Smart Faucet Co.

Subassembly Specification Report

Team 5

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14th December 2010

Version 1.2

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1. Product Overview

Smart faucet is aimed to cover the need for % 100 hygienic faucet controls. Both switch on, off and water temperature can be controlled by smart faucet with completely touch-less controls. This is essential to maintain a hygienic environment in public used restrooms, as many people use the same faucet day by day.

Smart faucet will turn on automatically as you put your hands in front of it and stop the water flow when you get your hands away from the sensor. The product will be smartly designed; not allowing water to flow mistakenly if it is not intended, and also will terminate unnecessary water flow after using it. The water temperature control will be easy to use; there will be sensors placed on the side of the faucet which will let the user adjust the temperature accurately with simple hand movements.

The hand gestures have a simple logic; if you move your hand towards the back of the faucet it will heat-up the water, and when you do the opposite it will cool down the water. The speed of the hand gesture will also have an effect on the temperature adjustment, fast gestures will make rapid changes on the temperature and slow gestures will be used to sensitive adjustments in order to fulfill the users' requirements accurately.

2. Block Diagram

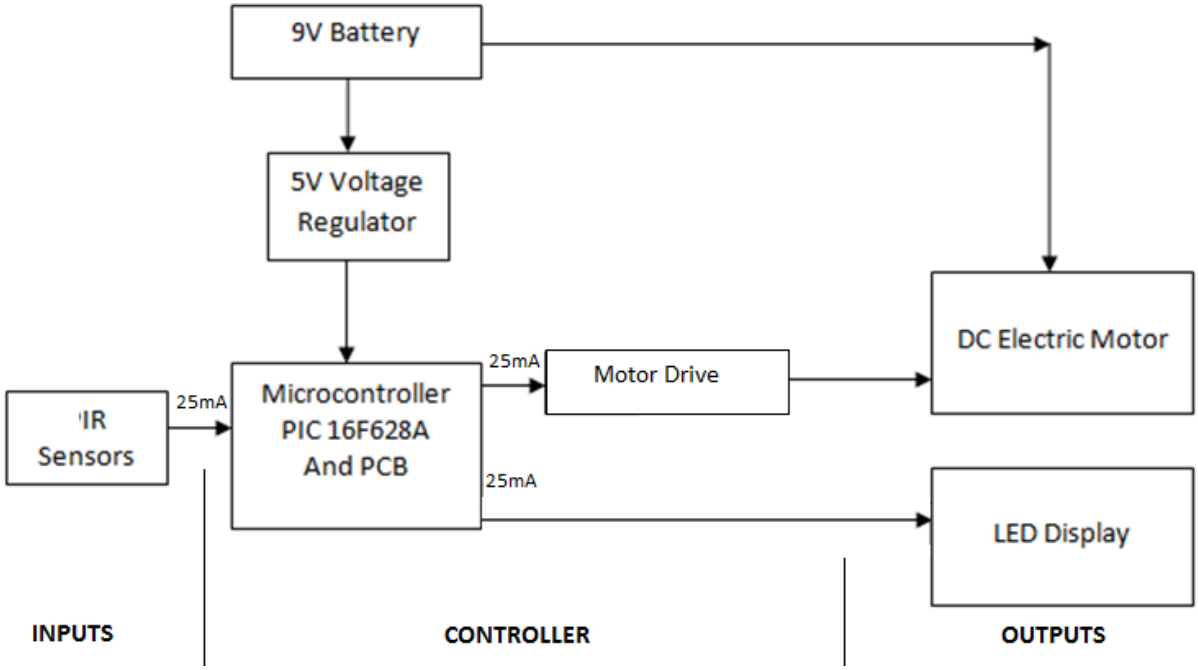

Figure 1: Block Diagram with Signals and Input / Output Directions

The block diagram shows the main blocks of the product which are the microcontroller, sensors, electric motor, and the LED display. The block diagram also shows the inputs outputs and the internal circuitry. The interface that interacts with the user which are the IR sensors will send the outputs directly to the microcontroller, and the outputs will be determined according to the software interface. There are two outputs of the main block, which are the electric motor and the LED display. LED display will be controlled directly; however, the output of the microcontroller will not satisfy the current demand of the electric motor. In order to do this, we will have a motor drive circuit to match the voltage & current requirements of the electric motor controlled by signals from the main block. Subassembly design details will be explained in the next part.

3. Flow Chart

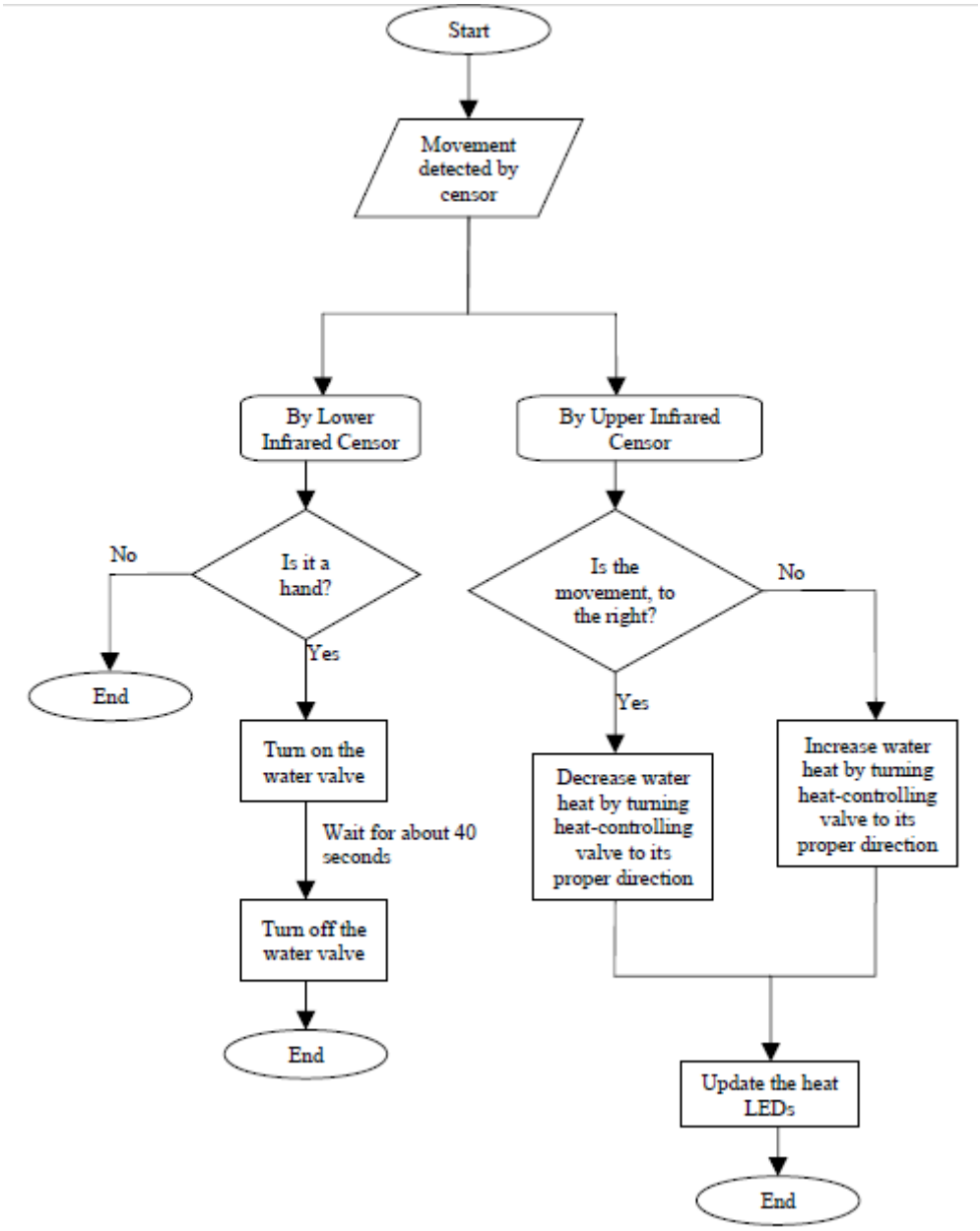

Figure 2: Flow Chart

4. Interface of the Product

[1]

Figure 3: Interface of the Product

The sensors will be placed on the side of the faucet for easy accessibility. The main body enclosure will be placed at the back of the faucet where the connections from the sensors and the electric motor will be made. The electric motor will be built on the water temperature valve as shown in the figure above. Dimensions of the new components will be specified in the following sections.

The working principle of water temperature control due to hand gestures will be explained here in order to easy the understanding of the coming parts in the report. The hand will be placed on the side of the faucet where the sensors are, and the optimal distance from the faucet is 5-15 cm. The first part is the hand gesture, as the figure below visualizes if we are looking from the side of the faucet, the water will be heated if the hand moves from right to left, and the water will be cooled if the movement is from left to right. Simply, the direction of the movement determines the action. The second thing is the speed of the hand gesture. Depending on how fast or slow you make the hand gesture; the change in water temperature will be decided. For example, if you move your hand fast, the water will be heated rapidly; but if you move your hand slow the water will be hated only slightly so that you can finely adjust the water temperature level.

-90 degrees (Hot) -- 0 degrees (Warm) -- +90 degrees (Cold)

Figure 4: Temperature Valve Positions

The direction and the speed of the hand gesture will be determined by the software of the microcontroller, the data from 3 sensors will be used to do this. Once the process is done, the microcontroller will send signals to change the water temperature and the LED display. The shaft of the motor will be fixed to the shaft of the water temperature valve core to core. According to the direction of the hand gesture, the motor will rotate to the left or to the right. Hence this will rotate the valve, and increase or decrease the water temperature. The limits of the valve are -90^{o} to $+90^{o}$. The second part is the speed of the hand gesture which determines the step of water temperature change. For example; if the hand gesture is fast the position of the valve will be changed by 30^{o}, and if the speed is slow the position of the valve will be changed by 5^{o}. There will be different speed – rotation degree couples determined in the software which we will design for optimal usage. Finally LED display will show the corresponding water temperature level according to the position of the valve to help user decide on the temperature level if they do not want to check it directly from the water.

5. Subassembly Specifications

a. LED Display

LED display consists of red & blue LEDs placed in a line similar to the figure shown below. This will be placed on top of the faucet for user to see easily. The water temperature level will be indicated by the LEDs, red for hot and blue for cold water temperatures. The increased number of lighted the LEDs, will show the temperature level accordingly. This means that as more red LEDs are lighted (starting from the middle and going to the left), the water temperature will increase. In order to satisfy the safety requirements, the LEDs will be placed in a plastic enclosure to ensure there will be no water contact with the internal electronic devices. Important specifications are that it drains 25 mA, and power dissipation is 60mW. Also it works in -40 to 85^{o}.

The interface of the LEDs will be as in the figure below. On the top of the faucet, the LEDs will be placed side by side, showing the current water temperature level. They will be fixed on to the faucet, and will be covered for water-protection and good looking.

Figure 5: LED display Interface

The dimensions for the waterproof enclosure are:

Height: 2cm Width: 3cm Length: 25cm Weight: 50 grams

Figure 5: Our LED display will look like this **[2]**

b. Controller Body

This is the main block that is shown in the block diagram previously. This body contains the microcontroller, the necessary electronic components on the PCB board such as voltage regulator, capacitors, together with the connections in and out from the body. For safety, the controller body will be placed at the back of the faucet, away from the water flow, and the body will have waterproof enclosure to avoid and water leakage into the body.

Height: 5cm Width: 6cm Length: 10cm Weight~200 grams **[4]**

Figure 6: Enclosure for the body **[4]**

- **PIC Parameters (16F684)**

PIC is the main part of the controller body. The input from the sensor is 25mA which is optimal for the microcontroller, and the outputs will be in this range as well. As discussed previously this output signal will be enough to control the LED display, the sensors, and servo motor. For the inputs and outputs of the microcontroller, we would not require analog – to – digital converters, or amplifiers since PIC 16F684 has a built-in 10-bit ADC for 8 channels. The controller divides the 0-5V range to 1024 integers, and according to the input voltage, it gives the corresponding integer. This will let us handle the infrared sensor input data directly with the controller, without any component in between them. The software

will determine the outputs for the servo motor and the LED display, and these components can also be controlled directly by the controller. The servo motor works with integer signals from the microcontroller (140 to rotate left, 150 to stop, and 160 to rotate right) hence we do not require a motor drive circuit. LED displays will be easily lit by the 25mA, 5V output of the microcontroller.

