Operator’s Manual

MEDSense: An Accessible Pill Cap Dispensing/Cutting Device

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Important Safety Instructions

Using the MEDSense Pill Cap for any other use than intended may result in serious injury. Please read all instructions carefully before attempting to operate this device. In case of serious injury due to this device contact a health care professional immediately.

The MEDSense Pill Cap can only be used with the specified medication. Each pill cap is specifically designed for use with the medication in the bottle to which it is attached. Do not mix these pill caps up. If you are unsure as to whether the correct pill cap is attached to the bottle, contact your local pharmacy.

Do not re-use this pill cap with any other medication. Once your medication runs out, return the pill cap to your local pharmacist so it can be properly disposed of.

When the device is in operation, make sure it remains inverted on a flat surface. Do not touch or disturb the device in any way.

Keep this device out of reach of children.

Do not use device near an open flame or water.

Do not attempt to open the pill cap.

Do not attempt to remove the pill cap from the bottle while it is in operation.

This device contains sharp objects. Do not stick hands, fingers, or any other body part into the device.

Follow all pharmacist and doctor instructions provided for taking medication.
Parts and Accessories

Medication Bottle
Pill Cap
Bluetooth Dongle
9 Volt Battery
Features

The MEDSense Pill Cap uses LABView to keep track of the times and doses of the medication. LABView is programmed by the pharmacist using a very simple user interface so the user does not have to worry about any programming.

This device has a multi-model alert system to let the user know when it is time to take medication. The alerts include audio commands and visual commands.

If a user misses a dose, the device sends a wireless signal to a third party off-site using Bluetooth. This ensures the health and safety of the user.

The MEDSense Pill Cap has the ability to cut pills in half and dispense half or whole doses depending on the user’s prescription.

The pill cap alerts the user as to when it is time to re-fill their medication.

This device is user-friendly and can be operated by handicapped individuals.
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1. Introduction

1.1 General Overview

MEDSense is an automated, portable pill cap that dispenses the correct amount of medication at a set time for elderly patients or patients with disabilities. It is difficult for some patients to remember when to take their medication, as well as how much medication to take. It may also be a problem for the patient to cut a pill in half if a half dosage is prescribed due to a range of disabilities.

This product alleviates the stress of the daily medication regimen. Using a multi-modal alarm system designed for a wide variety of patients, it alerts the user when it is time to take their medication. It automatically cuts and dispenses pills in the correct dosage at a pre-programmed time. It also lets the user know when it is time to re-order a prescription and alerts a third-party member offsite if a dose is missed.

The MEDSense Pill Cap comes to the user already attached to a standard medicine bottle from the pharmacy. The cap will be specifically fit to the bottle and will correspond to the size and shape of the pills inside the bottle. The cap should not be removed from the bottle by the user. The cap and bottle can be seen below in Figure 1.

Figure 1. Bottle and Cap
The pill cap has many different components. Each of these components work together to ensure that the device performs its intended action. Below is a description of each component.

1. Bottle

![Figure 2. Pill Bottle](image)

The pills come to the user from the pharmacist in a standard pill bottle with their prescription information printed on a label on the bottle.

2. Funnel

![Figure 3. Funnel](image)
The funnel ensures that only one pill goes from the bottle into the cutting mechanism at a time. This prevents jamming from occurring and ensures the smooth flow of pills through the system. This funnel is made out of polyethylene.

3. Rotating Discs

![Figure 4. Rotating Discs](image)

The rotating discs control the movement of the pills through the device. The top disc rotates and the hole gets aligned with the funnel and pill stabilizer so that the pill can fall from the funnel into the pill stabilizer. The discs rotate and help hold the pill in place when it gets cut then the bottom disc rotates so that the hole lines up with the pill stabilizer and exit chute and the pill falls from the pill stabilizer into the exit chute. The discs are controlled with one servo motor. The rotating discs are made out of PVC.

4. Rotating Axis

![Figure 5. Rotating Axis](image)
The rotating axis connects the two rotating discs to the servo motor. The motor rotates the discs to the correct position. The rotating axis is made out of steel.

5. Rotating Servo Motor

The rotating servo motor controls the position of the two rotating discs through the rotating axis. It is controlled directly by the microprocessor. The microprocessor sends signals and tells the servo motor where to rotate. The motor uses a closed-loop self-regulating system to ensure that it is in the correct position. This servo motor is the HiTec Delux HS-422.

6. Blade

A standard stainless steel razor blade is used to cut the pills in half. This razor blade is made by Stanley U.S.A.
7. Cutting Track

![Figure 8. Cutting Track](image)

The cutting track stabilizes the blade so that it accurately cuts the pills in half. The blade slides along the track and through the pill stabilizer to cut the pill. The cutting track is made out of acrylic.

8. Pill Stabilizer

![Figure 9. Pill Stabilizer](image)

The pill stabilizer holds the pill steady as it is being cut by the blade. The pill falls into the pill stabilizer from the funnel and out of the pill stabilizer into the exit chute. The pill stabilizer is made out of polyethylene.
9. Blade Stabilizer

The blade stabilizer is attached to the back of the blade. It provides a larger surface area for the cutting servo motor to push against in order to move the blade and cut the pill. The blade stabilizer is accurately fitted so that it slides through the cutting track. This component is made of acrylic.

10. Springs

The springs are used to retract the blade along the cutting track after it has cut the pill. The servo motor pushes the blade forward along the track and when it goes back to its original position the springs pull the blade back along with it. The springs are 302 SS Instruments Extension Springs from Small Parts, Inc.

11. Razor Backing

Figure 10. Blade Stabilizer

Figure 11. Springs

Figure 12. Razor Backing
The razor backing holds the cutting track securely to the wall of the enclosure. This backing is rounded since the enclosure is a cylinder. The curvature of the backing directly matches the curvature of the enclosure to ensure a tight fit. The razor backing is made of acrylic.

12. Cutting Servo Motor

![Cutting Servo Motor](image)

Figure 13. Cutting Servo Motor

The cutting servo motor is used to push the blade along the cutting track to cut the pill. Enough torque has to be provided to cut a pill. This servo motor is directly controlled from the microcontroller. The Hitec Ultra Torque HS-645 MG motor is being used for the cutting servo motor.

13. Exit Chute

![Exit Chute](image)

Figure 14. Exit Chute
The exit chute is positioned directly below the pill stabilizer. When the bottom rotating disc rotates so that the hole lines up with both, the pill falls through into the exit chute. The pill falls down through the exit chute and is dispensed out of the device. The exit chute uses the concept of gravity to move it through the device. The exit chute is attached to the wall of the enclosure. The exit chute is made out of Tygon tubing.

14. Battery

![Figure 15. Battery](image)

The battery is used to provide power to the device. The battery is attached in the device. This battery is a 9 volt battery. It is a Duracell ProCell Professional Alkaline Battery.

15. Bluetooth Device

![Figure 16. Bluetooth Device](image)

The Bluetooth device is used to send a wireless signal from the pill cap to a computer. The signal it sends is whether or not the dose has been taken by the user. The Bluetooth device is from A7 Engineering.
16. Speaker

![Speaker Image](image17.png)

Figure 17. Speaker

The speaker is used to amplify the speech produced by the text-to-speech module. This speaker is from Panasonic.

17. Microprocessor

![Microprocessor Image](image18.png)

Figure 18. Microprocessor

The microprocessor controls all of the functions of the pill cap. It is programmed using C++. This microprocessor is a PIC 16F877 from Microchip.

18. Photodetectors

![Photodetectors Image](image19.png)

Figure 19. Photodetectors
The photodetectors are a precautionary device to alert the user if a pill is jammed. When a pill is in the pill stabilizer, it blocks the flow of light from the transmitter to the receiver and the device works properly. However, if the light flows from the transmitter to the receiver, the pill is not in the correct position and the photodetectors cause an alert to go off.

19. LEDs

![Figure 20. LEDs](image)

The LEDs are part of the multi-modal alert system of this device. They alert the user when it is time to take their medication. They also let the user know when a pill gets jammed.

20. Pushbutton

![Figure 21. Pushbutton](image)

The pushbutton lights up when it is time for the user to take their medication. The user pushes the button when they are ready and the pill cutting and dispensing process is started. The button is also used to regulate whether or not the user is taking their
medication. If the button is not pushed, a signal will be sent to a third-party member alerting them that the user has missed a dose.

21. Bluetooth Dongle

![Figure 22. Bluetooth Dongle](image)

The Bluetooth dongle is a device that goes into a USB port on a computer. This enables the computer to receive and send wireless signals. The dongle is a Bluetooth Voice Star.

