

Application Note

Servo Demultiplexer

AN-CM-280

Abstract

This application note describes how to create a model servo motor signal demultiplexer using a GreenPAK IC.

This application note comes complete with design files which can be found in the References section.

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1 Terms and Definitions

ASIC	Application specific integrated circuit
ASM	Asynchronous state machine
CPLD	Complex programmable logic device
ICs	Integrated Circuits
MCU	Microcontroller

2 References

For related documents and software, please visit:

[GreenPAK™ Programmable Mixed-Signal Products | Renesas](#)

Download our free [GreenPAK Designer](#) software [1] to open the .gp files [2] and view the proposed circuit design. Use the [GreenPAK](#) development tools [3] to freeze the design into your own customized IC in a matter of minutes. Renesas Electronics provides a complete library of application notes [4] featuring design examples, as well as explanations of features and blocks within the Renesas IC.

- [1] [GreenPAK Designer Software](#), Software Download and User Guide, Renesas Electronics
- [2] [AN-CM-280 Servo Demultiplexer.gp](#), [GreenPAK](#) Design File, Renesas Electronics
- [3] [GreenPAK Development Tools](#), [GreenPAK](#) Development Tools Webpage, Renesas Electronics
- [4] [GreenPAK Application Notes](#), [GreenPAK](#) Application Notes Webpage, Renesas Electronics

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3 Introduction

Servo Motors are widely used for commercial and industrial applications as linear or rotary actuators. In this example the SG90 model is used, which is low cost, consumes little power, and is lightweight. This makes these type of servos ideal for consumer device RC toys such as RF-controlled race cars, airplanes, and others.

However, to properly control a servo motor, the electronic driver must generate appropriate voltage patterns to the servo motor DATA pin. The waveforms should be pulses shorter than 2 milliseconds, repeating every 20 milliseconds for one servo motor.

This application note will present the design of one 1 to 8 servo motor signal demultiplexer with the SLG46537V **GreenPAK™** IC. The designed signal demultiplexer would drive up to 8 servo motors on 8 output pins with the multiplexed signal coming in on 1 input pin. The SLG46537V can also integrate additional functionality, such as additional logic or voltage monitoring, depending upon the system requirements.

The following sections will show:

- A servo motor 1 RF channel signal multiplex;
- The SLG46537V **GreenPAK** servo demultiplexer design in detail;
- How to drive 8 servo motors with 1 **GreenPAK** device.



Figure 1: SG90 Model Servo Motor

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4 Servo Motor 1 RF Channel Multiplex

The standard for small 9g servo motors is that they operate from 0.5 ms ~ 1.5 ms HIGH pulses with a period of 20 milliseconds. 0.5 ms correlates to 0°, 1 ms to 90°, and 1.5 ms to 180°.

In this way, if we reserve a 2 milliseconds window for each motor pulse, 8 ms x 2 ms can be used for 8 motor pulse windows with the remaining 4 ms silence at the end used for synchronization. [Figure 2](#) shows a time multiplex period of 20 ms for 8 motors, all at 90° position (1 ms pulses). [Figure 3](#) shows a time multiplex period of 20 ms for 8 motors, all at 90° position (1 ms pulses) except for motor #5 at a 0° position (0.5 ms pulse).

[Figure 2](#) and [Figure 3](#) are waveforms of signed digital samples generated by a Python script for a sampling rate of 50,000 Hz.