The voltage/current specifications, maximum – minimum regulations are given in the components datasheet as follows:

Special Microcontroller Features:

- Precision Internal Oscillator:
  - Factory calibrated to ±1%, typical
  - Software selectable frequency range of 8 MHz to 125 kHz
  - Software tunable
  - Two-Speed Start-up mode
  - Crystal fail detect for critical applications
  - Clock mode switching during operation for power savings
- Software Selectable 31 kHz Internal Oscillator
- Power-Saving Sleep mode
- Wide operating voltage range (2.0V-5.5V)
- Industrial and Extended Temperature range
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Brown-out Reset (BOR) with software control option
- Enhanced low-current Watchdog Timer (WDT) with on-chip oscillator (software selectable nominal 268 seconds with full prescaler) with software enable
- Multiplexed Master Clear with pull-up/input pin
- Programmable code protection
- High Endurance Flash/EEPROM cell:
  - 100,000 write Flash endurance
  - 1,000,000 write EEPROM endurance
  - Flash/Data EEPROM retention: > 40 years

Peripheral Features:

- 12 I/O pins with individual direction control:
  - High current source/sink for direct LED drive
  - Interrupt-on-change pin
  - Individually programmable weak pull-ups
  - Ultra Low-Power Wake-Up (ULPWU)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (CV_{REF}) module (% of V_{DD})
  - Comparator inputs and outputs externally accessible
- A/D Converter:
  - 10-bit resolution and 8 channels
- Timer0: 8-bit timer/counter with 8-bit programmable prescaler
- Enhanced Timer1:
  - 16-bit timer/counter with prescaler
  - External Timer1 Gate (count enable)
  - Option to use OSC1 and OSC2 in LP mode as Timer1 oscillator if INTOSC mode selected
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Enhanced Capture, Compare, PWM module:
  - 16-bit Capture, max resolution 12.5 ns
  - Compare, max resolution 200 ns
  - 10-bit PWM with 1, 2 or 4 output channels, programmable “dead time”, max frequency 20 kHz
- In-Circuit Serial Programming™ (ICSP™) via two pins

c. Infrared Sensors

QTR-1C sensors will be placed on one side of the faucet. There will be 3 sensors placed with 4.5 cm in between them. These will be used to detect the direction and the speed of hand gestures so that the water can be heated or cooled at the required sensitivity. The working principle of the sensor is based on infrared technology; hence the visual light is not a restriction for the sensors, or the faucet. As in motion sensor lightings, complete darkness is not an issue or other specifications of the environment. The infrared LEDs signals are reflected back to the sensor hence the output is generated. The outputs will be given similar to figures below, when the hand is right across the sensor there will be a peak value which will allow us to place the sensors side by side and not care for the operating angle. Also the output is digital, which will be directly connected to the pins of the microcontrollers. For safety of the circuit, the sensors will have a waterproof enclosure

Height: 2cm Width: 3cm Length: 25cm Weight: 50 grams

Specifications

- Dimensions: 0.3" x 0.5" x 0.1" (without header pins installed)
- Operating voltage: 5.0 V
- Supply current: 25 mA
- Output format: digital I/O compatible
- Optimal sensing distance: 0.125" (3 mm)
- Maximum recommended sensing distance: 0.375" (9.5 mm)
- Weight without header pins: 0.008 oz (0.23 g)
- Max operating temperature: 150 ^{o}C