22. Printed Circuit Board

![Figure 24. Printed Circuit Board](image)

The printed circuit board minimizes the electrical circuit for the device. It incorporates all of the electrical components and is based on the prototyped circuits. The printed circuit board was manufactured by Express PCB.
23. Text-to-Speech Module

![Text-to-Speech Module](image)

Figure 25. Text-to-Speech Module

The Text-to-Speech Module was manufactured by Devantech. It converts written words to speech.
1.2 Instructions for Use

1. LEDs and pushbutton light up and beeps are heard from device.

Figure 26.
2. Invert device so that it is standing upright on a flat surface.
3. Push button so it is fully depressed.

Figure 28.
4. Pill enters device.

Figure 29.
5. If red LED lights up and beeps become more frequent, the pill is jammed. Re-invert the device so the pill can come free. Reset the device flat on its surface.

Figure 30.
7. Pill is cut and dispensed.

Figure 31.
7. Retrieve pill from device and take as indicated. Slight shaking may be necessary to get the pill from the device.

Figure 32.
8. Set the device upright again.

Figure 33.
2. Maintenance

1. Replacing the Batteries
   a. Unscrew bottom panel of device

   Figure 34.

   b. Carefully Remove Leads from existing batteries

   Figure 35.
c. Attach correct leads from the device to corresponding leads on new batteries

Figure 36.

d. Screw on bottom panel of device

Figure 37.
2. Tightening and Loosening Discs
   a. Unscrew bottle from pill cap

Figure 38.
b. Remove screws from the top of the pill cap and remove the top panel

![Figure 39.](image)

c. Insert wrench into small hole near the rotational motor.

![Figure 40.](image)

d. Turn the wrench right to tighten disc and turn left to loosen disc.
e. Screw on top panel of device

![Figure 41.](image)

f. Screw on the pill bottle

![Figure 42.](image)
3. Testing Motors
   a. Remove bottom panel

   Figure 43.

   b. Remove batteries

   Figure 44.
c. Remove rotational motor

![Figure 45.](image1)

d. Unscrew cutting motor from side of device

![Figure 46.](image2)
e. Remove cutting motor

f. Using a finger, test the operating range of cutting motor to ensure there are no obstructions
g. Using a finger, rotate the discs between the funnel position and testing position to ensure motor rotates freely

![Figure 49.](image)

h. Screw on cutting motor making sure that arm of motor is between the two springs

![Figure 50.](image)
i. Screw on bottom panel of device

Figure 51.
4. Cleaning Chute
   a. Remove Batteries

   Figure 52.

   b. Use paper towel to wipe clean any debris left from cutting pills

   Figure 53.
5. Cleaning Exterior
   a. DO NOT IMMERSE IN WATER
   b. Take damp cloth and lightly wipe exterior of device

Figure 54.
3. Technical Description

The MEDSense is a portable pill cap that not only cuts and dispenses pills but also communicates wirelessly to any off-site source in the event of an emergency. Powered by one 9V battery, the MEDSense is capable of executing a multi modal alarm sequence to ensure that patients with varying levels of handicaps can comfortably use the device. The visual alarm system is accomplished using multiple LEDs that flash in a sequence when the patient is expected to take their medications. Additional LEDs act as “status” notifications that indicate different scenarios. An auditory alarm system that uses an SP03 text-to-speech module to verbally notify the patient that it is time to take their medication is also provided. Additionally, the text-to-speech module provides a series of instructions that remind the user of the correct use of the device. Lastly, a vibrating DC motor provides mechanical alarm system that will vibrate in a series of pulses when it is time for pills to be dispensed. The logic driving the MEDSense is handled by a PIC16F877 microcontroller as well as passive elements that include a SPDT Micromini 5VDC relay and a number of 1N4004 Diodes. In the event of an emergency, wireless communication will be accomplished via Bluetooth through an eb505 Bluetooth module.

Microcontroller:

The PIC16F877 microcontroller is responsible for the majority of the logic and timing for each pill dispensing sequence. Connected to the controller are the cutting motor, rotational motor, SP03 text-to-speech module, eb505 Bluetooth module, real time clock module, switches and relays. By programming it to execute a set of commands, the microcontroller manages the function and timing of the cutting/rotational motor system, vibrating mechanical notification system, text-to-speech auditory notification, and the real time clock applications. There are also a number of passive devices attached to the microcontroller. These devices include a resistor at the MCLR/Reset pin, a 4MHz oscillator crystal, an npn transistor and a 5V voltage regulator.
Voltage Regulation:

Although the device is powered by 9V batteries, the majority of the peripheral devices are capable of running on only 5 volts. A listing of the required voltages to drive each device on the network is seen in table [----]. An LM317T adjustable voltage regulator is used to reduce the voltage from 9 volts to 5 volts. This three pin regulator has a limited current (Cout) of 1.5amps and a maximum power dissipation of 15 watts. This output current is more than sufficient to drive all the devices on the network as is seen in table [----]. The adjustable output voltage (Vout) ranges anywhere from +1.2V to 37V and is regulated by the values of R1 and R2 as seen in figure [----]. The output voltage can be calculated as:

\[
V_{out} = 1.25V \cdot (1 + \frac{R2}{R1})
\]

[@ Vout = 5V] 
\[
5 = 1.25V \cdot (1 + \frac{R2}{R1})
\]
The ratio, then, of $R_2$ to $R_1$ must be equal to 3. For the [Medicator v.1], the values of $R_2$ and $R_1$ are 6.07Kohms and 2.2Kohms. It should be noted that a resistance of 6.07 is accomplished using a 5.6Kohm and 470ohm resistors in series and the principles of Ohms Law. Additionally, two capacitors connect $V_{in}$ (pin 1) and $V_{out}$ (pin 2) to stabilize the transient response of the output signal.

![Voltage Regulator Schematic](image)

**Figure 56. Voltage Regulator Schematic**

**Power Indicator:**

With any device that is designed to ensure a strict time dependent regiment such as pill dispensing, it is important that there is always power being delivered to the system. As a result, a battery life indicator has been included in the circuit. The battery life indicator is composed of four LEDs driven by a power source traveling at different stages through a series of diodes. The more diodes before a LED, the more power will be required to drive the LED because of their threshold voltage of about 0.7 volts. As a result, a green LED is connected at the end of 9 diodes, indicating that that battery is full. The voltage required to exceed the total threshold of the diode system is about 9V, which will be the voltage of the battery source. If the battery life is full, the 9V threshold will be exceeded and the green LED will be illuminated. With 8 diodes before it, a yellow LED will indicate that
there is around 7.5 volts left in the batteries. There is also an orange a red LED to indicate lower battery lives:

Red LED: \(0.7 \times 2 \text{ Diodes} = 1.4 \text{ volts}\)

Orange LED: \(0.7 \times 7 \text{ Diodes} = 4.9 \text{ volts}\)

Yellow LED: \(0.7 \times 8 \text{ Diodes} = 5.6 \text{ volts}\)

Green LED: \(0.7 \times 9 \text{ Diodes} = 6.3 \text{ volts}\)

Figure 57.
Text-to-Speech:

In order to accomplish speech capabilities, the device will be installed with an IC2 text to speech synthesizer, a Devantech product distributed by Acroname Robotics. This compact module is 1.57 inches in length in 1.57 inches wide making it more than acceptable in size for the estimated design. The device runs on a 5V power source with a tolerance of approximately 10 percent. The standby current required is 20mA and the active speech current is 80mA. Additionally the device features an audio amplifier, an imbedded PIC processor, a Winbond WTS701 speech chip, and a 40mm speaker. The speech module has the ability to repeat 30 different text strings, each containing a maximum of 81 characters. A total of 1925 characters can be programmed. Although there are 30 predefined phrases available that are automatically programmed into the module, the user has the option of programming personalized text strings [13]. This can be accomplished by programming the device SP03 module using the Brainstem Console Program, which is downloaded for free from acroname.com. Once the programming is established, the computer can communicate to the speech synthesizer using a standard RS232 serial port that will connect to the GND, RX and TX pins on the SP03 chip embedded on the device. Once the speech module is implemented into the pill dispensing device, it will be programmed to initiate specific text strings at programmed time intervals.
As part of the auditory alarm system, an SP03 text-to-speech module is used to verbalize commands. This embedded device is programmed using Devantech’s own SP03.exe program which allows up to 5 user-defined phrases to be stored and recalled through the microcontroller using I2C communication. The pins required for I2C communication are 18 (SCK) and 23 (SDI) as is shown in figure 59.

![Figure 44. A look at the IC2 text to speech synthesizer. A) Schematic drawing B) Top view](image)

![Figure 59. Text-to-Speech Module with Connections](image)
Developed by Phillips, I2C is a relatively new form of serial communication that allows many peripheral devices, referred to as “slaves”, to be linked to a commanding unit called the “master”. In our particular application, the master will be the PIC16F877 microcontroller and the slaves will be the real time clock and the speech module. By using only a two-wire BUS, the use of I2C communication significantly reduces the number of pins and wires required to link electric devices, which will ultimately reduce the time and cost of purchasing a personally designed PCB board for the final prototype. These two lines include the Serial Data Acquisition (SDA) line and the Serial Clock (SCL) line. Each of these lines is bidirectional meaning they can Transmit (TX) and Receive (RX) data from any other devices on the I2C BUS. Additionally, the master is required to specify the unique seven bit address of the device that will receive information. If any of the devices on the BUS recognize the address, they will begin reading bits from the master device. It is possible, however, to issue a “general call” that will cause all devices on the BUS to read transmitted data along the SDA line.

Figure 60. I2C Communication Network

Before data is transferred, however, a series of steps must occur to initialize the transaction. First, the programming must ensure that both the SDA and SCL lines are at a constant “high” value. The voltage of a “high” varies based on the supply voltage (Vdd) to the serial BUS. In our application a “high” value will be +5V and a “low” will be 0V. The relationships between the transition timing from high to low on the SDA and SCL lines is the basis of data transferal along the I2C BUS. Once the values of each line is set to high, the “start” transaction will be initiated by switching the SDA from high to low while the SCL is kept constant. During a data transfer, the SDA can only change when the SCL is at a low value because the transitioning from high to low or vise versa while
the SCL is high is reserved for start and stop transactions. Once the start transition has been issued, all devices on the BUS will “wake up” and ready themselves for a possible data transfer. The next step is to specify the address of the device to which you would like to send data. This address will be comprised of a seven bit value and is unique to each device. If any unit on the BUS recognizes the address as its own, it will prepare itself for receiving or sending data. Because the SDA is bidirectional, the mast can then choose to read data from the slave or to write data to the slave. This specification will come as the 8th or least significant bit in the address specification. A value of 1 will signify that the master wants to receive data from the slave while a value of 0 will establish the master as the data transmitter. It is important for monitoring the connection that the slave device acknowledges a successful communication initiation by responding to the master with an “ACK” command. This command will allow the master to then begin sending or receiving data. Once data has been sent, communication is terminated by a stop command during which the SCL is floated at a high value and the SDA transitions from low to high.

Notice that there are resistors connecting each of the two I2C communication lines to the supply voltage. These act as pull-up resistors that ensure that if there are no signals on the line, the value will always read high.

**Wireless Communication:**

The specific device that will be built into the MEDSense system is an RCM3100, EmbeddedBlue eb506-AHC-IN Bluetooth Radio Module from A7 Engineering and distributed by Rabbit Semiconductors. With advances in technology, many of the tedious programming requirements are no longer need because the devices come pre-programmed. This particular model features fully implemented components on the board to ensure that no additional code is required. Additionally, the embedded UART interface will automatically search, connect, and communicate with other Bluetooth devices nearby. Once it is located, connection to another Bluetooth device is designed to mimic the appearance of a serial connection so that users do not need to have a full knowledge of wireless communication protocol. The rabbit Bluetooth module also requires a low driving current which should ultimately prolong the system’s battery life. A standby current of 3mA and a data transfer current of 25mA is required. The driving voltage is also low at a value of only 3.3 Vdc.

**Data Acquisition Details:**

The system that will be used to acquire data from the Bluetooth module is National Instrument’s LabVIEW. An image of the final front panel and block diagram is seen below. On the highest level, the health care provider is prompted to input a series of parameters that will ensure that the data is received correctly from the wireless module. These parameters include: the serial communication port, baud rate, data bits, parity, stop bits, flow control and delay. While the program prototype will prompt the user to
input these values each time communication is attempted, in actuality, these parameters will be constant for the device and can be input once and stored in the software memory. From here, the user has the option of reading data in from the microcontroller, writing data to the microcontroller, or executing both. Data written to the microcontroller is user defined and could be used, for example, to send a text string to the text to speech module as some kind of confirmation that data has been set. In the future, however, the ability to write material to the microcontroller wirelessly will allow the health care professional to send specific announcements to the user as reminders or notifications.
Once data is obtained, the software will automatically compose the information into an email and send it to an off site source, which can be programmed by the healthcare professional and stored in the software’s memory. Parameters that must be defined include: server address, email address (TO), return email address (FROM), the subject of the email, and the body of the message. When data is collected it will automatically compile the messages into the correct format such that the data being read in from the device will become the body of the email. As such, there will be a pre-programmed message that will be sent as a confirmation that the device is working or as an error message that the device has malfunctioned. If, however, the user wants to override the standard message, he or she has the option of doing so by activating a toggle switch on the front panel. When this occurs, the user will be prompted by an LED to write their own message in the “Attention Message” box, which will then become the body of the email that is sent out. This option is available for those patients that want to communicate something specific directly to their healthcare provider. Although it is often difficult for elderly patients to manage technology and the Internet, the MEDSense data acquisition and email front panel will provide such patients with an easy all in one place to communication directly with a doctor or pharmacist in the event of an emergency. It should be noted, however, that the option of overriding the original message is password protected to ensure that the doctor or pharmacist has full discretion as to whether or not the patient should have the option available to them.
A detailed explanation of each component of the LabVIEW software is provided below.

VISA Serial:

LabVIEW has provided programmers with a set of pre-programmed units that are intended to execute very specific functions. One such example is the VISA Serial unit, which initializes the serial port specified by the VISA resource name. In addition to being able to specify the port where data will be flowing, the user has the option to set a number of parameters including time out, baud rate, data bits, parity, stop bits and flow control. For this particular application, the time out option sets the time out value for the read and write operation and will be set to 10000 (10sec). After the specified amount of time has elapsed, communication will be terminated. The baud rate controls the speed of communication. Another way of thinking of the baud rate is the number of bits being sent per second. As a result, the unit of baud rate is bits per second or bps. For this application the baud rate will be 9600bps. The data bits is the number of bits in the incoming data signal. The value of data bits is between 5 and 8 and will default to a value of 8. Parity specifies the parity for every frame to be transmitted or received. Often times, parity can be used as a quick verification that data has been sent and received correctly. By specifying that the parity is either even or odd notifies the system that the data being transmitted contains either an even or an odd number of bits and, as such, should be received in that way. If for any reason, a byte of data is received that does not match the parity, the system knows that there was data corruption and the byte must be resent. A minor flaw in this method of signal paring, however, is that it is possible, although unlikely, that there will be two bits corrupted. As a result, the signal will once again have the original parity:

For Even Parity:

Sent Byte: 101010010010010001111011010101110101 (32-bits, even parity)
First Corruption: 10101001001001000111101101010110101 (31-bits)
Second Corruption: 10101001001001000111110101011101010 (30-bits)
Received Byte: 10101001001001000111110101011101010 (30-bit, even parity)

In the case of the example above, the system will not detect any errors because the parity is the same for the sent and received signal regardless of the number of bits. The stop bit options allows the number of stop bits to be specified to ensure that the program knows when to stop reading data in. For this application, the number of stop bits is one. Lastly, flow control sets the type of control used by the transfer mechanism. Below is a table that describes the types of flow control.

VISA Read:

It is important that the software is able to read data sent from the microcontroller. The VISA Read unit reads the specified number of bytes from the device that is specified
by the VISA resource name. This data is then sent through the read buffer which allows the strings to be viewed or sent to another sub-unit within the software.

VISA Write:

In addition to being able to read data in from the microcontroller, the MEDSense medical device is also capable of writing data to peripheral devices. This data could be anything from an acknowledge signal that tells the controller to continue its daily functions, or it could be a command that alters the function of the microcontroller code. The VISA Write function transmits data from the write buffer to the system or interface that is specified by the VISA resource name. For this particular application, the write buffer is the path that contains data that is to be written to the microcontroller. By writing information to the microcontroller, the pharmacist or health care professional is capable of modifying the timing and doses of medication dispensing to make it specific to the patient.

Table 1. Flow Control Types

- **None (default)**—The transfer mechanism does not use flow control. Buffers on both sides of the connection are assumed to be large enough to hold all data transferred.

- **XON/XOFF**—The transfer mechanism uses the XON and XOFF characters to perform flow control. The transfer mechanism controls input flow by sending XOFF when the receive buffer is nearly full, and it controls the output flow by suspending transmission when XOFF is received.

- **RTS/CTS**—The transfer mechanism uses the RTS output signal and the CTS input signal to perform flow control. The transfer mechanism controls input flow by unasserting the RTS signal when the receive buffer is nearly full, and it controls output flow by suspending the transmission when the CTS signal is unasserted.

