PORT MAP

USART &1 256 BY 8 RAM - USER RAM

Command register: Initial = C3

OUTPUT 40

INPUT 40

IN/OUT 41

IN/OUT 42

IN/OUT 43

IN/OUT 44

IN/OUT 45

OUTPUT 60

INPUT 60

OUTPUT 61

OUTPUT 62

INPUT 63

INPUT 64

IN/OUT 65

COMMAND REG. = C3

PORT A INPUT OR OUTPUT

PORT B INPUT OR OUTPUT

PORT C INPUT OR OUTPUT

LOW 8 BITS OF TIME COUNT

HIGH 6 BITS OF TIME MODE

USAR 42 256 BY 8 RAM USER STACK

COMMAND REGISTER INITIAL = C3

STATUS

PORT A

PORT B

PORT C 4 ALARMS & BRAKE & COS

LOW 8 BITS OF TIME

HIGH 6 BITS OF TIME MODE

INITIAL = C8

INITIAL = 72
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Specifications subject to change without notice

ITC-32 Software Copyright (c) 1983 ACC
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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 independent 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
ITC-32 Intelligent Touch-Tone Control Board Owner’s Manual

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 digits 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

![Block Diagram of ITC-32 Intelligent Touch-Tone Control Board]

OPEN COLLECTOR OUTPUTS

TTL LEVEL OUTPUTS

UNIVERSAL LOGIC LEVEL ALARM/STATUS MONITOR INPUTS

PITM

COS

PL

MORSE/TONE RESPONSE GENERATOR

MORSE KEYING

PERSONALITY PROM

VOLTAGE REGULATOR

I/O BUFFERS

REPEATER CONTROL FUNCTIONS

ALARM GENERATOR

MORSE/TONE RESPONSE GENERATOR

COMMAND DECODER

TOUCH-TONE RECEIVER

AUDIO INPUT

Telephone Interface Board

telephone line +8 to 14V

*High voltage, high current buffered

2-3

(V1.2, 7/83)
3. PHYSICAL CHARACTERISTICS

3.1 ITC-32 Board Layout

TELEPHONE INTERFACE CONNECTOR (J1)

PERSONALITY EPROM SELECT

JUMPER 2-1  2716
JUMPER 2-3  2732, 2764

PERSONALITY EPROM TYPE SELECT

DIP SWITCH FUNCTIONS

1 ON - Repeater Mode On
   OFF - Repeater Mode Off

2 ON - Tone Encoded Response
   OFF - Morse Code Response

3 ON - FCC Registered Telephone Interface
   OFF - Non-registered Telephone Interface

I/O CONNECTOR (P1)
3.2 Telephone Interface Board Layout
### 3.3 I/O Connector Pinout (P1)

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>PIN</th>
<th>FUNCTION</th>
<th>PIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>+8 to 14 V</td>
<td>A</td>
<td>OUT 9</td>
<td>Y</td>
</tr>
<tr>
<td>Ground</td>
<td>1,2</td>
<td>OUT 10</td>
<td>21</td>
</tr>
<tr>
<td>Audio IN</td>
<td>6</td>
<td>OUT 11</td>
<td>X</td>
</tr>
<tr>
<td>Reset</td>
<td>B</td>
<td>OUT 12</td>
<td>20</td>
</tr>
<tr>
<td>PTT</td>
<td>L</td>
<td>OUT 13</td>
<td>W</td>
</tr>
<tr>
<td>COS</td>
<td>C</td>
<td>OUT 14</td>
<td>19</td>
</tr>
<tr>
<td>PL</td>
<td>Z</td>
<td>OUT 15</td>
<td>V</td>
</tr>
<tr>
<td>Mute</td>
<td>11</td>
<td>OUT 16</td>
<td>18</td>
</tr>
<tr>
<td>Morse Keying</td>
<td>P</td>
<td>OUT 17</td>
<td>U</td>
</tr>
<tr>
<td>Morse/Tone</td>
<td>3</td>
<td>OUT 18</td>
<td>17</td>
</tr>
<tr>
<td>Alarm/Sense 1</td>
<td>D</td>
<td>OUT 19</td>
<td>T</td>
</tr>
<tr>
<td>Alarm/Sense 2</td>
<td>4</td>
<td>OUT 20</td>
<td>16</td>
</tr>
<tr>
<td>Alarm/Sense 3</td>
<td>E</td>
<td>OUT 21</td>
<td>S</td>
</tr>
<tr>
<td>Alarm/Sense 4</td>
<td>5</td>
<td>OUT 22</td>
<td>15</td>
</tr>
<tr>
<td>OUT 1</td>
<td>7</td>
<td>OUT 23</td>
<td>R</td>
</tr>
<tr>
<td>OUT 2</td>
<td>F</td>
<td>OUT 24</td>
<td>14</td>
</tr>
<tr>
<td>OUT 3</td>
<td>H</td>
<td>OUT 25</td>
<td>M</td>
</tr>
<tr>
<td>OUT 4</td>
<td>8</td>
<td>OUT 26</td>
<td>12</td>
</tr>
<tr>
<td>OUT 5</td>
<td>J</td>
<td>OUT 27</td>
<td>N</td>
</tr>
<tr>
<td>OUT 6</td>
<td>9</td>
<td>OUT 28</td>
<td>13</td>
</tr>
<tr>
<td>OUT 7</td>
<td>K</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OUT 8</td>
<td>10</td>
<td>NO CONNECT</td>
<td>22</td>
</tr>
</tbody>
</table>
### 3.4 Telephone Interface Connector Pinout (J1)

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>PIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUND</td>
<td>1, 9, 10</td>
</tr>
<tr>
<td>+12V</td>
<td>2</td>
</tr>
<tr>
<td>AUDIO TO PHONE</td>
<td>5</td>
</tr>
<tr>
<td>AUDIO FROM PHONE</td>
<td>6</td>
</tr>
<tr>
<td>RING</td>
<td>7</td>
</tr>
<tr>
<td>OFFHOOK</td>
<td>8</td>
</tr>
<tr>
<td>NO CONNECT</td>
<td>3, 4</td>
</tr>
</tbody>
</table>
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).

\[ +8-14V \]  
\[ 1,2 \]  
\[ \text{ITC-32} \]

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.

\[ \text{AUDIO} \]  
\[ 6 \]  
\[ 1,2 \]  
\[ \text{ITC-32} \]

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.

\[ \text{ITC-32} \]  
\[ J2 \]  
\[ J3 \]  
\[ \text{TEL. BD.} \]  
\[ J1 \]  
\[ \text{TELEPHONE LINE} \]
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 "x" 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 "x" 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 independently. 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**

<table>
<thead>
<tr>
<th>On</th>
<th>High Beep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off</td>
<td>Low Beep</td>
</tr>
<tr>
<td>Pulse (off/on/off)</td>
<td>Low/High/Low Beep</td>
</tr>
</tbody>
</table>

5-2
UNBUFFERED OUTPUTS AND SENSE INPUTS

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High Beep</td>
</tr>
<tr>
<td>Low</td>
<td>Low Beep</td>
</tr>
<tr>
<td>Pulse (1/h/1)</td>
<td>Low/High/Low Beep</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>16 15 14 13 12 11 10 9</th>
<th>GROUP 1 (8 bits, 0-255)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 20 19 18 17</td>
<td>GROUP 2 (5 bits, 0-31)</td>
</tr>
<tr>
<td>25 24 23 22</td>
<td>GROUP 3 (4 bits, 0-15)</td>
</tr>
<tr>
<td>28 27 26</td>
<td>GROUP 4 (3 bits, 0-7)</td>
</tr>
</tbody>
</table>

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 Digitalk 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:

<table>
<thead>
<tr>
<th>ALARM/SENSE 1</th>
<th>ALARM, TRANSMITTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALARM/SENSE 2</td>
<td>ALARM, TRANSMITTER</td>
</tr>
<tr>
<td>ALARM/SENSE 3</td>
<td>SENSE (INTERROGATE H/L)</td>
</tr>
<tr>
<td>ALARM/SENSE 4</td>
<td>SENSE (INTERROGATE H/L)</td>
</tr>
</tbody>
</table>

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 "ALU" 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 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.

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

![Diagram showing TTL input, 5V CMOS input, 12V CMOS output, and 1-of-8 select with 74LS138 decoder.]

