MOTOROLA

Integrated Information Systems Group
8201 E. McDowell Road
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Exhibit 8 – Users Manual

Card Acceptance Device (CAD⁺)

Low Power Transceiver Module

FCC ID: ABZMCAD200

Model Nos. T6480A *(and variants)*

8.0   Card Acceptance Device (CAD+) Users Manual

MOTOROLA

MCAD 200
CARD ACCEPTANCE DEVICE (CAD+)

Models   **T6479A (Parallel)**
T6480A (Serial)
T6481A (Serial)
T6499A (Serial)
T6500A (Serial)
T6501A (Serial)
T6548A (Serial)

Instruction Manual

MOTOROLA READER WARRANTY

Warranty: Motorola, Inc. ("Motorola") warrants its Motorola manufactured **smartcard reader or terminal ("Product")** to the original purchaser ("Buyer") as stated herein, except to the extent the terms herein may be modified by a written SmartCard Systems Agreement between Motorola and Buyer. Smartcards are not covered by this warranty.

Motorola warrants the Product against material defects in material and workmanship under normal use and service for a period of One (1) Year from the date of Product shipment. Motorola, at its option, will at no charge either repair the Product (with new or reconditioned parts), replace it with the same or equivalent product (using new or reconditioned parts), or refund the purchase price of the Product during the warranty period provided Buyer notifies Motorola within the warranty period in accordance with the terms of this warranty. Repaired or replaced product is warranted for the balance of the original applicable warranty period. All replaced parts of the Product shall become the property of Motorola.

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   (a) Use of the Product in other than its normal and customary manner.
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2. Product which has had the serial number removed or made illegible.
3. Normal and customary wear and tear.
4. Fraud, theft or loss resulting from unauthorized use of the Product.
5. Loss of value or data stored in the Product or in other equipment used with the Product.
6. Disclosure of personal or confidential information or data stored in or accessed by the Product.
7. Loss or damage from Product or system downtime.
8. Scratches or other cosmetic damage to Product surfaces that does not affect the operation of the Product.
9. That the software in the Product will meet the purchaser's requirements or that the operation of the software will be uninterrupted or error−free.

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(b) that Motorola will have sole control of the defense of such suit and all negotiations for its settlement or compromise; and

(c) should the Product or its parts become, or in Motorola's opinion be likely to become, the subject of a claim of infringement of a United States patent, that Buyer will permit Motorola, at its option and expense, either to procure for Buyer the right to continue using the Product or its parts or to replace or modify the same so that it becomes non−infringing or to grant Buyer a credit for the Product or its parts as depreciated and accept its return. The depreciation will be an equal amount per year over the lifetime of the Product or its parts as established by Motorola.

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FCC Compliance Statement

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions. (1) This device may not cause harmful interference. And (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the radiated limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- −− Reorient or relocate the receiving antenna.
- −− Increase the separation between the equipment and receiver.
- −− Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- −− Consult the dealer or an experienced radio/TV technician for help.

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference. And (2) this device must accept any interference received, including interference that may cause undesired operation.

The CAD+ was submitted and a grant of authorization received from the FCC as a modular device under the intentional radiator requirements of Part 15, Subpart C.

The party that incorporates this device into their product is responsible for verification of the emissions produced by the final product and must adhere to the limits specified in the Code of Federal Regulation 47, Part 15, Subpart B.

Furthermore, a label must be applied on the exterior of the final product referring to this enclosed module which states, "Contains FCC ID: **ABZMCAD200**" or "Contains Transmitter Module FCC ID: **ABZMCAD200**".

Notice: When an AC source is used to supply power to the integrated equipment, the final equipment will also have to verify compliance with the AC line conducted emissions according to FCC Part 15, Subpart B. If unsatisfactory emissions are measured at the fundamental frequency of the CAD+ then a Corcom 2VK1L power line filter may be used to suppress the line-conducted emissions.

Caution: Any changes or modifications not approved by the party responsible for compliance could void the user's authority to operate the equipment

CE Compliance Statement

The Motorola MCAD200 is in conformity with all essential requirements of the Radio & Telecommunications Terminal Equipment Directive (R&TTE 1999/5/EC). This product has been assessed to the following standards:

EN 300 330
ETSI EN 301 489−1
ETSI EN 301 489−3
EN 60950: 1992 Incl Amdt 1−4, 11

This product is marked with CE 0560 ⓘ , which signifies conformity with Class II product requirements specified in the R&TTE directive.

![Motorola logo] **MOTOROLA**

MCAD 2000
CARD ACCEPTANCE DEVICE (CAD+)

Models   **T6479A (Parallel)**
T6480A (Serial)
T6481A (Serial)
T6499A (Serial)
T6500A (Serial)
T6501A (Serial)
T6548A (Serial)

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October 15, 2000−eDOC

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Appendix

FOREWORD

Product Maintenance Philosophy

Due to the high percentage of surface-mount components and multi-layer circuit board design, the maintenance philosophy for this product is one of Field Replaceable Unit (FRU) substitution. Each Control Board and Antenna Board matched set is considered a FRU, and when determined to be faulty, may be quickly and easily replaced with a known good set to bring the equipment back to normal operation. The faulty CAD set must then be shipped to the Motorola Radio Support Center in Rockford, Illinois for further troubleshooting and repair to the component level.

Customer Support

For complete information on ordering FRU replacement modules, or instructions on how to return faulty modules for repair, contact the Motorola System Support Center as follows:

Motorola System Support Center
1311 E. Algonquin Road
Schaumburg, IL 60196

1−800−221−7144
FAX 847−576−2172
Int'l 847−576−7300

Scope of Manual

This manual is intended for use by experienced technicians familiar with similar types of equipment. In keeping with the maintenance philosophy of Field Replaceable Units (FRU), this manual contains functional information sufficient to give service personnel an operational understanding of all FRU modules, allowing faulty FRU modules to be identified and replaced with known good FRU replacements.

The information in this manual is current as of the printing date. Changes which occur after the printing date are incorporated by Standard Manual Revisions (SMR). These SMRs are added to the manuals as the engineering changes are incorporated into the equipment.

PERFORMANCE SPECIFICATIONS

Electrical

Required Supply Voltage	9.0 - 15.0 V dc; ripple less than 50 mV P-P
Required Supply Current	Maximum 320 mA @ 12 V dc (230 mA typical) **Note** *Ratings assume recommended tuning with no metal within 10 cm of antenna board*
Maximum Input Power Requirements	3.6 Watts
CAD Power-Up Time	Less than 1 second after power applied

Environmental

Operating Temperature	-30° C to +70° C (-22° F to +158° F)
Storage Temperature	-40° C to +85° C (-40° F to +185° F)
Cold and Heat Shock	-40° C to +85° C (-40° F to +185° F) within 2 hour duration
Vibration	Frequency Range: 10 Hz to 500 Hz Vibration Severity: 3 gn
Shock	Severity: 60 gn Duration: 11 msec
Bump	Severity: 40 gn Duration: 6 msec Number of bumps: 4000
Electromagnetic Fields	Compliant with ISO 10536-1, 4.2.8

Transmitter

Frequency	13.56 MHz $\pm$ .01%
Modulation	**ISO-14443 Type A** Rise/Fall Time: 2-3 μsec rise; <1.5 μsec fall ASK Percentage: 100% **ISO-14443 Type B** Rise/Fall Time: <2 μsec rise and fall ASK Percentage: 8% to 14%

Receiver

Carrier Frequency	13.56 MHz
Subcarrier Frequency	847.5 kHz
Subcarrier Data	**ISO-14443 Type A** Modified Manchester **ISO-14443 Type B** NRZ-L BPSK

Operational

CAD-to-Terminal Communication Protocols	**Serial** RS-232, RS-485, and CMOS (depending on model) **Parallel** Byte-Wide Parallel Transfer
CAD-to-Terminal Communication Rates	**Serial** 9600 bps, 19.2 bps, 38.4 Kbps, 57.6 Kbps, and 115.2 Kbps **Parallel** 25,000 bytes per second
CAD-to-Card Communication Rate	105.9375 Kbps
CAD-to-Card Operating Radio Frequency	13.56 MHz

Notes...

Chapter 1 ▶ Description

chapter contents

1 PRODUCT OVERVIEW

The Motorola Card Acceptance Device (CAD) is an electronic module capable of communicating with ISO 14443 Type A and Type B compatible smart cards via a radio frequency (RF) interface. This section provides general information about the application and physical properties of the CAD.

Physical Description

Overview

The CAD, which provides the communications interface between a terminal and customer smart cards, consists of a Control Board and an Antenna Board. These two boards are connected together by a 100 mm multi-conductor interconnect cable. The CAD is connected to the terminal via a 16-pin connector (parallel models) or a 10-pin connector (serial models) located on the Control Board.

Control Board

The Control Board contains a microprocessor, non-volatile memory, and radio frequency transmitting and receiving circuitry. This board communicates with smart cards via an RF link (provided by the Antenna Board), and to the terminal via RS-232, RS-485, or CMOS (serial models) or a byte-wide, proprietary parallel (parallel models) protocol. Note that serial rates range from 9600 bps to 115.2 kbps, and parallel rates are up to 25 kbytes/sec.

Antenna Board

The Antenna Board consists of a printed circuit board with copper traces forming the transmit and receive antenna. The Antenna Board may be one of several types, varying in dimensions and construction (some types are attached to a ferrite plate with a metal back plate serving as a ground plane).
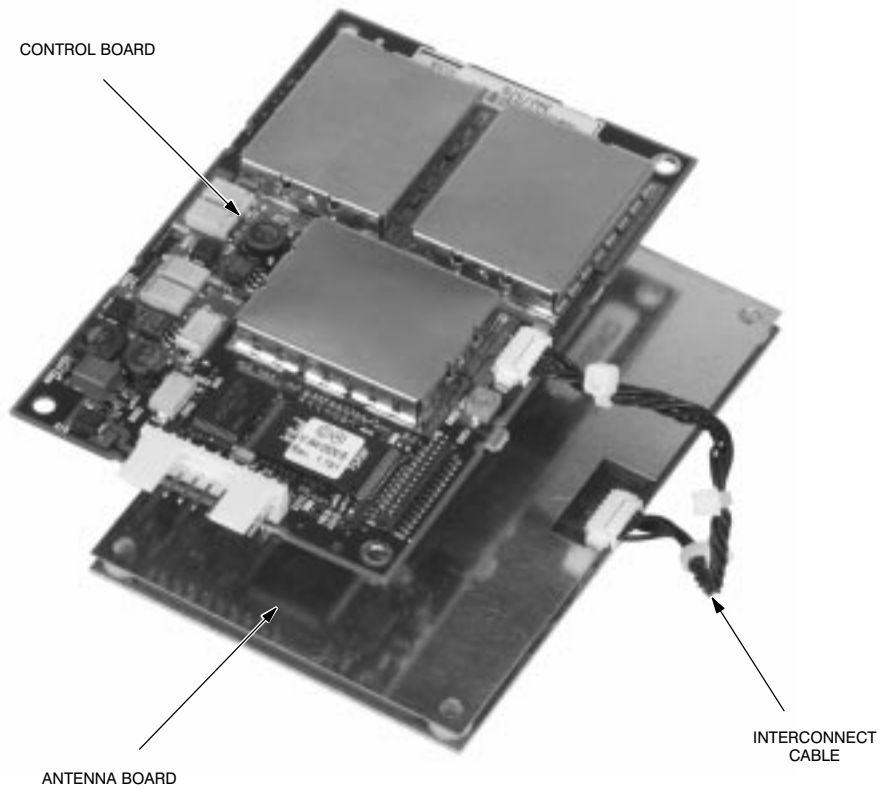
Typical Application

The CAD described in this manual is a device which allows communications to contactless smart cards by a host or terminal. It is suitable for applications such as automated fare collection, access control, electronic purse, and vending machines.

CAD Primary Components

1−3

CONTROL BOARD

INTERCONNECT
CABLE

ANTENNA BOARD

Available Models

The CAD+ is available in several models (shown on the next few pages). In general, the major differences between the models are the type of Antenna Board and the type of communications protocol used to communicate with the terminal.

T6479A
Parallel CAD+ (CMOS Interface)
with Parallel Connector and 104 x 67 mm Antenna Board
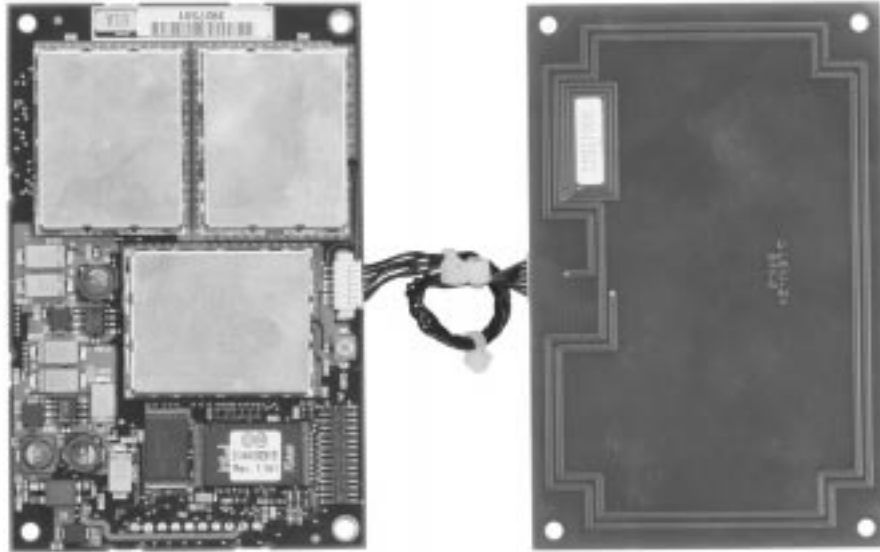
T6480A
Serial CAD+ (RS-485 Interface)
with Vertical Connector and 104 x 67 mm Antenna Board
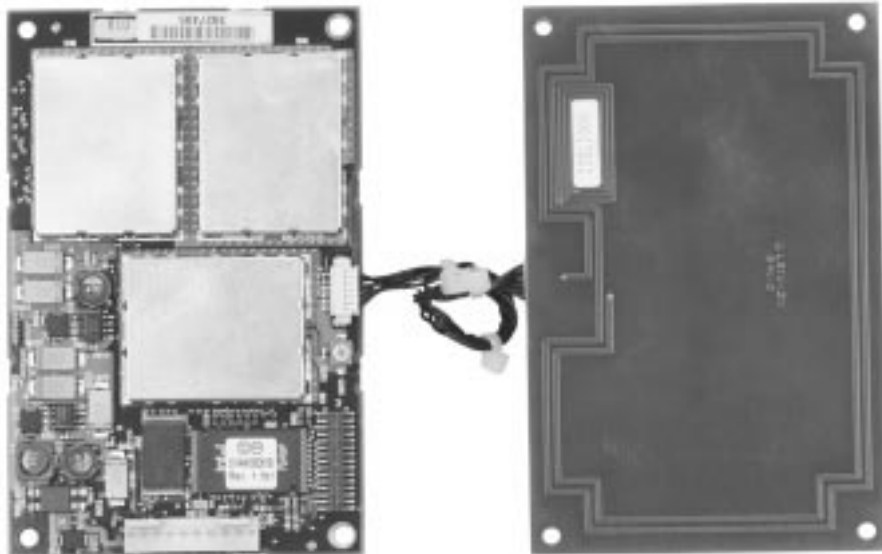
Available Models
(continued)

T6481A
Serial CAD+ (RS-485 Interface)
with Horizontal Connector and 104 x 67 mm Antenna Board
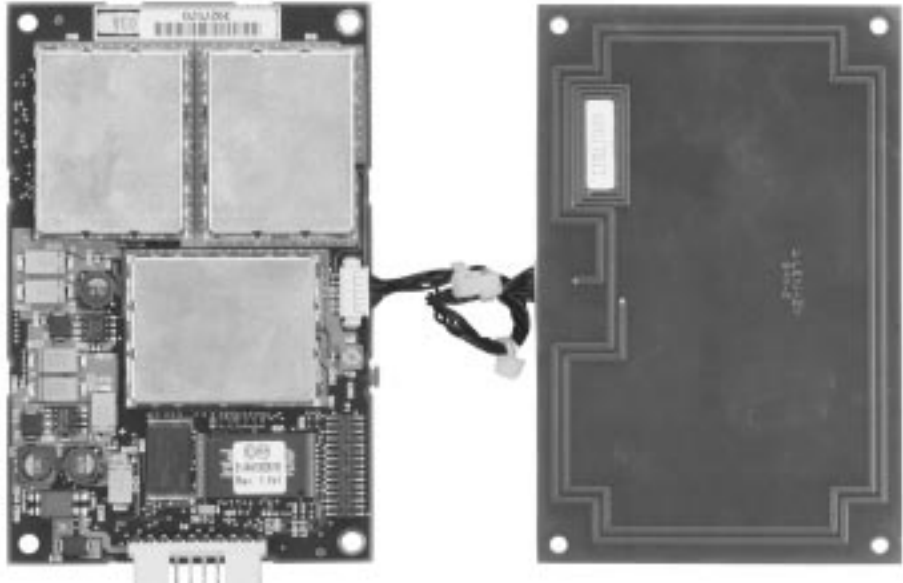
T6499A
Serial CAD+ (RS-485 Interface)
with Vertical Connector and 50 x 25 mm Antenna Board
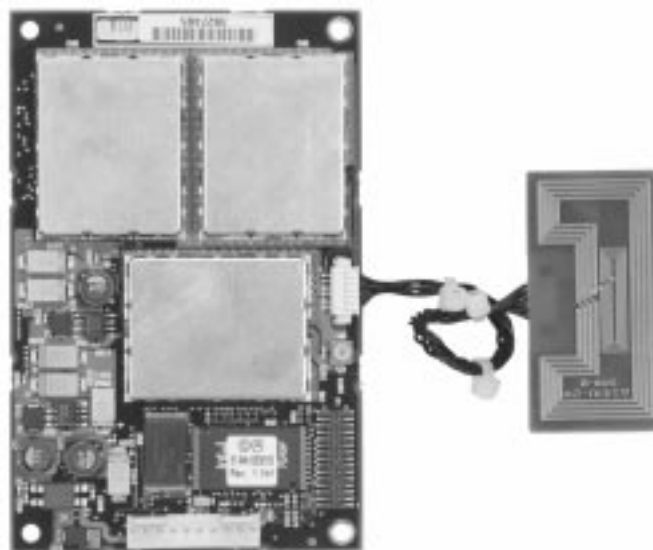
Available Models
(continued)

T6500A
Serial CAD+ (RS-485 Interface)
with Horizontal Connector and 50 x 25 mm Antenna Board
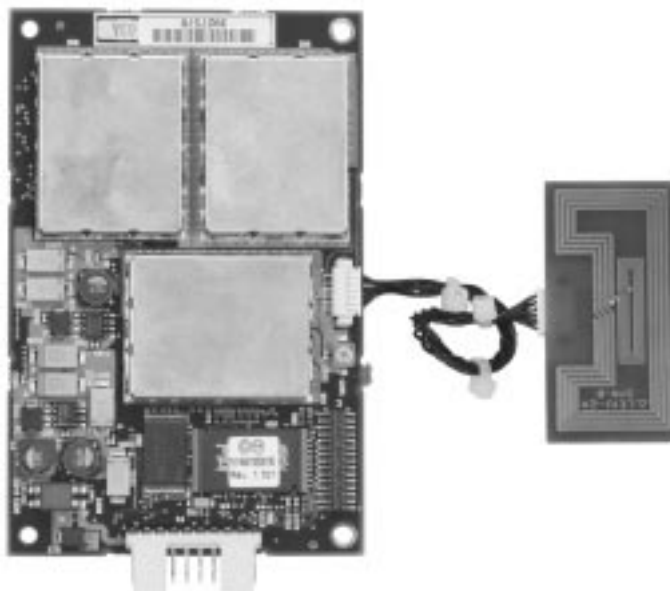
T6501A
Serial CAD+ (CMOS Interface)
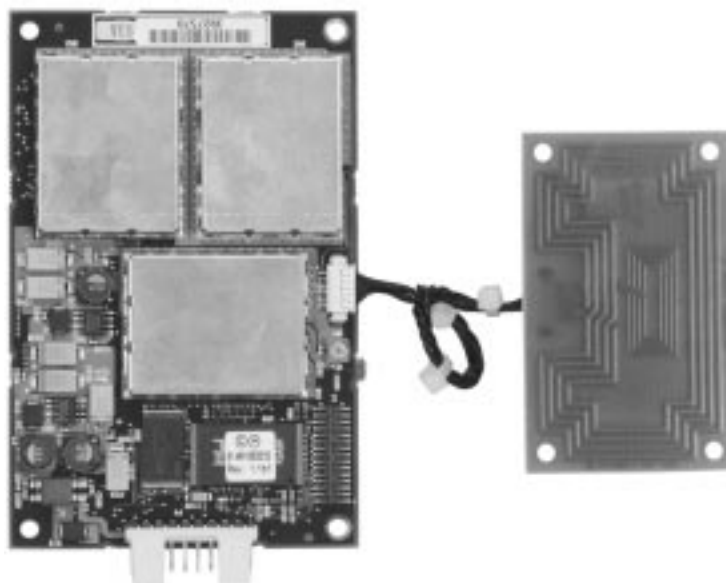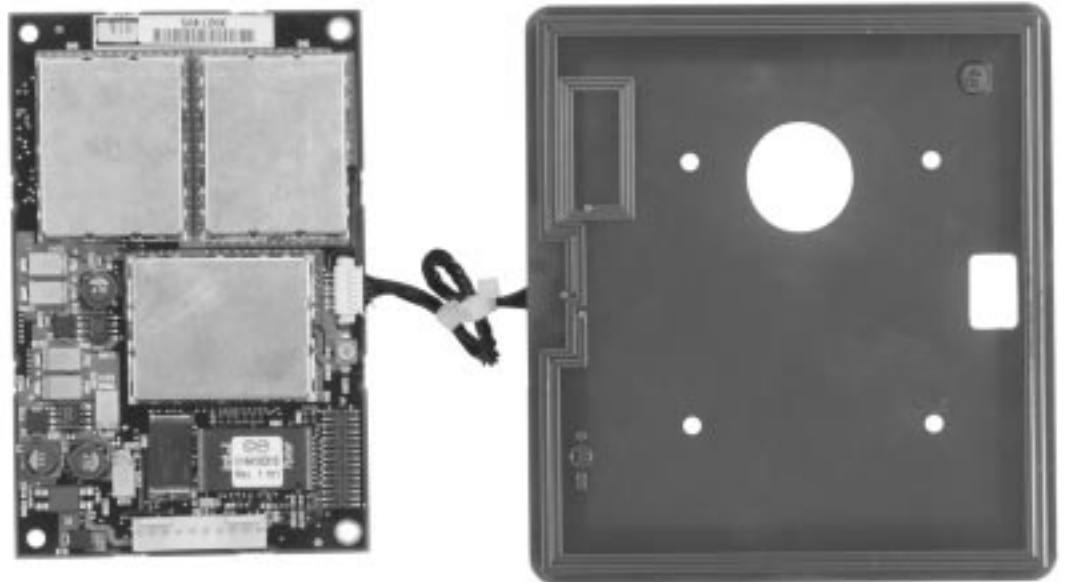**with Horizontal Connector and 65 x 40 mm Antenna Board**

Available Models
(continued)

T6548A
Serial CAD+ (RS-485 Interface)
with Vertical Connector and 100 x 110 mm Antenna Board

2   SIMPLIFIED BLOCK DIAGRAM THEORY

The illustration on the facing page shows a simplified block diagram of the CAD. This section is intended to provide a basic understanding of the CAD circuitry and how it interacts with the terminal and smart cards. (Refer to Chapter 4 for a more detailed block diagram and circuit descriptions.)

Overview of CAD Operation

The CAD serves as the data communications link between a smart card and the Terminal in which the CAD is installed (or to which the CAD is connected). The CAD operations are controlled by the Terminal. The CAD searches (polls) for smart cards within its range, notifies theTerminal when valid cards are found, and transfers data from the Terminal to the card, and from the card back to the Terminal.

For Terminal-to-Card communications, the CAD's Control Board receives a command from the Terminal to transmit data (received from the Terminal) to the card. The CAD then transmits the data via modulated encrypted RF signals to the card.

For Card-to-Terminal communications, the CAD's Control Board detects and demodulates encrypted RF data signals from the smart card and sends data back to the Terminal. Communications with the Terminal are made using RS-485, RS-232, or CMOS (serial models) or 8-bit byte-wide parallel (parallel models) protocols.

CAD Simplified Block Diagram

CARD ACCEPTANCE DEVICE (CAD)

CONTROL BOARD

TERMINAL

SERIAL OR PARALLEL DATA (DEPENDING ON MODEL)

MICROPROCESSOR

ANALOG FRONT END (AFE)

NON-VOLATILE MEMORY

POWER SUPPLY CIRCUITRY

+5V

+5V_A

100 MM INTERCONNECT CABLE

ANTENNA BOARD

SMART CARD
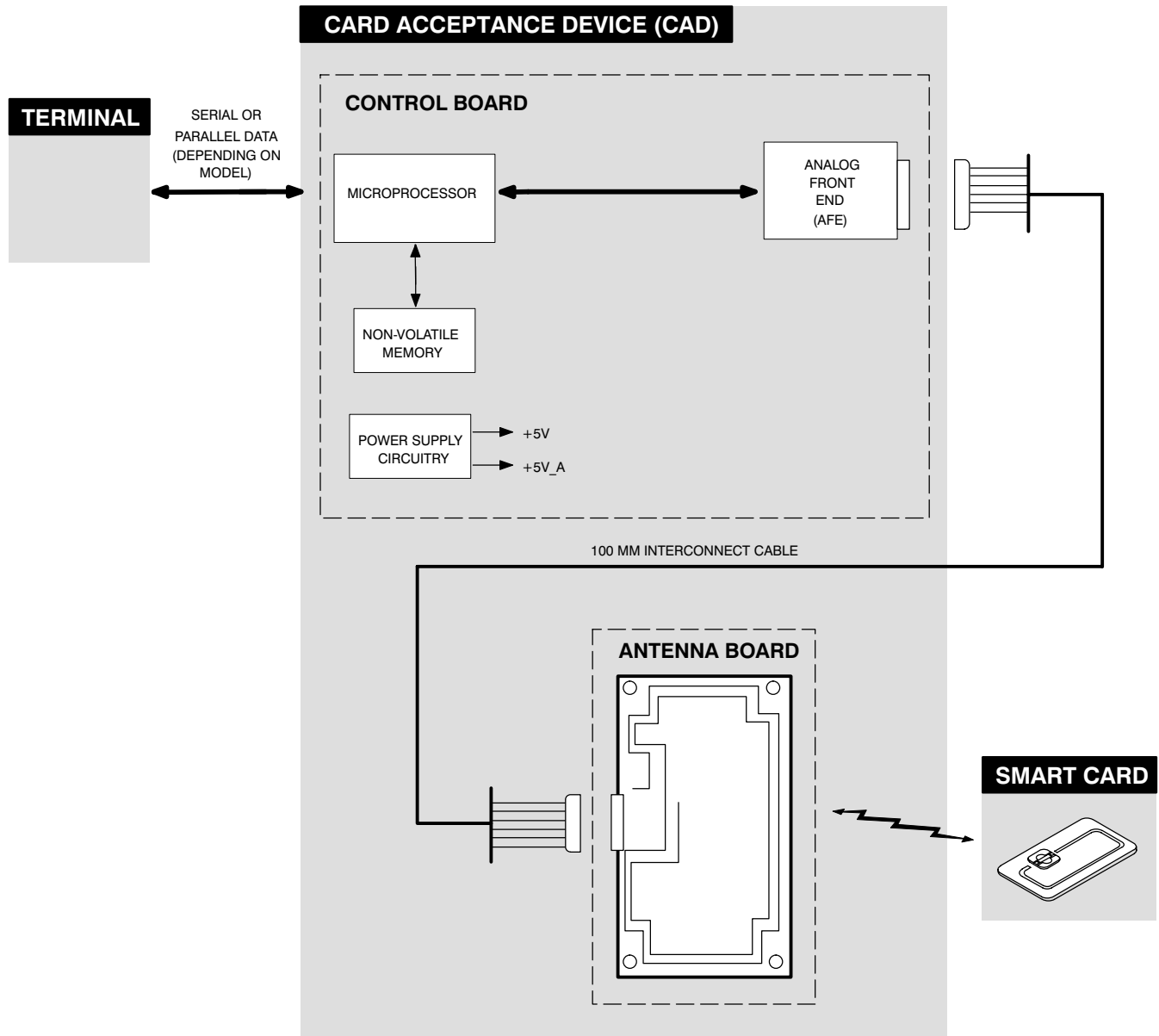
CAD Detailed Components

The Control Board contains components on both sides of the circuit board. The Antenna Board contains no components, but rather printed circuit traces which form the antenna. Refer to the photos on the next two pages for identification of the components on the two boards. A typical Parallel CAD+ and a Serial CAD+ are shown.

CAD Detailed Components (Typical Parallel CAD+)

TOP VIEW

CONTROL BOARD

ANTENNA BOARD

INTERCONNECT CABLE

P/O ANALOG FRONT END (AFE)

TUNING CAPACITOR

SRAM MEMORY

FLASH MEMORY

METAL BACK PLATE (GROUND PLANE)

BOTTOM VIEW

CONTROL BOARD

MICROPROCESSOR

ANTENNA BOARD

8-POSITION DIP SWITCH

PARALLEL CONNECTOR TO/FROM TERMINAL

STATUS LED (GREEN)

CLN7468A

FCC APPROVAL

ANTENNA CIRCUIT BOARD (TRACES FORM ANTENNA)
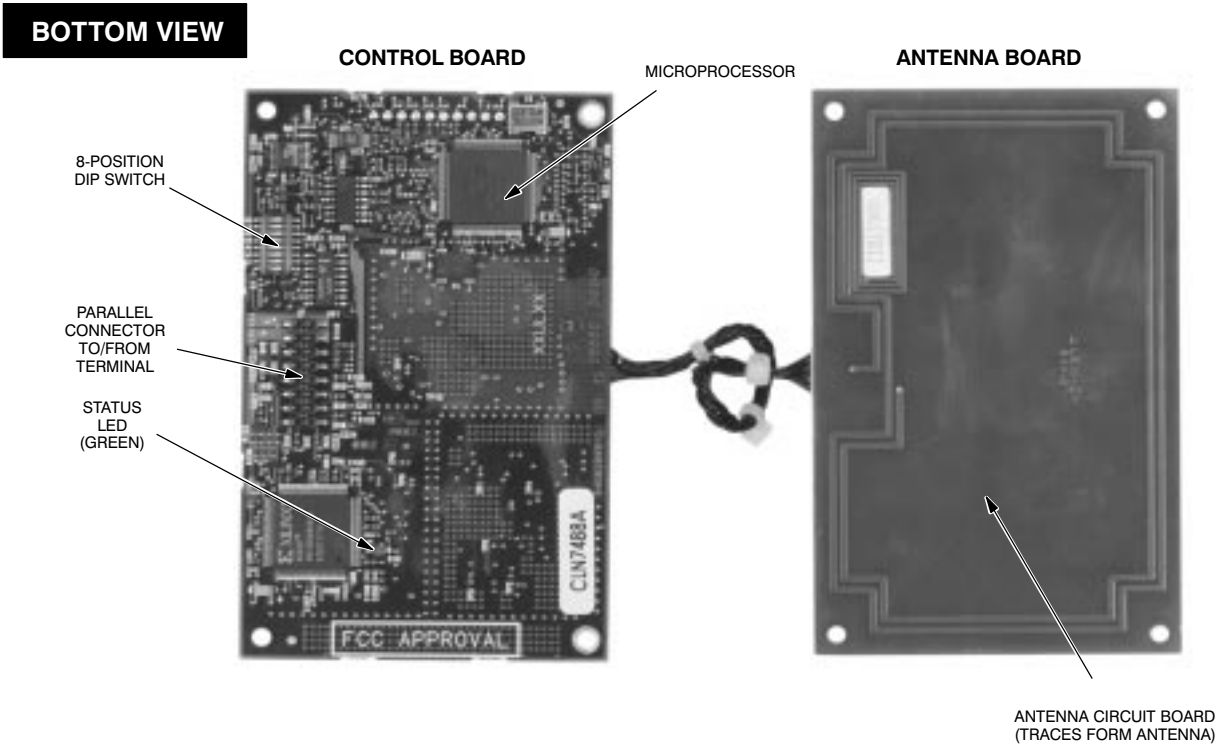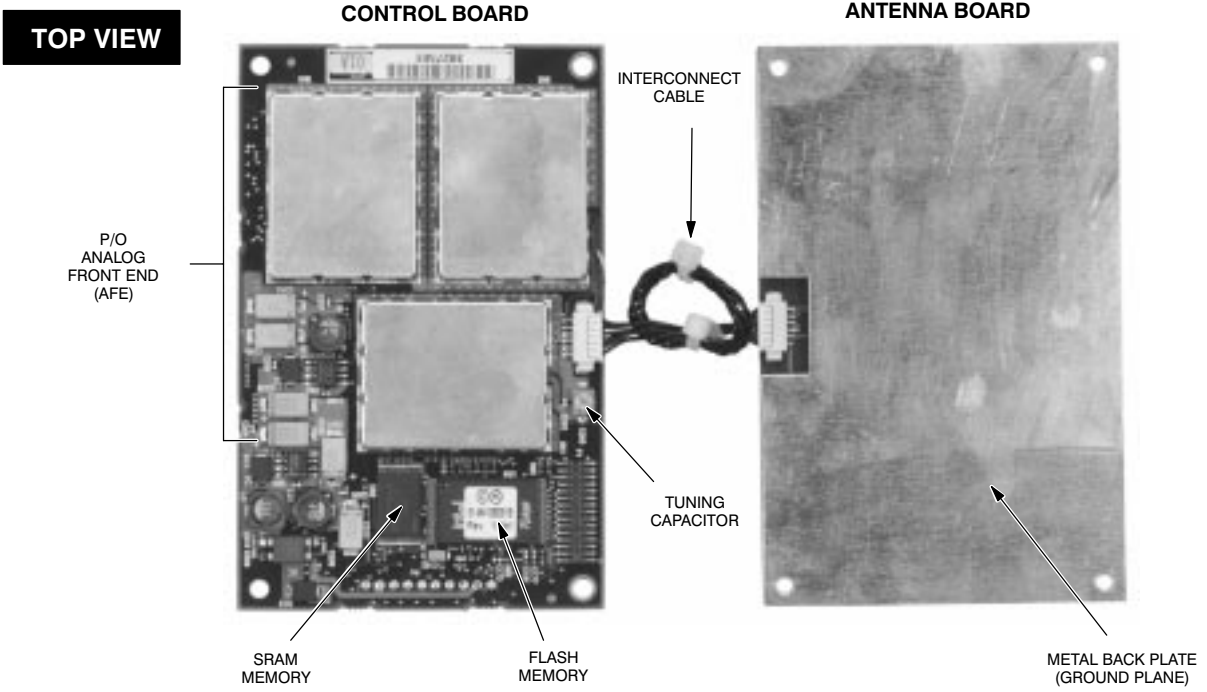
CAD Detailed Components (Typical Serial CAD+)

TOP VIEW

CONTROL BOARD

ANTENNA BOARD

INTERCONNECT CABLE

P/O ANALOG FRONT END (AFE)

TUNING CAPACITOR

SRAM MEMORY

FLASH MEMORY

CONNECTS TO TERMINAL

ANTENNA CIRCUIT BOARD (TRACES FORM ANTENNA)

BOTTOM VIEW

CONTROL BOARD

ANTENNA BOARD

MICROPROCESSOR

8-POSITION DIP SWITCH

STATUS LED (GREEN)

METAL BACK PLATE (GROUND PLANE)

chapter contents

1 UNPACKING AND INSPECTION

This section describes the procedures necessary to unpack and take inventory, run a Self Test utility to verify proper electrical operation, perform a tuning procedure, mechanically install the CAD set into an external terminal enclosure, and perform a final checkout procedure.

Important! *The CAD Control Board contains C-MOS and other static-sensitive components. When handling the CAD, be sure to observe all precautions to prevent damage to the components from static electricity. These include the use of a grounded anti-static wrist strap and anti-static mats and work surfaces.*

Unpacking and Inspecting the CAD Sets

General

Each CAD set (consisting of a Control Board and an Antenna Board) is tuned and tested at the factory prior to shipment. Each CAD set is shipped with a 100 mm multi-conductor interconnect cable connected between the Control Board and the Antenna Board.

Remove each CAD set from the packing material and inspect for visual damage. Report the extent of any damage to the transportation company and Motorola.

Verifying CAD+ Model Type

Examine the settings on the 8-position DIP switch (located on the bottom of the CAD+ Control Board and compare to the table below to verify the model type of the CAD+. (Refer to Appendix D for more details on the DIP switch settings.)
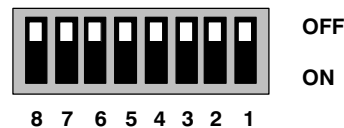
CAD+ Model	S1	S2	S3	S4−S8
T6479A	On	Off	Off	Off
T6480A, T6481A, T6499A, T6500A. T6548A	Off	Off	Off	Off
T6501A	Off	On	Off	Off

CAD Set Connected by Cable

MULTI-CONDUCTOR
INTERCONNECT
CABLE

CONTROL BOARD

ANTENNA
BOARD
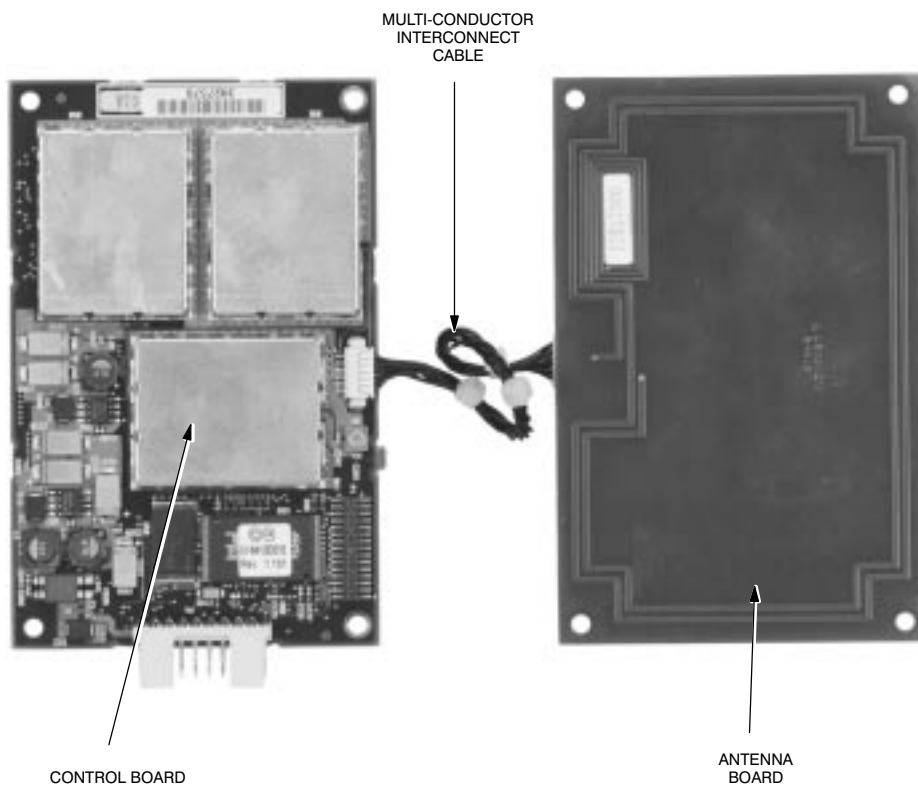
2 VERIFYING PROPER OPERATION

Although each CAD set is tested at the factory before shipment, it is recommended that the *Auto-Test* utility be run on each CAD set prior to installation into a terminal. This ensures that the CAD set is electrically functional and was not electrically damaged in transit or during unpacking.

The *Auto-Test* utility is part of the *CADTools* program included with the Model T6439A Parallel CAD Installation Kit or the Model T6367A Serial CAD Installation Kit (both available from Motorola). The *CADTools* program is a *Microsoft Windows* compatible program that includes a suite of factory test utilities and a firmware download utility for updating the CAD operating software.

Required Equipment

The following hardware and software is required in order to run the Self Test Utility on a CAD set.

- **Model T6367A Serial CAD Installation Kit** — includes Serial Converter Box, Power Supply, ISO Antenna Board, and *CADTools* Software (version V1.20 or higher required)
  — *or* —
  Model T6439A Parallel CAD Installation Kit — includes Test Cable, Power Supply, ISO Antenna Board, and *CADTools* Software (version V1.20 or higher required)
- *IBM* PC or *IBM*-compatible desktop or laptop computer (Pentium II class processor running at 200 MHz or greater, Windows 95, 98, 2000, or NT 4.0 operating system)

Installing the *CADTools* Software

The *CADTools* software is provided on a CD-ROM (typically). Install the software by performing the procedures located in the *CADTools User's Guide* (supplied with the software in printed and/or electronic format).

