Czech Technical University in Prague

Department of Electromagnetic Field

BACHELOR THESIS

Two Axis Positioning Platform for Radar System

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Title: Two Axis Positioning Platform for Radar System

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Abstract:

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Název práce: Dvojosá polohovací plaforma pro radar

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Abstrakt:

Klíčová slova: klíčová slova, klíčové fráze

Contents

Introduction

1. Design parameters

First of all it is necessary to outline basic requirements we have for the platform. We need to Accommodate SiRad Easy©from Radar company and provide control over its tilt and rotation in horizontal plane.

Transmission of the data from the radar ought not to be impeded and platform itself must provide sufficient data about its movement. As the radar data processing will be handled in MATLAB the platform needs to provide interface that is accessible from MATLAB, serial line comes up as the most straightforward option.

1.1 Physical capabilities

Main design limitations on physical design stem from radiation pattern of radar used as we want to prevent strong reflections from the structure. According to 122 GHz Transceiver datasheet angular width (-3dB) is roughly ±30°[1] both in E plane and H plane. With addition of radar dome this values comes down to ±4° [2]. The radiation pattern of for 24GHz micropatch antenna was not listed by the manufacturer but we can assume it is similar to other products. Conservative estimate of ±15° based on designed [3] and [4] is used. According to these values we can set rather forgiving limits – ±45° of clearance in front of the radar.

Due to relatively low polling rate of radar system (1Mbit/s) highspeed movement is not necessary. Advertised maximal polling rate with rather crude FFT setting in 50Hz (new update every 20ms) from following equation

$$t_{\text{angle}} = \frac{60}{360 \cdot N_{\text{RMP}}} \cdot \alpha, \tag{1.1}$$

where t_{angle} is time between spend on traveling angle of α in seconds and N_{RMP} is number of rotations per minute, we can get that even for low RPM of 60 the angle of 8° (angular width of main lobe for 122 GHz radar) is traveled in 10ms. Thus the information from radar at such speed will be heavily distorted.

1.2 Software requirements

Since G-code is widely used industry standard for controlling most multi-axis machines it is natural choice for our platform. Aside from basic functionality found in many G-code interpreters we need to provide some additional capabilities to not overburden the user with manual control. These include ability to set limits on movement or being able to preprogram movements which the platform will then execute on its own.

In terms of uplink user needs to know current position of the platform and have information about its current speed in order to make mathematical correction to the data gathered by radar. Since the platform is not concerned with what antenna is currently used calculating speed of the radar itself is not possible as different antennas wile have different angular speeds on the tilt axis. Thus the platform needs to provide information about its current position in relatively frequent intervals in order to enable an accurate calculation of speed in MATLAB.

2. Hardware construction

As we need to facilitate continuos rotating motion use of slipring was absolutely necessary. Due to relatively low transmission speeds of radar system (At max 1Mbit/s)

(a) 3D render

(b) Photo

Figure 2.1: Form of the final assembly

3. Software realization

In order to achieve maximal efficiency in processing commands and maintain accurate driving of stepper motors workflow of the program is split into three distinct layers, as showed on diagram 3.1. Using standard two component architecture with one part handling the parsing of commands and second managing their execution wasn't for this usecase - pre programming movements wouldn't be possible and precomputing multiple movements ahead unnecessary hard. Now with increasing layer the amount of abstraction in command decreases and processing gets easier. This enables the final stage to be really efficient thus moving form one command to another is more restricted by inertia of stepper motors.