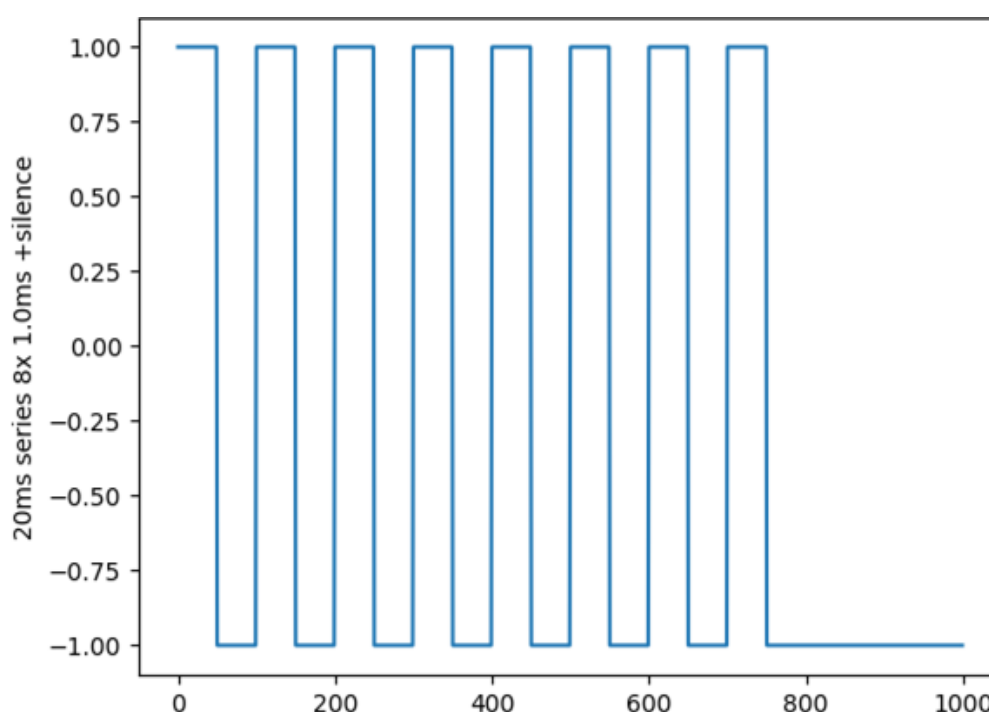


Figure 2: Time Multiplex – 8x 90° @ 50kS/s

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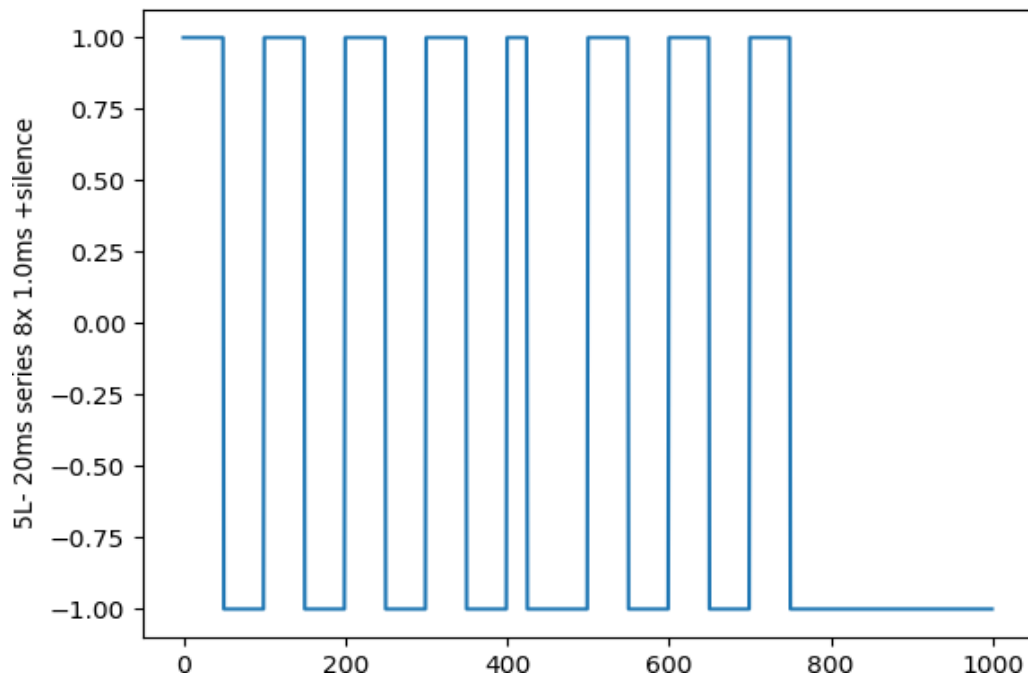


Figure 3: Time Multiplex – 7x 90°, #5 =0° @ 50kS/s

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5 GreenPAK Design Schematic

The schematic of the [GreenPAK](#) design is shown in [Figure 4](#). The fundamental blocks of the design are the internal Oscillator, 2x Counter, 2x Filter, 8x Flip-Flop, ASM with reset, 8x Pins with OE and Pull-downs, input pin and supply pins.

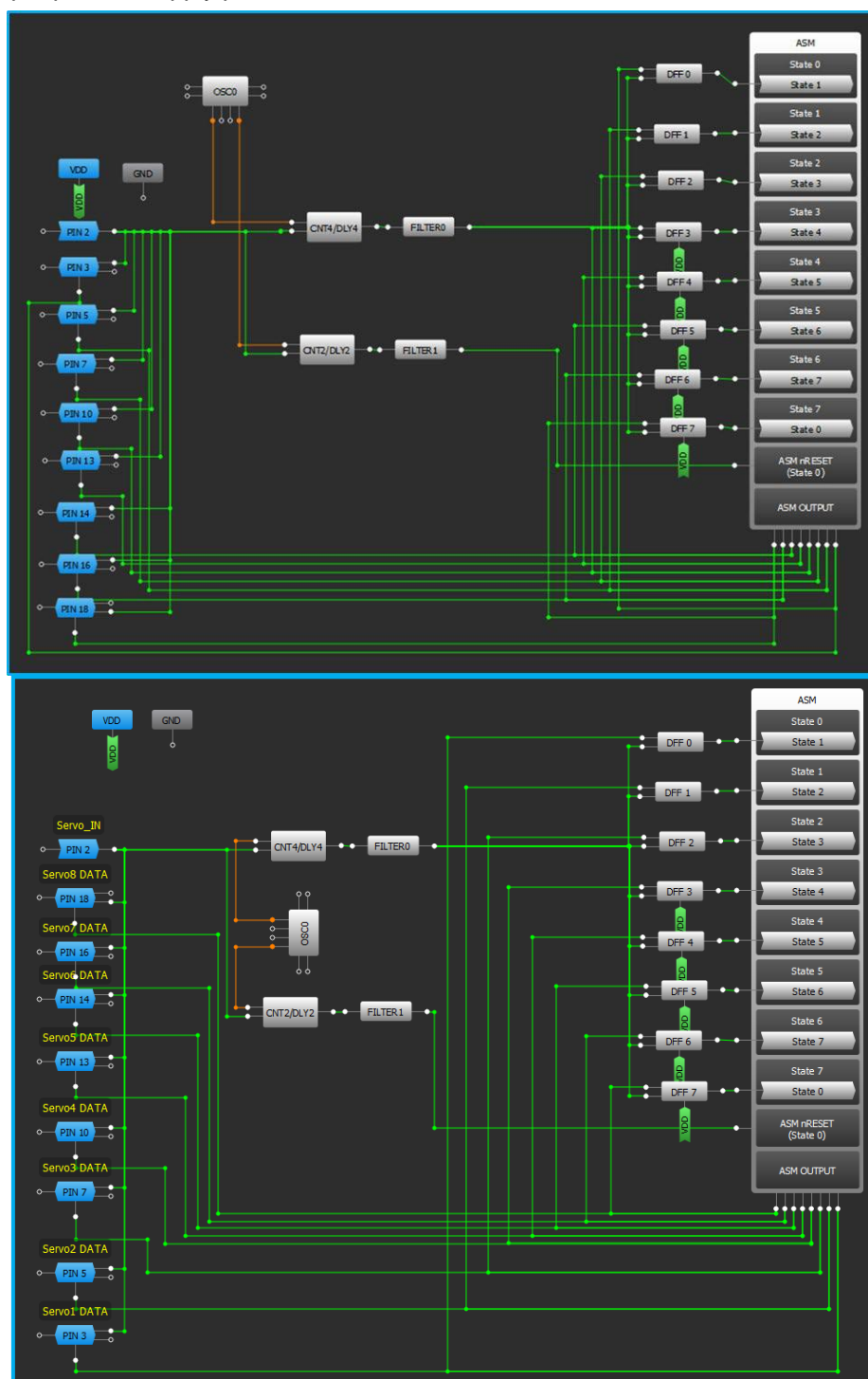


Figure 4: Top View of the GreenPAK Design Schematic

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5.1 GreenPAK Timing Blocks

The OSC0 internal oscillator is used. It drives the CNT2 counter with $2\text{ MHz}/8/64 \approx 3.9\text{ kHz}$ and the CNT4 counter with $2\text{ MHz}/8/4 \approx 62.5\text{ kHz}$. Settings are shown in Figure 5. CNT2 is set to trigger repeatedly on all falling edges (Delay Mode) and give a Non-inverted OUT after 4.096 ms. This is the 4 ms silence detection at the end of our 20 ms time multiplex period, which resets the ASM to State 0. CNT4 is set to trigger once every falling edge (One Shot Mode) after 96 μs to give a short pulse to all Flip-Flop CLOCK inputs. Only the Flip-Flop of the current state has a HIGH input and will trigger the ASM to transition to the following state.

OSC0 Properties

- Control pin mode: Force on
- OSC power mode: Force Power On
- Clock selector: OSC
- EXT CLK Pin selector: PIN 20 (IO17)
- Fast start-up: Enable
- RC OSC frequency: 2 MHz
- 'CLK' predivider by: 8
- 'OUT0' second divider by: 64
- 'OUT1' second divider by: 64

Information

RC OSC Output	Value
CLK /4	RC OSC Freq. /8 /4
CLK /12	RC OSC Freq. /8 /12
CLK /24	RC OSC Freq. /8 /24
CLK /64	RC OSC Freq. /8 /64
OUT0	RC OSC Freq. /8 /64
OUT1	RC OSC Freq. /8 /64

3-bit LUT7/8-bit CNT4/DLY4 Properties

- Type: CNT/DLY
- Mode: One shot
- Counter data: 5 (Range: 1 - 255)
- Pulse width (typical): 96 μs
- Edge select: Falling
- Output polarity: Inverted (nOUT)
- Q mode: None
- Stop and restart: None

Connections

- Clock: OSC0 CLK /4
- Clock source: RC OSC Freq. /8 /4
- Clock frequency: 62.5 kHz

3-bit LUT5/8-bit CNT2/DLY2 Properties

- Type: CNT/DLY
- Mode: Delay
- Counter data: 15 (Range: 1 - 255)
- Delay time (typical): 4.096 ms
- Edge select: Falling
- Output polarity: Non-inverted (OUT)
- Q mode: None
- Stop and restart: None

Connections

- Clock: OSC0 CLK /64
- Clock source: RC OSC Freq. /8 /64
- Clock frequency: 3.90625 kHz

FILTER0/EDGE DET0 Properties

- Type: FILTER
- Output polarity: Normal

Information

Delay and Filtered Pulse Width (Typical)		
VDD (V)	Delay (ns)	Pulse Width (ns)
1.8	210	<114
3.3	83	<47
5.0	55	<30

FILTER1/EDGE DET1 Properties

- Type: FILTER
- Output polarity: Normal

Information

Delay and Filtered Pulse Width (Typical)		
VDD (V)	Delay (ns)	Pulse Width (ns)
1.8	210	<75
3.3	83	<30
5.0	55	<19

Figure 5: Close-up of Timing Blocks Settings

5.2 GreenPAK ASM

The Flip-Flops in the GreenPAK design are used to change the asynchronous state machine into a synchronous machine. As described in the previous section, CNT/DLY4 delivers a short pulse to all Flip-Flop CLOCK inputs, but only the Flip-Flop of the current state has a HIGH input and will trigger the transition to State +1. ASM runaway thru more than one state is prevented since all the other Flip-Flops were just loaded with LOW inputs, so the ASM has to wait until the next pulse for the next transition. This is necessary since all state transition conditions are the same 1 condition. Settings are shown in Figure 6.

