Project documentation

Project name: Multifunctional Device
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Subject: Design Laboratory

Used modules:

- platform: FRDM-KL46Z
- PCB ring with 24 diodes (WS2812B) and one button on it,
- ultrasonic ranging module HCSR04,
- pressure, temperature and humidity sensor BME280
- magnetometer MAG3110,
- accelerometer MMA8451Q,

Short description:

The aim of a project was to design a device which would display data from sensors: time (hours, minutes, seconds), compass (direction which indicate magnetometer) and position in degrees (by using accelerometer) on 24 RGB diodes. Additional options has been added to project like: displaying temperature, pressure, humidity and distance between objects and LabView application which display precise values from sensors.

Used pin description:

Pin:	**Function:**
PTA1	UART0 receiver
PTA2	UART0 transmitter
PTD2	Din to diodes with right waveform
PTD4	Button input from ring
PTB2	I2C0 SCL to BME280 sensor
PTB3	I2C0 SDA to BME280 sensor
PTB1	Trigger to HCSR04
PTB18	Echo from HCSR04

WS2812B programming:

Specific waveform should be send to diode to enable it and display choosed color on it. Each diodes has 24 bits register which is responsible for color and brightness.

Composition of 24bit data:

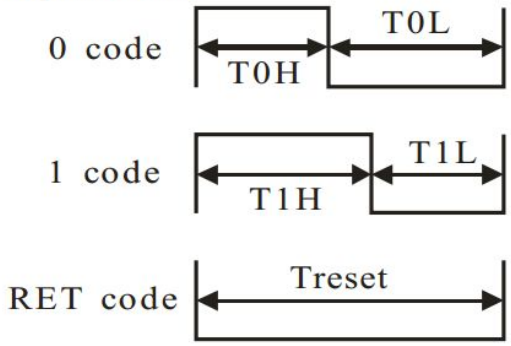
G7	G6	G5	G4	G3	G2	G1	G0	R7	R6	R5	R4	R3	R2	R1	R0	B7	B6	B5	B4	B3	B2	B1	B0

The main goal is to send the right waveform which consist of 0 and 1 like below:

Data transfer time(TH+TL=1.25μs±600ns)

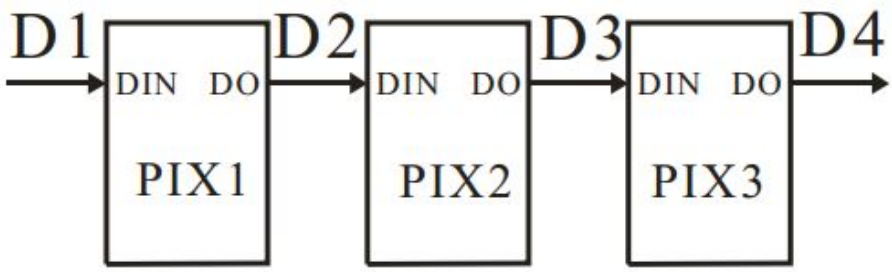
T0H	0 code ,high voltage time	0.35us	±150ns
T1H	1 code ,high voltage time	0.7us	±150ns
T0L	0 code , low voltage time	0.8us	±150ns
T1L	1 code ,low voltage time	0.6us	±150ns
RES	low voltage time	Above 50μs	

Sequence chart:

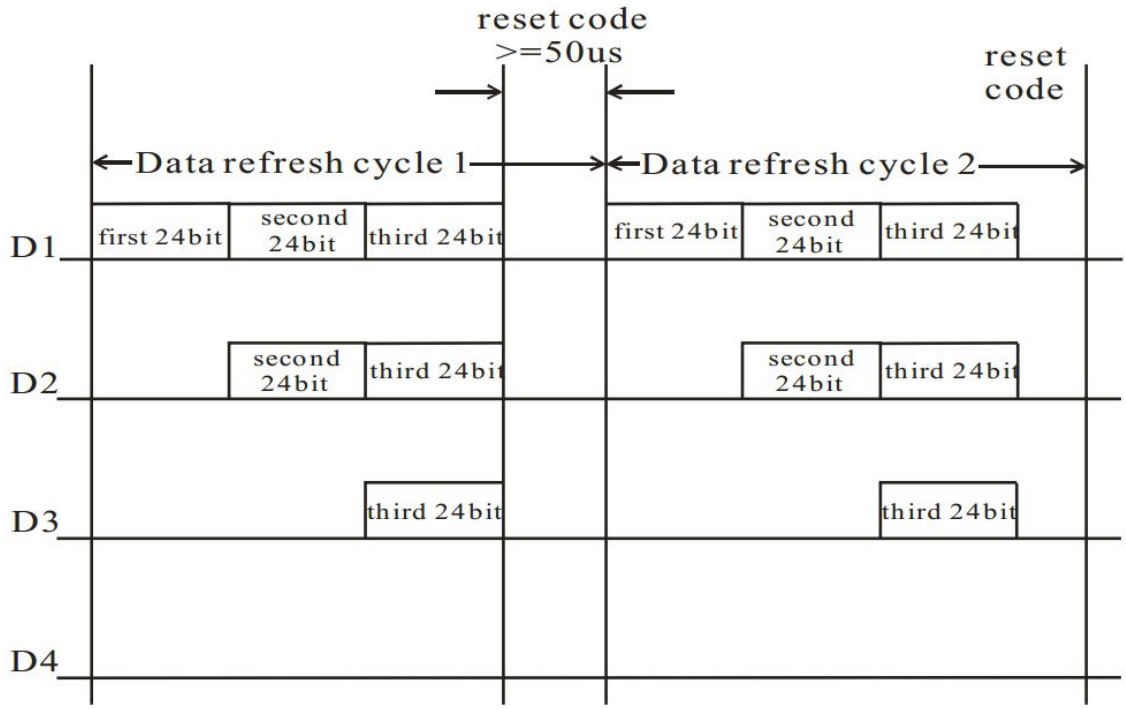


Diodes in ring were connected like in the picture below:

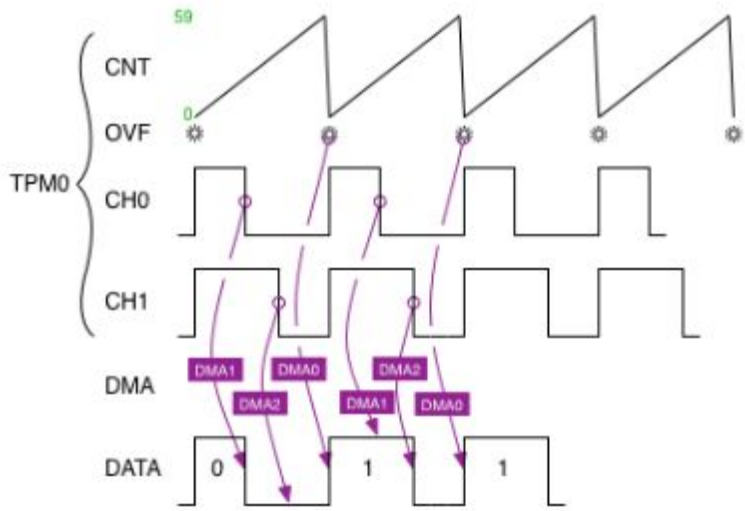
Cascade method:



When we want to program more diodes we need to create a waveform for first diode, then for the second etc. When we create new waveform we must wait 50us and then generate waveform like before. Picture below show this procedure:



We create proper waveform by using DMA transfer and TPM timer to trigger dma channels. Special tables are used as a source for dma values, destination address is PTD->PDOR register which sets 1 or 0 on pin. The procedure of generate waveforms is shown below:



Timer TPM0 generate events on overflow (OVF) on 1250 ns, at 250 ns (CH1) and on 650 ns (CH2). At 1250 ns timer count = 0.
When count = 0 then transmit DMA1. Source address in this case is a table which have only ones and then on PTD2 is high state.

At 650 ns DMA2 start transmit. Source address is table which have values 0 or 1 to set proper color and brightness of diode. Source adress is incremented by each request from TPM CH0.
At 1250 ns DMA3 start transmit and then output go low because source address is a table which has only zeros and then on PTD2 is on low state. Then the whole cycle repeats

Function description (each function is switched by pressing button on ring).

- first function is distance HCSR04 sensor, data is read from sensor by timers TPM1 and TPM2 and display on ring in centimeters
- second, third and fourth function is in order temperature, pressure and humidity display. Data is read from BME280 sensor and display on ring.
- fifth option is clock, in small ring we see seconds and in big ring we see hours and minutes,
- sixth option is compass which indicate direction,
- seventh option is accelerometer which indicate tilt,
- in LabView we also see precise values from sensor, data from sensor is send by UART via USB and then displayed. In picture below the GUI of program is shown: