Wireless Surface Leveller using Accelerometer

Amey Narvekar
EXTC Dept.
ACE Malad
Mumbai India

Akash Mishra
EXTC Dept.
ACE Malad
Mumbai India

Saurabh Nene
EXTC Dept.
ACE Malad
Mumbai India

Aditya Divekar
EXTC Dept.
ACE Malad
Mumbai India

Prof. Jyoti Dange
EXTC Dept.
ACE Malad
Mumbai India

Abstract*— In this project, we are using a pair of FRDM Kl25Z board which works on high-performance ARM cortex M0+ processor working at a frequency of 48MHz along with nRF24l01p modules that are basically Transceivers and multiceivers pairs used for wireless communication in our project. We will use accelerometer MMA8451Q which is a Capacitive sensing accelerometer on FRDM Kl25Z board. The accelerometer used here is to get the values of x, y, z-axes. These values are the relative values and not the absolute one. They are relative with Earth's G-force. As we incline the board i.e. change the inclination of the board at the transmitter side, the values of x, y, z-axes taken by accelerometer will change. The values range from -2 to +2 but this range is not appropriate for our further programming. Hence the values are scaled for better precision. Using the nRF24l01p modules these values are sent to the receiver. The values received at receiver side are stored and according to the values the board is programmed to provide electrical signals to the mechanism. The mechanism consists of two motors namely a Servo motor and a Stepper motor. The Servo motor is connected to the surface for its inclination. The stepper motor controls the rotation of the base corresponding to Y-axis inclination. By controlling the signals given to the motor we can incline the surface to the standard direction at any angle.

***Keywords*— FRDM-KL25Z board, ARM cortex M0+ processor, nRF24l01p module, MMA8451Q(Capacitive sensing accelerometer), Earth's G-force, Servo motor, Stepper motor.**

I. INTRODUCTION

This Standard pan and tilt systems that have been used with different systems all over the world which is the basic concept behind our project. Electronics like still cameras and video cameras are most commonly associated with these types of systems, but if you think about it even motion simulators like Star Tours at Disneyland is just a gigantic pan and tilt system. However, instead of building a motion simulator, we're going to stick with building a quick and easy system that provides us with the basics of wireless surface leveling. In this project, we will use a pair of nRF24L01p modules to build a simple wireless interface which will be used to wirelessly control a servo and stepper based surface leveling system which can move the surface at any angle in left-right-forward-backwards positions.

II. THE HARDWARE SYSTEM

A. FRDM Kl25Z board

The FRDM-KL25Z has been designed by NXP in collaboration with mbed for prototyping all sorts of devices, especially those devices that require the size and price point offered by Cortex-M0+ and the power of USB Host and Device. The package consists a development board with connectors in order to avoid the use of strip board and breadboard and includes a built-in USB FLASH programmer. It is based on the NXP KL25Z, with a 32-bit ARM Cortex-M0+ Processor running at 48MHz frequency. It includes 128KB FLASH Memory, 16KB Static RAM and lots of interfaces including USB Host and Device, SPI, ADC, DAC, PWM, Touch Sensor and other I/O interfaces and also consumes low power.

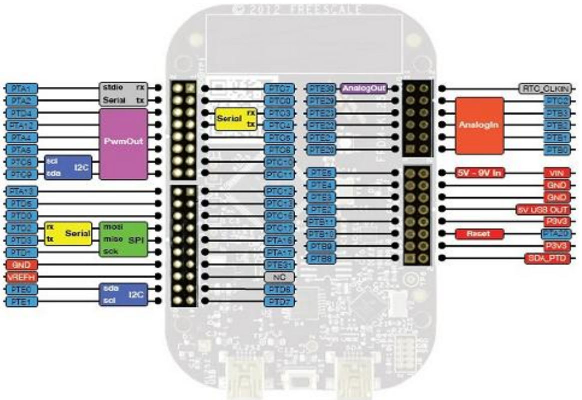

Fig 1. FRDM-KL25Z Pinout

B. MMA8451Q Accelerometer

The MMA8451Q is a smart, low-power, three-axis, capacitive, micro machined accelerometer having 14 bits of resolution. This accelerometer is packed with embedded functions with flexible user programmable options, configurable to two interrupt pins. Embedded interrupt functions allow for overall power savings relieving the host processor from continuously polling data. There is access to both low-pass and high-pass filtered data, which minimizes the data analysis required for jolt detection and faster transitions. The device can be configured to generate inertial wakeup interrupt signals from any combination of the configurable embedded functions allowing the MMA8451Q to monitor events and remain in a low-power mode during periods of inactivity. The package in which the MMA8451Q is available is 16 pin QFN, 3 mm x 3 mm x 1 mm.

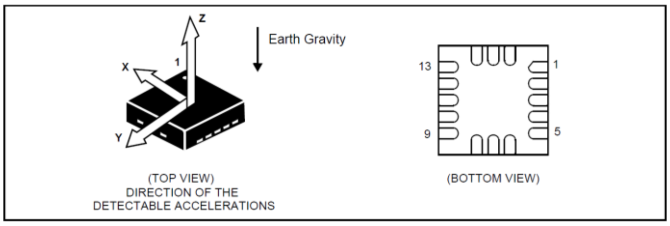

Fig 2. Direction of the detectable accelerations

C. nRF24l01p

The Nordic Semiconductor’s nRF21L01+ is a single-chip, 2.4GHz band wireless transceiver which is capable of up to 2Mbps air data rate, multi-point reception, and auto-acknowledge and retransmit. The nRF24L01+ consumes current of 11.3mA while transmitting, and 13.5mA while receiving. It has a simple 6-pin digital connection, which consists of a 4-wire SPI interface, an interrupt pin and dedicated enable pin. Spark fun’s module includes a chip antenna and claims a range of 100m.

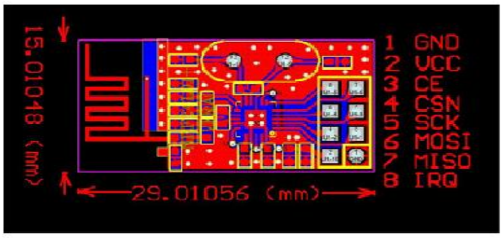

Fig 3. Schematic of nRF24L01p.

TABLE 1. INTERFACING TABLE FOR NRF24L01P AND MBED

nRF24l01p pins:-	mbed pins
GND	pin 12or14 (GND)
VCC	P3V3 (3.3V)
CE	PTD5
CSN	PTD0
SCK	PTD1
MOSI	PTD2
MISO	PTD3
IRQ	PTD4

III. MECHANISM

The mechanism is based on the fact that we cannot incline the surface in both x and y directions using a pair of motors, each attached to one axis since the motion of one is blocked by the other. To counter this we in our project use a stepper motor at the base to rotate the setup by 90 degrees and a servo motor at the top just below the surface to incline the surface to the desired angle within the range. The rotation of the base (90 degrees) allows us to change the axis and the same servo motor is used to provide inclination.

IV. BLOCK DIAGRAM

There are two block diagrams in our project:

A. Transmitter
B. Receiver

A. Transmitter:

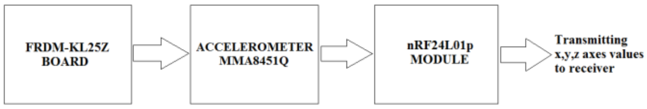

Fig 4. Block Diagram of transmitter.

Description:

In transmitter block diagram there are 3 main blocks:

- FRDM-Kl25z board: On FRDM Kl25z board there is ARM Cortex-M0+ processor working a frequency of 48MHz. It is a high-performance processor. It is having onboard sensors like accelerometer, capacitive touch sensor.
- Accelerometer: Accelerometer MMA8451Qis used in this project. This is a capacitive sensing accelerometer. The role of this accelerometer is to get the relative values of x,y and z-axes with respect to the G force. The values given by the accelerometer are scaled and given to nRF module for wireless transmission.
- nRF module: We are using an nRF24L01p module which wirelessly transmits the values(x,y,z) given by accelerometer to the receiver.

