Touch-Tone commands allow enabling or disabling a link function, which causes the link PTT to be keyed when a signal is received on the main receiver COS, and the main transmitter to be keyed when a signal is received on the link COS. The link may be another repeater at the site, or a transceiver, allowing linking the repeater over the air to other repeaters or simplex frequencies as a remote base.

In addition to enabling or disabling the link function with Touch-Tone commands, the frequency of the link 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 link transceiver's frequency synthesizer to allow remote control of the remote base frequency. Readback of the frequency entered verifies command entry.

The parallel format (selectable with the Personality PROM) provides all 16 frequency bits (3 BCD digits plus offset and on/off bits) directly at logic outputs. The serial format conserves function outputs by serially shifting information out of two logic outputs as shown in Figure 7.1. External shift registers capture the data shifted out the control board, and at the same time may perform any level translation required in interfacing to a particular radio. (The serial format is compatible with the RC-850 Repeater Controller.) A clock and data signal are present at OUT 6 and OUT 7, freeing up OUT 13 through OUT 28 for remote control functions.

Figure 7.2 shows circuitry suitable for capturing the serial frequency information for interface to an ICOM IC-22U two meter transceiver as a synthesized remote base.

7.6 Interface Signals

REPEATER MODE - SWITCH 1 ON

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

LINK FREQUENCY - PARALLEL MODE (ACTIVE HIGH OUTPUTS)

*** REQUIRES PERSONALITY PROM SELECTION ***

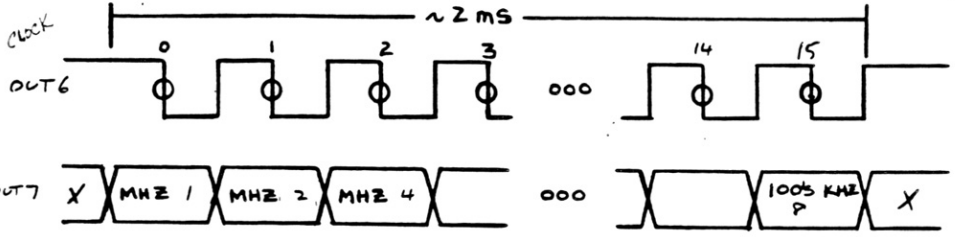
MHz 8	OUT 28	13
MHz 4	OUT 27	N
MHz 2	OUT 26	12
MHz 1	OUT 25	M
100KHz 8	OUT 24	14
100KHz 4	OUT 23	R
100KHz 2	OUT 22	15
100KHz 1	OUT 21	S
10KHz 8	OUT 20	16
10KHz 4	OUT 19	T
10KHz 2	OUT 18	17
10KHz 1	OUT 17	U
ON(H)/OFF(L)	OUT 16	18
5(H)/0(L) KHz	OUT 15	V
SIM(H)/DUP(L)	OUT 14	19
+(H)/-(L) OFFST	OUT 13	W