Figure 9: Infrared Sensors' place on faucet

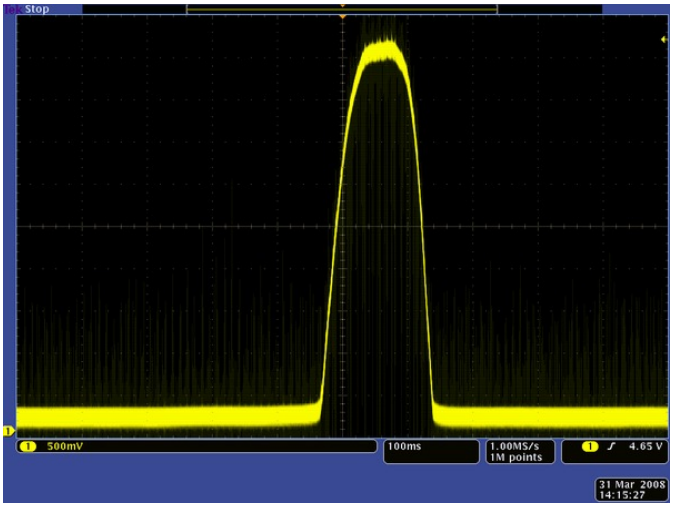

Figure 10: Example output of QTR-1C Reflective Sensor

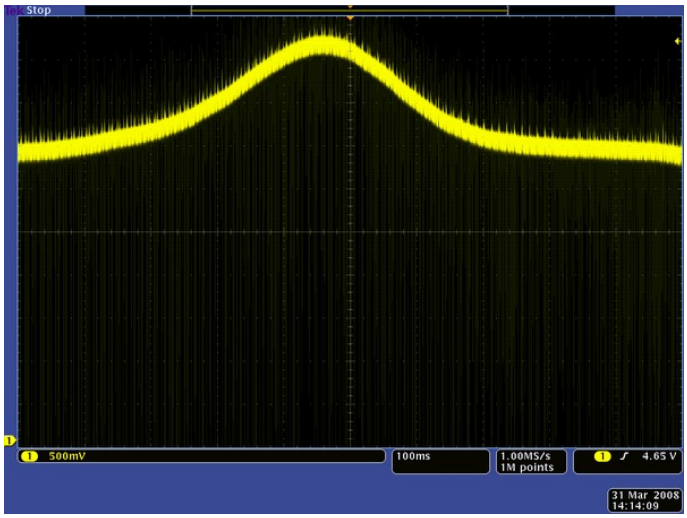

Figure 11: Example output of QTR-1C Reflective Sensor **[6]**

The interface of the infrared sensors will be as in the figure below. To the side of the faucet, the sensors will be placed side by side, where the hand movements will occur. They will be fixed on to the faucet, and will be covered for water-protection and good looking.

Figure 12: Sensor Interface

d. Electric Motor

We require 10N*1cm= 0.1Nm=100mNm of maximum torque. We will use a lower power consuming and small sized electric motor with a reducer. We will use a servo electric motor, which can generate a 1,5 kg/cm of torque, which will satisfy our requirements easily. Another important issue is the rotating speed of the motor, hence the speed of water adjustment. The motor rotates 60 degrees in 0.08 seconds which will easily handle our requirement. The adjustment will be done in a 180 degree axis, with one end cold and the other hand corresponding to hot water. The motor is working with 6 volts as we require, since our power supply is a 9 volt battery. We chose a lower power motor as it will be enough for us, and we require power consumption to be minimal not to suck up the battery. Since the motor will work for 1-2 seconds on average each usage, the energy consumption is not trivial.

Torque: 1.5kg/cm

Speed: 0.08second/60degrees

Height: 23mm Width: 12.2mm Length: 29mm Weight: 9 grams

Our range is [-90, 90] 180 degrees for the motor. Servo motor can be directly controlled by the microcontroller that we chose. Using a single output pin, the motor determines what to do with respect to three different signals that are sent to the servo motor. First one rotates the motor to the left, the second one stops the motor, and the last one rotates the motor to the right. Hence we can easily control this motor without using any device in between the motor and the controller.

Mechanically, the shaft of the motor and the heat valve of the faucet will be fixed with a metal piece, or directly with the internal shaft of the valve. For both parts, the rotation of the motor and the valve will be the same, [-90, 90] 180 degrees. The interface is shown below in the figure, where the motor shaft and the valve shaft will be fixed core to core. For safety, the motor will have a waterproof enclosure which will also hide the motor for a nicer look.

Figure 13: Faucet + Servo Motor (HD Mikro Servo - HD1900A)

e. Battery

Our requirements for the whole system are 5 to 9 volts range, and 25mA to 250mA current range. The electric motor will consume most of the power with 1-1.5 Watts; and together with the microcontroller, LEDs, sensors, and other circuit components, total power requirement will be around 3 Watts. We will use a 9-V Alkaline DC Battery. It will outperform a standard 500 mAh which will satisfy our requirements.

Height: 48.5 mm Width: 17.5mm Length: 26.5mm Weight: 400 grams

Figure 16: 9V – Battery [8]

6. Product Tree & Stock Numbers

SF-001-xxx: Electronic Parts
SF-002-xxx: Mechanical Parts

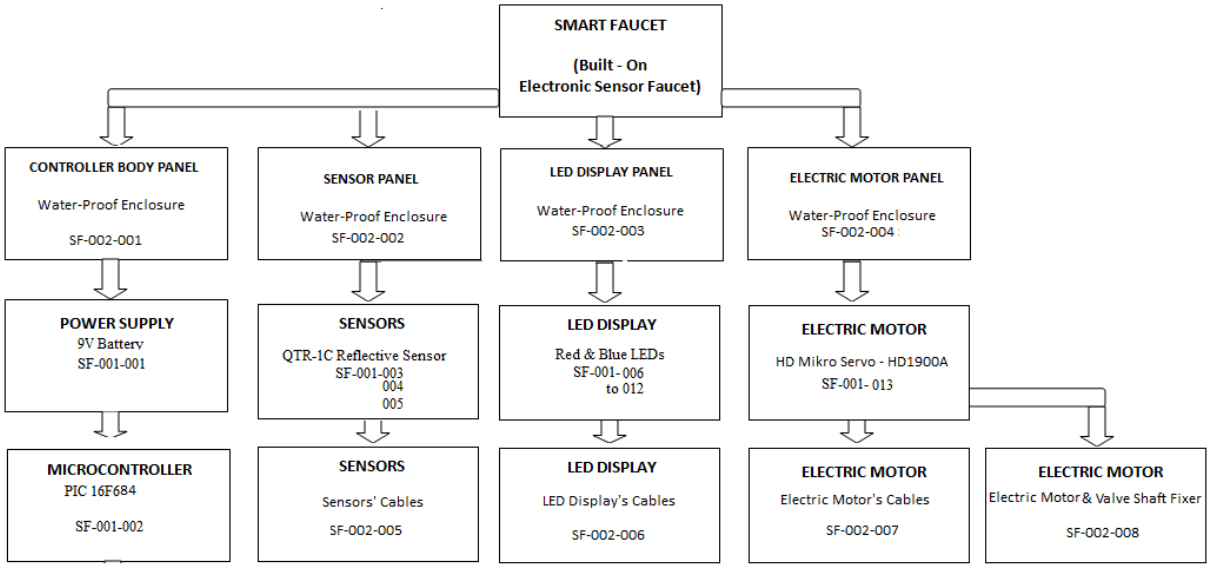

Figure 15: Product Tree with Component Details and Stock Numbers

7. Standards

We are not using any protocols or standards that are widely used, our product will have **ISO9001:2008** standard for quality managing of both the product and the company.

EN 50065-1:2001—Signaling on low-voltage electrical installations in the frequency range 3 to 148.5 kHz—Part 1: General requirements, frequency bands, and electromagnetic disturbances; Amendment A1:1992 to EN 50065-1:1991; Amendment A2:1995 to EN 50065-1:1991; Amendment A3:1996 to EN 50065-1:1991.

References

1) **Faucet**
http://www.tekzen.com.tr/newsite/prd-657815001-rainy_fotoselli_batarya.aspx

2) **LEDs**
http://i.ytimg.com/vi/LqnXRdc4KFs/0.jpg

3) http://www.melrose-nl.com/membrane_led_spec.pdf

4) **Enclosure**
http://altinkaya.com.tr/El_Tipi_Kutular/HH-004.html

5) **PIC 16F684:**
http://ww1.microchip.com/downloads/en/devicedoc/41202c.pdf

6) **QTR-1C Reflective Sensor:**
http://www.pololu.com/catalog/product/958/pictures

7) **HD Mikro Servo - HD1900A**
http://www.robotus.net/motorlar.asp

8) **Battery:**
http://photonlight-com-inc.amazonwebstore.com/Maha-PowerEx-MH96V230-Battery-rechargeable