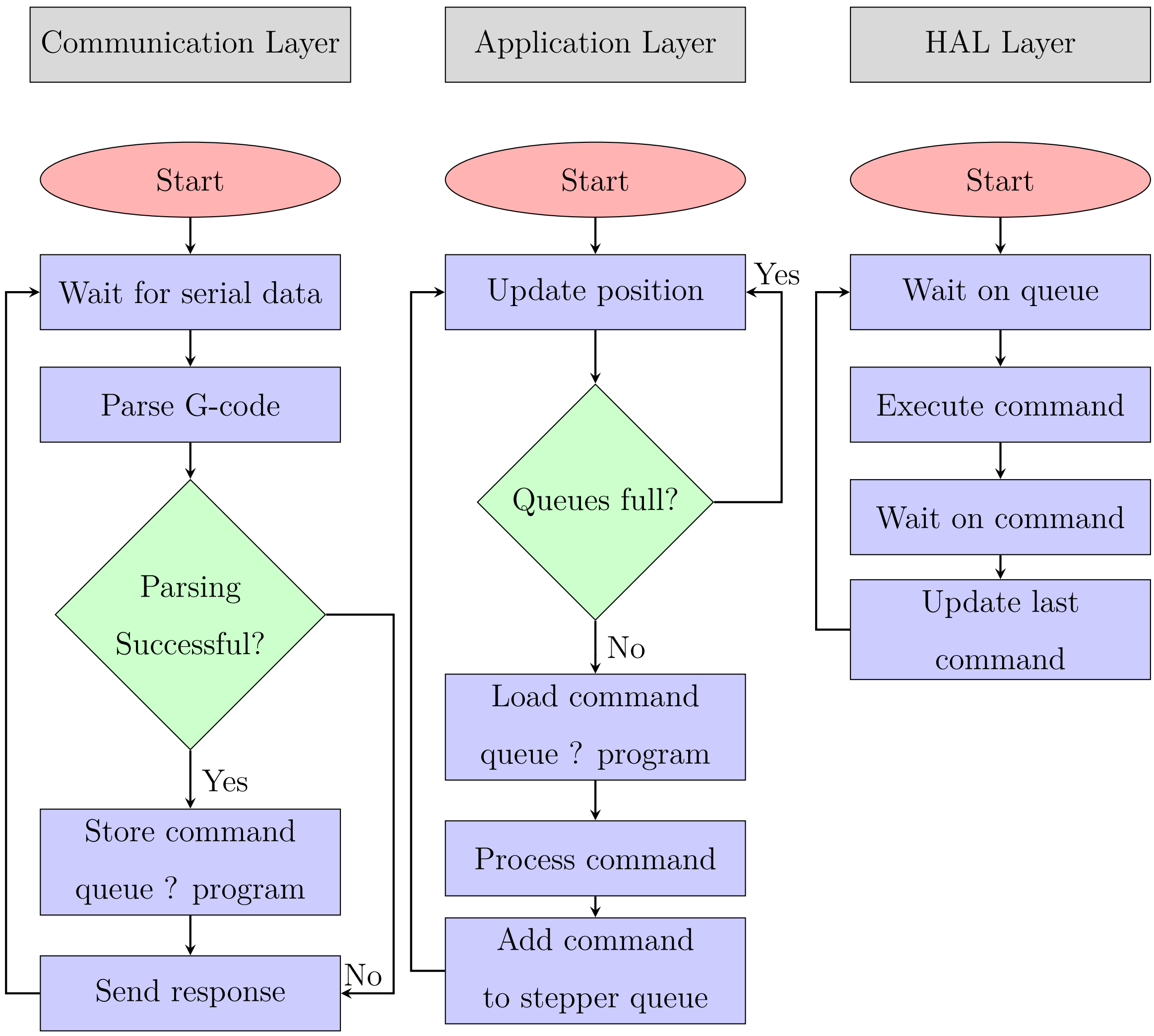

Figure 3.1: Programm diagram

3.1 Communication layer

Communication layer handles incoming data on serial line, reading from which is realized efficiently with the aid of RTOS queues. Upon receiving data the text string is parsed and either push to queue (if we are declaring a programm) or added to programm declaration. Immediately after data are processed a response is sent to the user however as Communication Layer doesn't check whole pipeline of commands response SUCCESS doesn't mean command will be valid in context it was sent.

3.2 Application layer

Application layers does two main things - keeps track of current device position and schedules commands to be sent to steppers. Tracking of current position and end position of last scheduled command also enables layer to do calculations needed for absolute positioning and limits enforcement.

3.3 HAL Layer

Final layer handles basic driving of steppers and provides Application layer with all necessary for position calculation. In its loop we simply wait on next command in queue than setup its execution after which we wait for stepper or both steppers to finish moving.

Main problem arises with generation of accurate PWM signal and having ability to stop generation upon given number of steps wer taken. From simple equation

$$t_{\text{delay}}(s) = \frac{60}{N_{\text{steps}} \cdot s}, \tag{3.1}$$

where s is speed in RMP, N_{steps} number of steps of the stepper and t_{delay} time between steps the time we can calculate that even for relatively low speed of 120 RPM delay between steps is only 2.5ms. Given the fact we need to change state two times within 2.5ms window and both steppers can operate on different RPM software/timer based driving is almost impossible.

ESP32 platform offers two solutions for this task - using Remote Controlled

Transceiver (RMT) or Motor Control Pulse Width Modulation (MCPWM) combined with PCNT.

Consclusions

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