LINK FREQUENCY - SERIAL MODE

DATA	OUT 7	K
CLOCK	OUT 6	9

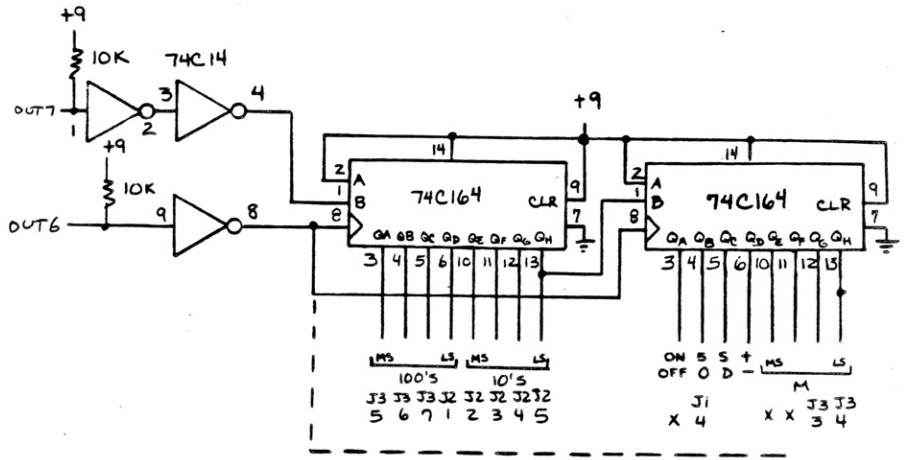
Figure 7.1

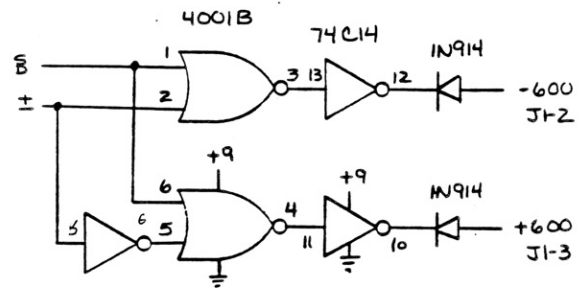
SYNTHESIZER INFO TIMING (SERIAL MODE)



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/Ø kHz	14	100's kHz 4
7	ON/OFF	15	100's kHz 8

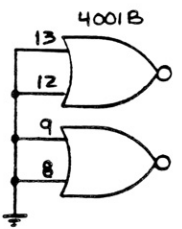
Figure 7.2- IC-22U Interface





IC'S MUST BE CMOS NOT TTL

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



8. PRINCIPLES OF OPERATION

8.1 ITC-32 Control Board

The ITC-32 control board is based on an 8085AH microprocessor, in conjunction with two 8155H I/O and RAM devices, and up to two EPROMs. The 8085 CPU clock input is derived from the Touch-Tone receiver chip 3.58 MHz oscillator. The CPU's multiplexed address/data bus is demultiplexed 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 second programmable timer, the timer times out, resetting the CPU 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 in 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, 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.

8.2 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 for automatic FCC registration of the board, which permits legal direct connect to the U.S. phone 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.

9. SERVICE AND MAINTENANCE

9.1 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.

9.2 Troubleshooting

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.

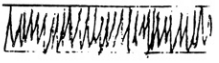
If the board is totally non-functional, check for presence of the input power supply, and the regulated 5 volts on the board. Check for the 3.58 MHz oscillator signal from the Touch-Tone receiver chip set. Look for microcomputer bus activity, and activity at the CPU's ALE pin.

Check also for hot components, or IC's not properly seated in their sockets.

9.3 Waveforms

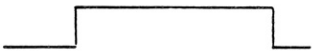
OSCILLATOR U4-1
(10X SCOPE PROBE)

ALE (U10-30)



TOUCH-TONE AUDIO
INPUT

STD (U7-15)
(INDICATING VALID
TOUCH-TONE DECODE)



APPENDIX I - PERSONALITY PROM SPECIFICATION

The Personality PROM optionally 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 independant of the factory, although factory support is also available.

Equipment required for field programming of the Personality PROM is any EPROM programmer capable of programming single supply 2716, 2732, or 2764 EPROMs, and a UV eraser. The format of the Personality PROM is defined below.

MODE SELECTS

0010H	Digitalker Speech installed	00H
	Speech not installed	FFH *
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 5.5)	
0016H	Command Evaluation Key	TOUCH-TONE KEY
0017H	Cancel Key	TOUCH-TONE KEY

MORSE / TONE PARAMETERS

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

0021H,0022H — Morse/Tone Pitch PITCH
Example 1000 Hz 1064
PERIOD = 1000 us 939.849 62
PITCH = 2 * ((1000-108)/26.8) = 66.57 62.07
67=0043H 003E
Address 0021H=43H, 0022H=00H

0023H,0024H — Courtesy Tone Duration # CYCLES OF TONE BURST
Example 100 ms at 440 Hz
440 Hz = 2.27 ms,
100 ms = 44 cycles 04h = 10ms
44=002CH
Address 0023H=2CH, 0024H=00H

0025H,0026H — Repeater Courtesy Tone Pitch 43h=1KC PITCH

0027H,0028H — Link Courtesy Tone Pitch 8Dh = 500hz PITCH

* Default

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

TIMERS

0030H	Interdigit Example 5 seconds 5=05H 05 = 5 SECS Address 0030H=05H	SECONDS
0031H	Repeater Hang Time Example 4 seconds 4=04H 04h = 4 SECS Address 0031H=04H	SECONDS
0032H,0033H	Repeater Timeout Time (Long) Example 180 seconds (3 minutes) 180=00B4H 480h = 20MIN Address 0032H=B4H, 0033H=00H	SECONDS
0034H,0035H	Repeater Timeout Time (Short) Example 45 seconds 45=002DH B4h = 3MIN Address 0034H=2DH, 0035H=00H	SECONDS
0036H,0037H	Delay to Courtesy Tone Example 600 ms 600=0258H C8 = 200MS Address 0034H=58H, 0035H=02H	MILLISECONDS
0038H	Phone Answer Delay Time	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	" "

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 = 0 (MORSE CODE)
1 (SPEECH)

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,53H,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
02C8H	ALARM 1 / STATUS 1 HIGH
02D0H	STATUS 2 LOW
02D8H	ALARM 2 / STATUS 2 HIGH
02E0H	STATUS 3 LOW
02E8H	ALARM 3 / STATUS 3 HIGH
02F0H	STATUS 4 LOW
02F8H	ALARM 4 / STATUS 4 HIGH

COMMAND CODE PREFIXES

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.

FORMAT: (COMMAND CODE STRING) (TERMINATOR)

STRING = TOUCH-TONE HEX REPRESENTATION
TERMINATOR = FFH

Example 3A7...
03H,0DH,07H,FFH

0300H	OUT 1	0460H	OUT 23
0310H	OUT 2	0470H	OUT 24
0320H	OUT 3	0480H	OUT 25
0330H	OUT 4	0490H	OUT 26
0340H	OUT 5	04A0H	OUT 27
0350H	OUT 6	04B0H	OUT 28
0360H	OUT 7		
0370H	OUT 8	04C0H	GROUP 1
0380H	OUT 9	04D0H	GROUP 2
0390H	OUT 10	04E0H	GROUP 3
03A0H	OUT 11	04F0H	GROUP 4
03B0H	OUT 12		
03C0H	OUT 13	0500H	STATUS 1
03D0H	OUT 14	0510H	STATUS 2
03E0H	OUT 15	0520H	STATUS 3
03F0H	OUT 16	0530H	STATUS 4
0400H	OUT 17		
0410H	OUT 18	0540H	ALARM
0420H	OUT 19		
0430H	OUT 20	0550H	REPEATER CONTROL OPERATOR
0440H	OUT 21		
0450H	OUT 22	0560H	REPEATER REMOTE BASE
		0570H	LOCK / UNLOCK
		0580H	INITIALIZE

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

HEXADECIMAL-DECIMAL CONVERSION

The following table is for hexadecimal to decimal and decimal to hexadecimal conversion. To find the decimal equivalent of a hexadecimal number, locate the hexadecimal number in the correct position and note the decimal equivalent. Add the decimal numbers.

To find the hexadecimal equivalent of a decimal number, locate the next lower decimal number in the table and note the hexadecimal number and its position. Subtract the decimal number from the table from the starting number. Find the difference in the table. Continue this process until there is no difference.

BYTE		BYTE		BYTE		BYTE	
HEX	DEC	HEX	DEC	HEX	DEC	HEX	DEC
0	0	0	0	0	0	0	0
1	4 096	1	256	1	16	1	1
2	8 192	2	512	2	32	2	2
3	12 288	3	768	3	48	3	3
4	16 384	4	1 024	4	64	4	4
5	20 480	5	1 280	5	80	5	5
6	24 576	6	1 536	6	96	6	6
7	28 672	7	1 792	7	112	7	7
8	32 768	8	2 048	8	128	8	8
9	36 864	9	2 304	9	144	9	9
A	40 960	A	2 560	A	160	A	10
B	45 056	B	2 816	B	176	B	11
C	49 152	C	3 072	C	192	C	12
D	53 248	D	3 328	D	208	D	13
E	57 344	E	3 548	E	224	E	14
F	61 440	F	3 840	F	240	F	15

HEXADECIMAL DECIMAL INTEGER CONVERSION

A table below provides for direct conversions between hexadecimal integers in the range 0 FFF and decimal integers in the range 0 4095. For conversion of larger integers, the table values may be added to the following figures.

