Accessed Controlled Pill Dispenser

San Jose State University
Department of Mechanical and Aerospace Engineering
ME 106 Fundamentals of Mechatronics

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Summary:

Our project team selected a project that applies to the pharmaceutical and medical field of engineering that incorporates the use of mechanical and mechatronic systems. It was decided that since many hospitals have experienced the effects caused by low nurse to patient ratios, an automatic pill dispenser would prove to be a very useful tool in reducing the amount of extra preparation time. An automatic pill dispenser with the ability to distribute multiple pills for a certain patient or private individual can allow more attention to be given to patients and elderly to remember when and what dosage of their medication to take. There has also been a great demand for a device that can reduce the amount of time that an average family spends getting their supplements ready in the morning, in which a simple key could dispense the persons own pills. The automatic pill dispenser was constructed successfully with the use of four transistors, a motor, three solenoids, a microcontroller, and a proximity sensor and key. The combination of these materials allowed us to construct a device that with an access controlled input (a proximity sensor) an output would dispense the pills based upon the individual’s key.

Since many patients are required to take multiple pills, it was decided that the pill dispenser would need to have multiple separate levels for every different pill. Perhaps the heart of the pill dispenser is the manipulation and use of a solenoid to “pop” a pill from the pill reservoir to the pill delivery chute. Because of the space constraints of the cylindrical pill dispenser an armature was designed with a brass rod to properly extend the pill slider, which delivers the pill to the pill delivery chute. As described above, our device utilized four transistors to properly control the motor and solenoids off and on state from the microcontroller. Since devices such as motors and solenoids are rated at much higher voltages and currents than the microcontroller can provide directly, an external power source is “allowed” to power the device by powering a transistor. The use of the motor with attached propellers allowed the pills to be placed in a correct position in the pill slider that delivers the pill. It also serves as a way to keep surrounding pills from falling into the pill slider and thus “jamming” the pill dispenser. Last, the proximity sensor and key, which were provided by Keri Systems, allowed our entire system to be initiated and begin dispensing pills. A simple program allowed us to run the solenoids and motor for a given time interval.

The greatest learning experience from this project was that many times, an intended design does not always work as planned. More specifically, the largest problems that occurred in the construction and design of the pill dispenser was with the delivery system of the pills. It was very difficult, even with the use of motor and propellers to align the pills, to properly place the pills in the pill slider without another pill falling into place. The result is that occasionally either the pill slider would “jam” or the pill slider would deliver two pills. Another experience worth mentioning is that group communication is one of the most important things about working on a project. It was very easy for our group to relate to one another what was required of each individual to complete the project. Without proper communication between group members we believe that it would be difficult if not impossible to design and produce a successful project.

Introduction:

There has been a need ever since medication was in a pill form for a device that could accurately replace a human being for the need of delivering pills. Humans can determine who to give the pill's to, when and how many and there has not been a pill dispenser to date that has had the capability to replace these three very important aspects. There are many other problems that plague the home pill user, such as someone stealing pills, forgetting to take them or having the pills available to take too many.

We started with these basic needs of a home user and came up with a solution using a simple microcontroller to manage the pill's dispersal and a proximity sensor to read and allow access of only a valid key to have the pill's dispensed. With this there are endless possibilities to where, how and when this pill dispenser could come to help and aid many different kind of people in their lives. With the addition of a buzzer this pill dispenser can also remind you when to take your pills, and also notify others when your pill's have not been taken.

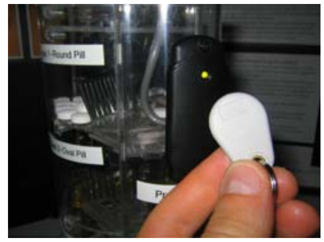
Below is just the beginning of some of the basic functions an accessed controlled pill dispenser could achieve.

- Hospitals - the automatic pill dispenser can simplify pill dispensing for hospitals with small to large capacities. With the presence of a pill dispenser, nurses and doctors can significantly reduce the amount of time for prep work and doing 'rounds,' this way more attention can be given to patients that are in greater need of medical attention. Medical professionals can also be notified by means of a simple database on whom and when dispensed pill's for the day, and also be notified if a patient has not taken their pills. By hooking up a dispenser to a simple network, access can be changed in a second with patients constantly changing rooms and coming in and out of the hospital.
- Home - the increased use of daily vitamins and dietary supplements that need to be taken before or after meals can also become a great area of interest for the use of an automatic pill dispenser. An individual keychain key can initiate the pill dispensing for the user's personal diet regime and a buzzer can remind them when the supplements need to be taken. This pill dispenser can also control the access to pills that can be sensitive for young children and teenagers, they are locked and only can be retrieved by the person who has the key on their keychain, and only when the right time of day is.
- Elderly - the automatic pill dispenser is an excellent way for the elderly to be reminded when to take their pills and the current access key can be worn around the neck or on a bracelet. With not only a pill dispenser that can remind an elderly person to take their pills, it can also limit the amount of pill's that someone could have access too without having an in house nurse and one that can still be monitored very simply with a database of all logs for pill's being dispersed.

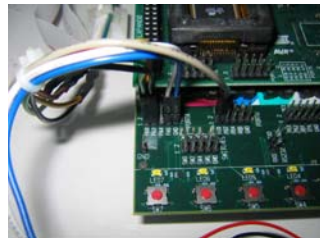
By adapting a very simple mechanical pill circulation and dispersal system to a microcontroller and adding access control, there is only but a world of applications and possibilities to how this device can be tailored to anyone within estimated costs of $300 for a home use with basic features and 5 preset keys, to $500 for a unit that could go into a hospital. A cost that within hours would make up for the ongoing expensive nursing and staff that are needed to dispense pill's that could be giving care instead.

Here is a step by step feature of how the Access Controlled Pill Dispenser works.

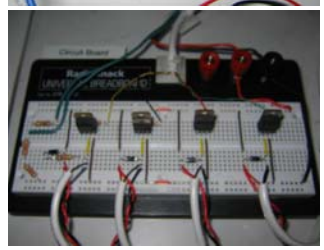
1. User inputs their key that has an associated number that is connected to them, proximity reader reads and compares key to stored database to ensure that key is valid. Proximity reader blinks green if Key is valid.



2. Microcontroller receives input by means of a voltage divider and the runs the code based upon the proximity key to output high (5V) from its ports to control the pill dispenser.



3. The microcontrollers 5V output goes into the base of a TIP120 transistor to allow 12V with 1.2 amps to be connected to the appropriate devices in the pill dispenser.



4. The first line of code for the display is to rotate the pills in each tray using the motor mounted on the bottom of the unit that ensures that there is a pill in the slider.

5. Once motor has gone for a preprogrammed amount of time the slider is activated by the solenoid and a pill is dispensed.

6. Pills are held by trap door for our display to show that the pills are dispensed and then they are dropped into the Dixie cup for next demonstration.

Design:

There have been many ways in the past that an automatic pill dispenser has been approached; most of them being gravity fed which leads to many different problems with pills becoming jammed. We approached this problem with adapting different pill “layers” that could be set on top of each other with a central motor that could spin the pills to the outside where a slide mechanism could dispense single pills, see figure 1.

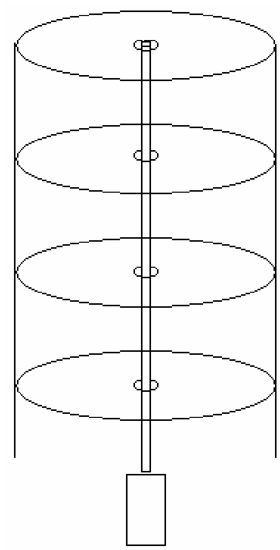


Figure 1: Center vertical shaft that can be connected to a single motor to spin all layers of pills, removes the need for individual motors on each pill layer and also greatly reduces the chance of pill’s jamming.

By keeping the shape of the dispenser circular we could use one motor on the bottom with a center shaft that could have “arms” in each layer to circulate the pills to ensure that they drop into the slide mechanism and also keep the pills to the outside so that even the last pill will be able to be dispensed, see figure 2. We also decided that we were going to use two different pill layers and use two different kinds of pills. One is a calcium-magnesium pill that is round and one is fish oil that was oval.

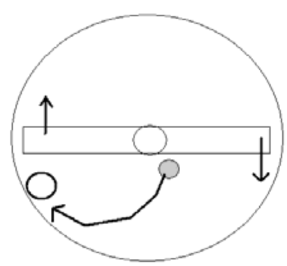


Figure 2: Diagram showing how a center shaft could rotate the pills and move them to the outside where they can drop into the slide mechanism to be dispensed.

We purchased all acrylic at Tap Plastics and soon found that the 8” circular acrylic cutouts where not going to fit into the 6in diameter acrylic cylinder. We used a set of digital calipers to measure the inside diameter of the tube and setup a routing table with a hole that was half the diameter away to spin the acrylic and cut out perfect layers for the pill dispenser. All acrylic was cut using bonded abrasive cutoff wheels on a Dremel with a right angle air grinder that was attached to a quick change 320 grit disc to sand all edges. Everything was purchased, cut, sanded and even some pieces heated and remolded by hand.

We found a 12V 1.3amp Dc motor that was already geared down to 25rpm that was used along with a coupler to attach the motor to a 5/16in rod that goes the length of the Pill dispenser and connects with a mounted bearing on the top. See figure 3. See appendix B for datasheets for major components.

Figure 3: Pictures showing the connection of the Dc motor to the shaft through the coupling and to the aluminum stock through to the mounted bearing at the top of the pill dispenser.

The next part of the design was to make a slide mechanism that would allow a single pill to easily slide into an opening and be deep enough so that only one pill would stay in so that a second on top would not jam when a pill was ejected. We found a slide that was at Tap Plasitcs that we used along with, from top to bottom, ¾ in 3/16 in think acrylic, 1 in ¼ in acrylic and then ½ in 3/16 in thick acrylic for the slide. The very bottom was 1 ¼ in 3/16 in acrylic that was used so that the pill did not fall out before it was ejected. Check appendix A for the list of raw materials that were used.

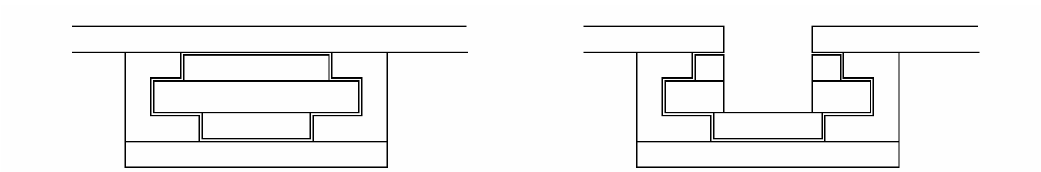


Figure 4: Diagram showing the end view of the slide mechanism, the left one is of the inner slide part surrounded by the slides on the side and the right one is a cut out view of the part of the slide where it is cut out for the pill to fall into.

To properly explain how the slide mechanism works please look at figure 5. The pill slides in the top with the bottom of the slider that is stationary not allowing the pill to fall all the way through the slide which has a hole all the way through it. When the slide is all the way out it blocks another pill from being jammed because the slide has been cut to be only one pill deep, and the pill falls right out the bottom. There was some additional etching that took place to ensure that the pill fell in while being circulated and also that if there was another pill on top of one in the slide it was sure not to get jammed, see figure 6.

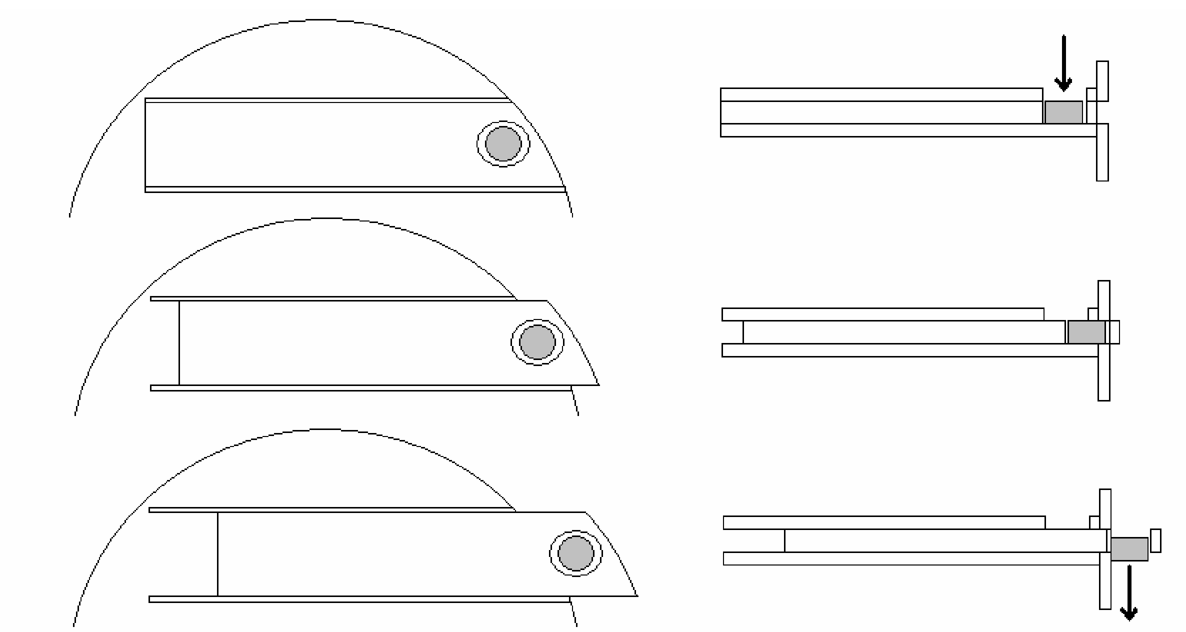


Figure 5: Diagram showing the top cutaway view and the side view of the slide mechanism and how it was able to dispense only one pill at a time with the top not ejected to the bottom completely ejected.

The next and most complicated part of the design process was to design and make the armature that connected the solenoid to the slide mechanism and also add a spring to return the slide to its starting position once the solenoid has pushed it out. Because the motor spun a center shaft the arm needed to be shaped in a way so that it could bend around the center shaft and connect to the slide mechanism. One of the hardest parts of the project was to come up with a way to connect the 1/8 in solenoid rod to a 1/8 in brass rod for the armature, See figure 6.

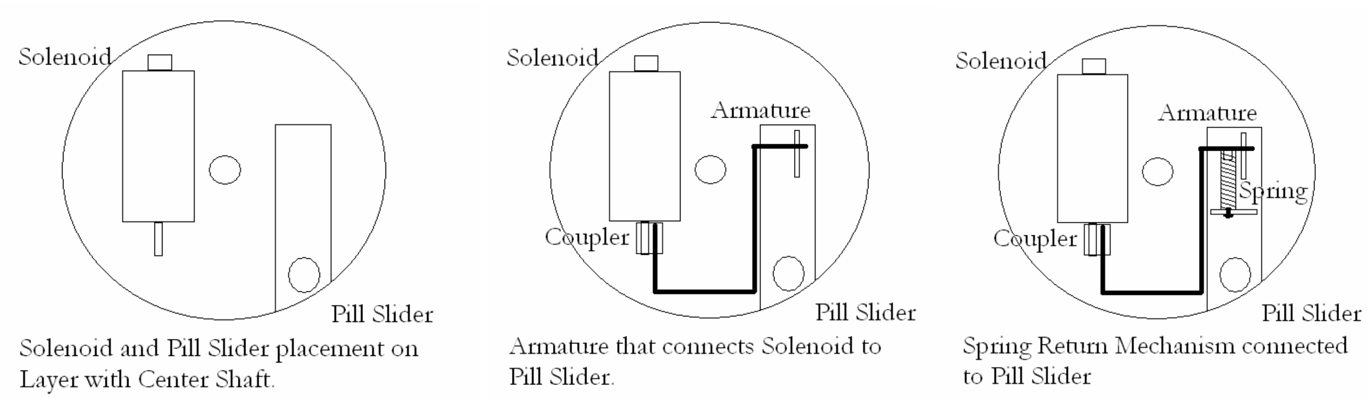


Figure 6: Diagram from left to right showing the development and design of the armature and the spring mechanism to return the pill slide after the solenoid has ejected.

We originally wanted to "tee" off of the solenoid arm but could not find anything besides possibly welding on a 1/8 in steel bar. We finally found a compression coupling that was used for 1/8 in cable and used that not only for measurement but it was easily attached to the solenoid arm by squeezing it in a vise. We found springs that had relatively low spring rates at a local hardware store and used some plastic L brackets to attached the springs to the arm and the arm to the slide mechanism, see figure 7.

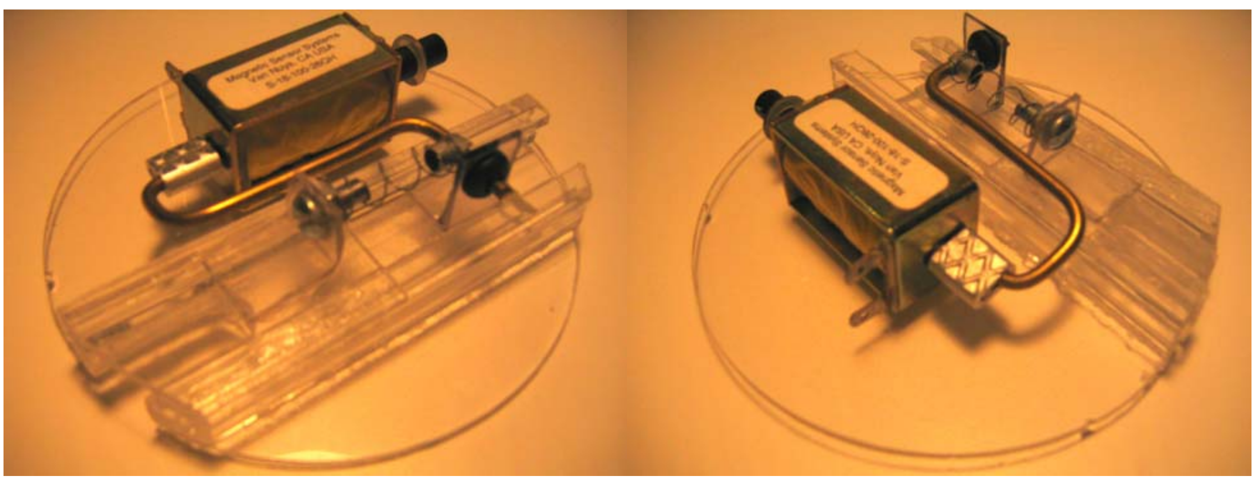


Figure 6: Picture of the complete slide unit from the bottom to show the completed armature connected to the slide and the L bracket that was used to hold the spring to the armature.

The next step was to figure out how to circulate the pills from something that could connect to the center shaft and would easily rotate the pills without damaging them. Model airplane propellers were used because they had angles on them and already had a center hole with relatively soft plastic. We found an electrostatic brush at Target that was cut into strips and epoxy was used to attach the brush strips to the propellers, see figure 8. The electrostatic brush featured rubber 1/8 in bristles that were rough enough to pull a jammed pill out of the slide most of the time, but was soft enough not to break or damage the pills.

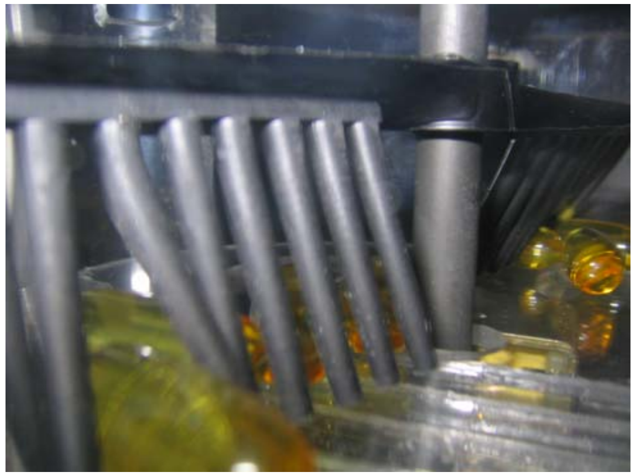


Figure 8: Picture of the brush strip that was cut and then glued using epoxy to the airplane propeller.

The last step for the mechanical aspects of the pill dispenser was to measure from the bottom of the large circular acrylic tube and drill holes in which ¼ in plugs were glued in to hold up each layer of the pill dispenser. Holes were also cut for each pill slide to eject and also on the back for wiring and to load more pills into the dispenser, see Appendix C for pictures of the competed pill dispenser from different angles. We used 4 main levels with the level 1 (the top) for round pills, level 2 for oval pills, then we had a trap door for demonstration and the bottom level had the motor mounted to it.

The next step in the electronics part of the pill dispenser was to create a circuit using four transistors to allow more voltage and current to flow to the solenoids and dc motor than the microcontroller could provide. We decided to use a 12V 1.2 amp power supply and decided to use the TIP120 transistors, see appendix B for datasheet, that we would well be under all the maximums. We calculated that we needed to use a 200 ohm resistor between the microcontroller and the transistor to ensure saturation and that we would not pull to much current off the microcontroller, see Appendix E for sample calculations. We knew from ME 106 that we needed a diode to prevent back emf from damaging the transistors for the solenoids, but we knew that we would need a resistor in line with the diode for the motor. We then used a 100 kohm resistor across the diode for the motor after calculating it based upon the amps of the motor and the diodes voltage. We then used some Led's that had their own built in resistors to show when the transistors were allowing current to flow through.. See figure 9 for picture of circuit and see appendix C for a circuit schematic. See appendix B for datasheets for the TIP120 and the diodes.

We then needed to convert the voltage that was coming from the proximity brain to something lower that the microcontroller could input and use as a high. We found that the proximity was outputting 12V and we needed a voltage divider that is on the left of figure 9 to lower the voltage with the available resistors to 4.9 V going into the microcontroller. We used a 10 kohm resistor for R1 and a 2.2 kohm and 4.7 kohm in series for R2 see appendix E for sample calculations.

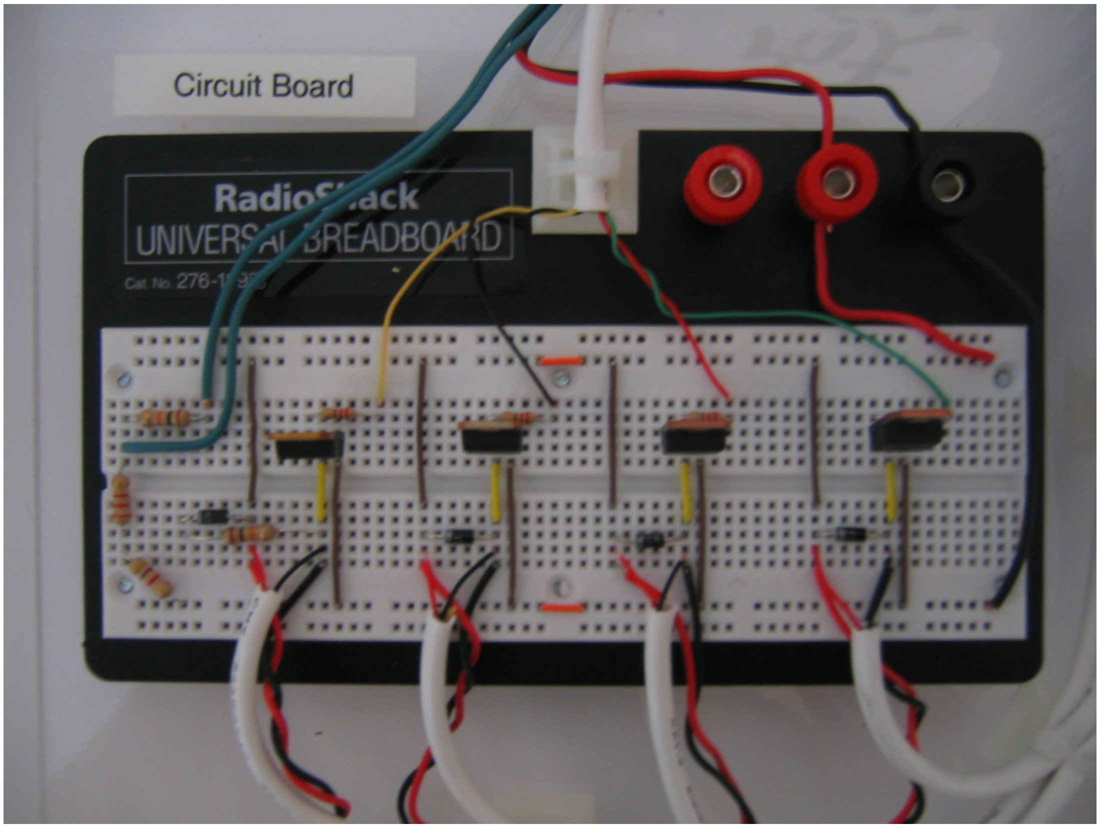


Figure 9: Picture of the circuit board, from left to right we have the voltage divider, the transistor for the dc motor and the three transistors for the trap door, level 2 and level 1.

The final step was to program the microcontroller in which we decided to use a very straight forward if and else statement to check the state of PD0 for our input high from the proximity brain. We then used a For the if-else statement a delay_ms was used to control the delay of the outputs of our different ports, and timing for the entire run. We added a buzzer to attract onlookers to our display that was in the else statement with a delay. We could not get programmers notepad that we used in all the labs to work at home so we opted to work with a program called codevisionavr that had all the #include functions already in the program for use. For our program we had the motor turn the pill's then level 1 ejected, the motor ran and then level 2 ejected and then there was a delay before the trap door would release the pills into the Dixie cup. We then had the else statement include a delay and then activated the buzzer that was used to attract onlookers and also show how a timer function could allow for reminders to take pills, see appendix c figure 2 for program.

To review the completed pill dispensers flow chart to show the logic part of the system is in figure 10.

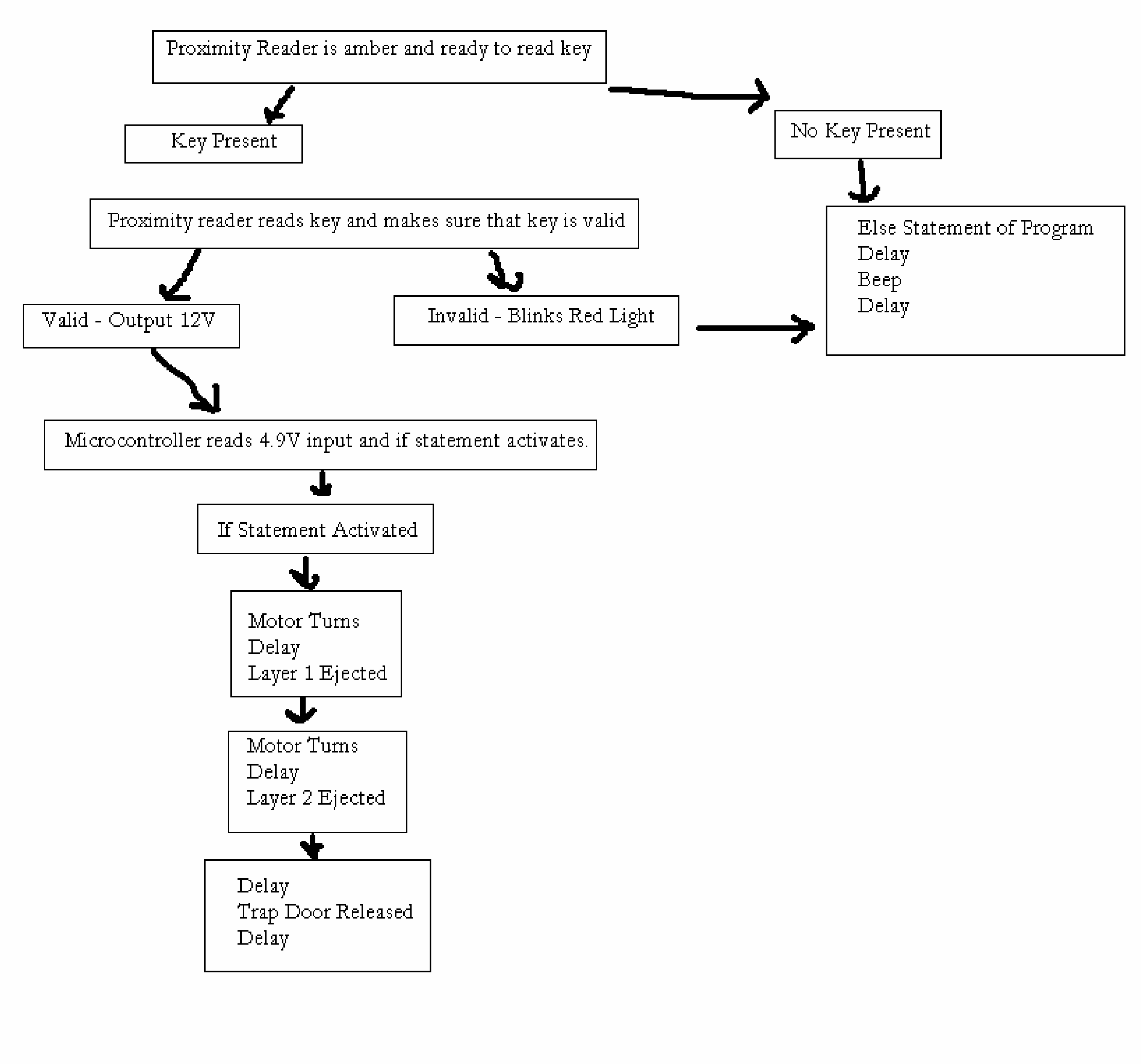


Figure 10: Schematic of the system block diagram for the logic and functions in the process of identifying a valid key card to activating the pill dispensing mechanisms.

Outcome:

How Well It Worked:

Overall our automatic pill dispenser worked very effectively. It was observed that every time the proximity sensor was triggered the program would run through its entirety. The motor successfully aligned the pills in the pill slider most of the time and the solenoids were activated with occasional jamming occurring. The most important thing is that the pill dispenser was activated many times during the day of the presentation, without ever failing to run through the entire process. The apparatus clearly showed that with a given input from a proximity sensor, that the pills can aligned and dispensed.

How Well It Didn't Work:

- Level two of the pill dispenser, which contained the oval shaped pills, would either jam the slider mechanism or two pills would be dispensed into the pill chute.
- Level one of the pill dispenser, which contained the round pills, would occasionally jam the pill delivery mechanism because more than one pill would enter the slider. Therefore, when the solenoid was activated to dispense the pill, none of the pills would be ejected from the slider into the pill chute.
- There was no confirmation via sensors to verify whether a pill was dispensed or whether more than one pill was dispensed from the desired level.
- The slider extension was slightly short for the solenoid and the allowable space to mount components was very restrictive.
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What Changes That Can Be Made:

- In order to make sure that pills are placed in the slider mechanism properly and dispensed without jamming the area where the pill is placed can be custom molded. This would ensure that only one pill would enter into this slot. It was observed that our sliders were slightly too deep, which allowed an additional pill to lie on top of the pill to be dispensed. This resulted in jamming up the slider mechanism.
- Another improvement that would ensure proper pill delivery would be to lengthen the extension of the slider. This would allow the pill (the extra pill) to be pushed off the top.
- Lower the position of the propeller on Level one would help align the round pills more for dispensing.
- A sensor just below each level of pill dispensing to verify that a pill was dispensed, and that if one was not dispensed to dispense that pill again.
- Make the automatic pill dispenser more compact by integrating microcontroller, circuit, and proximity brain with the location of the motor.
- The addition of multiple layers to make the addition of other pills very easy for users.
- An Analog to Digital Converter that would allow different proximity keys to be read and dispense a different set of pills for different users. This would make the pill dispenser much more versatile and expandable especially for larger families.

What We Learned:

- The ability of working together as a team relies heavily on how well group members cooperate. It is important that group members keep an open mind while discussing design ideas and concepts. This proved to be one of the most important things in our design process because a lot of new and effective ideas were discovered by brainstorming and discussing different ideas.
- Communication skills is yet another important thing that was learned from the project. Without the ability to properly communicate with each other and inform one another what tasks were expected to be completed and how it would have been impossible to produce a successful device.
- Yet another lesson learned from this project was that not all design concepts are flawless. Especially in the case of the pill slider mechanism, it was very difficult to foresee problems with pill dispensing and alignment.

References:

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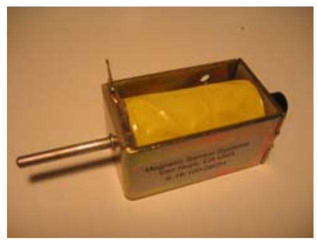
Appendices:

Appendix A: Raw Materials

Main Components

(1) 12 Volt Geared Motor to 25 RPM

(4) 12 Volt Solenoids with 1 in travel



(1) Aluminum Coupling and (1) Mounted Bearing – 5/16in

(1) Aluminum Rod – 5/16

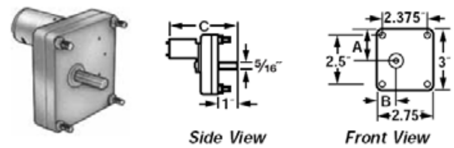
(1) 6 in diameter Acrylic Tube – 18in

(1) 2 in diameter Acrylic Tube – 18in

Other Components

- Brass Rod – 1/8in
- (3) Small Springs
- (1) 1/4in thick Acrylic Sheet – 18in by 24in
- (4) Acrylic Sliders – 12in
- (4) 3/16in Acrylic Strips – 12in by 1in
- (4) 1/4in Acrylic Strips – 12in by 1in
- (4) Acrylic Hinged
- (2) Acrylic Latches
- (2) Small Locks
- (1) Radio-shack Breadboard
- (3) Tip120 Transistors
- (4) 220ohm Resistors
- (1) 100kohm Resistor
- (1) 10kohm Resistor
- (1) 2.2kohm Resistor
- (1) 4.8kohm Resistor
- 8ft of Telephone wire
- 4ft of blue 20 guage wire
- (3) Red LED's with built in resistors
- (3) Green LED's with built in resistors
- (8) Clear Feet that base is on
- Misc. Stick on Cable Tie hold downs and Cable Ties.
- Keri-systems Inteliprox proximity sensor and brain
- Atmega128L Microcontroller mounted to STK500

Appendices B: Manufactures Datasheets

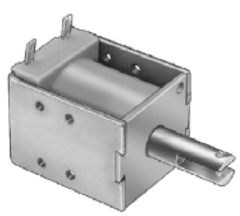


With less than 1/100 hp, these permanent magnet gearmotors are ideal for use in small spaces such as business machines, appliances, and valve actuators. A gearmotor consists of a motor and fan matched with a geared speed reducer to lessen speed while increasing torque. Shaft has a flat to accept set screws for easy connection to your equipment.

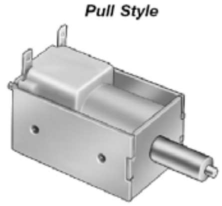
Motors are brush style and have two terminals for electrical connection. Rotation is clockwise when facing the shaft end. To reverse rotation, switch the lead wires (follow the included wiring diagram). For speed controllers, see 7729K on page 851. Housing is die cast zinc with bronze sleeve bearings. Gears are iron and Delrin. Motor face has four 10-32 threaded mounting studs.

rpm	Torque, in.-lbs.	(A)	(B)	(C)	Full Load Amps		Each
12 VDC							
.6	50	1.43″	0.91″	3.45″	0.12	6409K11	$45.76
1.3	50	1.43″	0.91″	3.65″	0.45	6409K12	45.76
4	40	1.43″	0.91″	3.45″	0.68	6409K13	42.03
8	40	1.43″	0.91″	4.17″	0.73	6409K14	42.03
12	40	1.43″	0.91″	3.65″	1.3	6409K15	42.03
16	25	1.43″	0.91″	3.65″	1.4	6409K16	37.42
25	20	1.43″	0.91″	3.65″	1.3	6409K17	37.42
50	10	2.33″	1.38″	3.65″	1.2	6409K18	37.42

Figure 1. Data Sheet for the 12V DV motor that was used for the pill dispenser. We used the 25 RPM motor that had plenty of torque to move the pills around. We used the 6409K17 Dc Motor. [1]



Pull Style



Push Style

MCM Part No.	Input Voltage	Max. Stroke	Force, oz. @ ⅛″ Stroke	Power Rating (Watts)	Coil Resistance (Ohms) 12V Model	24V Model	120 VAC Model
Pull Style—Intermittent Duty							
70155K1	DC	½″	20	11.5	12.5	50.1	—
70155K3	DC	½″	43	19.0	7.6	30.3	—
70155K5	DC	1″	120	38.0	3.8	15.2	—
70155K72	120 VAC	½″	14	22	—	—	232.1
70156K47	120 VAC	⅞″	24	40	—	—	85
70155K41	120 VAC	⅞″	45	60	—	—	32.2
Pull Style—Continuous Duty							
70155K2	DC	½″	11	5.0	28.8	115.0	—
70155K4	DC	½″	29	8.0	18.0	72.0	—
70155K6	DC	1″	76	11.0	13.1	52.4	—
70155K55	120 VAC	½″	12	8	—	—	400
70155K48	120 VAC	⅞″	12	12	—	—	200
70155K42	120 VAC	⅞″	14	10	—	—	133
Push Style—Intermittent Duty							
70155K11	DC	½″	42	19.0	7.6	30.3	—
70155K13	DC	1″	40	30.0	7.4	30.3	—
70155K65	120 VAC	½″	14	22	—	—	220
70155K61	120 VAC	⅞″	20	40	—	—	85
Push Style—Continuous Duty							
70155K12	DC	½″	16	8.0	18.0	72.0	—
70155K14	DC	1″	20	29.0	30.3	117.0	—
70155K66	120 VAC	½″	9	8	—	—	400
70155K62	120 VAC	⅞″	10	12	—	—	200

Figure 2. Data Sheet for the DC solenoids. We used a intermittent duty 12V solenoid with 1" of maximum stroke to allow for the pill slider to have the maximum travel. We used the 70155K13 solenoids. [2]

Set-Screw Couplings

Slide on the coupling and tighten the two set screws for a positive lock on the shaft.

Choose ***aluminum*** (6061-T651; lightweight and corrosion resistant), ***steel*** (Grade 12L14), or ***stainless steel*** (Type 303 for excellent corrosion resistance). Couplings ***with keyway*** give you a more secure hold and are especially good for alternating-motion applications. They have standard ANSI keyway dimensions.

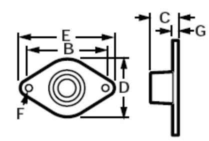
				Aluminum				Steel				Stainless Steel			
OD	O'all Lg.	Bore	Screw Size	Max. rpm	Max. Torque, in.-lbs.		Each	Max. rpm	Max. Torque, in.-lbs.		Each	Max. rpm	Max. Torque, in.-lbs.		Each
Without Keyway															
1/2"	3/4"	1/4"	10-32	2029	41	2424K11	$5.51	3450	69	6412K11	$4.84	3450	43	6099K21	$8.78
5/8"	1"	5/16"	10-32	2029	51	2424K12	6.26	3450	86	6412K12	5.44	3450	54	6099K22	10.15
3/4"	1"	3/8"	1/4"-20	2029	105	2424K13	6.88	3450	178	6412K13	4.47	3450	111	6099K23	10.39
1"	1 1/2"	1/2"	1/4"-20	2029	140	2424K14	7.67	3450	238	6412K14	7.49	3450	149	6099K24	13.30
1 1/4"	2"	5/8"	5/16"-18	2029	276	2424K15	10.07	3450	469	6412K15	9.39	3450	293	6099K25	19.04
1 1/2"	2"	3/4"	5/16"-18	2029	331	2424K16	11.44	3450	563	6412K16	10.62	3450	352	6099K26	23.43
1 3/4"	2"	7/8"	5/16"-18	1024	386	2424K17	14.74	1740	656	6412K17	12.49	1740	410	6099K27	28.07
2"	3"	1"	5/16"-18	1024	441	2424K18	16.98	1740	750	6412K18	13.84	1740	469	6099K28	43.96
2 1/8"	3"	1 1/8"	3/8"-16	1024	695	2424K19	24.88	1740	1181	6412K31	21.80				
2 1/4"	4"	1 1/4"	3/8"-16	1024	772	2424K21	30.23	1740	1313	6412K32	22.51				
2 1/2"	4 1/2"	1 3/8"	3/8"-16	1024	849	2424K22	42.42	1740	1444	6412K33	28.11				
2 1/2"	4 1/2"	1 1/2"	3/8"-16	1024	926	2424K23	64.53	1740	1575	6412K34	38.06				

Figure 3. Data Sheet for the DC solenoids. We used a 5/16 in coupling without a keyway to secure the dc motor to the aluminum shaft. We used the 2424K12 coupling. [3]

Black-Oxide-Coated Steel Flange-Mounted Needle-Roller Bearings

CAD

These small bearings accommodate small shaft diameters and handle extremely high speeds for their size. A black-oxide coating adds corrosion resistance and a self-aligning feature compensates for 5° shaft misalignment. Designed for use on hardened and ground shafts. Flange and bearing cage are steel with a black-oxide coating; other components are steel. Temperature range is −22° to +212° F.



