

Wireless Rear Derailleur – Project Plan

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September 18, 2022

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MR3016 – Project of Mechatronics Engineering

ITESM



Introduction

The project's objective is to research and develop a mostly universal wireless rear derailleur that can compete with available market options by being a cheaper yet good quality alternative with an added value by being easily serviceable on most of its components. The solution will focus on removing a cable connecting the cockpit to the derailleur and will try to keep the most original components possible, the shifter at the handlebar can be completely replaced if no universal solution can be applied to the existing shifter, however, the rear derailleur must be kept original for the solution to be cost effective.

Furthermore, a working prototype will be manufactured and attached to a bicycle, and the project is intended to be featured on *Expo Ingenierías*. For the project to be considered successful, the drivetrain must be capable of shifting between cassette's positions and be tunable to compensate for slack on the shifter cable. Documentation to replicate the project and facilitate a mass production model will also be provided as part of the deliverables.

Background

The bicycle as a mean of transportation and sporting tool is required to maintain safety features and a way of transmitting power from the crankset to the rear sprocket, features that can be controlled one way or another, one of the most popular means to do so is by using levers situated on or near the handlebar on what can be called the cockpit which, depending on the number of features, can be more or less cluttered, making maneuverability difficult and the bike heavier. On flat and consistent roads, the braking system of a bicycle can be implemented on the rear hub and used by turning the crankset backwards, and there might be no need for multiple sprocket ratios to create multiple speeds, thus a single speed can be used, then you'll leave the cockpit with not a single lever. However, for mountain and road biking, the braking power that a rear hub brake provides is way less than enough for safety reasons, thus, levers for operating hydraulic brake systems for both wheels are an industry standard, those are, then, two levers with cables that must be part of the cockpit; also, a way of changing between different sprocket ratios to facilitate riding on uneven roads, such is the case for mountain and road biking, is needed.

Modern mountain bicycles have only one rear derailleur for shifting, this gets rid of the front derailleur thus reduces weight and gets rid of a lever and cable at the cockpit. Assuming the two levers for braking are completely necessary, there is only the shifter lever that can be optimized. Since normal commuters rely only on moving to one point to another, the solution of getting rid of the cable that connects the shifter from the rear derailleur is targeted to the enduro rider that can benefit from having less cables to get caught up into things, as well as the mountain rider who can be interested on having a less cluttered cockpit for the sake of a better looking bicycle which is, in fact, a big market.

Current solutions already exist on the market, however, although they are brand-name products with reputable quality, there are some disadvantages to using them: they are proprietary systems, for instance, if a person is to buy a SRAM Wireless Derailleur system, that person must also buy

the rear cassette, shifter lever, and sometimes, even the chain and crankset of the same brand for it to work properly; furthermore, the prices for these systems can range from 1453 to 2690 US dollars according to SRAM's manufacturer website¹. Giving room for much cheaper and universal alternatives since there is also little competition on the market.

Project Proposal

The main proposal and the testing case for the project is focused on rear shifting only, using a stock nine-speed cassette, with the original rear derailleur. As shown on Fig. 1, the main proposal works using a shifting module mounted near the rear derailleur and connected with a cable. Note that this cable will run along either the chainstay or the seatstay, keeping a low profile and keeping sense to the wireless characteristic of the system.

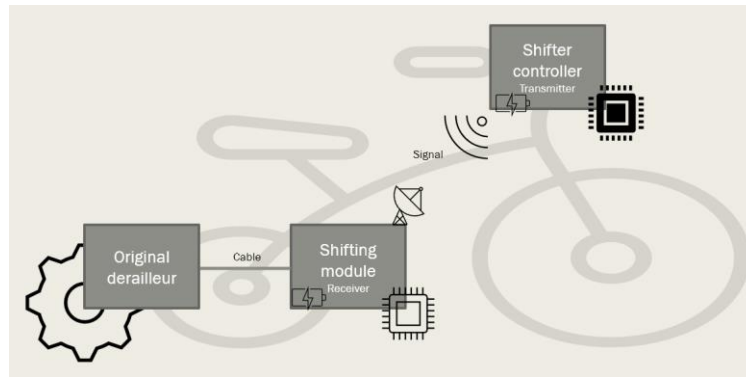


Fig. 1. Compact diagram of the proposal.

There will also be a shifter controller on the handlebar for controlling both up and down shifting and two buttons for tuning the cable's tension as needed. The communication between the shifter and the shifting module will work on a 2.4GHz radio interface with four channels. Both the shifting module and the shifter will have a sturdy case with at least IP5 rating for water resistance, easy to service with removable batteries and battery level indicators. The main elements of each module are shown on TABLE I, note that elements on parenthesis indicate that such element is optional if it turns out to be strictly required or there is time to further develop it.

Shifting module	Shifter
Stepper motor	Two shifting buttons
Motor driver	Two tuning buttons
Microcontroller	Levers
Signal receiver	Signal transmitter
Plastic case	Plastic case
Metal mounting bracket	Metal or plastic mounting bracket
Battery and indicator	Battery and indicator
Power management System	-
(Gearing)	-
(Control system)	-

TABLE I. Main elements of each module

¹ <https://www.sram.com/en/sram/models/gs-red-e-b1>

An additional and more detailed diagram is shown on Fig. 2, in which the two modules are shown as subsystems. For the shifter controller module, it will work on a 3V CR2025 Battery, it will have four buttons, each operated by either a lever or the button itself, each button will send a signal through each one of the channels of the 2.4GHz radio transmitter; this module will have a casing enclosing all electronic components and a battery indicator. For the more complex sub system, which will be enclosed on another plastic casing mounted on a metal bracket, a power management system will take care of energizing both the microcontroller and the motor/driver, the microcontroller (probably a programmable ESP-32) will power and manage the signals of the receiver to control the stepper motor; finally, there can be an optional gearing to facilitate the tensioning of the cable to shift the bike's stock derailleur.

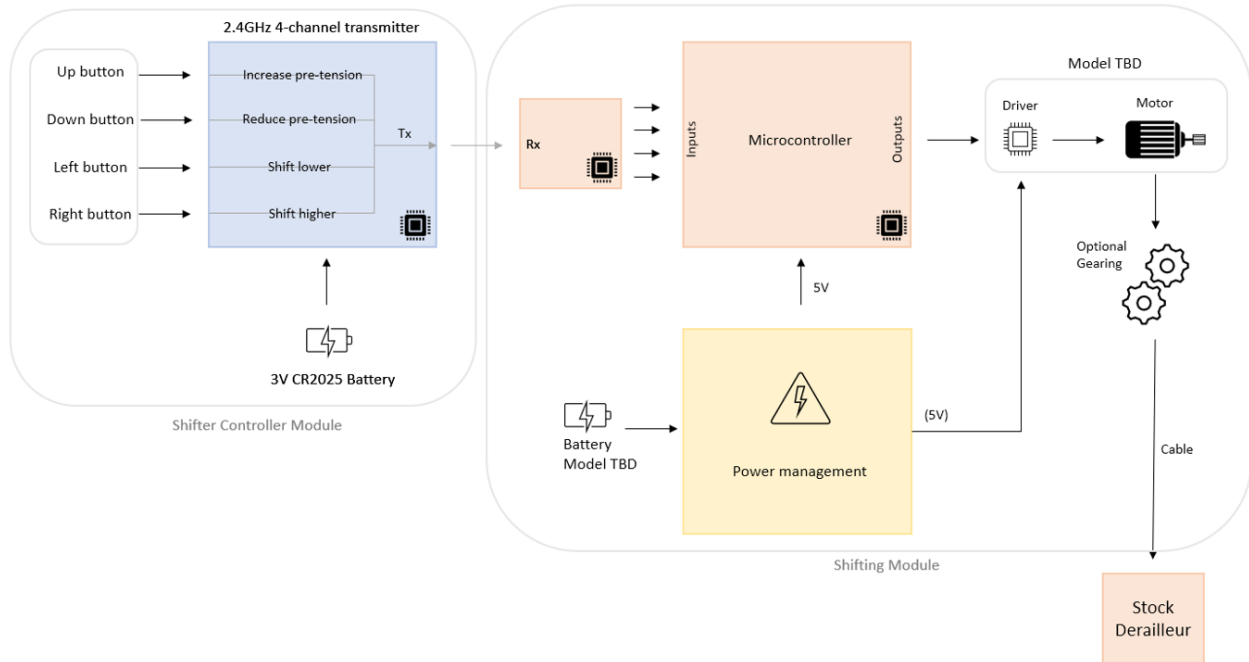


Fig. 2. Detailed system diagram.