Hexadecimal	Decimal	Hexadecimal	Decimal
01 000	4 096	20 000	131 072
02 000	8 192	30 000	196 608
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07 000	28 672	80 000	524 288
08 000	32 768	90 000	589 824
09 000	36 864	A0 000	655 360
0A 000	40 960	B0 000	720 896
0B 000	45 056	C0 000	786 432
0C 000	49 152	D0 000	851 968
0D 000	53 248	E0 000	917 504
0E 000	57 344	F0 000	983 040
0F 000	61 440	100 000	1 048 576
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11 000	69 632	300 000	3 145 728
12 000	73 728	400 000	4 194 304
13 000	77 824	500 000	5 242 880
14 000	81 920	600 000	6 291 456
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930	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367
940	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383
950	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399
960	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415
970	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431
980	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447
990	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463
9A0	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479
9B0	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495
9C0	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511
9D0	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527
9E0	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543
9F0	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
A00	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575
A10	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591
A20	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607
A30	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623
A40	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639
A50	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655
A60	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671
A70	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687
A80	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703
A90	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719
AA0	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735
AB0	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751
AC0	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767
AD0	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783
AE0	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799
AF0	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815
B00	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831
B10	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847
B20	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863
B30	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879
B40	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895
B50	2896	2897	2898	2899	2900	2901	2902	2903	2904	2905	2906	2907	2908	2909	2910	2911
B60	2912	2913	2914	2915	2916	2917	2918	2919	2920	2921	2922	2923	2924	2925	2926	2927
B70	2928	2929	2930	2931	2932	2933	2934	2935	2936	2937	2938	2939	2940	2941	2942	2943
B80	2944	2945	2946	2947	2948	2949	2950	2951	2952	2953	2954	2955	2956	2957	2958	2959
B90	2960	2961	2962	2963	2964	2965	2966	2967	2968	2969	2970	2971	2972	2973	2974	2975
BA0	2976	2977	2978	2979	2980	2981	2982	2983	2984	2985	2986	2987	2988	2989	2990	2991
BB0	2992	2993	2994	2995	2996	2997	2998	2999	3000	3001	3002	3003	3004	3005	3006	3007
BC0	3008	3009	3010	3011	3012	3013	3014	3015	3016	3017	3018	3019	3020	3021	3022	3023
BD0	3024	3025	3026	3027	3028	3029	3030	3031	3032	3033	3034	3035	3036	3037	3038	3039
BE0	3040	3041	3042	3043	3044	3045	3046	3047	3048	3049	3050	3051	3052	3053	3054	3055
BF0	3056	3057	3058	3059	3060	3061	3062	3063	3064	3065	3066	3067	3068	3069	3070	3071
C00	3072	3073	3074	3075	3076	3077	3078	3079	3080	3081	3082	3083	3084	3085	3086	3087
C10	3088	3089	3090	3091	3092	3093	3094	3095	3096	3097	3098	3099	3100	3101	3102	3103
C20	3104	3105	3106	3107	3108	3109	3110	3111	3112	3113	3114	3115	3116	3117	3118	3119
C30	3120	3121	3122	3123	3124	3125	3126	3127	3128	3129	3130	3131	3132	3133	3134	3135
C40	3136	3137	3138	3139	3140	3141	3142	3143	3144	3145	3146	3147	3148	3149	3150	3151
C50	3152	3153	3154	3155	3156	3157	3158	3159	3160	3161	3162	3163	3164	3165	3166	3167
C60	3168	3169	3170	3171	3172	3173	3174	3175	3176	3177	3178	3179	3180	3181	3182	3183
C70	3184	3185	3186	3187	3188	3189	3190	3191	3192	3193	3194	3195	3196	3197	3198	3199
C80	3200	3201	3202	3203	3204	3205	3206	3207	3208	3209	3210	3211	3212	3213	3214	3215
C90	3216	3217	3218	3219	3220	3221	3222	3223	3224	3225	3226	3227	3228	3229	3230	3231
CA0	3232	3233	3234	3235	3236	3237	3238	3239	3240	3241	3242	3243	3244	3245	3246	3247
CB0	3248	3249	3250	3251	3252	3253	3254	3255	3256	3257	3258	3259	3260	3261	3262	3263
CC0	3264	3265	3266	3267	3268	3269	3270	3271	3272	3273	3274	3275	3276	3277	3278	3279
CD0	3280	3281	3282	3283	3284	3285	3286	3287	3288	3289	3290	3291	3292	3293	3294	3295
CE0	3296	3297	3298	3299	3300	3301	3302	3303	3304	3305	3306	3307	3308	3309	3310	3311
CF0	3312	3313	3314	3315	3316	3317	3318	3319	3320	3321	3322	3323	3324	3325	3326	3327