- **XON/XOFF and RTS/CTS**—The transfer mechanism uses the XON and XOFF characters and the RTS output signal and CTS input signal to perform flow control. The transfer mechanism controls input flow by sending XOFF and unasserting the RTS signal when the receive buffer is nearly full, and it controls the output flow by suspending transmission when XOFF is received and the CTS is unasserted.
**DTR/DSR**—The transfer mechanism uses the DTR output signal and the DSR input signal to perform flow control. The transfer mechanism controls input flow by unasserting the DTR signal when the receive buffer is nearly full, and it controls output flow by suspending the transmission when the DSR signal is unasserted.

**XON/XOFF and DTR/DSR**—The transfer mechanism uses the XON and XOFF characters and the DTR output signal and DSR input signal to perform flow control. The transfer mechanism controls input flow by sending XOFF and unasserting the DTR signal when the receive buffer is nearly full, and it controls the output flow by suspending transmission when XOFF is received and the DSR signal is unasserted.

**Programming Device:**

In addition to being able to program the device wirelessly, the pharmacist is capable of programming the device using “in circuit serial programming” (ICSP). Unlike many microcontrollers that require the chip to be locked into a development board to be programmed before it is soldered into a circuit, the PIC 16F877 features an In Circuit Serial Programming (ICSP) capability that allows the user to program the chip “in vitro.” Connected to the microcontroller circuit is one of two data transfer options: RS232 or a parallel port. Both of these connection options require additional hardware to interface communication between the programming code and the ICSP circuit. Serial RS232 connections allow the transfer of data consisting of 3 to 22 signals each in one direction at baud rate of 100-20kbps. The baud rate of data transaction can be thought of more easily as the transmission speed measured in bits per second (bps), which describes the frequency of each period. In other words, a baud rate of 20kbps will have a frequency of 2000Hz. Additionally, the bit period can easily be calculated:

\[
BaudFrequency = 2000 \text{Hz}
\]

\[
BitPeriod = \frac{1}{BaudFrequency}
\]

\[
BitPeriod = \frac{1}{2000 \text{Hz}} = 5 \times 10^{-4} = 500\mu\text{s}
\]
Data traveling in two different directions must be done on two different wires. A wire that transmits (TX) data, for example, must be independent of a wire that receives (RX) different data. As such, a two way communication (TX and RX) requires three wires: TX, RX and ground (GND). Unlike other serial communications that use a 5 voltage TTL range (+5 to 0), an RS232 connector has an increased voltage range of 20 volts (-10 to +10). Transmitting data creates an asynchronous digital data stream, meaning that there is no “clock” timer or direct timing correlation between the transmitter and the receiver. Instead, there is a start bit that is transmitted before each bit of information is sent to ensure that the receiver is prepared to receive information. If only text is being transmitted, there will be 7 bits of information per data “package” out of the total of 8 available bits per transmission. This ultimately reduces the transmission speed rather than sending an 8 bit data package when sending large sets of text. Transmitting data will occur using digital highs and lows were different voltages distinguish between 1 (high) and 0 (low). Although the voltage swing can be anywhere from -25 to +25 and -5 to +25 volts, the typical voltage swing is -12 to +12 volts. At a voltage of +12V the serial device will transmit a logic 0 value and at a voltage of -12V the device will transmit a logic 1 as is seen in Fig. 58. The use of parity bits allows the serial system to check itself for transmission errors by evaluating the number of bits transmitted. If an even number of bits is expected and an even number of bits is received, the parity bit will return a logic value of one, suggesting that the data set was successfully sent. Similarly, an odd number of transmitted bits for a set of odd bits will return a value of 1 and a value of 0 for an even number of transmitted bits. While the use of parity bits is a good preliminary way to evaluate transmission error, an even number of errors will nullify the check and give a false parity reading. If there is no parity bit, however, a stop bit will be sent for 1-2 bit periods to end the transmission of data. A parity bit, however, can also act as a stop bit. Using an RS232 serial connection requires additional circuit to convert data from programming code to RS232 format which is then transmitted to the PIC microcontroller. The main element in the “conversion” circuit is a MAX232 chip which acts as a buffer for communication signals between devices. The MEDSense medical device, however,
uses only embedded devices that have built-in chips that assimilate the MAX232. As a result, the circuit board contains no additional signal buffering.

**Motor Relay:**

The vibrating motors on the system must be controlled by the microcontroller, but require far more current than the controller can provide. To avoid having to amplify the current from the microcontroller, the system uses the current from the microcontroller to trigger a 5V relay. To ensure that the current driving the relay is sufficient, it is first passed through a simple NPN transistor that amplifies the small current out of the microcontroller. The current into the base of the transistor is amplified by a factor of the transistors Beta value, which is approximately 100. A diode between the collector of the transistor and the 5V power supply acts as a switch that will trigger the relay. When a current is applied to the base of the transistor, the diode is forward biased and 5V passes into the relay trigger. When this occurs, the relay passes the 5V power supply into the miniature vibrating motor, which acts as a notification system.

![Figure 64. Relay Schematic](image)

**Power Consumption:**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Minimum Voltage (V)</th>
<th>Operating Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcontroller</td>
<td>5</td>
<td>70</td>
</tr>
<tr>
<td>Text-to-Speech</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>idle: 8</td>
</tr>
<tr>
<td>------------------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>data tx: 35</td>
</tr>
<tr>
<td>eb505 Bluetooth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motors</td>
<td>5</td>
<td>500</td>
</tr>
<tr>
<td>LEDs (all)</td>
<td>Variable</td>
<td>100</td>
</tr>
<tr>
<td>Average Running</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>200</td>
</tr>
</tbody>
</table>

Table 2. Power Consumption
4. Troubleshooting

This device has many components that are removable for easy maintenance and trouble shooting. The device is disposable and if a large problem arises, dispose of it in a proper trash receptacle. For the trouble shooting part there will be a professional use and a personal use.

Error: Pill Jammed

![Inverted Pill Cap](image)

Figure 65. Inverted Pill Cap
Pill has not entered into the system. The system will recognize when the medication has dropped correctly into the slot. LED alert lights shown below will light up when the medication has correctly entered into the system.
Figure 67. LED light system

To correct the error that has occurred, the user will need to invert the device and then re-invert it so that the medication can correctly fall into the system.
Error: Batteries run out

In the case where the batteries run out, remove the bottom panel and replace the batteries.

![Figure 68. Batteries](image)

Replace the batteries.

![Figure 69. Replacing batteries](image)
**Error: Pill jams while in system**

In the case that the pill becomes jammed in the system turn off device and return to pharmacy. A technician will have to remove the internal components and remove the jammed pill.

Technician: To remove jammed pill, remove the top panel of the device, loosen the set screw on the axis and the rotational motor. Remove the rotating disks and clean the pill holder.

![Figure 70. Jammed pill in system](image-url)
Error: Pill jams while exiting the system

In the case where the medication becomes jammed in the exit chute, the user will need to invert the device until the medication has been dispensed.

Figure 71. Jammed pill in exit chute
Error: Blade breaks in the cutting mechanism

In the case where the blade breaks in the cutting mechanism, the user will need to return the device to the pharmacist where it will be replaced.

Technician: To remove the cutting mechanism, unscrew the bolts in which the cutting mechanism is held to the device. After the cutting mechanism has been removed, remove the razor backing in which the razor is attached to and replace the razor.

Figure 72. Bolts securing the cutting mechanism

Figure 73. Razor backing
Error: Springs break

In the case where the springs break, use the same method for replacing the razor.
Error: Motors break

In the case where the motors stop working, remove the bottom and top panel to access both of the motors. The two motors have backings on them for easy replacement.

Figure 76. Replacement of the motors
Error: Turning disk breaks

In the case of the rotating disks breaking, remove the top and bottom panels, loosen set screws on the axis and the rotating motor. Remove the rotating disks and replace.

Figure 77. Rotating disks

Figure 78. Replacement of turning disks
Error: Electrical connections fail

In the case that the electrical connections fail, remove the top and bottom panels, so as to see the PCB board and view inside to see what connections have failed.

Figure 79. Failure of Electrical Connections
**Error: Bluetooth fails**

In the case that the Bluetooth fails, return to the pharmacist.

Technician: To replace Bluetooth, unscrew from the enclosure, remove from PCB board and replace.

![Figure 80. Bluetooth system replacement](image)
Error: Text-to-speech fails

In the case that the text-to-speech fails take the same precautions and steps that you would removing the Bluetooth system.

Technician: Unscrew from the outer enclosure and replace.

Figure 81. Text-to-speech system replacement
**Error: LED lights go out**

In the case that the LED lights go out, simply remove the cover and replace the LED lights.

Technician: Remove top panel so to see the connections between the LED and PCB board, remove from the PCB board and replace with new lights

![Image of LED replacement](image-url)

Figure 82. LED Replacement