Launching the
CADTools **Software**

1. Before launching the *CADTools* program, the CAD must be powered and connected to the PC, as shown below. Make these connections using the cables and power supply provided in the Model T6367A (Serial) or T6439A (Parallel) CAD Installation Kit.

Serial CAD Connections

CONNECTS TO
COM 1 PORT
ON PC

+12 V
POWER
SUPPLY

CAD SET

SERIAL
CONVERTER
BOX

Important! *Do not attach or remove the ribbon cable from the 16-pin connector on the Control Board with DC power on (either from the Terminal or from the DC Power Supply included with the Installation kit). Doing so may result in corrupted Control Board firmware.*

Important! *Make sure that the PC's parallel port is set for* **bi-directional***. This setting is usually provided in the PC's BIOS setup menu (accessed by pressing a designated key during the PC's bootup period).*

Parallel CAD Connections

+12 V
POWER
SUPPLY

CONNECTS TO
PARALLEL PORT
ON PC

TEST CABLE

CAD SET

Launching the
CADTools **Software**
(continued)

2. Click on the Start button, then select:
   Programs ⇒ **Motorola** ⇒ **CADTools**
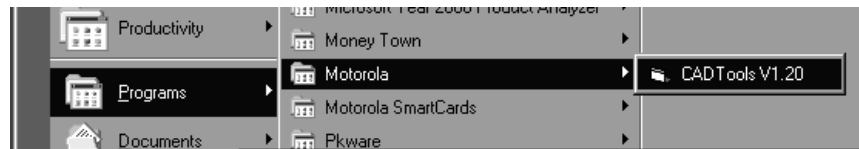
3. The *CADTools Main Screen* will appear. Click in the *Port Select* list box and select **COM1** (serial CAD) or **LPT1** (parallel CAD). LPT1 is selection is shown below.
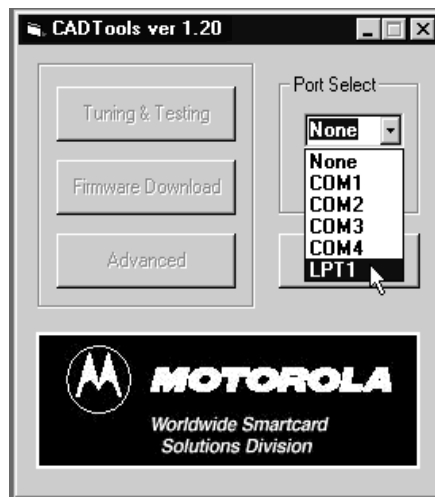
4. The following screen may appear, prompting you to power cycle the CAD. Disconnect, then reconnect the black DC power connector to power cycle the CAD. Then click on **OK**.

2−7

**Launching the
CADTools Software
(continued)**

5. The *CADTools* main screen will appear. It is from this screen that you can access the *Tuning & Testing* tool (used to run self-test diagnostics and perform field tuning) and the *Firmware Download* utility (used to download CAD operating software from the PC into FLASH memory in the CAD Control Board).

◆ *End of this Procedure* ◆

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Running the Self-Test Utility

1. With the CAD connected to the PC and the *CADTools* program running (refer to *Launching the CADTools Software* on page 2−5), click on the **Tuning & Testing** button.
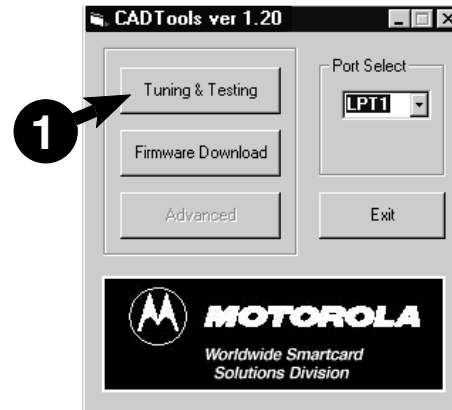
2. The following *CADTools Tuning & Testing* main screen will appear.
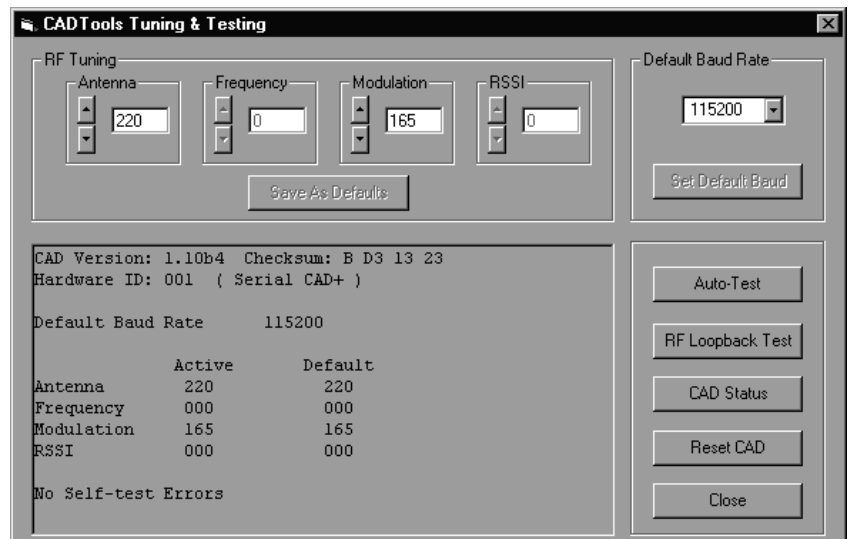
**Running the Self Test
Utility
(Continued)**

3. Click on the **Reset CAD** button to cause the CAD set to perform a reboot process. When complete, the *Reset command sent* message will be displayed.
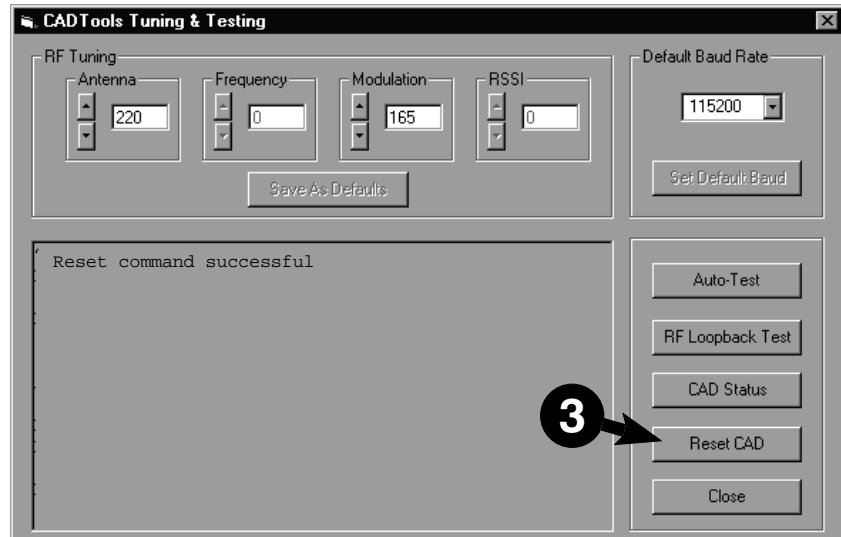
4. Click on the **Auto-Test** button to initiate the self-test routine. The results will be displayed as shown below. Verify that all test results are **OK**.
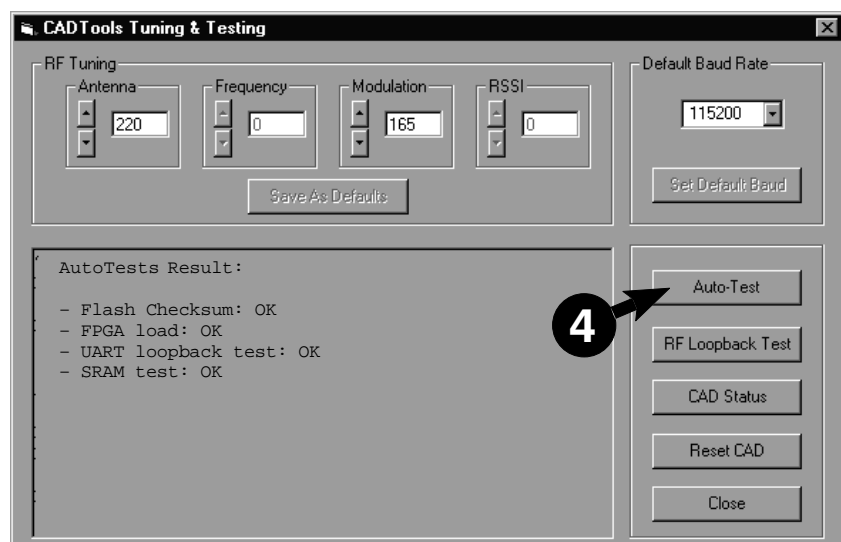
◆ *End of this Procedure* ◆

3 **TUNING PROCEDURE**

Introduction

Each CAD set is tuned at the factory for maximum operating range with minimal power. However, in some cases it may be necessary to tune the CAD set again when it is installed in the terminal due to characteristics of the terminal (such as metal or metallic paint near the Antenna Board) which can affect the operating range or reliability. It may also be required to tune the CAD set again if a terminal (such as a battery-powered terminal) requires *minimal power draw* from the CAD and a *nominal* operating range.

CAD Tuning Guidelines

If the CAD set requires tuning due to Terminal characteristics such as metal or metallic paint near the Antenna Board (which can affect operating range or reliability), it is recommended that the CAD be installed into the Terminal first and then tuned. This may require some special adapters (e.g., to connect the CAD to the PC).

However, there may be situations where tuning the CAD while installed in the Terminal is not possible (e.g., access to the tuning capacitor is not possible while installed in the Terminal housing). In these cases, a special tuning "fixture" may have to be constructed to simulate the CAD installed in the Terminal housing while also providing access to the tuning capacitor. The fixture must be constructed so as to simulate any metal shielding in the Terminal, as well as the precise distance between a presented smart card and the Antenna Board. For further assistance in constructing a tuning fixture, consult with the Motorola System Support Center.

If, instead, the Terminal has little or no effect on the CAD performance and the CAD needs to be adjusted, this can be done prior to installation in the Terminal. In cases such as this, tuning may be performed on a test bench with the distance between the Antenna Board and the Terminal card presentation target simulated. The tuning procedure beginning on page 2−12 describes this method.

Note *To perform the tuning procedure, you will use the **CADTools** program. This software application was used previously to perform the Self-Test utility to verify that the CAD is electrically functional. Refer to page 2−4 for instructions on installing this software application on your PC.*

Required Equipment

The following hardware and software is required in order to perform the tuning procedure on a CAD set.

- **Model T6367A Serial CAD Installation Kit** — includes Serial Converter Box, Power Supply, ISO Antenna Board, and *CADTools* Software (version V1.20 or higher required)
  — or —
  Model T6439A Parallel CAD Installation Kit — includes Test Cable, Power Supply, ISO Antenna Board, and *CADTools* Software (version V1.20 or higher required)
- *IBM* PC or *IBM*-compatible desktop or laptop computer (Pentium II class processor running at 200 MHz or greater, Windows 95, 98, 2000, or NT 4.0 operating system)
- Oscilloscope (Tek TDS420A, or equivalent)

Tuning the CAD

1. Place the Control Board and the Antenna Board on a grounded anti-static mat as shown below. Because of the metallic content of the anti-static mat, the CAD Antenna Board must be raised approximately 5 cm above the mat by using a non-metallic spacer (e.g., a few pads of paper).

2. Refer to the photos on page 2−5 to connect the Parallel CAD+ or Serial CAD+ to DC power and the PC. However, make sure you perform the following substeps in order:

    — Connect the test cable (supplied in the Installation Kit) to the CAD and the PC.

    — Plug the power supply line cord into an AC outlet.

    — Connect the DC connector from the power supply to the DC connector on the test cable. The green LED on the Control Board should light within approximately 1 second.

ANTENNA BOARD RAISED 5 CM ABOVE MAT
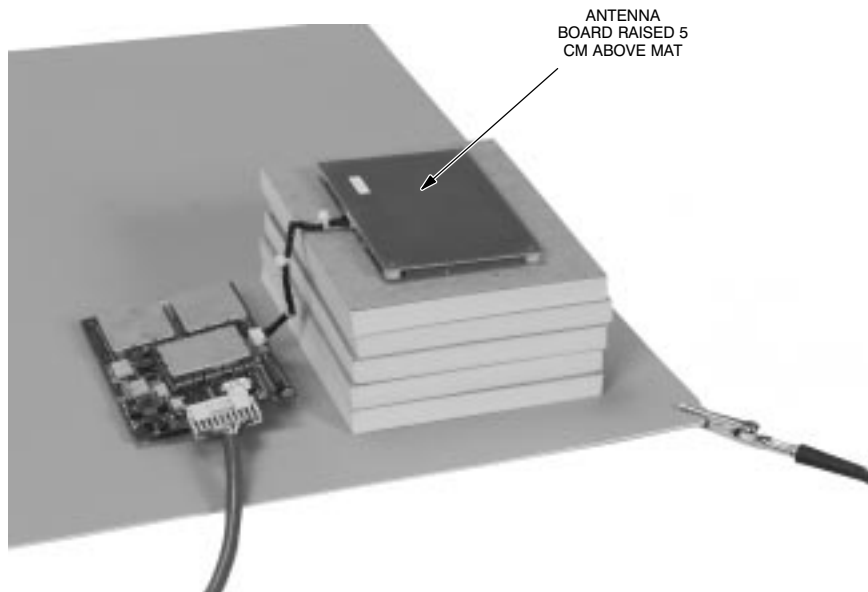
Tuning the CAD (continued)

3. Place a non-metallic spacer (e.g., small pad of paper) on top of the Antenna Board. Note that the pad must be the same thickness as the distance from the reader surface ("target" spot on the outside of the particular Terminal housing) to the top of the Antenna Board (where it will be mounted in the Terminal).

PAD OF
PAPER
(OR SIMILAR)
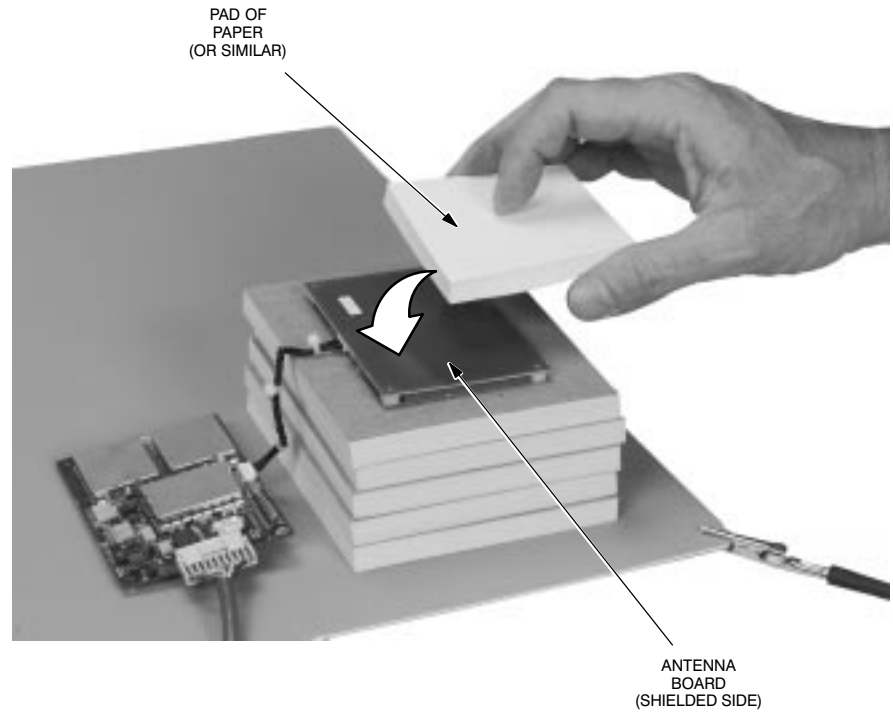
ANTENNA
BOARD
(SHIELDED SIDE)

Tuning the CAD
(continued)

4. Attach the scope probe to the ISO Antenna wires and position the antenna on the spacer, centered over the Antenna Board. While monitoring the waveform on the oscilloscope, move the antenna around until you achieve the maximum Vpp reading (approximately 5 to 10 Vpp). Secure the ISO Antenna in place using electrical tape or equivalent.

ISO ANTENNA

ATTACH SCOPE PROBE CONNECTED TO OSCILLOSCOPE TO THESE LEADS

SECURE ANTENNA USING TAPE
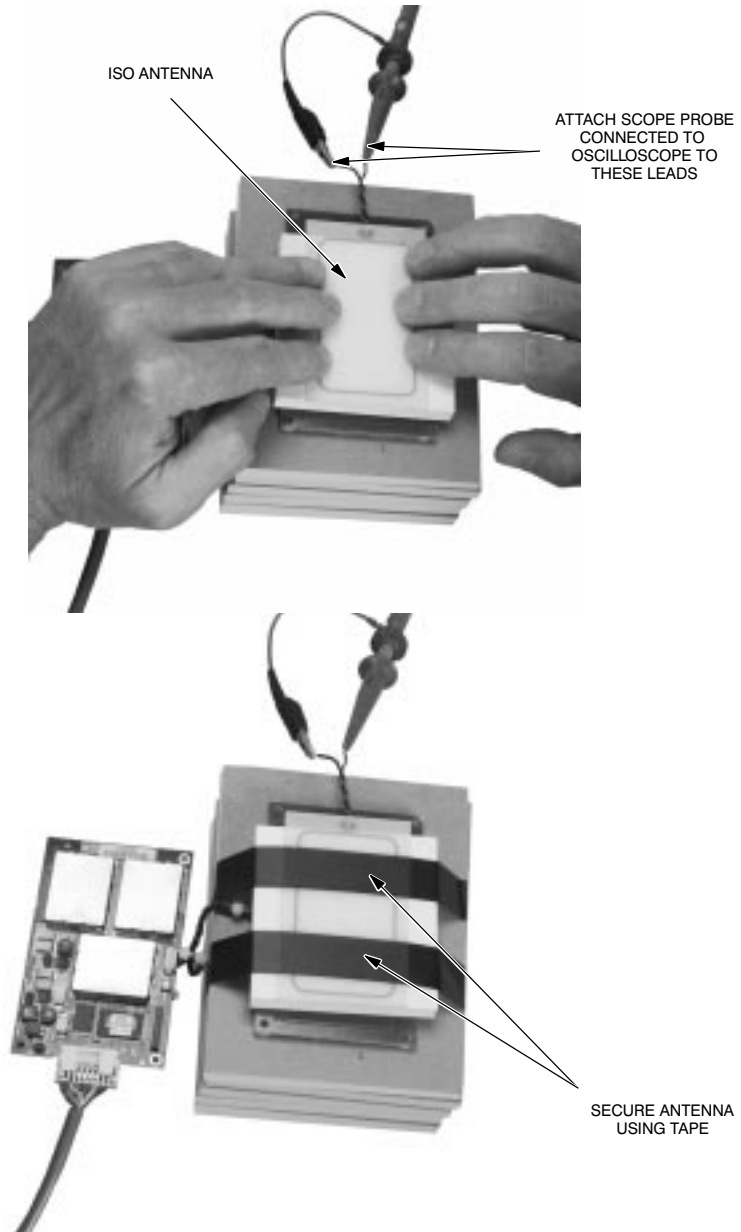
Tuning the CAD (continued)

5. Launch the *CADTools* program (described on page 2−5) and click on the **Tuning & Testing** button to access the *CADTools Tuning & Testing* main screen. The current settings from the CAD will be retrieved and displayed, as shown below.

Note   *The **Frequency** and **RSSI** tuning parameters are not used (and are not adjustable) for CAD+ models.*
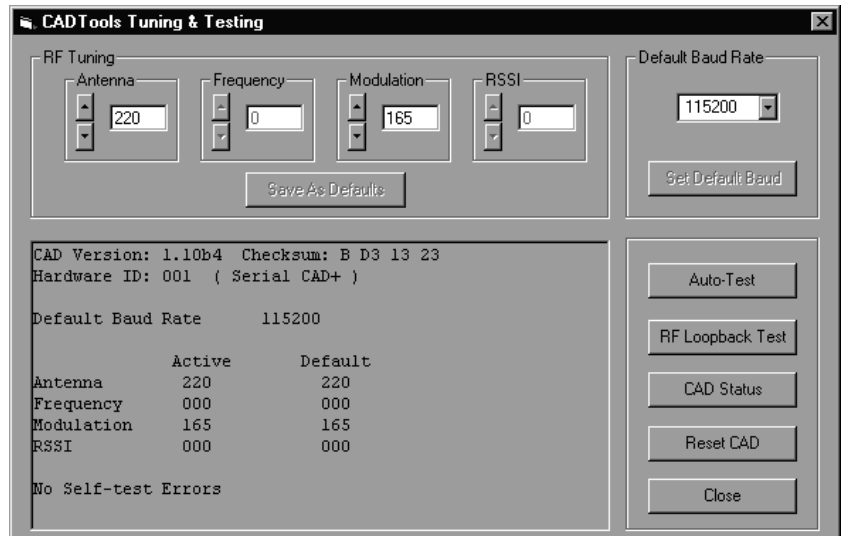
6. Locate the tuning capacitor on the CAD Control Board and adjust it using a plastic tuning tool to achieve the maximum Vpp reading on the oscilloscope.

Tuning Capacitor
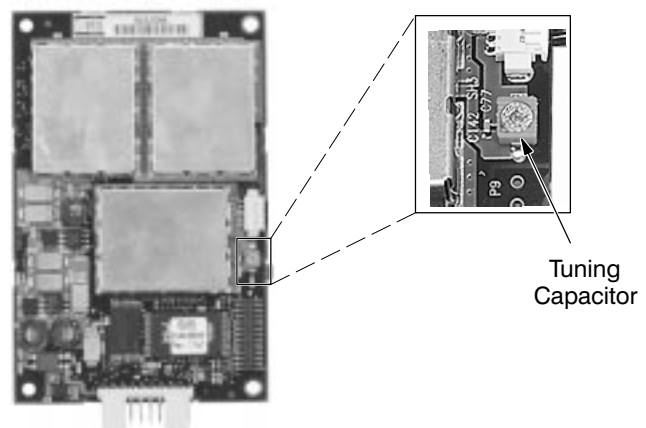
**Tuning the CAD
(continued)**

7. Click on the up/down arrows in the *Antenna* adjustment box to set the RF power to the approximate desired level, as indicated by the waveform on the oscilloscope. Set to a value of 30 for minimal power and operating range (as required by some portable terminals) or a starting value of 220 for maximum operating range. To adjust for maximum range, continue to adjust the *Antenna* value up or down as necessary to obtain the maximum Vpp reading (not to exceed 10.9 Vpp).
    Note *The table below shows the various CAD+ models and the Vpp reading you should be able to obtain.*

    Write down the Vpp reading (label as **V max**) for use in later steps. (Always adjust the *Antenna* value at least one digit from its starting value to ensure a proper reading on the oscilloscope.)
    Important! *Do not place a SmartCard near the antenna board while making this adjustment.*

Maximize
Vpp Reading
(10.9 Vpp max)
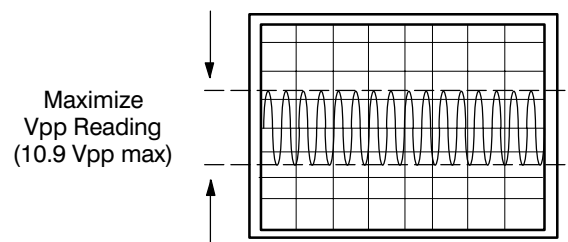
Antenna Board Size	Nominal Obtainable Vpp (max RF power 1 cm from Antenna)
100 x 110 mm	7.5 Vpp
104 x 67 mm	10.9 Vpp (Note 1)
65 x 40 mm	8.0 Vpp
50 x 25 mm	2.8 Vpp

Note 1 *Maximum allowable Vpp for any Antenna Board is 10.9 Vpp. Do not exceed this voltage.*

8. Click on the up/down arrows in the *Modulation* adjustment box (to increment/decrement the value one step at at time) to set the value at a starting value of **165**. Change the value (click up once, then down once) to ensure a proper reading on the oscilloscope. This value represents an approximate 11% modulation level. Write down the Vpp reading for use in the next step.
    Important! *Do not place a SmartCard near the antenna board while making this adjustment.*

Tuning the CAD
(continued)

Note *You can calculate the Amplitude Modulation percentage using the following formula:*

$$\%AM = 100 * \frac{(V\ max - V\ min)}{(V\ max + V\ min)}$$

9. In the table below, locate the *V max* voltage (from Step 7) in the left column and compare the *V min* voltage (from Step 8) to the *V min* values in the corresponding row. The *V min* voltage from Step 8 should be between the *V min (9%)* and *V min (13%)* range. If it is not within the range, click on the up/down arrows in the *Modulation* adjustment box until the peak-peak voltage of the CAD is closer to the *V min (11%)* value.

V max	V min (9%)	V min (11%)	V min (13%)
11	9.183	8.820	8.469
10.9	9.100	8.740	8.392
10.8	9.017	8.659	8.315
10.7	8.933	8.579	8.238
10.6	8.850	8.499	8.161
10.5	8.766	8.419	8.084
10.4	8.683	8.339	8.007
10.3	8.599	8.259	7.930
10.2	8.516	8.178	7.853
10.1	8.432	8.098	7.776
10	8.349	8.018	7.699
9.9	8.265	7.938	7.622
9.8	8.182	7.858	7.545
9.7	8.098	7.777	7.468
9.6	8.015	7.697	7.391
9.5	7.931	7.617	7.314
9.4	7.848	7.537	7.237
9.3	7.764	7.457	7.160
9.2	7.681	7.377	7.083
9.1	7.597	7.296	7.006
9	7.514	7.216	6.929
8.9	7.430	7.136	6.852
8.8	7.347	7.056	6.775
8.7	7.263	6.976	6.698
8.6	7.180	6.895	6.621
8.5	7.096	6.815	6.544
8.4	7.013	6.735	6.467
8.3	6.929	6.655	6.390
8.2	6.846	6.575	6.313
8.1	6.762	6.495	6.236
8	6.679	6.414	6.159
7.9	6.595	6.334	6.082
7.8	6.512	6.254	6.005
7.7	6.428	6.174	5.928
7.6	6.345	6.094	5.851
7.5	6.261	6.014	5.774
7.4	6.178	5.933	5.697
7.3	6.094	5.853	5.620
7.2	6.011	5.773	5.543
7.1	5.928	5.693	5.466
7	5.844	5.613	5.389
6.9	5.761	5.532	5.312
6.8	5.677	5.452	5.235
6.7	5.594	5.372	5.158
6.6	5.510	5.292	5.081
6.5	5.427	5.212	5.004
6.4	5.343	5.132	4.927
Table Continues on Next Page			

**Tuning the CAD
(continued)**

V max	V min (9%)	V min (11%)	V min (13%)
6.3	5.260	5.051	4.850
6.2	5.176	4.971	4.773
6.1	5.093	4.891	4.696
6	5.009	4.811	4.619
5.9	4.926	4.731	4.542
5.8	4.842	4.650	4.465
5.7	4.759	4.570	4.388
5.6	4.675	4.490	4.312
5.5	4.592	4.410	4.235
5.4	4.508	4.330	4.158
5.3	4.425	4.250	4.081
5.2	4.341	4.169	4.004
5.1	4.258	4.089	3.927
5	4.174	4.009	3.850

10. To adjust for operating range, remove the ISO antenna and place a non-metallic spacer with the depth of the desired operating range on the Antenna Board (or Terminal target area if CAD is installed in the Terminal) and place an initialized compatible SmartCard on top of the spacer. For example, if the desired operating range is 5 cm, then place an additional 5 cm spacer on the Antenna Board (or Terminal target area) and place the SmartCard on top of it.

Note   *The operating range of a card and CAD depends upon three primary factors: card type, Antenna Board size, and the RF power level from the CAD. When adjusting RF power for operating range, use the following table to determine the typical maximum range with a given Motorola SmartCard and Antenna Board. (Note that the ranges shown below are measured from the surface of the Antenna Board.)*

Antenna Board Size	Card Operating Range ($\pm$ 1 cm)	
	MV Series	**MM Series**
100 x 110 mm	7 cm	10 cm
104 x 67 mm	6 cm	9 cm
65 x 40 mm	3 cm	6 cm
50 x 25 mm	2 cm	4 cm

Tuning the CAD
(continued)

11. Click on the **RF Loopback Test** button and verify the status shows **% of the CAD requests read**. If the percentage is 100%, then proceed to Step 12. Otherwise, increase the RF power by clicking a few times on the up arrow in the *Antenna* box. Recheck the percentage of success by clicking the **RF Loopback Test** button again. Repeat this procedure until the status shows 100% or a maximum is obtained. Proceed to Step 13.

RF Loopback Test
completed successfully
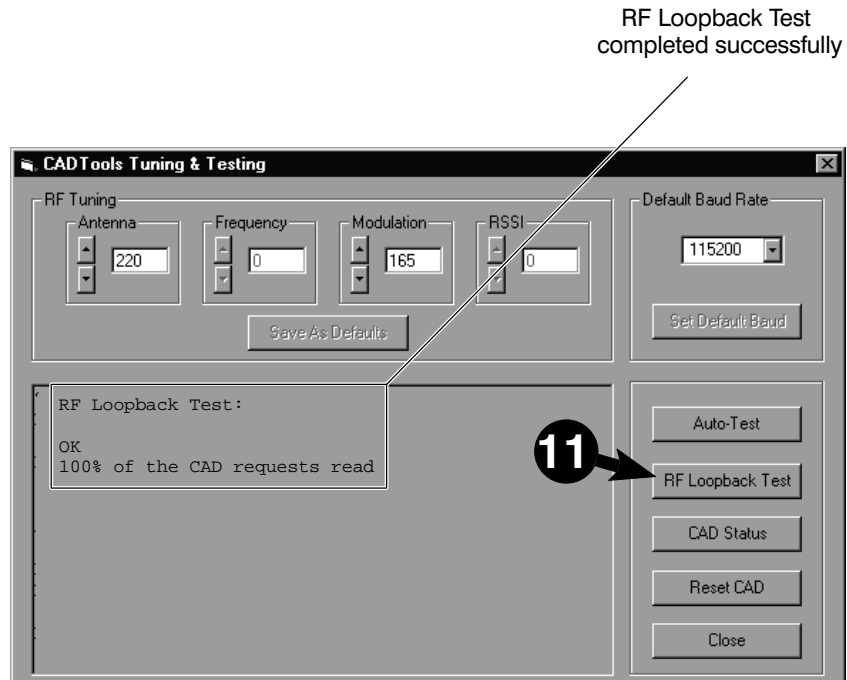
12. If the initial success rate is 100%, then continue to adjust the RF power level down (by clicking on the down arrow in the *Antenna* box) a bit and click on the **RF Loopback Test** button until the percentage is just less than 100%. Then adjust up a bit until it shows 100% again. This minimizes the CAD current draw for the operating range desired.

13. Click on the **Save as Defaults** button to store the adjustment settings in FLASH memory on the CAD Control Board.

◆ *End of this Procedure* ◆

4 INSTALLING CAD INTO TERMINAL

The information in this section describes the typical mounting methods for installing a CAD set into a Terminal.

Note *Refer to Appendix B for pin-out details of the CAD connectors, and Appendix C for physical dimensions and clearances.*

Mounting Methods

Introduction

The CAD may be mounted in one of two ways:
- Stacked
- Separated

Each of these mounting methods is described below.

"Stacked" Mounting Method

The Control Board and the Antenna Board have been designed so that they may be stacked as shown on the facing page. The mounting holes line up with each other, and may be used with screws and spacers to secure the CAD to the terminal chassis.

Note that the two boards may be stacked so that the metal shields on the Control Board are either touching or not touching the metallic surface of the Antenna Board.

"Separated" Mounting Method

The 100 mm cable allows the Control Board and the Antenna Board to be separated to accommodate various mounting scenarios, as shown on the facing page.

Other Things You Should Know

- The non-metallic side of the Antenna Board must face towards the card reading surface of the terminal.
- The Antenna Board should be mounted as close as possible to the Reader target area.
- The Antenna Board should be located at least 15 mm (in all directions) from any metallic materials.
- Route the multi-conductor interconnect cable away from any metallic materials. Also, dress and secure cable to prevent movement.

Mounting Methods

"Stacked" Mounting Method

CONTROL BOARD
(CONNECTOR SIDE UP)

ANTENNA BOARD
(METALLIC SIDE UP)

"Separated" Mounting Method

CONTROL BOARD

ANTENNA BOARD
(NON-METALLIC SIDE FACES TOWARD
CARD READING SURFACE)
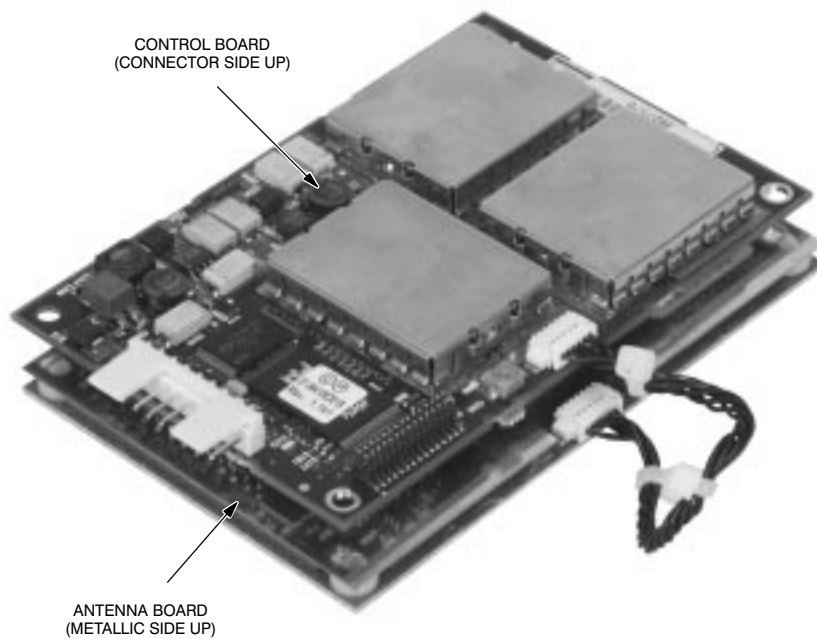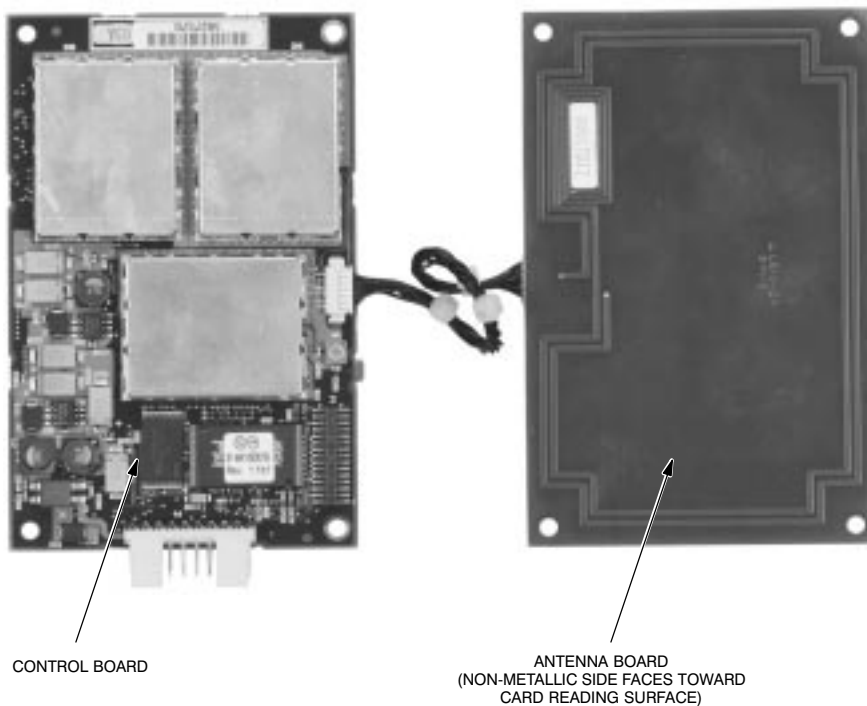
5   FINAL CHECKOUT PROCEDURE

Once the CAD has been tuned and installed into the terminal, a final checkout procedure must be performed to ensure that the CAD can communicate with a compatible SmartCard. Once this final checkout has been performed, the terminal may be placed into service.

Required Equipment

The following hardware and software is required to perform the final checkout procedure:

- Compatible SmartCard (e.g., Model MV4000D)
- Powered terminal with CAD installed

Performing the Final Checkout Procedure

Place an active SmartCard (one that has been initialized and personalized for use with the particular terminal application) within reading distance and verify that the desired results are achieved. For example, for a transit application, the terminal should generate a receipt ticket (or some other verification, such as a ''beep" or light, that the transaction was successful).

chapter contents

1 FAULT ISOLATION PROCEDURES

There are four basic techniques for isolating the CAD as the source of a faulty terminal:

- Verify dc power from the terminal (+12 V dc)
- Observe LED Indicator on the Control Board
- Perform the Self Test diagnostics checkout procedure
- Perform the Tuning Procedure

Verify DC Power

With the terminal turned on, the CAD should be receiving +12 V dc on the following pins:

- **Parallel CAD+** Pins 1 and 2 of the 16-pin parallel connector located on the Control Board (use pin 3 or 4 as ground)
- **Serial CAD+** Pin 3 of the 10-pin serial connector located on the Control Board (use pin 2 as ground)

Verify that the voltage is present using a digital voltmeter. If the dc voltage is not present:

- Make sure the cable from the terminal is securely attached to the 16-pin (parallel) or 10-pin (serial) connector on the Control Board.
- Troubleshoot the terminal to determine source of faulty +12 V dc.

Verify LED Indicator

A green LED is provided on the Control Board to provide a visual indication that the Control board has received dc power and has successfully performed its startup routine. If this LED is not lit after applying power:

- Verify +12 V dc power from the terminal (see above)
- Reload the CAD operating software into FLASH memory (refer to Appendix A in this manual)

Perform the Self Test Checkout Procedure

Run the Self Test Utility as described in Chapter 2.

Perform the CAD Tuning Procedure

Perform the CAD tuning procedure as described in Chapter 2.

2 RETURNING FAULTY CADS TO MOTOROLA

If you have performed the troubleshooting procedures on page 3-2 and have determined that the CAD is faulty, the entire CAD (Control Board, Antenna Board, and interconnect cable) must be returned to Motorola. The faulty CAD will be either repaired or replaced by Motorola service personnel. Contact the Motorola System Support Center at the contact numbers in the Foreword in this manual for shipping instructions.

Chapter 4 ▶ Functional Theory of Operation

chapter contents

1 FUNCTIONAL THEORY OF OPERATION

The following theory of operation describes the operation of the CAD circuitry at a functional level. The information is presented to give the service technician a basic understanding of the functions performed by the CAD in order to facilitate fault isolation. Refer to Figure 1 for a block diagram of the CAD.

Microprocessor Circuitry

Overview

The CAD uses a Motorola ColdFire MCF5204 microprocessor (μP) which serves as the main controller for the CAD. The microprocessor, running at a clock speed of 18.432 MHz (generated by an external clock circuit) controls the operation of the CAD as determined by the CAD software contained in the FLASH memory.

Address and Data Buses

The μP is equipped with a 32-bit address bus used to access the memory (FLASH and SRAM) and provide control (via memory mapping) for other circuitry in the CAD. A 16-bit data bus is used to transfer data to/from the μP, memory, and the AFE.

Reset Circuit

A Low +5V Detect circuit monitors the level of the +5V supply voltage and generates a reset signal if it falls below a threshold level. The reset signal is sent to the μP, the I/O Register, the AFE, and FLASH memory.

A hardware reset can also be initiated from both the Serial and Parallel connectors by applying a low active pulse (1 μsec minimum) on the EXTERNAL_RST# line of either connector.

Non-Volatile Memory Circuitry

FLASH Memory

The CAD software resides in a 256k x 16 FLASH memory IC. The FLASH memory is accessed by the μP via the 32-bit Address Bus and the 16-bit Data Bus.

SRAM Memory

To supplement the μP's internal 512 bytes of internal SRAM, a 32k x 8 SRAM IC is provided.

AFE Circuitry

The Analog Front End (AFE) circuitry operates under control of the μP to provide a number of functions, as follows:

- Controls the power output to the antenna
- Modulates TX data and sends to card (via Antenna Board)
- Receives (via Antenna Board) RX data from card and provides demodulation

Supply Voltages Circuitry

The CAD Control Board contains on-board regulators and filtering circuitry to generate the various voltages required by the CAD circuitry. +12 V from the terminal (via connector P8) is used as the source to generate +5V and +5V_A supply voltages. Also, the variable PA_PWR supply voltage is generated and fed to the Power Amplifier (p/o AFE) to control the RF output power of the CAD.

Antenna Board

The Antenna Board consists of a printed circuit board (with traces that form the antenna), a ferrite plate (which magnetically shields the antenna from the Control Board), and a metal back plate (which electrically shields the antenna from the Control Board). The Antenna Board is connected to the Control Board by a 6-wire cable.

Serial Interface Circuitry

The CAD+ Control Board supports a variety of serial protocols (RS-485, RS-232, and CMOS). In order to accomplish this, the Serial Interface Logic Circuitry routes the desired transmit and receive data to/from the 10-pin Serial Connector as determined by the settings on an 8-position DIP switch located on the board.

MICROPROCESSOR CIRCUITRY

+5V

18.432 MHz
OSCILLATOR
CIRCUITRY

+5V

CLK

RS232_TXD

RS232_RXD

RS232_TXD

RS232_RXD

D

MICROPROCESSOR

+5V

CS05

I/O
REGISTER

AFE_CONTROLS

TO
AFE

RESET

AFE_CONTROL

FROM
AFE

ADDRESS

ADDRESS BUS

A

A0−A20

D8−D13

DATA

D0−D15

DATA BUS

B

CAD_STRB#

CAD_STRB#

+5V

CAD_STRB#

LOW +5V
DETECT

RESET

**SERIAL
CONNECTOR**

P/O P4

TO OTHER
DEVICES

EXTERNAL_RST#   RESET

ADDRESS BUS

1

EXTERNAL_
RST#

MATES WITH
CABLE FROM
TERMINAL

NON−VOLATILE MEMORY

+5V

**PARALLEL
CONNECTOR**

P/O P8

FLASH
256K X 16

CAD W/R#

14

A1−A20

D0−D15

CAD_ACK#

16

RESET

SRAM MEMORY

CAD_STRB#

13

EXTERNAL_RST#

15

MATES WITH
CABLE FROM
TERMINAL

+5V

SRAM
32K X 8

5

A0−A14

D8−D15

D0−D7

12

Figure 1. Card Access Device (CAD) Functional Block Diagram (1 of 3)

Figure 1.   Card Access Device (CAD) Functional Block Diagram (2 of 3)

SERIAL INTERFACE CIRCUITRY

RS-485

SERIAL CONNECTOR
P/O P4

SERIAL INTERFACE LOGIC CIRCUITRY (See Note Below)

TXA — 7
TXB — 6
RXA — 5
RXB — 4

MATES WITH CABLE FROM TERMINAL

A
B
C

RS-232

SERIAL CONNECTOR
P/O P4

RS232_TXD

RS232_RXD

TXB — 8

RXB — 10

MATES WITH CABLE FROM TERMINAL

A
B
C

SERIAL CONNECTOR
P/O P4

CMOS

TXB — 8

RXB — 10

MATES WITH CABLE FROM TERMINAL
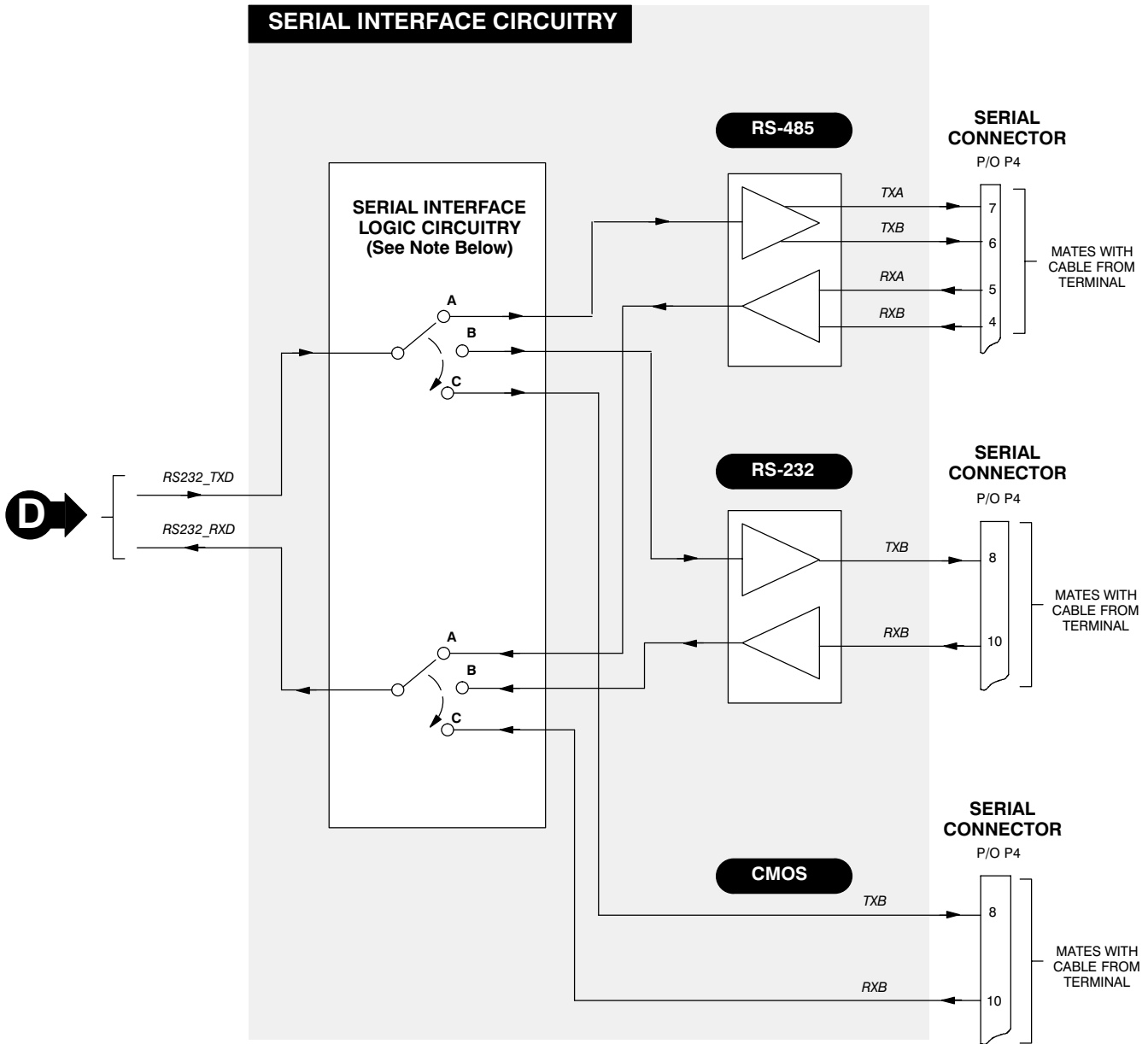
NOTE **Selection of RS-232, RS-485, or CMOS Serial Interface is accomplished by DIP Switch Settings, as follows:**

SW1	SW2	SW3	Type of Serial Interface Selected
OFF	OFF	x	RS-485 (Selection A Above)
OFF	ON	ON	RS-232 (Selection B Above)
OFF	ON	OFF	CMOS (Selection C Above)

Figure 1. Card Access Device (CAD) Functional Block Diagram (3 of 3)

Chapter 5 ▶ CAD Protocols and Commands

chapter contents

1 TERMINAL-TO-CAD COMMAND PROTOCOL

This section defines the structure of commands initiated by the terminal for transmission control and for specific control in asynchronous half-duplex transmission protocols. Block protocol type ISO 7816-3 T=1 is used.

The command structure (shown below) consists of the following blocks:

- **prologue** field
- **information** field
- **epilogue** field

The prologue and epilogue fields are mandatory, and must be sent in every case. The information field is optional. The number of bytes of the information field is indicated by length (LEN) byte (part of the prologue field).

Command Structure

Prologue Field			Information Field	Epilogue Field
NAD	**PCB**	**LEN**	**Inf**	**EDC**
1 Byte	1 Byte	1 Byte	0 to 254 Bytes	2 Bytes

Prologue Field

NAD

The NAD byte in the Prologue field contains the block's target (DAD) and source (SAD) node addresses, as shown below.

NAD Byte Structure

b8	b7	b6	b5	b4	b3	b2	b1	Meaning
x	x	x	x	−	−	−	−	DAD (Destination Node Address)
−	−	−	−	x	x	x	x	SAD (Source Node Address)

Prologue Field
(continued)

PCB

The PCB byte in the Prologue field serves to control and supervise the transmission protocol. The PCB byte encodes first and foremost the block type, as well as supplementary data needed in this context. The PCB byte information for an I-block, an R-block, and an S-block are shown below.

PCB Byte Information for an I-Block

b8	b7	b6	b5	b4	b3	b2	b1	Meaning
0	–	–	–	–	–	–	–	b8=0, Signals I-block
0	N(S)	–	0	0	0	0	0	b7=N(S), Send sequence number
0	–	x	0	0	0	0	0	b6= Chaining (more data)

PCB Byte Information for an R-Block

b8	b7	b6	b5	b4	b3	b2	b1	Meaning
1	0	0	–	–	–	–	–	b8=1, Signals R-block
1	0	0	N(R)	–	–	–	–	b5=N(R), Sequence Number
1	0	0	N(R)	0	0	0	0	b4-b1=0, No errors
1	0	0	N(R)	0	0	0	1	b4-b1=1, EDC or parity error
1	0	0	N(R)	0	0	1	0	b4-b1=2, Other errors
1	0	0	N(R)	0	0	1	1	b4-b1=3, Timeout error

PCB Byte Information for an S-Block

b8	b7	b6	b5	b4	b3	b2	b1	Meaning
1	1	–	–	–	–	–	–	b8=1 & b7=1, Signals S-block
1	1	0	0	0	0	0	0	RESYNCH req = C0
1	1	1	0	0	0	0	0	RESYNCH ans = E0
1	1	0	0	0	0	1	0	Abort request = C2
1	1	1	0	0	0	1	0	Abort response = E2
1	1	0	0	0	0	1	1	WTX request = C3
1	1	1	0	0	0	1	1	WTX response = E3
1	1	x	x	x	x	x	x	RFU values used for the CAD management

Information Field (INF)

The presence of INF is optional. When present, INF conveys either application data in I-blocks for cards, miscellaneous data for the CAD or non-application control and status information in S-blocks.

In an S-block, this field is used for the management of the CAD. The CAD does not support the exhaustive list of S-Blocks defined in ISO 7816−3 T=1. However, the CAD supports Motorola proprietary definition of S-Blocks as commands for management.

R-blocks do not contain an INF field.

Epilogue Field

This field contains the error detection code (EDC) of the transmitted block. The protocol definition permits this to be either an LRC or a CRC. The LRC is calculated as the exclusive OR (XOR) of all the bytes starting with the NAD through the last byte of the information field, and is typically referred to simply as the checksum. For CRC see ISO 3309. The CAD uses the CRC.

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2 ANSWER TO RESET (ATR)

After cycling the power supply or software reboot, the CAD sends out an ATR. For serial transmission, the ATR is sent at 9.6 Kbps and then the CAD switches to its programmed baud rate (from 9.6 Kbps to 230.4 Kbps). For parallel transmission, the rate is synchronous. The ATR is a data string, up to 33 bytes long, which contains various data relevant to the transmission protocol and to the card. The ATR's data string and data elements are defined and described in detail in ISO/IEC 7816−3.

ATR Format

The basic ATR format consists of:

- **TS** — one byte, the initial character; specifies the conventions to code data bytes in all subsequent characters. There are two possible values of TS (ten consecutive bits from start to end and corresponding hexadecimal value). The CAD uses direct convention: (Z)AZZAZZZAAZ(Z) where logic level ONE is Z (LSB is first). It equals to "3B" when decoded by direct convention.

- **T0** — one byte, the format character; serves to indicate the subsequent "interface character" a bit field is used, from b5 to b8. It further contains the number of subsequent "historical characters," from b1 to b4.

T0 Byte Information

b8	b7	b6	b5	b4	b3	b2	b1	Meaning
–	–	–	1	–	–	–	–	TA1 is transmitted
–	–	1	–	–	–	–	–	TB1 is transmitted
–	1	–	–	–	–	–	–	TC1 is transmitted
1	–	–	–	–	–	–	–	TD1 is transmitted
–	–	–	–	x	x	x	x	Number of historical characters

ATR Format (continued)

The four least significant bits of any interface byte TDi indicates a protocol type T, specifying rules to be used to process transmission protocols. When TD_1 is not transmitted, T=0 is used. TA_1 TB_1 TC_1 and TB_2 are the global interface bytes. These global interface bytes shall be interpreted in order to process any transmission protocol correctly.

The interface characters specify all transmission parameters of the current protocol. They are constructed from the bytes TA_i, TB_i, TC_i, and TD_i (i =1, 2, 3...). TA_i, TB_i and TC_i indicate the protocol parameters. Their interpretation depends on the protocol type indicated by T in TD_{i-1}. TD_i indicates the protocol type T, as defined in [1] Section 6.1.4.3, and the presence of subsequent interface characters. The ATR transmission of these bytes is optional and may be omitted if appropriate.

TDi Byte Information

b8	b7	b6	b5	b4	b3	b2	b1	Meaning
−	−	−	1	−	−	−	−	TA_{i+1} is transmitted
−	−	1	−	−	−	−	−	TB_{i+1} is transmitted
−	1	−	−	−	−	−	−	TC_{i+1} is transmitted
1	−	−	−	−	−	−	−	TD_{i+1} is transmitted
−	−	−	−	x	x	x	x	Protocol type for subsequent transmission

When TD_i is not transmitted, the default value of TA_{i+1} TB_{i+1} TC_{i+1} is null, indicating that no further interface characters TA_{i+1} TB_{i+1} TC_{i+1} TD_{i+1} will be transmitted. TA_1 to TC_3 convey information that shall be used during exchanges between the terminal and the CAD subsequent to the Answer to Reset. They indicate the values of the transmission control parameters F, D, I, P, and N, and the IFSC, block waiting time integer (BWI), and character waiting time integer (CWI) applicable to T=1 as defined in ISO/IEC 7816−3. The information contained in TA_1 to TC_1 and TC2 shall apply to all subsequent exchanges.

The historical characters, T1 T2 −TK, maximum 15 characters. It designates general information, for example, the CAD firmware version.

The value of check character TCK shall be such that the exclusive−ORing of all bytes from byte T0 to the last byte before the TCK.

ATR Format (continued)

The structure of the ATR is the initial character TS followed by a variable number of subsequent characters in the following order: the format character T0, optionally the interface characters TAi, TBi, TCi, TDi and optionally the historical characters T1 T2 − TK and, conditionally, the check character TCK.

ATR Data Information

Charac-ter	Value	Meaning
TS	3B	Indicates direct convention
T0	F3	**F** = $(1111)_{bin}$, TA_1, TB_1, TC_1, and TD_1 present; **3** indicates the number of historical bytes present
TA_1	71	Most significant half byte (b8 to b5): Default Baud Rate (0...7) Least significant half byte (b4 to b1): $D_i = 1$
TB_1	00	Vpp is not required
TC_1	FF	Indicates amount of extra guard time required (FF = no guard time)
TD_1	91	**9** = $(1001)_{bin}$, TB_2 and TC_2 absent; TA_2 and TD_2 present; **1** indicates that T=1 is to be used
TA_2	81	"specific mode" ; [6] **8** = $(1000)_{bin}$, b8 = 1 mode change not allowed **1** indicates that T=1 is to be used
TD_2	71	**7** = $(0111)_{bin}$, TA_3, TB_3, TC_3 present; TD_3 absent **1** indicates that T=1 is to be used
TA_3	FF	IFSI = FF, which indicates initial value (255 bytes) for information field size for the CAD
TB_3	01	b8−b5 = 0 BWI minimum b4−b1 = 0 CWI minimum
TC_3	00	01 = CRC in use
T1 T2 T3	XX XX 11	Version Number of CAD Firmware (MSB) Version Number of CAD Firmware (LSB) NAD used by the CAD
TCK	XX	LRC used for Check character

3 | CAD MANAGEMENT COMMANDS

Commands in proprietary S-Blocks supported by the CAD are:

- RF POWER CONTROL: control of the RF field parameters (page 5−10)
- SLEEP: put the CAD in low power mode (page 5−12)
- DOWNLOADING: put the CAD in downloading mode (page 5−14)
- ERROR REPORT: the CAD indicates an Hardware error (page 5−16)
- POLL: put the CAD in card registration mode (page 5−18)
- ANSWER TO POLL: the CAD sends the parameters of a card detected (page 5−20)
- DETECT CARD: put the CAD in card detection mode (page 5−22)
- CARD PRESENCE: the CAD sends to the terminal the result of the DETECT CARD command. (page 5−24)
- REBOOT: forces the CAD to reset (page 5−25)
- BREAK CHARACTER: forces the CAD to reset (page 5−26)

Commands issued from the Terminal to the CAD are called "Requests."
Commands issued from the CAD to the Terminal are called "Responses."

RF POWER CONTROL

RF POWER CONTROL request

Description

This command allows the terminal to control the RF field power. The four options of the PCON byte can turn on the 13.56MHz carrier, turn off the carrier, increase the power of the RF field and to decrease the power of the RF field.

Direction

Terminal to CAD

Size

6 Bytes

Format

See below

RF POWER CONTROL Request Format

NAD	PCB	LEN	PCON	CRC1	CRC2
0x11	0xC5	1	(see below)	(see below)	(see below)

PCON Values	Meaning	CRC1 Values	CRC2 Values
0x00	Power On	0x3B	0x09
0x01	Power Off	0xB2	0x18
0x02	Decrease Power	0x29	0x2A
0x03	Increase Power	0xA0	0x3B
Other Values	Forbidden	—	—

**RF POWER
CONTROL
(continued)**

RF POWER CONTROL response

Description

The response frame is an acknowledgement of the previous command, indicating that the command was properly received and has been executed.

Direction

CAD to Terminal

Size

5 Bytes

Format

See below

RF POWER CONTROL Response Format

NAD	PCB	LEN	CRC1	CRC2
0x11	0xE5	0	0xA4	0x8E

SLEEP

SLEEP request

Description

This command switches the CAD board to a low-power mode. It sequentially turns off the RF power, stops watchdog timer, unmask only the UART (serial CAD) or STROBE (parallel CAD) interrupt and switches to the STOP mode of the ColdFire. While no interrupt from the UART (or STROBE) is received (any frame from the terminal), the CAD stays in this mode. Any UART (or STROBE) interrupt wakes the CAD processor core, turns on the RF power and switches to the state of frame reception.

Direction

Terminal to CAD

Size

5 Bytes

Format

See below

SLEEP Request Format

NAD	PCB	LEN	CRC1	CRC2
0x11	0xC8	0	0xEF	0x1D

SLEEP response

Description

The response frame is an acknowledgment of the previous command that indicates that the command was properly received and is ready to be executed. This response is sent before the CAD switches to SLEEP state.

Direction

CAD to Terminal

Size

5 Bytes

Format

See below

SLEEP Response Format

NAD	PCB	LEN	CRC1	CRC2
0x11	0xE8	0	0xDC	0x3E

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DOWNLOADING

DOWNLOADING request

Description

This command makes the CAD switch to downloading mode. It is only accepted as the first command after the CAD reboots. The code of the Parameters 1 & 2, processor and FPGA can be downloaded by selecting the TARGET byte 0x00.

This command must be sent both at the beginning and at the end of the downloading sequence. At the end of the downloading sequence, this command confirms that the downloading sequence is correctly complete and provokes the reset of the CAD processor. The TARGET field of this last block must be identical to the TARGET field of the previous DOWNLOADING command.

Direction

Terminal to CAD

Size

6 Bytes

Format

See below

DOWNLOADING Request Format

NAD	PCB	LEN	TARGET	CRC1	CRC2
0x11	0xC6	1	(see below)	(see below)	(see below)

TARGET Values	Meaning	CRC1 Values	CRC2 Values
0x00	Parameters 1-2, MCU, and FPGA Code	0x5F	0xE6
0x01	All FLASH Code (including Boot Block) **Note:** *This is the recommended download mode*	0xD6	0xF7
Other Values	RFU	RFU	RFU

DOWNLOADING
(continued)

DOWNLOADING response

Description

The response frame is an acknowledgment of the previous command that indicates that the command was properly received and is ready to be executed.