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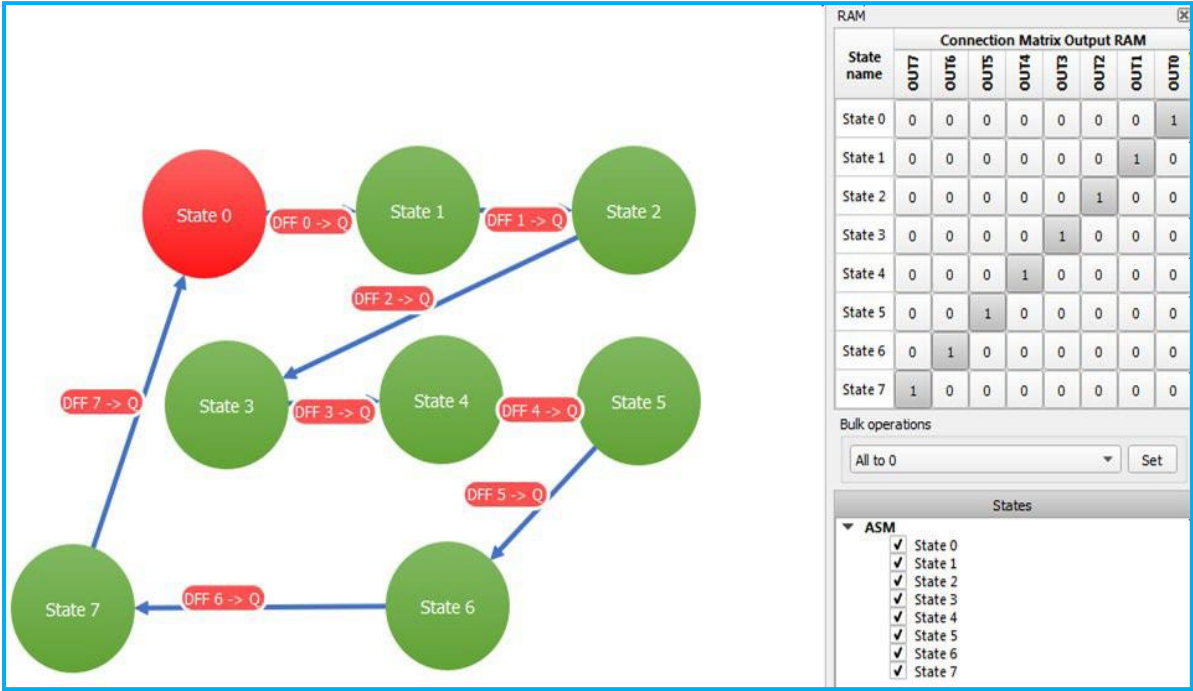


Figure 6: Close View of ASM Settings

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6 GreenPAK Design Pinout

The Signal input IO0 is configured as a Digital in without Schmitt trigger. The ServoX DATA outputs are configured as 1x Push-Pull at OE = 1, at OE = 0 they are inputs with a 10 k Pull-down resistor. Pinout is shown in Table 1 and Figure 7.

Table 1: Design Pinout

Pin #	Signal Name	Pin Function
1	V _{DD}	+5 V Supply
2	IO0	Signal Input
3	IO1	Servo1 DATA
4	IO2	
5	IO3	Servo2 DATA
6	IO4	
7	IO5	Servo3 DATA
8	IO6	
9	IO7	
10	IO8	Servo4 DATA
11	GND	Ground
12	IO9	
13	IO10	Servo5 DATA
14	IO11	Servo6 DATA
15	IO12	
16	IO13	Servo7 DATA
17	IO14	
18	IO15	Servo8 DATA
19	IO16	
20	IO17	

