SmartWalker

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***Abstract* — The purpose of this project is to build a walker that enhances the convenience and comfort for elderly people that need assistance in getting around. The walker will be remote controlled so that the user does not have to worry about leaving the walker at some distance away and having to move and get it under their own power. They can instead use the controller to bring the walker to them.**

***Index Terms* — DC Motors, Displays, Motor drives, Receivers, Remotely operated vehicles**

I. Introduction

The main goal, above all, for this project is to create a lightweight, portable multifunction walker whose main function is to make day-to-day life easier for the user. The *SmartWalker*, also referred to as the walker in this document, will have a remote control that will be able to control the walker. This will allow the user to move the walker for without having to move. If the user is in need of the walker and cannot reach it, they will be able to use the remote control to bring the walker to them. The SmartWalker will also have a camera mounted on it to live stream video to the remote control so that the user can see where the walker is going. The SmartWalker will have the ability to carry a significant amount of weight, up to 200 lbs. (The walker itself is weighs approximately 15 lbs.) so that it may provide ample support to the elderly user. Due to the readiness ability of the *SmartWalker*, we should optimize its power consumption the best we can. This can be done by reducing charging time and using components that use very little power. Since we are building this project with the idea of helping senior citizens, we should make it as light-weight and easy to handle as possible so that it isn't a burden to move from place to place. The walker will also preferably have a storage area for everyday items that the user will need nearby for their convenience. The design should be done in the most efficient way in terms of power consumption, responsiveness and real-time readiness of the system. Effective engineering principles and values must be practiced carefully throughout the entire design to achieve the best possible solution using the least amount of resources, whether it be cost or labor. The complete and final product should be user-friendly and self-explanatory.

A. Description and Specifications

The group will construct a remote control that will have buttons to control the direction that they wish the walker to go. The user will be able to see where the walker is going by viewing a screen that is in the remote control. The controller will communicate with the walker via a radio frequency (RF) transmitter and receiver. The walker will receive the control signals from the remote control and drive the wheels of the walker in the desired direction. The video will be streamed from a camera. Once the signal is received from the controller, the wheels will steer the walker. For specifications the SmartWalker shall:

- weight less than 50 pounds
- be able to support up to 200 pounds of weight
- travel no faster than 3 mph
- have no more than a 2 second delay in video streaming and control
- be able to sustain functionality for up to 2 hours without recharging
- be able sustain functionality up to 100 meters away from the walker

II. Subsystem Interfacing

The three main subsystems that will be communicating in this project are the remote controller sending the user's commands to the walker, the walker controlling the motors to drive the walker in the direction commanded by the user, and the camera transmitting live video to the remote control for the user to see where the walker is going. The remote control has switches for the user to input their desired commands and those signals will go through an encoder to be sent to the walker by a RF transmitter/receiver combination. Once the signal reaches the walker it will be decoded and the command will be given to the motor driver. The motor driver will then power the motors in a fashion that drive the walker in the desired direction of the user.

A. Remote Controller Interfacing

Shown below in Figure 1 is the block diagram for the remote controller which is about in this section.

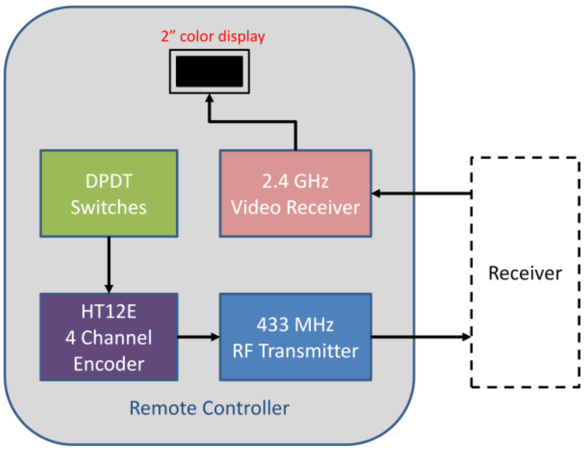


Figure 1: Remote Controller Block Diagram

All control signals that user inputs via DPDT switches will first go through the HT12E RF encoder. The HT12E, and its partner the HT12D, are CMOS ICs with 8 address bits and can process up to 4 bits of data at a time. The HT12E has a serial ouput that begins when the enable TE (pin 14) becomes low. The 4 bits of data are then transmitted through the Dout pin (Pin 17). The four bits will be used to represent forward, reverse, left and right. Rather than using four separate buttons, 2 momentary on/off DPDT switches are used. Shown below in figure 2 is the schematic for connecting the DPDT switches. This type of configuration is commonly used to reverse the polarity of voltage applied to the motors which is required in order to make the DC motors spin forwards and backwards when desired.