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
D00	3328	3329	3330	3331	3332	3333	3334	3335	3336	3337	3338	3339	3340	3341	3342	3343
D10	3344	3345	3346	3347	3348	3349	3350	3351	3352	3353	3354	3355	3356	3357	3358	3359
D20	3360	3361	3362	3363	3364	3365	3366	3367	3368	3369	3370	3371	3372	3373	3374	3375
D30	3376	3377	3378	3379	3380	3381	3382	3383	3384	3385	3386	3387	3388	3389	3390	3391
D40	3392	3393	3394	3395	3396	3397	3398	3399	3400	3401	3402	3403	3404	3405	3406	3407
D50	3408	3409	3410	3411	3412	3413	3414	3415	3416	3417	3418	3419	3420	3421	3422	3423
D60	3424	3425	3426	3427	3428	3429	3430	3431	3432	3433	3434	3435	3436	3437	3438	3439
D70	3440	3441	3442	3443	3444	3445	3446	3447	3448	3449	3450	3451	3452	3453	3454	3455
D80	3456	3457	3458	3459	3460	3461	3462	3463	3464	3465	3466	3467	3468	3469	3470	3471
D90	3472	3473	3474	3475	3476	3477	3478	3479	3480	3481	3482	3483	3484	3485	3486	3487
DA0	3488	3489	3490	3491	3492	3493	3494	3495	3496	3497	3498	3499	3500	3501	3502	3503
DB0	3504	3505	3506	3507	3508	3509	3510	3511	3512	3513	3514	3515	3516	3517	3518	3519
DC0	3520	3521	3522	3523	3524	3525	3526	3527	3528	3529	3530	3531	3532	3533	3534	3535
DD0	3536	3537	3538	3539	3540	3541	3542	3543	3544	3545	3546	3547	3548	3549	3550	3551
DE0	3552	3553	3554	3555	3556	3557	3558	3559	3560	3561	3562	3563	3564	3565	3566	3567
DF0	3568	3569	3570	3571	3572	3573	3574	3575	3576	3577	3578	3579	3580	3581	3582	3583
E00	3584	3585	3586	3587	3588	3589	3590	3591	3592	3593	3594	3595	3596	3597	3598	3599
E10	3600	3601	3602	3603	3604	3605	3606	3607	3608	3609	3610	3611	3612	3613	3614	3615
E20	3616	3617	3618	3619	3620	3621	3622	3623	3624	3625	3626	3627	3628	3629	3630	3631
E30	3632	3633	3634	3635	3636	3637	3638	3639	3640	3641	3642	3643	3644	3645	3646	3647
E40	3648	3649	3650	3651	3652	3653	3654	3655	3656	3657	3658	3659	3660	3661	3662	3663
E50	3664	3665	3666	3667	3668	3669	3670	3671	3672	3673	3674	3675	3676	3677	3678	3679
E60	3680	3681	3682	3683	3684	3685	3686	3687	3688	3689	3690	3691	3692	3693	3694	3695
E70	3696	3697	3698	3699	3700	3701	3702	3703	3704	3705	3706	3707	3708	3709	3710	3711