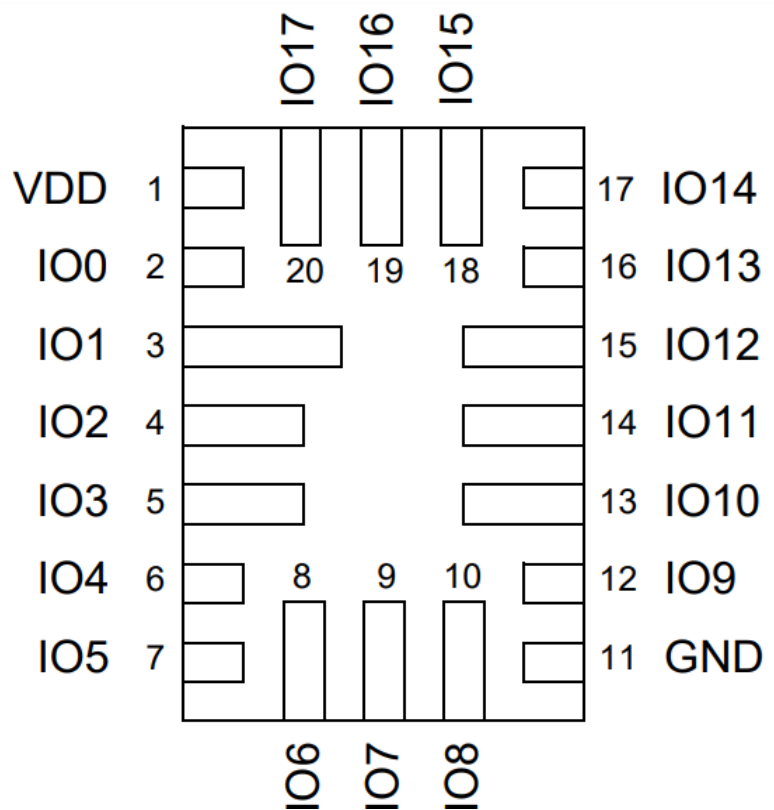


Figure 7: Pin Configuration - STQFN20L

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7 Test Results

The Signal input is driven by an amplified Audio Out signal (0 ~ 5 V) generated by a Python script (Appendix A). Figure 8 shows the Signal Input in yellow and the Servo1 DATA output in blue. The generated .wav file has 20 seconds of choreographed servo movements and the GreenPAK design decodes all 8 ServoX DATA signals accordingly which is seen by movements of the servo motors.