B. Receiver :

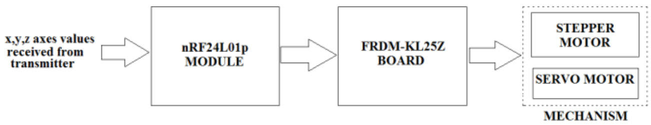

Fig 5. Block Diagram of receiver

Description:

In receiver side also there are 3 main blocks.

- nRF module: This module is used for the reception of values sent by the transmitter.
- FRDM-Kl25z board: The values received by nRF module is stored and processed using ARM Cortex-M0+ processor which is on board. According to the values received an appropriate signal is given to the mechanism.
- Mechanism: The mechanism consists of a servo motor and a stepper motor. After the signal is received from the Rx board appropriate supply will be given to the motors so that the surface will tilt at the required angle.

V. SOFTWARE USED

We are using an online compiler for programming of FRDM Kl25z boards. The link for the compiler is https://developer.mbed.org. This platform simplifies and speeds up the creation and deployment of IoT device based on ARM microcontroller.

VI. ALGORITHM

Transmitter:

1. Start
2. Get the values of x, y-axes from the accelerometer.
3. Scale the values according to requirements.
4. Send the values to the receiver using nRF module.
5. Go to step 2.

Receiver:

1. Start
2. Store the received values in the variables.
3. Rescale the values.
4. Check if the value of y is zero or not. If it is non-zero go to step 6.
5. Check the value of x-axis. If it is non-zero go to step 7.
6. Rotate the base motor by 90 degrees.
7. Incline the surface according to values of x-axis received.
8. Go to step 4.
9. End.

VII. MAPPING TABLE

Table 2. Mapping between accelerometer values and signals to be given to the motors.

Acc. Tx .output (x,y)	Command printed on serial terminal	Signal to Stepper	Signal to Servo
138<y<=192	Y(R45)	Steps =50 Direction= 0	Angle =45deg
62<=y<=118	Y(L45)	Steps=50 Direction =1	Angle= 135deg
135<x<=192	X(R45)	Steps=50 direction=0	Angle= 45deg
62<=x<121	X(L45)	Steps=50 Direction=1	Angle =135deg
118<=y<=138 121<=x<=135	X(0),Y(0) Rest position	steps=50 direction=0	Angle= 0deg

VIII. WORKING

At the transmitter side, we will tilt the transmitter board according to required surface inclination and the values of axes sensed by accelerometer will change. These values will be scaled and sent to Rx board connected at receiver side using a nRF24L01p module. At receiver side the values sent by transmitter will be received and rescaled; these values will be passed to the mechanism consisting of motors which will be responsible for the inclination of the surface.

IX. APPLICATIONS

- Hospitals: Can be used in hospitals for bed ridden patients to incline their bed (neck portion). Nowadays beds are remotely controlled instead of remote control this circuit can be used.
- Antennas: As the radiation from antennas is harmful to human health so to control the position of antennas this device can be used.
- Wildlife Photography: The prototype can be used to rotate the camera to the desired angle from a farther distance which is a very important aspect of Wildlife photography
- It can be used in chemical laboratory to work with the toxic chemicals.

X. CONCLUSION

Thus the project wireless surface leveller using accelerometer has various advantages and it has very good future scope in various fields. Also, this prototype can be converted into a full furnished product with some advancement in the present one.

XI. ACKNOWLEDGMENT

We would like to thank our professor Jyoti Dange Ma'am and our Electronics and Telecommunication department for helping us and guiding throughout with the project.

XII. REFERENCES

[1] https://www.youtube.com/watch?v=bfwbdHbL688
[2] https://developer.mbed.org/
[3] https://developer.mbed.org/users/Harshavardan61/code/StepperMotor/
[4] http://cache.nxp.com/assets/documents/data/en/data-sheets/MMA8451Q
[5] https://www.gme.cz/data/attachments/dsh.772-147.1.pdf
[6] http://embedjournal.com/stepper-motors-introduction-and-working-principle/