6-3
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:

<table>
<thead>
<tr>
<th>OUT 8</th>
<th>Link PTT (active low)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALARM/SENSE 4</td>
<td>Link COS (active low)</td>
</tr>
<tr>
<td>ALARM/SENSE 2</td>
<td>ID Select (low=ID1, high=ID2)</td>
</tr>
<tr>
<td>OUT 13-28</td>
<td>Link Frequency (parallel mode)</td>
</tr>
<tr>
<td>OUT 6,7</td>
<td>Link Frequency (serial mode)</td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Repeater Function</th>
<th>Signal Name</th>
<th>Connector Pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTT (active low)</td>
<td>PTT</td>
<td>L</td>
</tr>
<tr>
<td>COS (active high)</td>
<td>COS</td>
<td>C</td>
</tr>
<tr>
<td>PL (active high)</td>
<td>PL</td>
<td>Z</td>
</tr>
<tr>
<td>LINK PTT (active low)</td>
<td>OUT 8</td>
<td>10</td>
</tr>
<tr>
<td>LINK COS (active high)</td>
<td>ALARM/SENSE 4</td>
<td>5</td>
</tr>
</tbody>
</table>

**LINK FREQUENCY - PARALLEL MODE (ACTIVE HIGH OUTPUTS)**

- **XXX REQUIRES PERSONALITY PROM SELECTION XXX**

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

**LINK FREQUENCY - SERIAL MODE**

| DATA      | OUT 7 | K  |
| CLOCK     | OUT 6 | 9  |
SYNTHESIZER INFO TIMING (SERIAL MODE)

Figure 7.1

OUT6

OUT7

0 MHz 1
1 MHz 2
2 MHz 4
3 MHz 8
4 Plus/Minus
5 Simplex/Doublex
6 5/8 KHz
7 ON/OFF

9 10's KHz 1
9 10's KHz 2
10 10's KHz 4
11 10's KHz 8
12 100's KHz 1
13 100's KHz 2
14 100's KHz 4
15 100's KHz 8
Figure 7.2 - IC-220 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.

9-1 (V1.2, 7/83)
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*, 25 WPM) WORDS PER MINUTE
        Example 15 WPM
        15=0FH
        Address 0020H=0FH

0021H, 0022H  Morse/Tone Pitch
        Example 1000 Hz
        PERIOD = 1000 vs
        $939.24\times10^6$
        PITCH = $2 \times \left(\frac{1000-108}{26.8}\right) = 66.57$
        67=0043H
        Address 0021H=43H, 0022H=00H

0023H, 0024H  Courtesy Tone Duration
        Example 100 ms at 440 Hz
        $440 \text{ Hz} = 2.27 \text{ ms},$
        $100 \text{ ms} = 44 \text{ cycles}$
        44=002CH
        Address 0023H=2CH, 0024H=00H

0025H, 0026H  Repeater Courtesy Tone Pitch
        $43k=1kHz$  PITCH

0027H, 0028H  Link Courtesy Tone Pitch
        $8D_1=500Hz$  PITCH

* Default

PITCH = $2 \times \left(\frac{(\text{PERIOD}(\text{us}) - 108\text{us})}{26.8\text{us}}\right)$
# Timers

**0030H**
**Interdigit**
Example 5 seconds  
5 = 05H  
Address 0030H = 05H  

**0031H**
**Repeater Hang Time**
Example 4 seconds  
4 = 04H  
Address 0031H = 04H  

**0032H, 0033H**
**Repeater Timeout Time (Long)**
Example 180 seconds (3 minutes)  
180 = 0084H  
Address 0032H = 84H, 0033H = 00H  

**0034H, 0035H**
**Repeater Timeout Time (Short)**
Example 45 seconds  
45 = 002DH  
Address 0034H = 2D0H, 0035H = 00H  

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

**0038H**
**Phone Answer Delay Time**

---

# Initialization Parameters

<table>
<thead>
<tr>
<th>Address</th>
<th>Function</th>
<th>MS</th>
<th>LS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0040H</td>
<td>OUT 1-8</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>0041H</td>
<td>OUT 9-16</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>0042H</td>
<td>OUT 17-24</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>0043H</td>
<td>OUT 25-28</td>
<td>xx</td>
<td>xx</td>
</tr>
</tbody>
</table>

0 = on, 1 = off  
0 = high, 1 = low  

**0044H**
**Repeater Enable**
Enable  
Disable  

**0045H**
**Remote Base Enable**
Enable  
Disable  

**0046H**
**Carrier / PL Operation**
Carrier  
PL  

**0047H**
**Repeater Timer Enable**
Enable  
Disable  

**0048H**
**Repeater Timer Select**
Long Timer  
Short Timer  

*The following apply to Repeater Mode only.*
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 FWR"
00H, 48H, 49H, 20H, 50H, 57H, 53H, FFH