For Shaft Dia.	Dyn. Load Cap., lbs.	Max. rpm	O'all Lg. (B)	O'all Ht. (C)	O'all Wd. (D)	Ctr.-to-Ctr. (E)	Bolt Hole Size (F)	Thick. (G)		Each
Inch Sizes										
1/8"	240	28,800	1.80"	0.40"	0.88"	1.22"	7/32"	0.05"	1434K1	$12.80
3/16"	620	24,000	2.10"	0.46"	1.19"	1.53"	7/32"	0.06"	1434K22	10.57
1/4"	570	21,000	2.10"	0.46"	1.19"	1.53"	7/32"	0.06"	1434K23	9.03
5/16"	650	17,400	1.80"	0.64"	1.25"	1.22"	7/32"	0.09"	1434K24	6.89
3/8"	650	15,000	1.80"	0.64"	1.25"	1.22"	7/32"	0.09"	1434K25	7.57
1/2"	1,040	11,400	2.34"	0.77"	1.56"	1.78"	7/32"	0.09"	1434K6	9.09
Metric Sizes—*Dimensions in millimeters.*										
4	400	24,600	53	11.6	30.0	39.0	5.5	1.5	1434K31	12.80
6	455	21,000	53	11.6	30.0	39.0	5.5	1.5	1434K32	9.03
8	620	16,800	45	16.3	31.7	30.9	5.5	2.3	1434K33	8.34
10	990	13,800	45	16.3	31.7	30.9	5.5	2.3	1434K34	7.17
12	1,110	12,000	60	19.5	39.6	45.2	5.5	2.3	1434K15	9.46

Figure 4. Data Sheet for the mounted bearing. We used a 5/16 in mounted bearing atop the aluminum shaft. We used the 1434K34. [4]

Rods—Hard Anodized Coating

- Hardness: Rockwell C70 (with coating)
- Yield Strength: 40,000 psi
- T6 Temper up to 1/2" dia.; T6511 for 5/8" dia. and up (before anodization)

About half of the coating penetrates the material, while the other half covers the surface. Coating resists wear and corrosion, is 0.001" to 0.002" thick, and meets MIL-A-8625. Straightness tol. is not rated. Length tol. is ±1/16". **To Order:** Please specify 1- or 3-ft. length.

Dia.	Dia. Tolerance		Each 1 ft.	Each 3 ft.	Dia.	Dia. Tolerance		Each 1 ft.	Each 3 ft.	Dia.	Dia. Tolerance		Each 1 ft.	Each 3 ft.
1/8"	±0.003"	6750K11	$1.97	$4.40	5/16"	±0.003"	6750K14	$3.15	$8.05	5/8"	±0.003"	6750K17	$5.95	$16.52
3/16"	±0.003"	6750K12	2.46	5.86	3/8"	±0.003"	6750K15	3.65	9.58	3/4"	±0.003"	6750K18	7.43	20.86
1/4"	±0.003"	6750K13	3.06	7.57	1/2"	±0.003"	6750K16	4.88	13.25	1"	±0.003"	6750K19	10.53	30.02

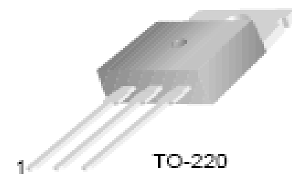
Figure 5. Data Sheet for the Aluminum Rod, we used the 5/16 in 6750K14. [5]

FAIRCHILD
SEMICONDUCTOR®

TIP120/121/122

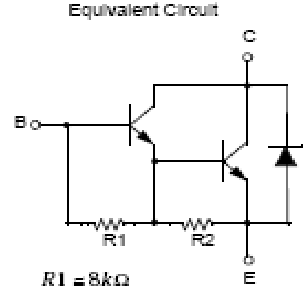
Medium Power Linear Switching Applications

- Complementary to TIP125/126/127



1.Base 2.Collector 3.Emitter

NPN Epitaxial Darlington Transistor



Absolute Maximum Ratings T_C=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CBO}	Collector-Base Voltage : TIP120	60	V
	: TIP121	80	V
	: TIP122	100	V
V_{CEO}	Collector-Emitter Voltage : TIP120	60	V
	: TIP121	80	V
	: TIP122	100	V
V_{EBO}	Emitter-Base Voltage	5	V
I_C	Collector Current (DC)	5	A
I_{CP}	Collector Current (Pulse)	8	A
I_B	Base Current (DC)	120	mA
P_C	Collector Dissipation (T_a=25°C)	2	W
	Collector Dissipation (T_C=25°C)	65	W
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	- 65 ~ 150	°C

Electrical Characteristics T_C=25°C unless otherwise noted

Symbol	Parameter	Test Condition	Min.	Max.	Units
$V_{CEO}(sus)$	Collector-Emitter Sustaining Voltage				
	: TIP120	I_C = 100mA, I_B = 0	60		V
	: TIP121		80		V
	: TIP122		100		V
I_{CEO}	Collector Cut-off Current				
	: TIP120	V_{CE} = 30V, I_B = 0		0.5	mA
	: TIP121	V_{CE} = 40V, I_B = 0		0.5	mA
	: TIP122	V_{CE} = 50V, I_B = 0		0.5	mA
I_{CBO}	Collector Cut-off Current				
	: TIP120	V_{CB} = 60V, I_E = 0		0.2	mA
	: TIP121	V_{CB} = 80V, I_E = 0		0.2	mA
	: TIP122	V_{CB} = 100V, I_E = 0		0.2	mA
I_{EBO}	Emitter Cut-off Current	V_{BE} = 5V, I_C = 0		2	mA
h_{FE}	* DC Current Gain	V_{CE} = 3V, I_C = 0.5A	1000		
		V_{CE} = 3V, I_C = 3A	1000		
$V_{CE}(sat)$	* Collector-Emitter Saturation Voltage	I_C = 3A, I_B = 12mA		2.0	V
		I_C = 5A, I_B = 20mA		4.0	V
$V_{BE}(on)$	* Base-Emitter ON Voltage	V_{CE} = 3V, I_C = 3A		2.5	V
C_{ob}	Output Capacitance	V_{CB} = 10V, I_E = 0, f = 0.1MHz		200	pF

* Pulse Test : PW≤300μs, Duty cycle ≤2%

Figure 6. Data Sheet for the TIP120, notice that the circuit that we used is well below the maximums and that this transistor has a hfe of 1000. [6]

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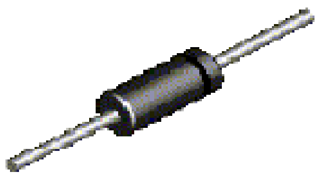
1N/FDLL 914/A/B / 916/A/B / 4148 / 4448



DO-35

LL-34

THE PLACEMENT OF THE EXPANSION GAP HAS NO RELATIONSHIP TO THE LOCATION OF THE CATHODE TERMINAL

COLOR BAND MARKING

DEVICE	1ST BAND	2ND BAND
FDLL914	BLACK	BROWN
FDLL914A	BLACK	GRAY
FDLL914B	BROWN	BLACK
FDLL916	BLACK	RED
FDLL916A	BLACK	WHITE
FDLL916B	BROWN	BROWN
FDLL4148	BLACK	BROWN
FDLL4448	BROWN	BLACK

Small Signal Diode

Absolute Maximum Ratings*

T_A = 25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{RRM}	Maximum Repetitive Reverse Voltage	100	V
$I_{F(AV)}$	Average Rectified Forward Current	200	mA
I_{FSM}	Non-repetitive Peak Forward Surge Current Pulse Width = 1.0 second Pulse Width = 1.0 microsecond	 1.0 4.0	 A A
T_{stg}	Storage Temperature Range	-65 to +200	°C
T_J	Operating Junction Temperature	175	°C

*These ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

NOTES:
1) These ratings are based on a maximum junction temperature of 200 degrees C.
2) These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.