As seen on the previous diagram, there are some parts or components that are already defined and/or selected, such components are shown on TABLE II. Additional components, which used to work on the prototype, are a 2014 *Alubike Sierra* bicycle, with a *Shimano Alivio* groupset and a 9-speed cassette. Note that, while the project will be tuned to work specifically on these settings and original components, it is also intended to be universal, since all derailleurs work under the same principle, shifting positions due to a tensioning cable.

Component	Part number or model
Shifter battery	3V CR2025
Shifting module battery	5 to 9 V TBD
Transmitter/Receiver	4CH 2.4GHz RC TBD
Motor	5V 28BYJ-48
Driver	ULN2003A
PCB Proto Board	TBD
Mechanical Misc.	Cables, Sheet metal, Bolts, etc.
Electronics Misc.	Resistors, Diodes, Cables, Soldering, etc.

TABLE II. Components list

Scope

For the project scope, keeping it simple, there must be research conducted on the mechanical part, it must meet all mechanical and electrical requirements listed on the requirements matrix shown on TABLE III. A working prototype assembled and mounted on a bicycle to demonstrate functionality. Complete documentation and mass production insights must be well reported. Furthermore, as specified on the introduction, this project is expected to be featured on the Engineering Expo at ITESM Campus Guadalajara on Fall 2022.

ID	Tag	Description	Additional info
1	Tension	Operate within a specific tension range (TBD) to prevent components from breaking or unnecessary movement.	Data and testing
2	Motor	Work on a 5VDC stepper motor, must be easy to service/replace by the user.	28BYJ-48 ROHS
3	MC	Work on a small microcontroller operating at 3.3V and 5V. Such microcontroller must be securely mounted on the casing.	ESP-32
4	Rx/Tx	Must have a low latency communication system with at least four channels.	2.4GHz RC 4CH
5	Gearing	Optional requirement in case the stepper motor does not meet the required torque necessary to shift positions on the rear derailleur.	Gear ratio and torque
6	Power	The main system must work on 5V and have disposable batteries or rechargeable ones. Easy to service. This includes the power management system or PMS.	Batteries and PMS
7	Mechanism	It must have a (mostly) metal drive. Plastic parts are okay for the prototype, but all-metal alternatives should be readily available.	SolidWorks
8	Casing 1	A sturdy and compact casing capable of withstanding impacts and fit every component.	SolidWorks
9	Casing 2	A sturdy and universal casing that is easy to operate and maintain.	SolidWorks
10	Molding	Casing must have a designed and documented mold for mass production.	SolidWorks and CNC
11	Water res.	Must have some degree of water resistance.	IP5
12	HMI	Must have a battery life indicator.	LED
13	Control	Optional requirement in case there is enough time to develop. An automated control system that detects slack on the cable and tensions it back to operating specs.	Control algorithm
14	Assembly	Must have an assembly diagram sheet.	Report
15	Manual	Must have an instruction manual.	Report

TABLE III. Requirements matrix.

Preliminary Project Plan

Schedule

Using a Gantt, shown in the following pages, the project is scheduled to deliver a midterm report on October 19, and the final report on November 30.

Wireless Rear Derailleur

Planning

Buy parts

- Order on-line
- Microcontroller ESP-32
- RC Tx/Rx 2.4GHz
- PCB Proto Board
- Li Battery ~5V

Project Plan Document

- Work on Document
- Document delivery

Project Status Report

- Work on Document
- Document delivery

Final tasks

- Testing and Tuning

Project Report

- Work on Document
- Document delivery

Programming

Motor Testing

- Shifting Algorithm
- Tuning Algorithm

Buttons

- Button delay
- User feedback

Testing 1

Wireless communication

- Transmitter testing
- Receiver algorithm
- Testing 2

Mechanics

Shifting Module

Bracket

- Design
- Manufacture prototype
- Testing

Transmission

- Design lever or gearing
- Manufacture
- Testing

Casing

- Design
- Manufacture
- Testing

Cable

- Manufacture