Example Speech "Control up"
01H, 48H, 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

01F0H  OUT 16 HIGH
01F8H  STATUS 4 LOW
01F8H  ALARM 4 / STATUS 4 HIGH
0200H  OUT 17 LOW
0200H  OUT 17 HIGH
0208H  OUT 17 LOW
0208H  OUT 17 HIGH
0210H  OUT 18 LOW
0210H  OUT 18 HIGH
0218H  OUT 18 LOW
0218H  OUT 18 HIGH
0220H  OUT 19 LOW
0220H  OUT 19 HIGH
0228H  OUT 19 LOW
0228H  OUT 19 HIGH
0230H  OUT 20 LOW
0230H  OUT 20 HIGH
0238H  OUT 20 LOW
0238H  OUT 20 HIGH
0240H  OUT 21 LOW
0240H  OUT 21 HIGH
0248H  OUT 22 LOW
0248H  OUT 22 HIGH
0250H  OUT 22 LOW
0250H  OUT 22 HIGH
0258H  OUT 22 LOW
0258H  OUT 22 HIGH
0260H  OUT 23 LOW
0260H  OUT 23 HIGH
0268H  OUT 23 LOW
0268H  OUT 23 HIGH
0270H  OUT 24 LOW
0270H  OUT 24 HIGH
0278H  OUT 24 LOW
0278H  OUT 24 HIGH
0280H  OUT 25 LOW
0280H  OUT 25 HIGH
0288H  OUT 25 LOW
0288H  OUT 25 HIGH
0290H  OUT 26 LOW
0290H  OUT 26 HIGH
0298H  OUT 26 LOW
0298H  OUT 26 HIGH
02A0H  OUT 27 LOW
02A0H  OUT 27 HIGH
02A8H  OUT 28 LOW
02A8H  OUT 28 HIGH
02B0H  OUT 28 LOW
02B0H  OUT 28 HIGH
02B8H  OUT 28 LOW
02B8H  OUT 28 HIGH
02C0H  OUT 28 LOW
02C0H  STATUS 1 LOW
02C0H  STATUS 1 HIGH
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
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
0440H OUT 21 OPERATOR
0450H OUT 22 0560H REPEATER REMOTE BASE

0570H LOCK / UNLOCK
0580H INITIALIZE

ALARM AUTO-DIAL 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 = 08H )
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 in 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.

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### HEXADECIMAL-DECIMAL INTEGER CONVERSION

A table below provides direct conversions between hexadecimal integers in the range 0FFF and decimal integers in the range 0-4095. For conversion of larger integers, the table values may be added to the following figures.
MORSE CODE CHARACTER ASCII HEX VALUES

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<th>Hex</th>
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WORD SPACE

WAIT (AS)

END OF MSG (AR)

END OF LINE (SK)

PARENTHESIS

COMMA (,)

DASH (-)

PERIOD (.)

SLANT BAR (/)

COLON (;)

SEMICOLON (;)

QUESTION (?)

TOUCH-TONE DIGIT REPRESENTATION IN HEX
(For Command Prefixes and Command Evaluation and Cancel Keys)

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APPENDIX II  Speech Synthesizer Interface  
(National Semiconductor Digitalker DT1050)
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</tbody>
</table>

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

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

FW (xx) (x)  

Output #01-28
0=Low, 1=High, 
2=Pulse, Empty—
Interrogate

GROUP OUTPUT FORCE / INTERROGATE

FW 4 (x) (x(x(x)))  

Group #1-4
0-255=Value, Empty—
Interrogate

STATUS INPUT INTERROGATE

FW 3 (x)  

Input #1-4

ALARM

FW 5 (x) (x)  

Alarm #1-4
0=Disable, 1=Enable, 
2=Clear

(Any command over phone cancels dial out alarm —
i.e., "x", assuming x 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

REPEATER REMOTE BASE

FW 7 (x) PP (x)

1 Receive Only
2 Transmit
3 Off

FW 7 (MHz/T) PP (MHz/T)

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

LOCK / UNLOCK

--- PP (x)

0=Unlock, 1=Lock

INITIALIZE

--- PP

HANGUP PHONE

# (x) # (x)

(V1.2, 7/83)