Thermal Characteristics

Symbol	Characteristic	Max 1N/FDLL 914/A/B / 4148 / 4448	Units
P_D	Power Dissipation	500	mW
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	300	°C/W

Figure 7. Data Sheet for the 1N4148 diode that was used to drain off the back emf stored in the solenoids and motor. [7]

Appendices C: Circuit Diagram and Program

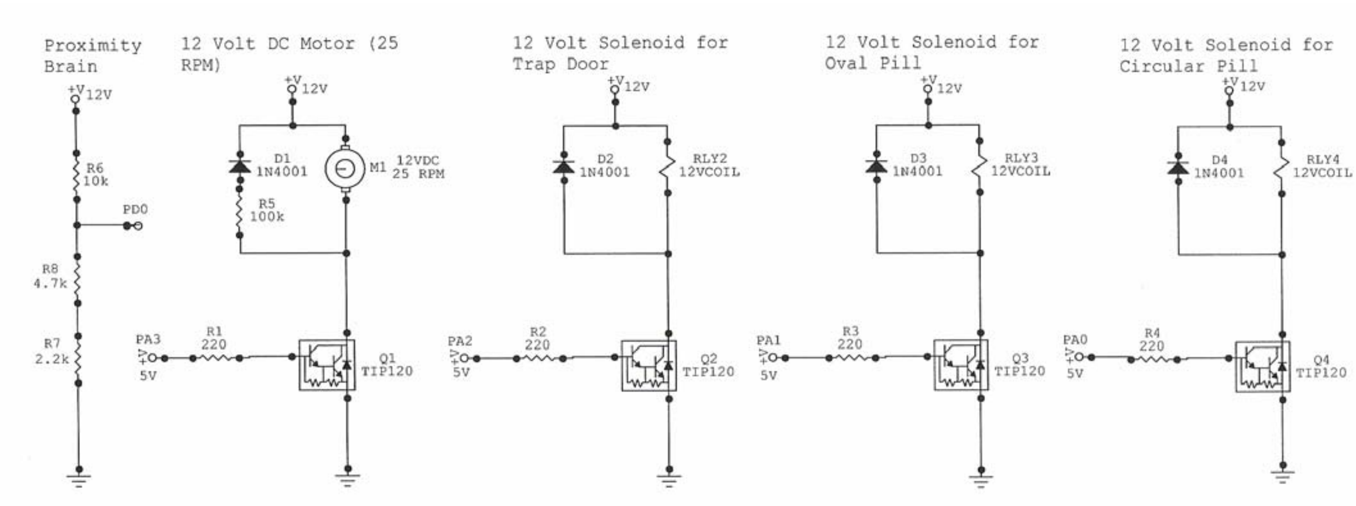


Figure 1. Circuit design schematic showing locations of all connections to the microcontroller and all values for the resistors in the circuit.

```
/*********************************************
Project :Automated Pill Dispenser - ME106 SPRING 06
Date    :Initially Presented on 5/11/06
Author  :Group of Abrams and Barsoumian
School : San Jose State University
Comments: Programmed with CodeVisionAVR


Chip type           : ATmega128L
Program type        : Application
Clock frequency     : 8.000000 MHz
Memory model        : Small
External SRAM size  : 0
Data Stack size     : 1024
*********************************************/

#include <mega128.h>
#include <delay.h>

void main(void)
{
PORTA = 0x00;
DDRA = 0xFF;
PORTC = 0x00;
DDRC = ~0xFF;
PORTD = 0x00;

while (1)                       //Loop Forever
     {
          if(PIND & 0x01) // checks state input from Proximity Sensor 4.9V
                    {
                    PORTA=0x00;     // Output to Control Delay
                    PORTA=0x08;     // Output Logical 1 to rotate pills with Geared Motor
                    delay_ms(2500); // Delay 2500ms
```

```
PORTA=0x01;     // Output Logical 1 to Top Pill Layer (round pills)
            delay_ms(1000); // Delay 1000ms
            PORTA=0x00;     // Output to Control Delay
            delay_ms(500);  // Delay 500ms
            PORTA=0x08;     // Output Logical 1 to rotate pills with Geared Motor
            delay_ms(2500); // Delay 2500ms
            PORTA=0x02;     // Output Logical 1 to Bottom Pill Layer (oval pills)
            delay_ms(1000); // Delay 1000ms
            PORTA=0x00;     // Output to Control Delay
            delay_ms(5000); // Delay 5000ms
            PORTA=0x04;     // Output Logical 1 to Pill Release Trap
            delay_ms(500);  // Delay 500ms
            PORTA=0x00;     // Output to Control Delay
            delay_ms(7000); // Delay 7000ms
            }

      else
            {
            PORTA=0x00;     // Return state of Porta to 0x00
            delay_ms(5000); // Delay 5000ms
            PORTA=0x40;     // Output Logical 1 to reminder buzzer
            delay_ms(200);  // Delay 200ms
            }
      };
}
```

Figure 2. Program that was loaded into the microcontroller to output the different pills with the appropriate delays.

Appendices D: Pictures of Completed Pill Dispenser.

Appendices E: Circuit Sample Calculations

SAMPLE CALCULATIONS

Solenoid 12V 7.6Ω

$V_{sat} = 0.8V$

$$I_{Csat} = \frac{12V - 0.8V}{7.6\Omega}$$

$I_{Csat} = 1.5A$

$$I_B = \frac{I_C}{h_{fe}} = \frac{1.5A}{1000}$$

$I_B = 1.5mA$

$$\frac{5V - 1.5V}{R_b} = 1.5mA$$

$R_b = 233\Omega$

use 200Ω

Voltage divider

$$V_{R2} = \frac{R_2}{R_1 + R_2} V_s$$

$R_2 = ?$ $R_1 = 10k\Omega$

$V_{R2} = > 5V$ $V_s = 12V$

Motor 12V 1.3A

$= 9.2\Omega$

$$I_{Csat} = \frac{12V - 0.8V}{9.2\Omega}$$

$I_{Csat} = 1.2A$

$$I_B = \frac{I_C}{h_{fe}} = \frac{1.2A}{1000}$$

$I_B = 1.2mA$

$$\frac{5V - 1.5V}{R_b} = 1.2mA$$

$R_b = 287.5$

use 200Ω

$$R_{ld} = \frac{1.3A}{12.7V}$$ 100kΩ

$R_2 = 7k\Omega$

= use 2.2 + 4.7 kΩ

$V_{R2} = 4.9V$