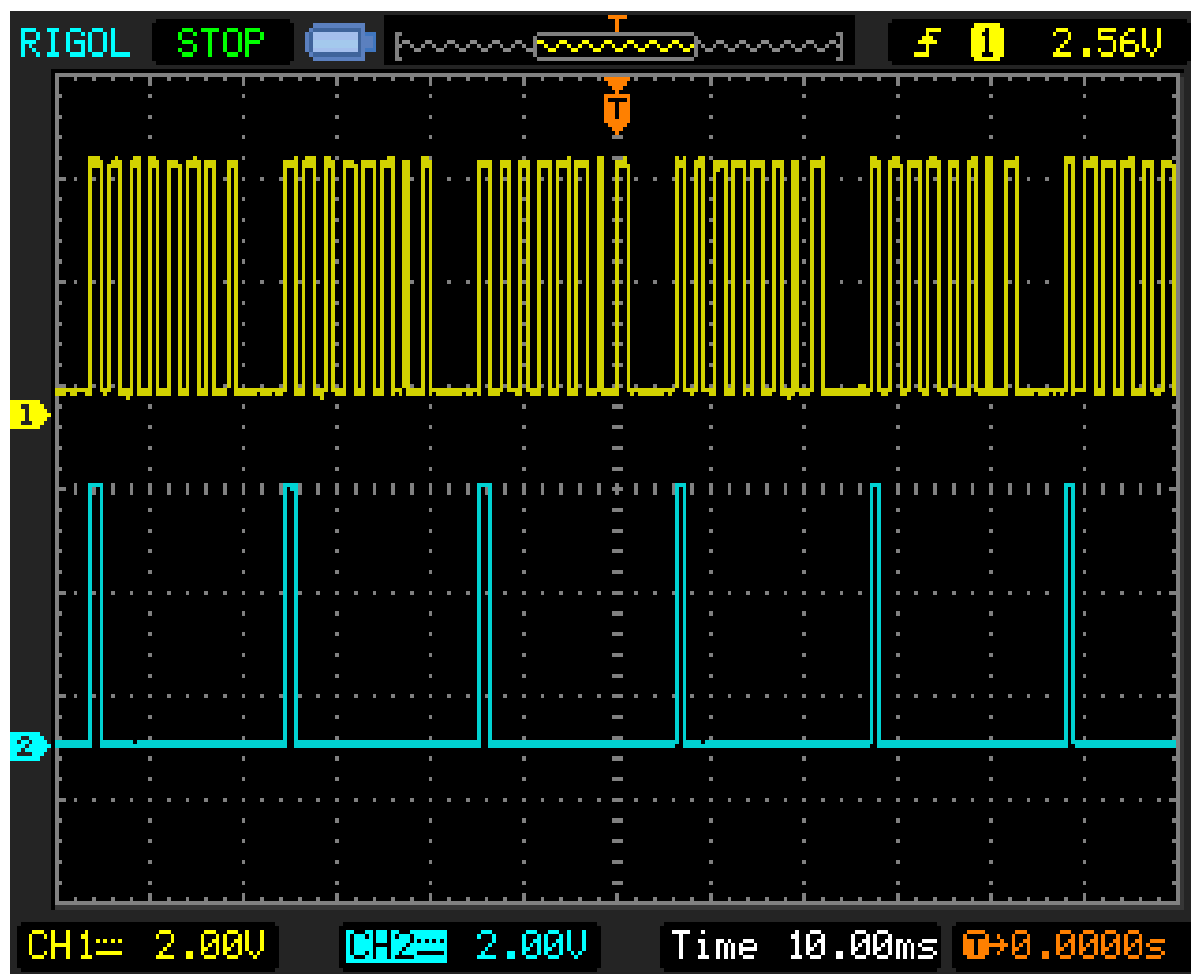


Figure 8: Input/Output - Measurement

8 Conclusion and Results Discussion

The Design of a Model Servo Motor Demultiplexer was presented. Through a [GreenPAK](#) design with the SLG46537V we have successfully implemented a lightweight, low-power, cost-effective solution. [Figure 9](#) shows the resource usage of the SLG46537V. The design successfully decodes all 8 ServoX DATA signals from one Time Multiplexed signal input - [Figure 10](#).