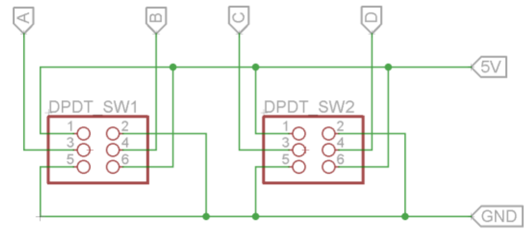


Figure 2: Control Wiring Schematic

The outputs of the HT12E encoder will be sent to the RF433 transmitter. We chose the Linx RF433 transmitter and receiver, shown below in figure 3, for its low power use.

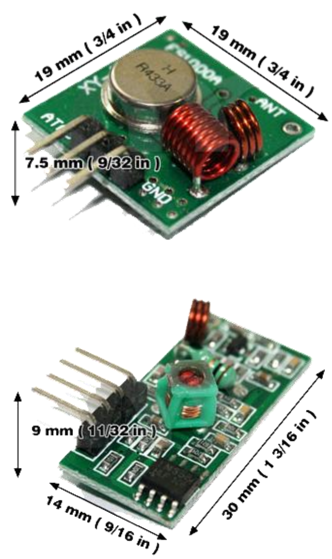


Figure 3: RF433 Transmitter (top) and Receiver (bottom)

The transmitter has a transmission power of 25 milliwatts (315 MHz at 12V) and a maximum transmission velocity of 10 Kbps. The transmitter module is rated for voltages from 3 to 12 volts and a max current of 40 milliamps at 12 volts input. We plan to run the transmitter at 5 volts which means the power will be even less than that. This allows us to increase our battery life while still meeting our signal transmission needs. The layout of the remote controller that is fabricated for this project is shown in Figure 4.

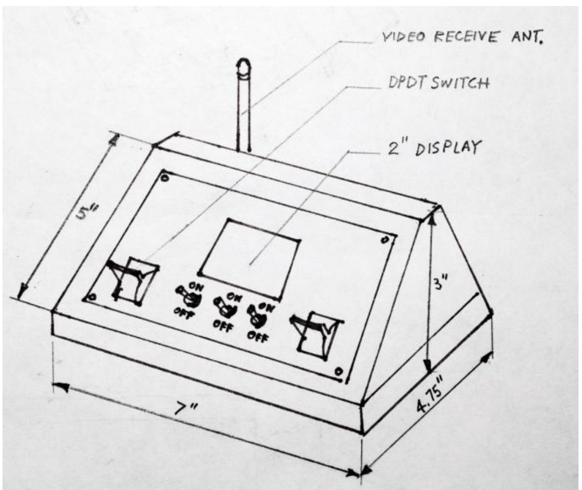


Figure 4: Remote Controller Layout

As you can see, the DPDT switches are located near the bottom corners giving a user-friendly, easy-to-understand control system. The three switches in between the DPDT switches are for (from left to right in the figure above) turning the remote controller on and off, turning the video display on and off, and turning the video receiver on and off. The screen shown above the switches will be where the user can view the video streaming from the camera mounted on the walker. The device used to receive that video will be the 2.4 GHz 4-channel Wireless Audio/Video Transmitter/Receiver, shown in figure 5.

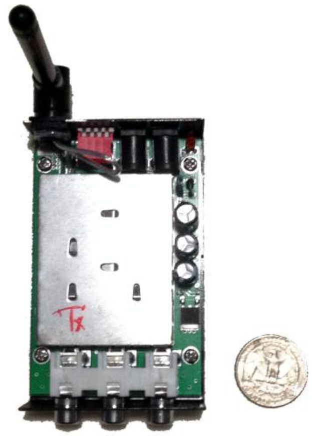


Figure 5: 2.4 GHz Audio/Video Transmitter/Receiver

The transmitter for the video will be located on the walker and will be discussed in further detail later in this document. The receiver will take in the video and display it on the 2 inch screen inside of the remote control via RCA connector. The receiver requires 9 volts DC and a current of 180 milliamps which means it will only consume a small amount of power. This will help towards increasing our battery life. This concludes the components located in the remote controller. Shown below in figure 6 is our PCB layout for the controller.

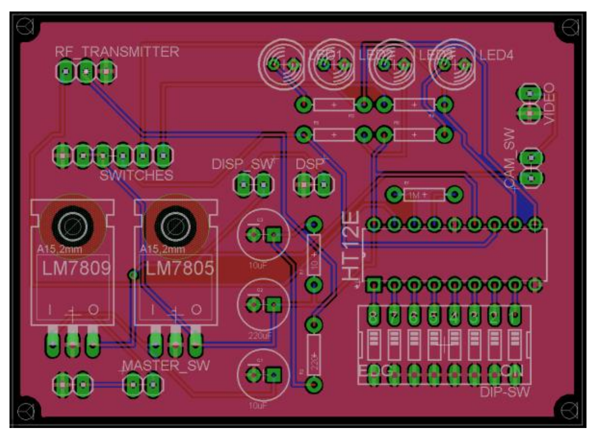


Figure 6: Remote Controller PCB Layout

B. Receiver Interfacing

The receiver will be located on the walker and will complete our wireless communication circuits between the remote controller and walker. Shown in figure 7 is a general block diagram of the receiver interfaces.

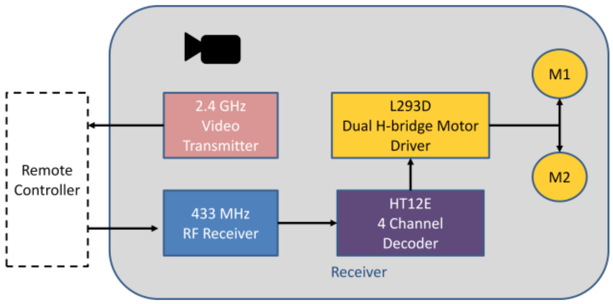


Figure 7: Receiver Block Diagram

The RF433 Receiver will first take the transmitted control signals from the transmitter on the remote controller. The RF433 receiver has a bandwidth of 2 MHz and uses slightly less power than the transmitter. It requires an input voltage of 5 volts DC and has a working current of 5.5 milliamps. The RF433 transmitter and receiver combined only use approximately one eight of a watt of power which is great for our battery life. This increases the convenience for the user by not forcing them to charge the system so often. After the control signals are received, they are sent from the RF433 to the HT12D. This component will decode the signals sent from the encoder located in the remote controller. The decoder will take the signal sent from the controller decode it into a forward, backward, left or right signal and send it to the L293D motor controller. From there, the L293D will control the two motors in order to drive the motor in the direction commanded by the user. Also on walker side of our project is the camera. The camera will stream video to the display on the remote control through the 2.4 GHz Wireless Audio/Video Transmitter that was mentioned before. The transmitter takes the video from the camera via RCA connector and sends the video to the receiver on the remote control. This 2.4 GHz transmitter/receiver was chosen for this project because of its wireless video transmitting capability, its ease of installation and operation, and its ability to transmit over a range suited for this project. The 2.4 GHz has adopted advanced microwave wireless transmission technology giving it the ability to send high quality video and audio signals. It picks up very little interference due to the fact that it uses frequency modulation. This ensures a strong, clear signal being viewed by the user during operation of the SmartWalker. The 2.4 GHz transmitter/receiver is also versatile. It can be used with CCTV cameras, DVD players, and of course video cameras. This helped in our decision process by showing us that by being versatile it must be easy to manipulate for whatever application is needed. Shown below in figure 8 is the PCB layout of our receiver that will be placed on the walker.

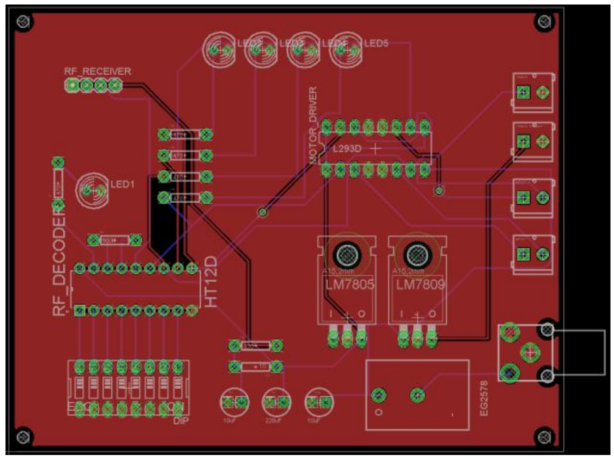


Figure 8: SmartWalker Receiver PCB Layout

C. Camera Interfacing

The camera used for the video streaming is going to come from a Q-SEE security camera with RCA video output. The camera will connect directly to the RCA connector of the 2.4 GHz video transmitter which will send the video the receiver in the remote control which will then show the video stream on the 2 inch display. The camera has night vision capability up to 40 feet and 400TV Lines of Resolution. This will provide the user with a quality picture and they can use the *SmartWalker* at night with less limited vision. The display that the video will be shown on is an OEM Colour TFT Monitor. It consists of a TFT screen with an associated control board connected by a flat flexible cable. The screen has a wide power supply range of 5 to 12 volts and a low power consumption. The OEM module only draws 120 milliamps of current at 5 volts.

D. Power System

The SmartWalker will be powered by one battery pack. The Pitsco TETRIX 12V Rechargeable NiMH Battery is used to provide power for the motor directly. The battery was purchased with a charger that connects to the battery via tamiya connectors. The charger features over charging protection which decreases the current flow when the battery voltage reaches a certain threshold. This will protect the battery's capacity over the course of numerous recharges. In order to connect the battery to the circuit, a tamiya connector adapter that will allow the power from the current to be connected to the receiver circuit without damaging the connectors. The remote controller part of the project will be powered by a smaller 5 volt rechargeable battery pack with bare leads. Other components require lower voltages of 3.3 and 5 volts. These voltages will be provided from linear regulators. The components requiring 3.3 volts will have a LM1117T-3.3 providing their input power. The 5 volt components will have their input power provided by the uA7805CKC. These regulators are a simple and cheap solution to the voltage regulation needed for our smaller electrical components.

III. Physical Design Aspects

A. Walker Modifications

The SmartWalker's physical design will consist of a standard rollator with a few modifications. The original rollator that will be modified into the SmartWalker is shown in Figure 9.

Figure 9: Original Walker

The SmartWalker is going to have a sheet metal platform welded horizontally underneath the seat cushion of the walker to serve as a holder for the battery, PCB and camera. On the sides of that platform will be two more plates hanging vertically that will serve as a mounting service for the two motors. The bottoms of those vertical plates will be connected by another plate that will serve as support for the weight of the motors. Together these plates will form a rectangular shell for our electronics. In addition to that rectangular shell will be L-shaped pieces attached at the top of the vertical pieces that will hang down parallel to the vertical plates that will serve as mounting points for the additional wheels. We will be using DC geared motors for this project, the specifics of the motors will be discussed later in this document, and will not turn freely. Therefore, in order to maintain manual use of the walker without needing the remote control, it was decided that the motors mounted on the side of the walker will directly spin two discs with a single hole drilled through them. The wheels mounted on the bracket will also have an opening of similar size to the hole on the discs. If the user wishes to drive the walker with the remote control, a rod must be inserted between the disc and the wheel so that when the motor spins the disc it will also spin the wheels thus driving the motor. When manual use is desired, simply remove the rod and the wheels will be allowed to turn freely. The motors used for the SmartWalker will be DC geared motors which are unable to turn unless powered. In order to enable manual use of the walker by the user, two wheels smaller than that of the wheels shown in the picture above will be driven by the motors. When motor drive is desired a small rod will be inserted between the two wheels causing the motors to turn both wheels thus driving the walker. When manual use is desired, the rods will be removed and the original walker's wheels will be allowed to turn freely.

B. Motor

In choosing a motor for this project the attributes that were taken into consideration were the cost, reliability, and low speed - high torque capability. The motor needed for this project is one that is cheap, can push a heavy load at a slow speed, and won't break. After researching many different options between AC and DC motors it was decided that a geared DC motor would be used due to its reliability, simplicity, and low speed - high torque ability. The motor chosen was the Wondermotor 12V DC Reversible Electric Gear Motor, shown in figure 10.

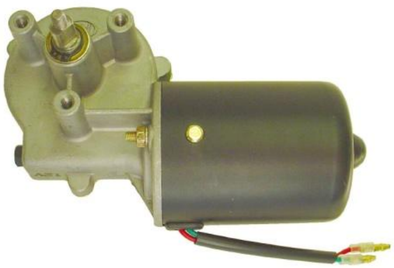


Figure 10: Wondermotor 12V DC Reversible Electric Motor

This is a simple 2-lead motor that is rated for 13.5 volts DC which is easily supplied by a battery that won't require any additional components in order to power. The rated power is 60 watts which will decrease our battery life but the low power consumption of the rest of the project will make up for it. The rated speed is 50 RPM which is a good speed for the walker to move at when the user is controlling it. At 50 RPM and knowing that the walker has wheels with 8 inches in diameter, the maximum speed it can obtain is approximately 2.37 miles per hour. It's not too fast as to where the elderly user could lose control and crash but it's also not too slow so that the user doesn't have to wait very long if they drive it correctly. The rated torque is 8.5 ft-lb which provides enough power to drive the walker along with any possible small possessions that the user may store on board the walker. As you can see in figure 10, the motor is a right angle worm gear which makes the mounting of the motors easier. Also, due to the fact that the motor is DC powered, simply reversing the polarity of the applied voltage allows the motor to spin in the opposite direction which gives the walker the ability to go forwards and backwards. Two of these motors working together on opposite sides of the walker is what will drive the walker. How the motors will work together will be discussed in the next section.

C. Motor Drive Method

As previously described in this document, the motor driver will take command signals from the decoder and power the motors accordingly in order to cause the motors to drive the walker in the desired direction. In deciding this section of the project, a few different steering options were considered. It is important to note that the front wheel, the wheels furthest from the user when holding the grips, rotate freely similar to a front wheel drive car. The back wheels, the wheels closest to the user when holding the grips, are fixed and cannot turn. With this in mind, we looked at four different steering options. The first option was to control the front wheels for steering purposes while driving the back wheels for propulsion like a front wheel drive car. The second option was to modify the wheels so that all four wheels can be used for steering and propulsion. This configuration is often used in heavyweight vehicles that run on uneven, less-traction terrain. This configuration isn't ideal for this project since it is unlikely that any uneven terrain will be encountered. The third option was to add a single wheel in the front that would be used to drive and steer the walker. The fourth option was to have two driving wheels that only travel in a single direction but can still be used to steer by only moving one wheel at a time. This method has also been called "tank drive mode." This method works by propelling both wheels in the same direction to move forward and backward in straight lines and moves the wheels at different speeds in order to turn. For the vehicle to turn left using this method, the right wheel will turn faster than the left wheel causing a rotation about the z-axis for the vehicle and vice versa for turning right. This method was selected due to its simplicity and the availability of the back wheels being fixed which meant less modification to the walker. The motors are mounted on the back wheels and the walker is driven with the back wheels leading. From here on, the walker will be called driving "forward" when the fixed wheels in the back are leading and "backwards" when the walker is driving with the front, rotating wheels leading. This allows the "tank drive" method to be implemented and makes sense ergonomically since the grips will be closer to the user if they are driving the SmartWalker to themselves. A table of how the motion of the motors will result in the direction of movement of the SmartWalker is shown below in table 1. In order to simplify the drive method even more, the motors will not be set at different speeds in order turn. In order to turn left, the right wheel will be set to forward and the left wheel will remain stationary and vice versa for turning right.

Direction of SmartWalker	Motion of Motor	
	Left Motor	Right Motor
Forward	Forward	Forward
Reverse	Reverse	Reverse
Left	Stationary	Forward
Right	Forward	Stationary
Stop	Stationary	Stationary

Table 1: Motor Motion vs. Direction of SmartWalker

When the user pushes the left and right DPDT switches, the motor driver, upon receiving the commands, will power the respective motors in the commanded direction. For instance, if the user wishes to turn left they will push the right DPDT switch forward causing the right wheel to drive forward along with leaving the left wheel in the off position. These simple controls combined with this drive method is a simple and easily understood method of driving the walker for an elderly user. It isn't the smoothest option, but it does allow for turning around tight corners and it's slower motion makes it less likely that the elderly user will lose control and cause damage to the SmartWalker or other objects. The motors are mounted in a way such that the rotors of the right and left motors are facing each other. This means that they will actually have opposite applied voltages in order to drive the walker in the same direction. If you're looking from the grip side of the walker where the user would grab hold, the left motor will have to spin counterclockwise in order to drive forward while the right motor would have to spin clockwise. This means when the SmartWalker is commanded to drive forward that the left motor will receive a negative voltage and the right motor will receive a positive voltage. This logic outputs of the L293D motor driver reflect this system. The logical outputs of the motor driver are shown below in table 2.

Motion	L293D Output Terminals (Motor Input Terminals)			
	1Y (+ Motor 1)	2Y (- Motor 1)	4Y (+ Motor 2)	3Y (- Motor 2)
Forward	1	0	0	1
Reverse	0	1	1	0
Left	0	0	0	1
Right	1	0	0	0
Stop	0	0	0	0

Table 2:L293D Output Terminals per Direction

Note that Motor 1 is considered the right motor and Motor 2 is considered the left motor when looking from the grip side of the walker. With these logical outputs, the user will control the walker intuitively and won't be distracted by a complex drive method. The motor control connections to the motors are shown below in figure 11.

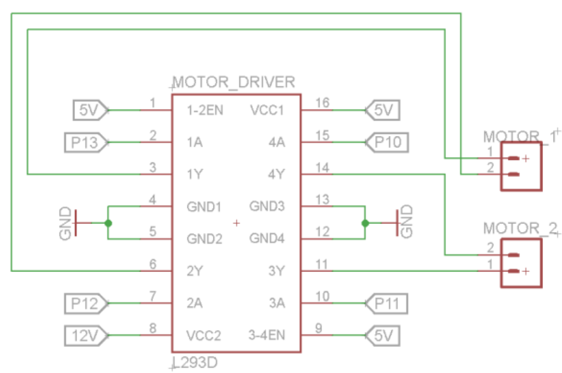
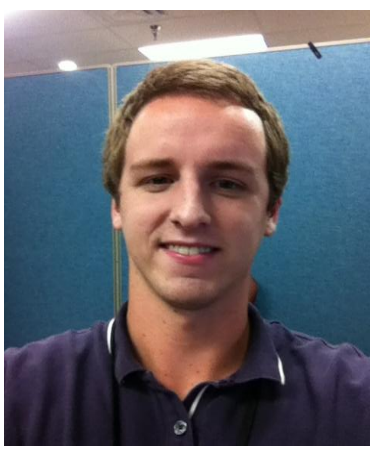


Figure 11: Motor Control to Motor Interfaces

IV. Conclusion

In conclusion, the weight of the walker has not exceeded our specification weight of 50 pounds total so that it can be lifted and transported if necessary. It can support up to 200 pounds so that the user may lean and sit on the walker as necessary to provide comfort. The motors are chosen for this project such that the walker will not be able to travel faster than 3 miles per hour which increases the safety by not allowing the walker to move too fast for the user. The transmitting and receiving devices have been picked out with enough power to send/receive signals fast enough such that the delay between sending a command and getting a reaction for controls along with video streaming is much less than 2 seconds. This will make for easier use of the *SmartWalker* without having to deal with any lag time during operation. The components will draw a low enough amount of power such that the batteries will be able to sustain 2 hours of use without needing to recharge. The transmitting/receiving devices have been picked such that the user will be able to control the walker at distances up to 100 meters.

Biography



Mike Orr is a 23 year old Electrical Engineer currently working at Lockheed Martin through the CWEP Program at UCF. He is seeking employment but is also considering grad school for a MBA or Master's in Electrical Engineering.

Loc Truong is currently a senior at the University of Central Florida majoring in Electrical Engineering. He is also a guardsmen in the Florida Air National Guard as an Electrical Power Production Journeyman. Upon earning his Bachelor of Science in Electrical Engineering in December 2013, he expects to get commissioned by the USAF.

DangKhoa Le is currently a senior student of the Electrical Engineering department at the University of Central Florida. DangKhoa's goals after graduation are to pursue a career at companies like Lockheed Martin or Siemens. He might also continue his study at University of Central Florida for to obtain his master degree in Electrical Engineer. His main interest lies in designing circuits and working with power systems.

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