Direction

CAD to Terminal

Size

5 Bytes

Format

See below

DOWNLOADING Response Format

NAD	PCB	LEN	CRC1	CRC2
0x11	0xE6	0	0xCC	0xA4

ERROR REPORT

ERROR REPORT request

Description

The Terminal sends this command to the CAD to determine if the CAD software has detected any error during the test sequence at boot up. It is recommended that the Terminal always issue this command immediately after the CAD boots and has sent an ATR to ensure the CAD is working properly before further communications are made.

Direction

Terminal to CAD

Size

5 Bytes

Format

See below

ERROR REPORT Request Format

NAD	PCB	LEN	CRC1	CRC2
0x11	0xE7	0	0x14	0xBD

ERROR REPORT (continued)

ERROR REPORT response

Description

The CAD sends this response after receiving an Error Report Request. The Error Report Response contains any errors found during the test sequence at boot up. The tests executed by the CAD at boot−up are the verification of the processor code checksum, the verification of the FPGA code and a UART test (serial CAD only) in loopback mode.

Direction

CAD to Terminal

Size

6 Bytes

Format

See below

ERROR REPORT Response Format

NAD	PCB	LEN	ERR	CRC1	CRC2
0x11	0xC7	1	(see below)	(see below)	(see below)

ERR Values	Meaning	CRC1 Values	CRC2 Values
0x00	No Error	0x83	0xBC
0x01	Code Checksum Error	0x0A	0xAD
0x02	FPGA Code Error	0x91	0x9F
0x04	UART Initialization Error (serial CAD only)	0xA7	0xFA
0x08	SRAM Error	0xCB	0x30
Other Values	RFU	RFU	RFU

POLL

POLL request

Description

This command makes the CAD switch to the card detection/anti−collision sequence. The card must be out of the RF field before sending a *Poll request*.

The STRAT byte supports two options that order the CAD to detect all cards (Long Poll) or the first card (Quick Poll) in the RF field.
As the CAD manages the attribution of the NAD for the cards detected in the field, it reserves NAD values that are already in use and gives free NAD values to a new card that is detected. But the CAD has no information about the transactions between the terminal and the card(s). Thus, when the terminal has completed all the transactions with the card(s) registered, it may indicate to the CAD that the busy values can be freed or not by setting the appropriate value in the ERASE field.

The TYPE byte of this command indicates to the CAD which type of application of contactless card in the field must be selected.

Direction

Terminal to CAD

Size

8 Bytes

Format

See below

POLL Request Format

NAD	PCB	LEN	STRAT	ERASE	TYPE	CRC1	CRC2
0x11	0xD0	3	(see below)	(see below)	(see below)	xx	xx

STRAT Values	Meaning	ERASE Values	Meaning
0x00	Quick Poll	0x00	Do not erase NAD table
0x01	Long Poll	0x01	Erase NAD table
Other Values	RFU	Other Values	Forbidden

TYPE Values	Meaning	TYPE Values	Meaning
0x00	All	0x06	Multimedia
0x01	Transport	0x07	Gaming
0x02	Financial	0x08	Data Storage
0x03	Identification	0x09−0x7E	RFU
0x04	Telecommunication	0x7F	All previous
0x05	Medical	0x80−0xFF	Proprietary

POLL (continued)

POLL response

Description

The response frame is an acknowledgment of the previous command that indicates that the command was properly received and is ready to be executed.

Direction

CAD to Terminal

Size

5 Bytes

Format

See below

POLL Response Format

NAD	PCB	LEN	CRC1	CRC2
0x11	0xF0	0	0x8D	0x65

ANSWER TO POLL

ANSWER TO POLL request

There is no ANSWER TO POLL request.

ANSWER TO POLL response

Description

When a card is successfully registered in the CAD (the card answered correctly to the REQUEST/SLOT MARKER or ATTRIB frames), the CAD sends this frame to the terminal to indicate that a new card is to be registered. For a long poll, the CAD responds with as many Answer To Poll messages as the number of cards polled. The Answer To Poll response frame transports all necessary information about the card and the card−terminal link.

The NEW NAD byte is the value of the NAD that will be used by the terminal and the card during the transaction. This NAD is ISO 7816−3 T=1 compliant. The terminal must use the value received in the Answer To Poll response to send data to the card, without inverting the most significant and the least significant nibble of the byte. Once the Terminal sends a command with the new NAD (other than 0x11), the CAD sets the data transmission to Pipeline Mode that allows the Terminal to directly communicate to the card (and visa versa). This process may continue until the CAD receives its own NAD (0x11) from the Terminal.

The four−byte PUPI field identifies formally the card. The terminal may use it to detect non−valid cards.

The HB field may be n bytes long (0−15) and is the exact image of the Historical Bytes field of the card ATQ frame.

Direction

CAD to Terminal

Size

12+n Bytes

Format

See below

ANSWER TO POLL Response Format

NAD	PCB	LEN	DATA from the ATQ				CRC1	CRC2
0x11	0xD1	7 +n*	NEW NAD	PUPI	TC2	TA3	HB	xx	xx

* n = number of Historical Bytes (HB)

DATA from ATQ Values	Meaning
NEW NAD	NAD chosen by the CAD for the new Terminal-Card link
PUPI	4-byte Card Identifier (Pseudo Unique PICC Identifier)
TC2	POW (Minimum and Maximum Power Level
TA3	LEN (Maximum Block Length)
HB	Historical Bytes from the ATQ frame

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DETECT CARD

DETECT CARD request

Description

After a Quick Poll command, the DETECT CARD command may be sent by the terminal to know if there are additional cards in non−application phase in the RF field. After this command, the CAD sends a REQUEST command parameterized with 1 slot through the RF field. Consequently, if one or more additional cards are present in the RF field, it must answer to the REQUEST command. The card which is communicating with the Terminal will not answer to the REQUEST if it has received a DESELECT command (see ISO/IEC 14443−3).

The TYPE byte of this command indicates to the CAD which type of application of contactless card in the field must be detected.

Whatever is the result of the detection (nothing, a collision or a correct answer), the CAD uses the CARD PRESENCE command to indicate the result of this detection sequence.

Note   *Since this command is to be sent after a Quick Poll command, do not try to send this command under any other circumstances (like immediately after reboot).*

Direction

Terminal to CAD

Size

6 Bytes

Format

See below

DETECT CARD Request Format

NAD	PCB	LEN	TYPE	CRC1	CRC2
0x11	0xD3	1	(see below)	(see below)	(see below)

TYPE Values	Meaning	CRC1 Values	CRC2 Values
0x00	All	0x77	0x5A
0x01	Transport	0xFE	0x4B
0x02	Financial	0x65	0x79
0x03	Identification	0xEC	0x68
0x04	Telecommunication	0x53	0x1C
0x05	Medical	0xDA	0x0D
0x06	Multimedia	0x41	0x3F
0x07	Gaming	0xC8	0x2E
0x08	Data Storage	0x3F	0xD6
0x09−0x7E	RFU	RFU	RFU
0x7F	All Previous	0x07	0xD1
0x80−0xFF	Proprietary	Proprietary	Proprietary

DETECT CARD (continued)

DETECT CARD response

There is no response for the DETECT CARD command.

CARD PRESENCE

CARD PRESENCE request

There is no CARD PRESENCE request.

CARD PRESENCE response

Description

The CAD sends this frame to the terminal as a result of the card detection sequence initiated by the DETECT CARD command.

The PRES byte of the command indicates if something new is detected or not.

Direction

CAD to Terminal

Size

6 Bytes

Format

See below

CARD PRESENCE Response Format

NAD	PCB	LEN	PRES	CRC1	CRC2
0x11	0xD4	1	(see below)	(see below)	(see below)

PRES Values	Meaning	CRC1 Values	CRC2 Values
0x00	No Card	0x72	0xD6
0x01	Card(s) Detected	0xFB	0xC7
Other Values	Forbidden	—	—

REBOOT

REBOOT request

Description

This command makes the CAD processor reset. After this command is executed the CAD board is reset and any configuration different from the CAD default configuration is lost.

Direction

Terminal to CAD

Size

5 Bytes

Format

See below

REBOOT Request Format

NAD	PCB	LEN	CRC1	CRC2
0x11	0xD2	0	0x0E	0x75

REBOOT response

Description

The response frame is an acknowledgment of the previous command that indicates that the command was properly received and is ready to be executed.

Direction

CAD to Terminal

Size

5 Bytes

Format

See below

REBOOT Response Format

NAD	PCB	LEN	CRC1	CRC2
0x11	0xF2	0	0x3D	0x56

BREAK CHARACTER

BREAK CHARACTER request

Description

A break character makes the CAD processor reset. After this character is sent, the CAD board is reset (after 100 msec delay) and any configuration different from the CAD default configuration is lost. (Only applicable for Serial CADS)

Direction

Terminal to CAD

Size

1 Bytes

Format

All the bits are set to 0. The Stop Bit is included.

BREAK CHARACTER response

Description

There is no response to the BREAK CHARACTER command.

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4 COMMAND SEQUENCES

The illustrations on the next few pages show the command sequences between the Terminal, CAD, and Card for the following scenarios:

- Boot Sequence
- Downloading Sequence
- Quick Poll Sequence
- Long Poll Sequence
- Detect Card Sequence
- RF Power Control Sequence
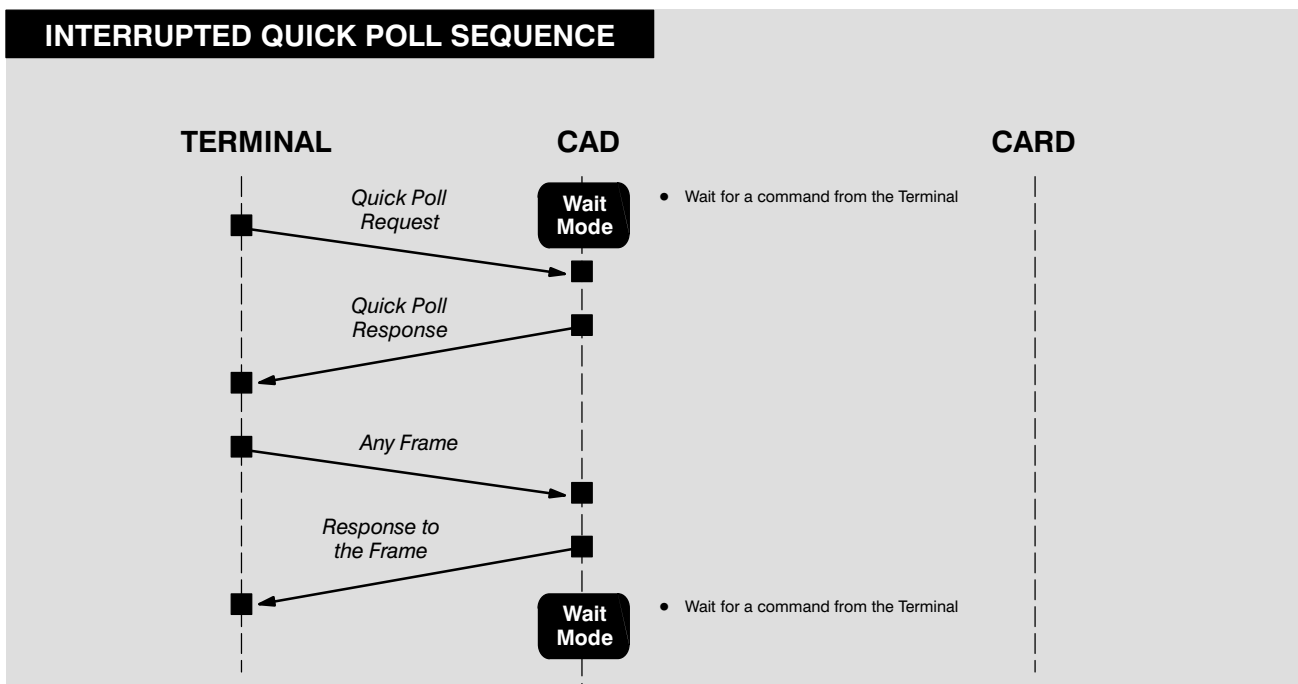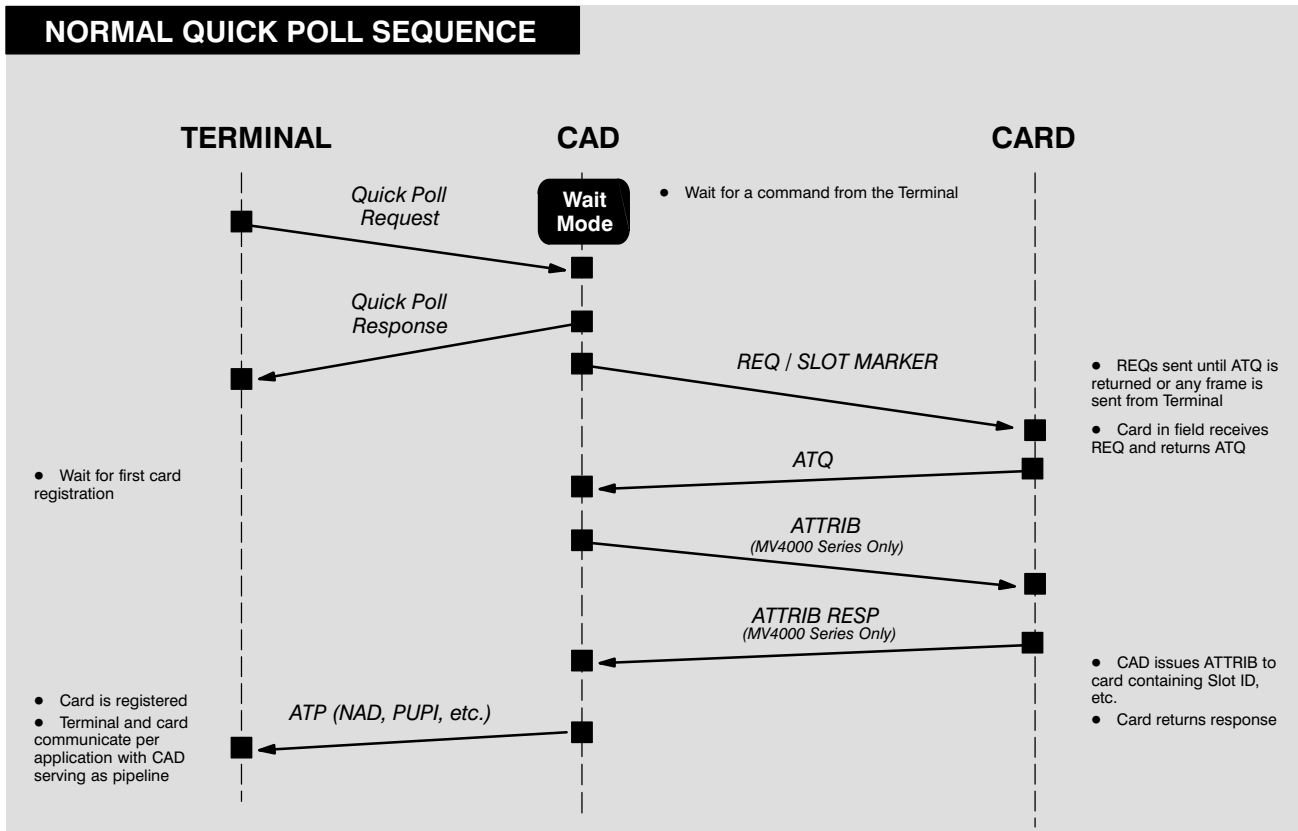- Sleep Sequence
- Reboot Sequence

Boot Sequence

NORMAL BOOT SEQUENCE

TERMINAL   **CAD**

Power Up
- CPU registers configuration
- Run Auto-Tests
- FPGA Code Loading
- Configure UART at 9600 BPS (Serial CAD only)

ATR

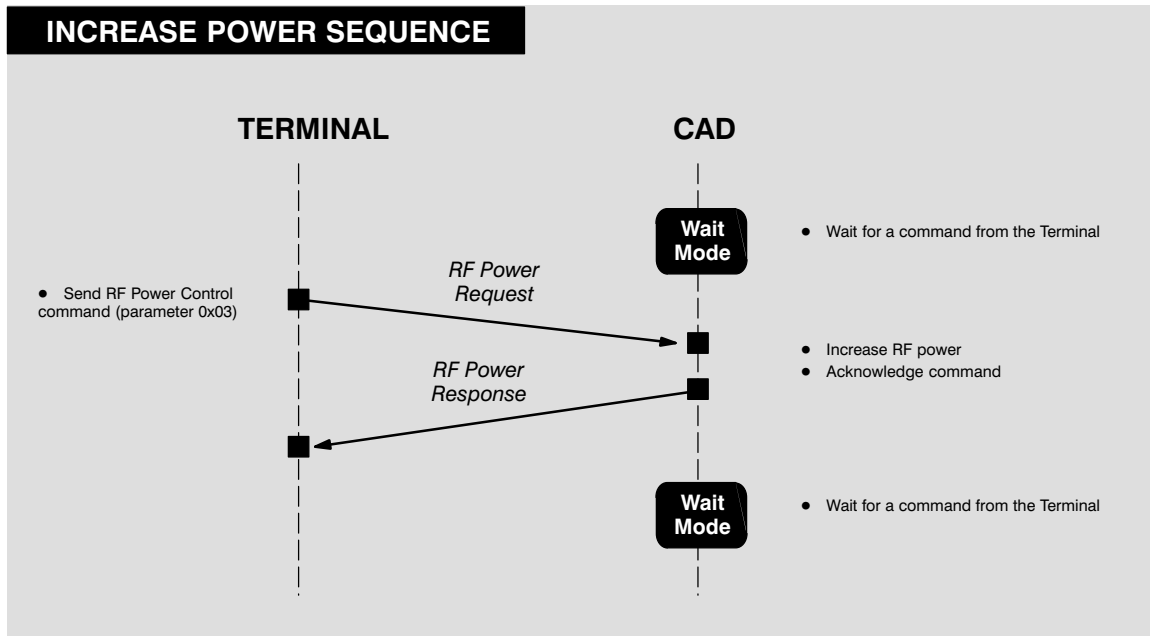**Decode CAD Parameters**

Finish Power Up
- Configure UART to programmed baud rate (Serial CAD Only)
- Wait for first command from terminal

BOOT SEQUENCE WITH ERROR REPORT

TERMINAL   **CAD**

Power Up
- CPU registers configuration
- Auto-Test Fails

ATR

Decode CAD Parameters

Continue Power Up
- Configure UART to programmed baud rate (Serial CAD Only)

Error Report Request

Error Report

- If error from Power On Self-Test

Prepare Data to Download

Finish Power Up
- Switch to download process
- Wait for the first I−Block of downloading

Downloading Sequence

SUCCESSFUL DOWNLOADING SEQUENCE

TERMINAL   **CAD**

Downloading Request → **Wait Mode** • Wait for a command from the Terminal

Downloading Response ←

• Send new code to the CAD in chained mode

I (0,1) →
R (1) ←
I (1,1) →
R (0) ←
•
•
•
•
•
I (0,0) →
R (xx,xx) ←

• Decode frame
• Write data in FLASH memory

• Confirm end of downloading

Downloading Request →
Downloading Response ←

CAD Resets

ATR ←

Downloading
Sequence
(continued)

INTERRUPTED DOWNLOADING SEQUENCE

TERMINAL   **CAD**

Wait Mode

Downloading Request

● Wait for a command from the Terminal

Downloading Response

I (0,1)

R (1)

I (1,1)

R (0)

● Send new code to the CAD in chained mode

● Decode frame
● Write data in FLASH memory

INTERRUPTION

Reboot Request

Reboot Response

● Confirm end of downloading

CAD Resets

ATR

Quick Poll Sequence

NORMAL QUICK POLL SEQUENCE

TERMINAL　　**CAD**　　**CARD**

Wait Mode

- Wait for a command from the Terminal

Quick Poll Request

Quick Poll Response

REQ / SLOT MARKER

- REQs sent until ATQ is returned or any frame is sent from Terminal
- Card in field receives REQ and returns ATQ

- Wait for first card registration

ATQ

ATTRIB
(MV4000 Series Only)

ATTRIB RESP
(MV4000 Series Only)

- CAD issues ATTRIB to card containing Slot ID, etc.
- Card returns response

- Card is registered
- Terminal and card communicate per application with CAD serving as pipeline

ATP (NAD, PUPI, etc.)

INTERRUPTED QUICK POLL SEQUENCE

TERMINAL　　**CAD**　　**CARD**

Wait Mode

- Wait for a command from the Terminal

Quick Poll Request

Quick Poll Response

Any Frame

Response to the Frame

Wait Mode

- Wait for a command from the Terminal

Long Poll Sequence

LONG POLL SEQUENCE

TERMINAL	CAD	CARD

Wait Mode

Long Poll Request

- Wait for a command from the Terminal

- Process anti-collision algorithm
- Log the first detected card
- Send an ATTRIB command to this card

Long Poll Response

- CAD sends REQ/SLOT MARKER until ATQ is returned, or CAD terminates the polling if any frame is received from Terminal.

REQ / SLOT MARKER

- Card in field receives REQ/SLOT MARKER and returns ATQ

ATQ

- Wait for first card registration

ATTRIB
(MV4000 Series Only)

ATTRIB RESP
(MV4000 Series Only)

- CAD issues ATTRIB to card containing Slot ID, etc.
- Card returns response

- Card is registered
- Terminal and card communicate per application with CAD serving as pipeline

ATP (NAD, PUPI, etc.)

This sequence may be repeated up to four times (should four cards be presented at the same time).

Detect Card Sequence

DETECT CARD SEQUENCE

TERMINAL	CAD	CARD

Detect Card Request

Wait Mode

● Wait for a command from the Terminal

REQ

● Card in field receives REQ and ruturns ATQ

● Wait for detection result

ATQ

Card Presence Response

Wait Mode

● Wait for a command from the Terminal

RF Power Control Sequence

TURN ON SEQUENCE

TERMINAL   CAD

- Wait for a command from the Terminal

Wait Mode

- Send RF Power Control command (parameter 0x00)

RF Power Request

- Turn on RF power
- Acknowledge command

RF Power Response

Wait Mode

- Wait for a command from the Terminal

TURN OFF SEQUENCE

TERMINAL   CAD

- Wait for a command from the Terminal

Wait Mode

- Send RF Power Control command (parameter 0x01)

RF Power Request

- Turn off RF power
- Acknowledge command

RF Power Response

Wait Mode

- Wait for a command from the Terminal

RF Power Control Sequence (continued)

DECREASE POWER SEQUENCE

TERMINAL   CAD

Wait Mode
- Wait for a command from the Terminal

- Send RF Power Control command (parameter 0x02)

RF Power Request

- Decrease RF power
- Acknowledge command

RF Power Response

Wait Mode
- Wait for a command from the Terminal

INCREASE POWER SEQUENCE

TERMINAL   CAD

Wait Mode
- Wait for a command from the Terminal

- Send RF Power Control command (parameter 0x03)

RF Power Request

- Increase RF power
- Acknowledge command

RF Power Response

Wait Mode
- Wait for a command from the Terminal

Sleep Sequence

SLEEP SEQUENCE

TERMINAL   **CAD**

Wait Mode

- Wait for a command from the Terminal

- Send Sleep Command

Sleep Request

- Acknowledge command
- Turn off RF power
- Enter STOP mode until a frame from terminal is received

Sleep Response

Any Frame

- Exit STOP mode
- Turn on RF power
- Receive frame

Reboot Sequence

REBOOT SEQUENCE

TERMINAL	CAD

Wait Mode
- Wait for a command from the Terminal

- Send Reboot Command   *Reboot Request*

- Acknowledge command
- Reset CPU

Reboot Response

ATR

Wait Mode
- Wait for a command from the Terminal

Appendix A ▶ Performing FLASH Upgrades

chapter contents

1 FLASH UPGRADE PROCEDURE

Operating software for the CAD+ is stored in FLASH memory on the Control Board. The software may be upgraded (or reinstalled) by using the Firmware Download utility included as part of the *CADTools* software program (provided with the appropriate Parallel or Serial CAD Installation Kit).

Note *CADTools V1.20 or higher is required for use with the CAD+.*

Preparing for Upgrade Procedure

Locating CAD Operating Software

The upgrade process installs CAD operating software (stored on the PC hard disk or floppy diskette) into FLASH memory on the CAD Control Board. Before you begin the upgrade procedure, make sure you have available the desired version of CAD software. It is recommended that you copy this software into the following location on the PC hard disk:

C:\Program Files\CADTools

(Since the *Firmware Upgrade* utility automatically looks in this directory first for CAD operating software, locating the software here will streamline the process as well as provide one central directory in which to store all of your CAD operating software versions.)

Setting Up the CAD and PC

Connect the CAD to the PC and launch the CADTools program as described in *Launching the CADTools Software* on page 2−5 of this manual.

Performing FLASH Upgrade Procedure

Refer to the *CADTools User's Guide* (provided with the *CADTools* software package) for step-by-step instructions for performing a FLASH upgrade procedure.

Appendix B ▶ CAD Connector Pin-Outs

chapter contents

Pin-Out Details for Parallel CAD+ Models
(T6479A)

CONNECTOR P6		CAD-to-ANTENNA BOARD
Pin #	**Signal**	**Function**
1	ANTENNA_RX	Receiver Input
2	ANTENN_RX_RTN	Receiver Input Return
3	GND	Ground
4	GND	Ground
5	ANTENNA_COIL	Antenna RF Power
6	ANTENNA_COIL	Antenna RF Power

CONTROL BOARD

TYPICAL
ANTENNA BOARD

P8

1   2

15   16

6

1
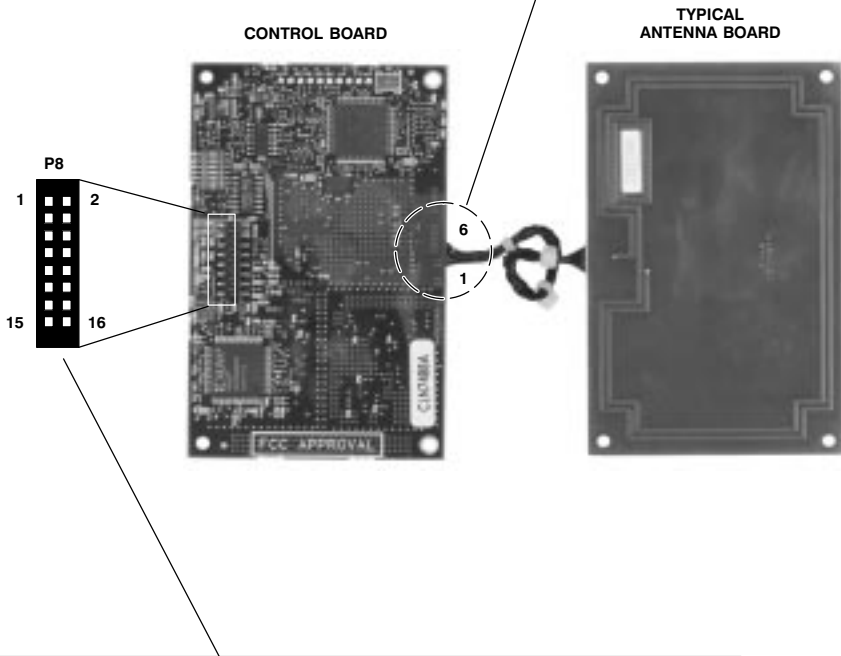
CONNECTOR P8				16-PIN PARALLEL TERMINAL CONNECTOR
Pin #	**Signal Name**	**Signal Level**	**Source**	**Function**
1	+12V	+12 V dc	Terminal	Main DC Power
2	+12V	+12 V dc	Terminal	Main DC Power
3	GND	0 V	—	Ground
4	GND	0 V	—	Ground
5	D1	TTL	Bi-Direct	Data Bit 1 (between CAD and Terminal)
6	D0	TTL	Bi-Direct	Data Bit 0 (between CAD and Terminal)
7	D3	TTL	Bi-Direct	Data Bit 3 (between CAD and Terminal)
8	D2	TTL	Bi-Direct	Data Bit 2 (between CAD and Terminal)
9	D5	TTL	Bi-Direct	Data Bit 5 (between CAD and Terminal)
10	D4	TTL	Bi-Direct	Data Bit 4 (between CAD and Terminal)
11	D7	TTL	Bi-Direct	Data Bit 7 (between CAD and Terminal)
12	D6	TTL	Bi-Direct	Data Bit 6 (between CAD and Terminal)
13	STRB−	TTL	Terminal	Data Strobe (active low)
14	R/W−	TTL	Terminal	Read from Terminal (high) or Write to Terminal (low)
15	RESET−	TTL	Terminal	Hard Reset (active low)
16	ACK−	TTL	CAD	Acknowledge (active low)

Pin-Out Details for Serial RS-485 CAD+ Models
(TT6480A, T6481A, T6499A, T6500A, T6548A)

CONNECTOR P6		CAD-to-ANTENNA BOARD
Pin #	**Signal**	**Function**
1	ANTENNA_RX	Receiver Input
2	ANTENN_RX_RTN	Receiver Input Return
3	GND	Ground
4	GND	Ground
5	ANTENNA_COIL	Antenna RF Power
6	ANTENNA_COIL	Antenna RF Power

CONTROL BOARD
(Right Angle Connector)

TYPICAL
ANTENNA BOARD

CONTROL BOARD
(Vertical Connector)
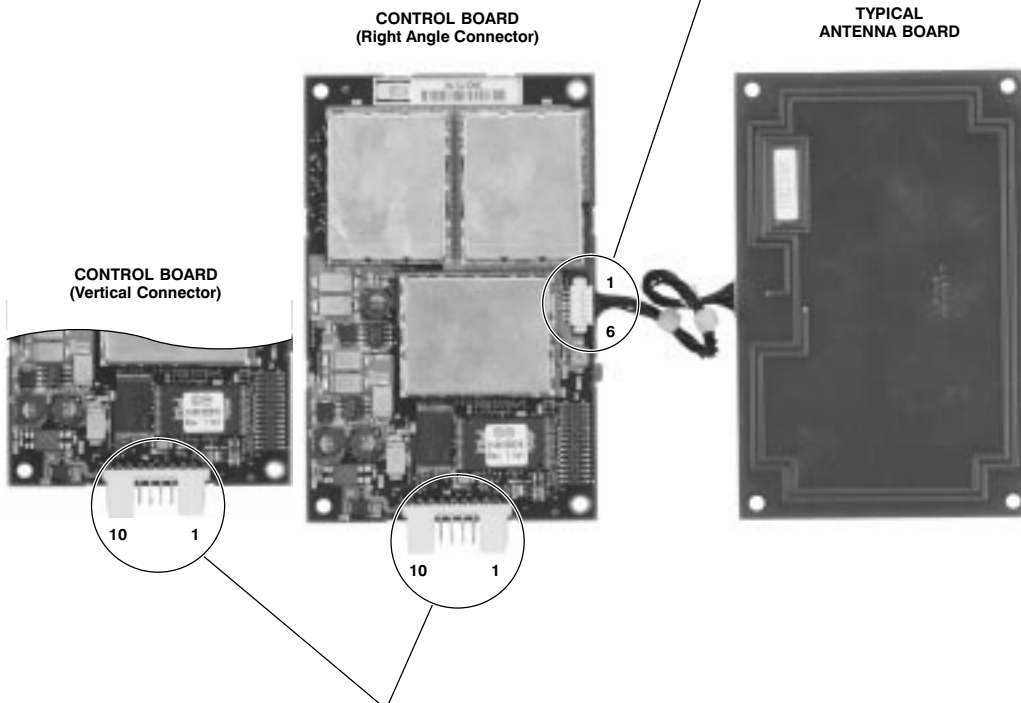
CONNECTOR P4				RS485 TERMINAL CONNECTOR
Pin #	**Signal**	**Input**	**Output**	**Function**
1	EXTERNAL_RST#	✓		External Reset
2	GND	✓		Ground (Power Supply Negative)
3	+12V	✓		+VEE (Power Supply Positive)
4	RXB	✓		RS485 Serial Data from Terminal to CAD (to be sent to Smart Card)
5	RXA	✓		RS485 Serial Data from Terminal to CAD (to be sent to Smart Card)
6	TXB		✓	RS485 Serial Data from CAD to Terminal (received from Smart Card)
7	TXA		✓	RS485 Serial Data from CAD to Terminal (received from Smart Card)
8	NC			NO Connection
9	GND	✓		Ground (Power Supply Negative)
10	NC			No Connection

Pin-Out Details for Serial RS-232 CAD+ Models

CONNECTOR P6		CAD-to-ANTENNA BOARD

Pin #	Signal	Function
1	ANTENNA_RX	Receiver Input
2	ANTENN_RX_RTN	Receiver Input Return
3	GND	Ground
4	GND	Ground
5	ANTENNA_COIL	Antenna RF Power
6	ANTENNA_COIL	Antenna RF Power

CONTROL BOARD
(Right Angle Connector)

TYPICAL
ANTENNA BOARD

CONTROL BOARD
(Vertical Connector)
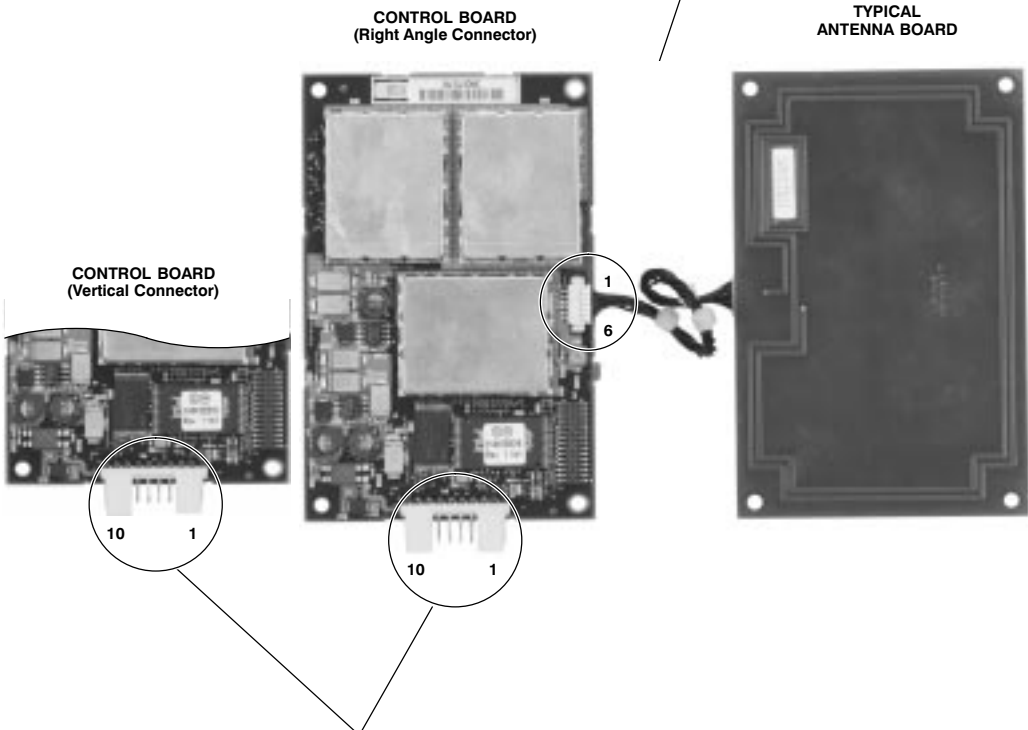
CONNECTOR P4			RS232 TERMINAL CONNECTOR

Pin #	Signal	Input	Output	Function
1	EXTERNAL_RST#	✓		External Reset
2	GND	✓		Ground (Power Supply Negative)
3	+12V	✓		+VEE (Power Supply Positive)
4	NC			No Connection
5	NC			No Connection
6	NC			No Connection
7	NC			No Connection
8	TXD		✓	RS-232 Serial Data from CAD to Terminal
9	GND	✓		Ground (Power Supply Negative)
10	RXD	✓		RS-232 Serial Data from Terminal to CAD

Pin-Out Details for Serial CMOS CAD+ Models
(T6501A)

CONNECTOR P6		CAD-to-ANTENNA BOARD
Pin #	**Signal**	**Function**
1	ANTENNA_RX	Receiver Input
2	ANTENN_RX_RTN	Receiver Input Return
3	GND	Ground
4	GND	Ground
5	ANTENNA_COIL	Antenna RF Power
6	ANTENNA_COIL	Antenna RF Power

CONTROL BOARD
(Right Angle Connector)

TYPICAL
ANTENNA BOARD

CONTROL BOARD
(Vertical Connector)

1

6

10   **1**

10   **1**
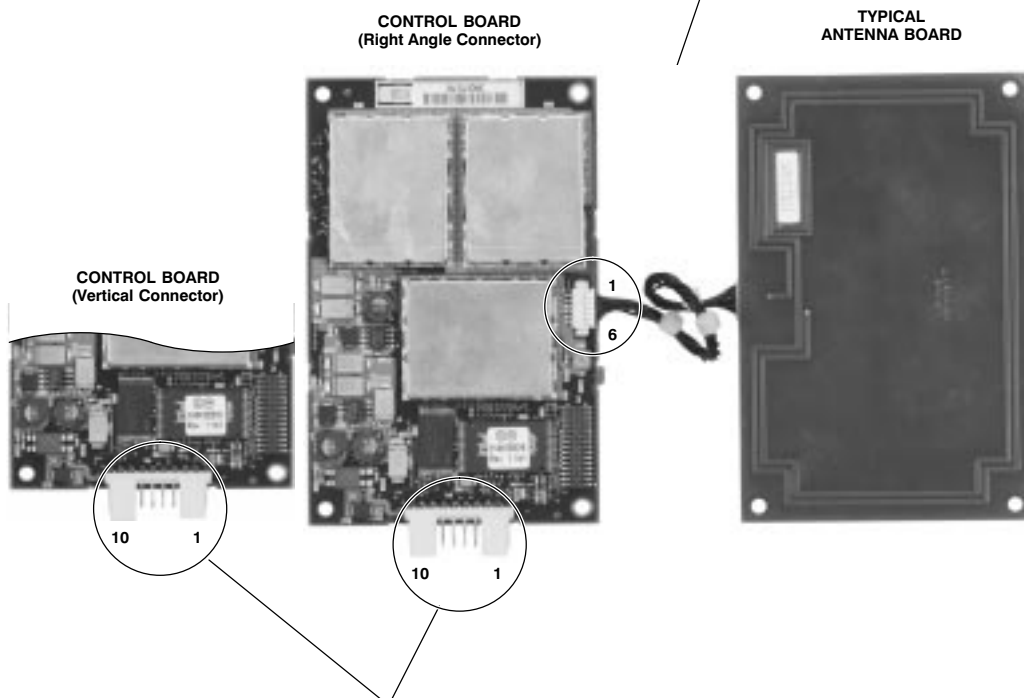
CONNECTOR P4				CMOS TERMINAL CONNECTOR
Pin #	**Signal**	**Input**	**Output**	**Function**
1	EXTERNAL_RST#	✓		External Reset
2	GND	✓		Ground (Power Supply Negative)
3	+12V	✓		+VEE (Power Supply Positive)
4	NC			No Connection
5	NC			No Connection
6	NC			No Connection
7	NC			No Connection
8	TXD		✓	CMOS Serial Data from CAD to Terminal
9	GND	✓		Ground (Power Supply Negative)
10	RXD	✓		RS-232 Serial Data from Terminal to CAD

Notes...

Appendix C ▶ Dimensions and Clearances

chapter contents

Model T6479A Dimensions
All dimensions in millimeters
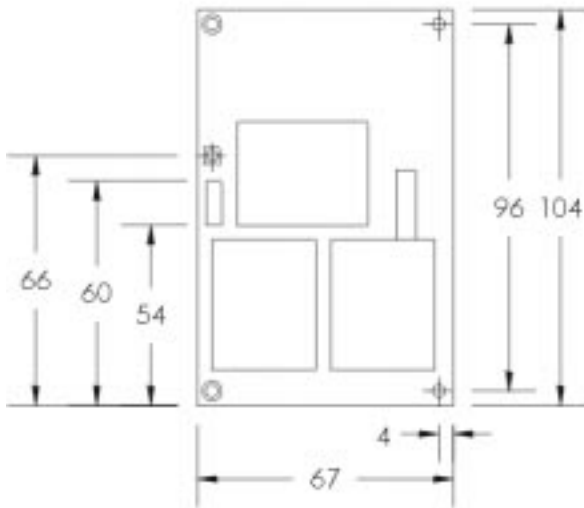
Control Board
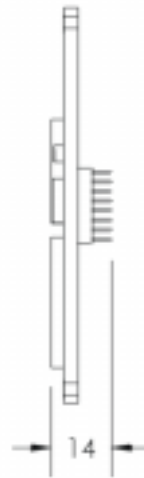
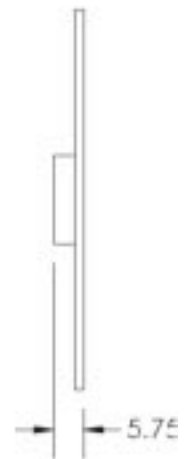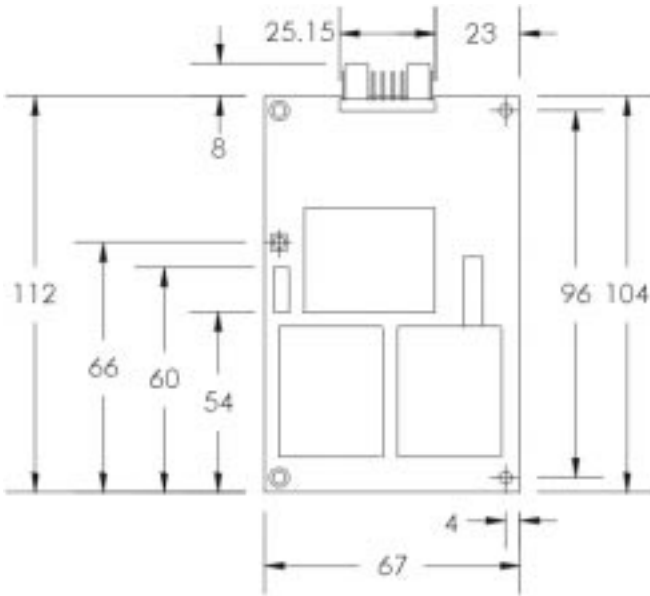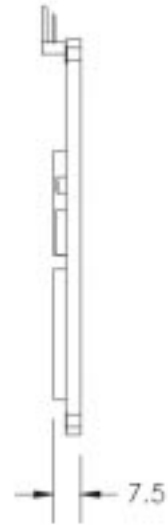**TOP VIEW**
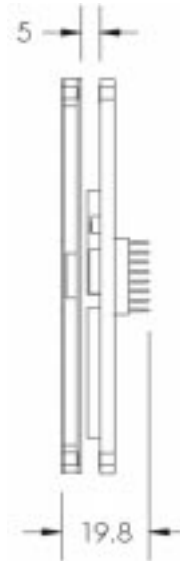
SIDE VIEW

Antenna Board
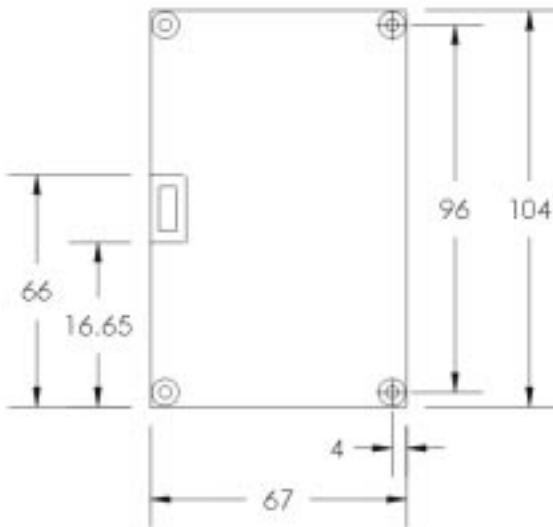
TOP VIEW

SIDE VIEW

Stacked

SIDE VIEW

Model T6480A Dimensions
All dimensions in millimeters

Control Board

25.15   23

66   60   54   96   104   17

4

67

TOP VIEW   **SIDE VIEW**

Antenna Board

66   16.65   96   104

4

67

4.81

TOP VIEW   **SIDE VIEW**

Stacked

22
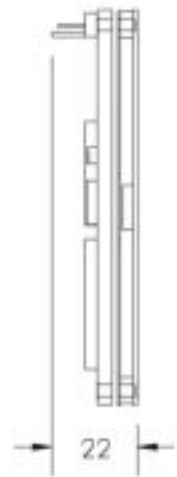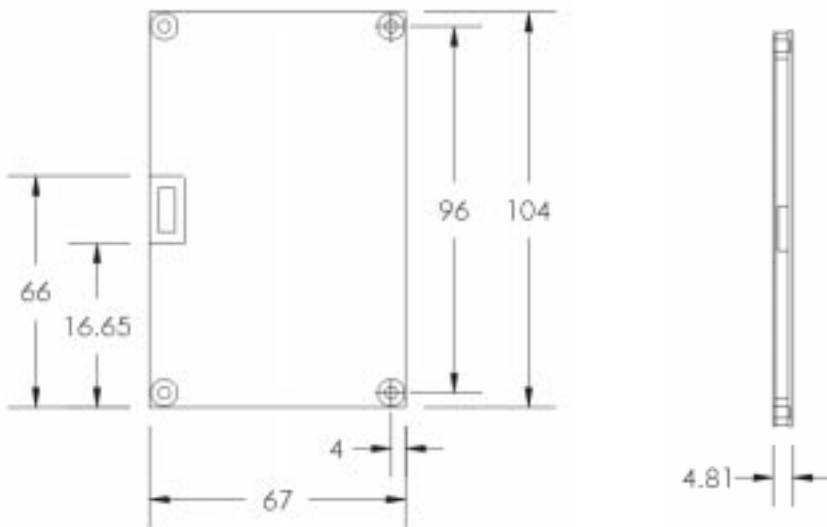
SIDE VIEW

Model T6481A Dimensions
All dimensions in millimeters

Control Board

25.15   23

8

112   66   60   54

96   104

67   4

TOP VIEW

7.5

SIDE VIEW

Stacked

16

SIDE VIEW

Antenna Board

96   104

66   16.65

67   4

TOP VIEW

4.81
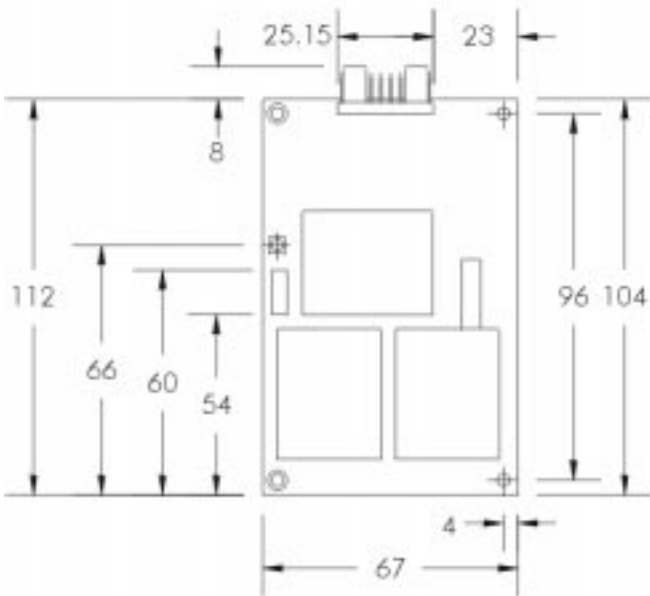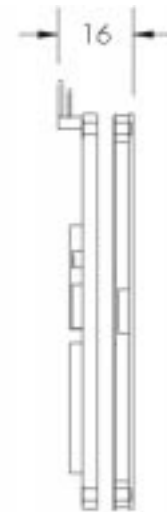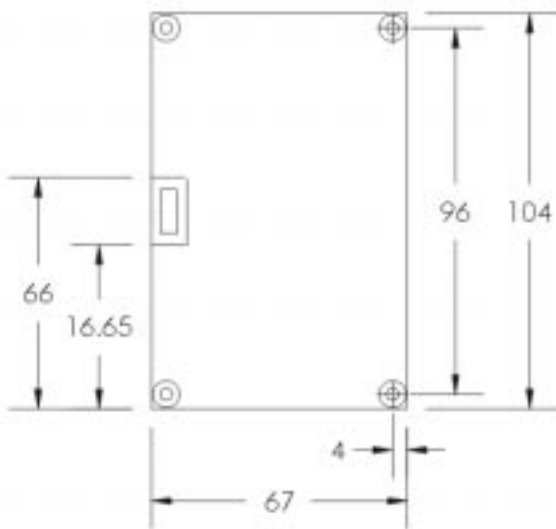
SIDE VIEW

Model T6499A Dimensions
All dimensions in millimeters
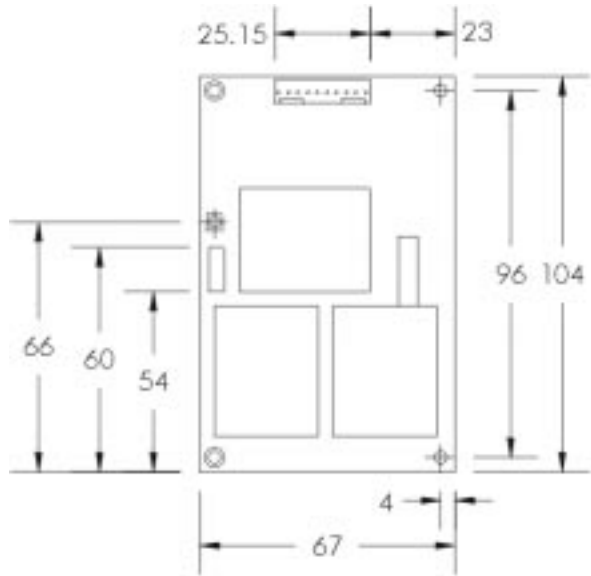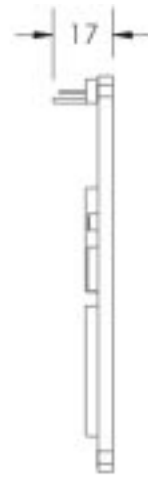
Control Board

25.15   23

17

96   104

66   60   54

4

67

TOP VIEW

SIDE VIEW

Antenna Board

50

30.35

18.67

25

4.4
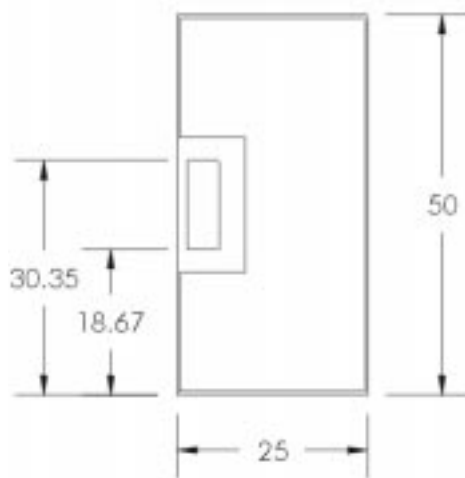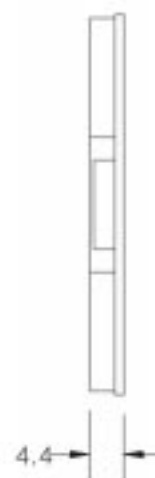
TOP VIEW

SIDE VIEW

Model T6500A Dimensions
All dimensions in millimeters
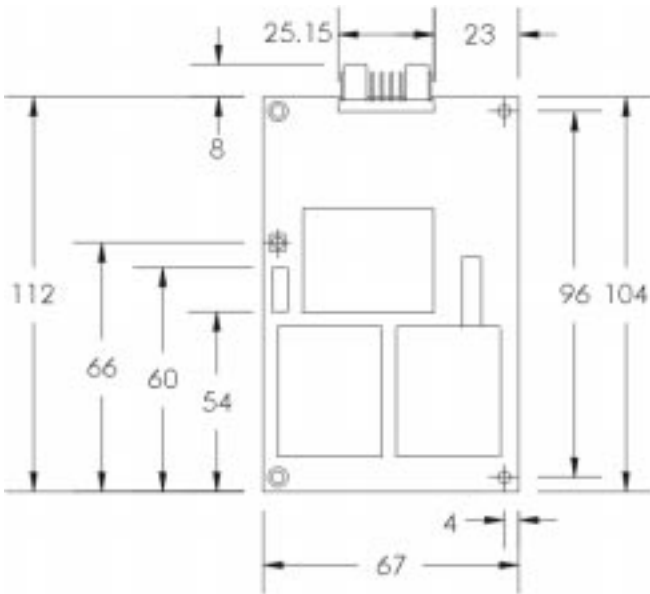
Control Board

TOP VIEW

SIDE VIEW
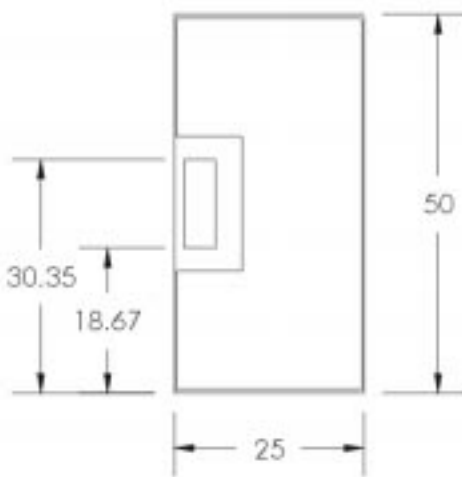
Antenna Board
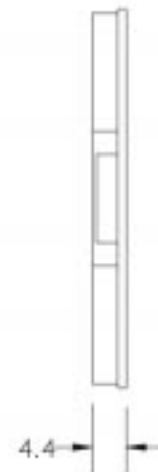
TOP VIEW

SIDE VIEW

Model T6501A Dimensions
All dimensions in millimeters

Control Board

25.15   23

8

112   66   60   54   96 104

4

67

7.5

TOP VIEW

SIDE VIEW

Antenna Board

58   65

39   26.5

4

40

5.75
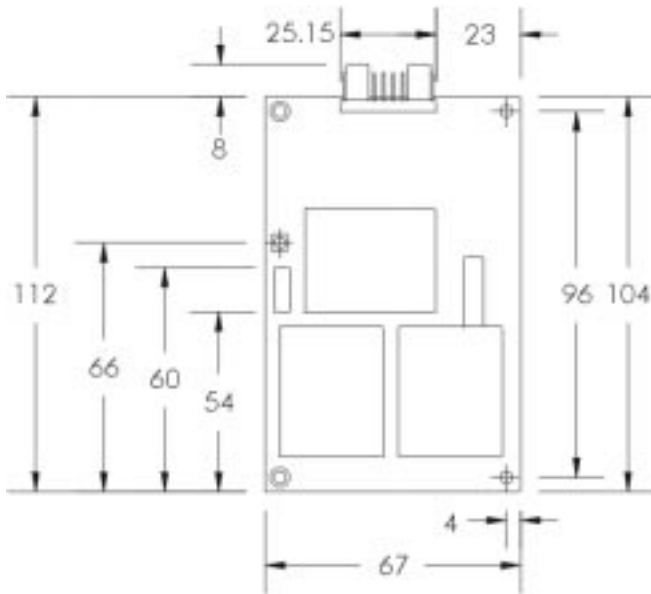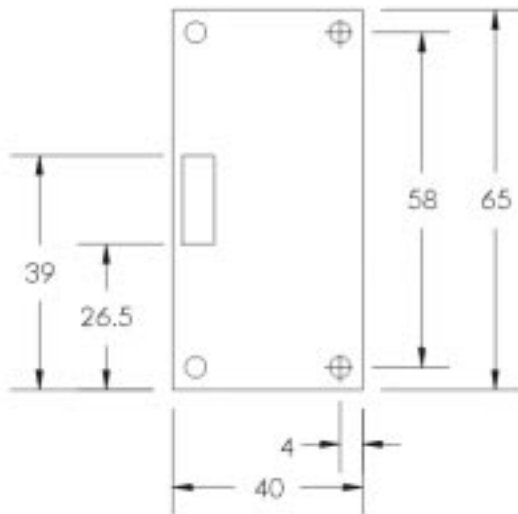
TOP VIEW

SIDE VIEW

Model T6548A Dimensions
All dimensions in millimeters

Control Board

25.15   23

8

112   66   60   54   96 104

67   4

TOP VIEW

7.5

SIDE VIEW

Antenna Board

100

80   61   48   32   30   110   62   48

31

52

77

6.3
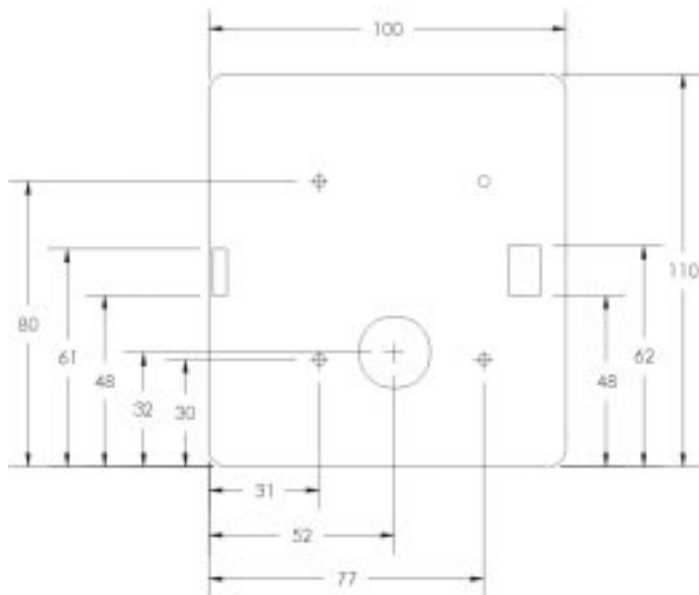
TOP VIEW

SIDE VIEW

Appendix D ▶ CAD+ DIP Switch Settings

chapter contents

DIP Switch Settings for CAD+

Boot Write Enable (On or Off)

BDM (On or Off)

OFF

ON

8 7 6 5 4 3 2 1

Reserved
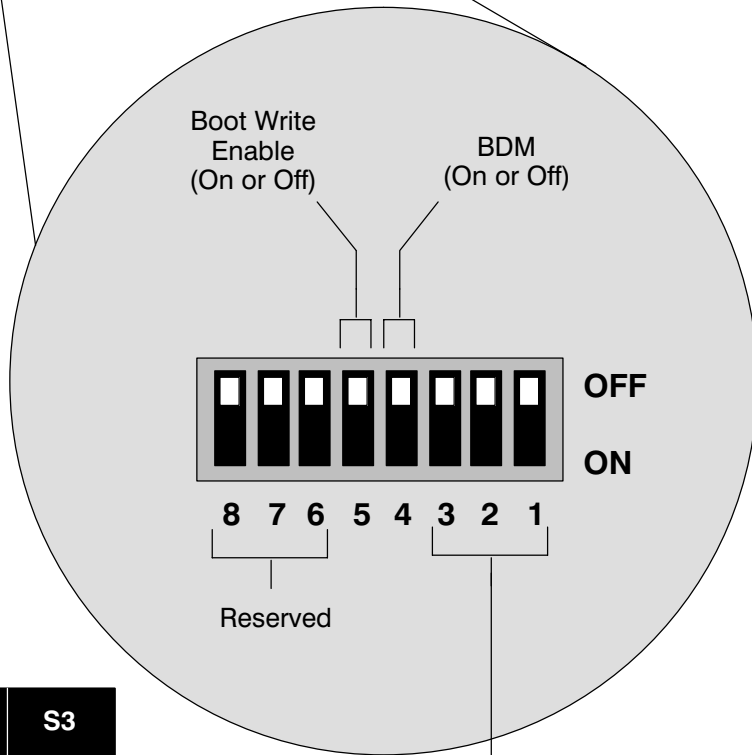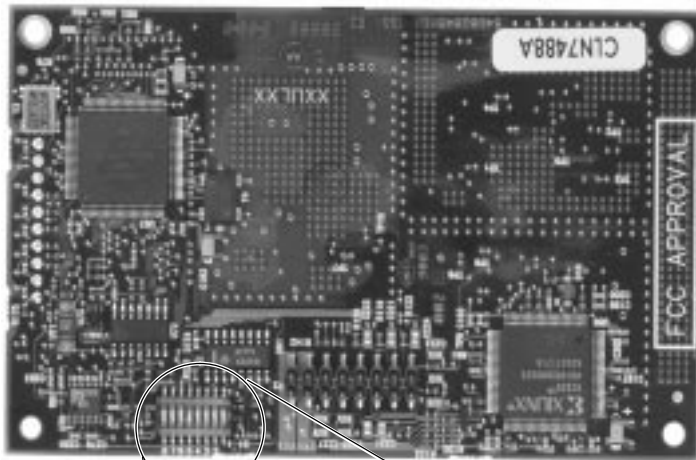
I/O Type	S1	S2	S3
Parallel	On	Off	X
RS-485/422	Off	Off	Off
RS-232	Off	On	On
CMOS	Off	On	Off

INDEX