E80	3712	3713	3714	3715	3716	3717	3718	3719	3720	3721	3722	3723	3724	3725	3726	3727
E90	3728	3729	3730	3731	3732	3733	3734	3735	3736	3737	3738	3739	3740	3741	3742	3743
EA0	3744	3745	3746	3747	3748	3749	3750	3751	3752	3753	3754	3755	3756	3757	3758	3759
EB0	3760	3761	3762	3763	3764	3765	3766	3767	3768	3769	3770	3771	3772	3773	3774	3775
EC0	3776	3777	3778	3779	3780	3781	3782	3783	3784	3785	3786	3787	3788	3789	3790	3791
ED0	3792	3793	3794	3795	3796	3797	3798	3799	3800	3801	3802	3803	3804	3805	3806	3807
EE0	3808	3809	3810	3811	3812	3813	3814	3815	3816	3817	3818	3819	3820	3821	3822	3823
EF0	3824	3825	3826	3827	3828	3829	3830	3831	3832	3833	3834	3835	3836	3837	3838	3839
F00	3840	3841	3842	3843	3844	3845	3846	3847	3848	3849	3850	3851	3852	3853	3854	3855
F10	3856	3857	3858	3859	3860	3861	3862	3863	3864	3865	3866	3867	3868	3869	3870	3871
F20	3872	3873	3874	3875	3876	3877	3878	3879	3880	3881	3882	3883	3884	3885	3886	3887
F30	3888	3889	3890	3891	3892	3893	3894	3895	3896	3897	3898	3899	3900	3901	3902	3903
F40	3904	3905	3906	3907	3908	3909	3910	3911	3912	3913	3914	3915	3916	3917	3918	3919
F50	3920	3921	3922	3923	3924	3925	3926	3927	3928	3929	3930	3931	3932	3933	3934	3935
F60	3936	3937	3938	3939	3940	3941	3942	3943	3944	3945	3946	3947	3948	3949	3950	3951
F70	3952	3953	3954	3955	3956	3957	3958	3959	3960	3961	3962	3963	3964	3965	3966	3967
F80	3968	3969	3970	3971	3972	3973	3974	3975	3976	3977	3978	3979	3980	3981	3982	3983
F90	3984	3985	3986	3987	3988	3989	3990	3991	3992	3993	3994	3995	3996	3997	3998	3999
FA0	4000	4001	4002	4003	4004	4005	4006	4007	4008	4009	4010	4011	4012	4013	4014	4015
FB0	4016	4017	4018	4019	4020	4021	4022	4023	4024	4025	4026	4027	4028	4029	4030	4031
FC0	4032	4033	4034	4035	4036	4037	4038	4039	4040	4041	4042	4043	4044	4045	4046	4047
FD0	4048	4049	4050	4051	4052	4053	4054	4055	4056	4057	4058	4059	4060	4061	4062	4063
FE0	4064	4065	4066	4067	4068	4069	4070	4071	4072	4073	4074	4075	4076	4077	4078	4079
FF0	4080	4081	4082	4083	4084	4085	4086	4087	4088	4089	4090	4091	4092	4093	4094	4095

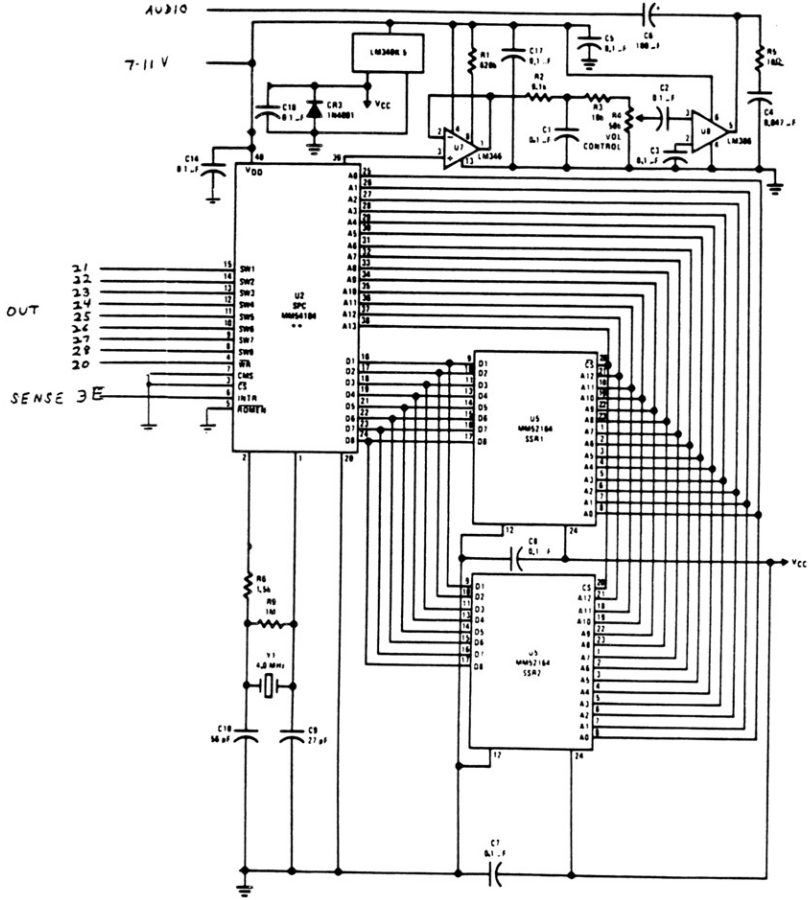
MORSE CODE CHARACTER ASCII HEX VALUES

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
(For Command Prefixes and Command Evaluation and Cancel Keys)

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
(National Semiconductor Digitalker DT1050)



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
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
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.

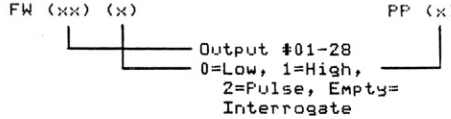
* Digitalker IC's available from Jameco Electronics, (415) 592=8097, or any National Semiconductor distributor.
* Voice Response mode defined in Personality PROM status byte.
* OUT 20 - OUT 28, and ALARM/SENSE 3 redefined in Voice Response mode to support speech hardware.

FW=_____

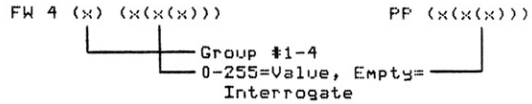
APPENDIX III - COMMAND CODES

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 ***

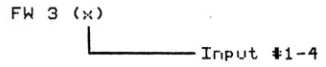
INDIVIDUAL OUTPUT FORCE / INTERROGATE



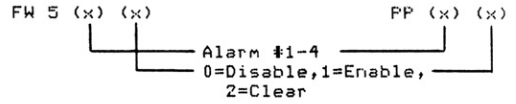
GROUP OUTPUT FORCE / INTERROGATE



STATUS INPUT INTERROGATE

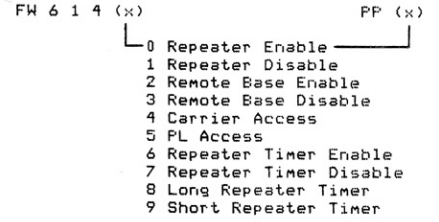


ALARM

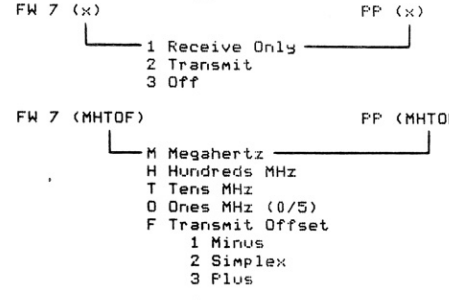


(Any command over phone cancels dial out alarm - i.e. "*", assuming * is command evaluation key.)

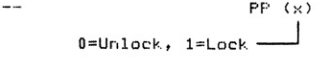
REPEATER CONTROL OPERATOR



REPEATER REMOTE BASE



LOCK / UNLOCK



INITIALIZE

HANGUP PHONE

(V1.2, 7/83)