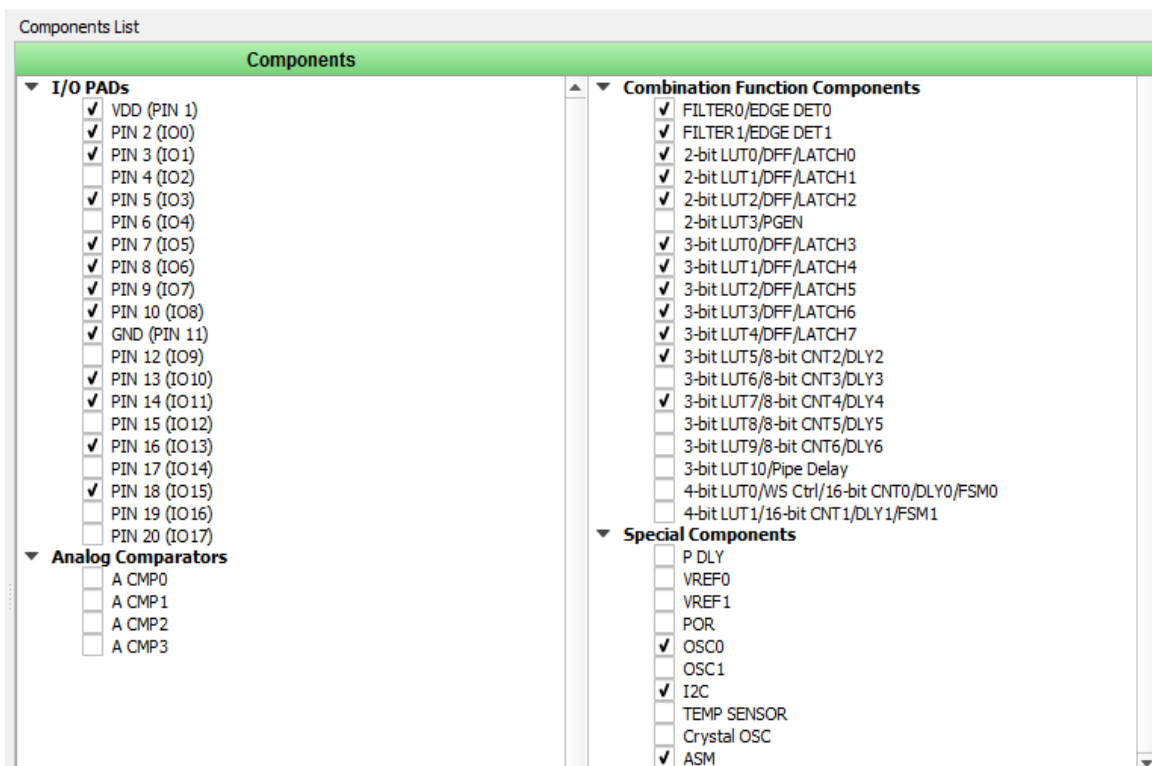


Figure 9: SLG46537V Resources Used

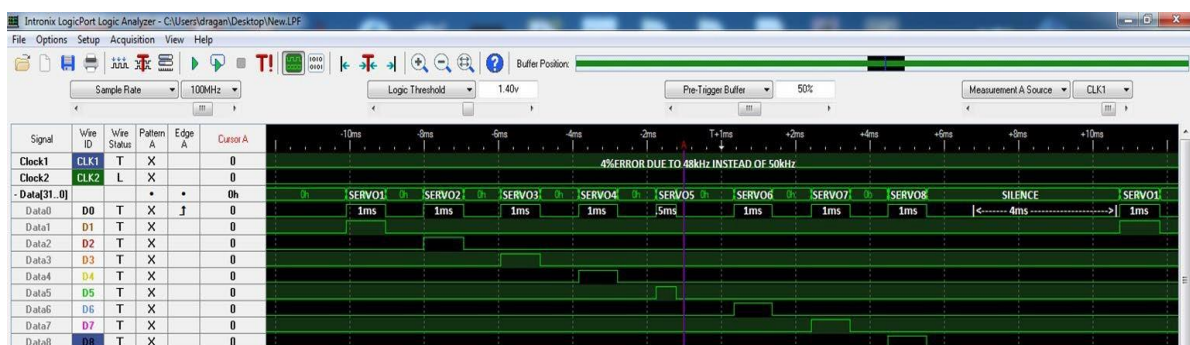


Figure 10: Logic Analyzer – All Signals

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Appendix A Source Code

```
#servoMUX.py#####BEGIN#
import wave
import numpy as np
import matplotlib.pyplot as plt

def repeat48x(series):
    return np.concatenate(( series, series, series, series, series, series, series, series, series, series, se-
    ries, series, series, series, series, series, series, series, series, series, series, series, series, se-
    ries, series, series, series, series, series, series, series, series, series, series, series, series, series, se-
    ries, series, series, series, series, series, series, series, series, series), axis=None)

silence=-np.ones(200)

pulse10=np.concatenate((np.ones(50), -np.ones(50)), axis=None)
plt.plot(pulse10)
plt.ylabel('pulse 1.0ms')
plt.show()
pulse05=np.concatenate((np.ones(25), -np.ones(75)), axis=None)
plt.plot(pulse05)
plt.ylabel('pulse 0.5ms')
plt.show()
pulse15=np.concatenate((np.ones(75), -np.ones(25)), axis=None)
plt.plot(pulse15)
plt.ylabel('pulse 1.5ms')
plt.show()

#second10
series=np.concatenate((pulse10, pulse10, pulse10, pulse10, pulse10, pulse10, pulse10, pulse10, pulse10, si-
lence), axis=None)
plt.plot(series)
plt.ylabel('20ms series 8x 1.0ms +silence')
plt.show()
second10=repeat48x(series)
plt.plot(second10)
plt.ylabel('1s- 20ms series 8x 1.0ms +silence')
plt.show()
```

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```
#second1L
series=np.concatenate((pulse05, pulse10, pulse10, pulse10, pulse10, pulse10, pulse10, pulse10, si-
lence), axis=None)
plt.plot(series)
plt.ylabel('1L- 20ms series 8x 1.0ms +silence')
plt.show()
second1L=repeat48x(series)
plt.plot(second1L)
plt.ylabel('1L-1s- 20ms series 8x 1.0ms +silence')
plt.show()

#second2L
series=np.concatenate((pulse10, pulse05, pulse10, pulse10, pulse10, pulse10, pulse10, pulse10, si-
lence), axis=None)
plt.plot(series)
plt.ylabel('2L- 20ms series 8x 1.0ms +silence')
plt.show()
second2L=repeat48x(series)
plt.plot(second2L)
plt.ylabel('2L-1s- 20ms series 8x 1.0ms +silence')
plt.show()

#second3L
series=np.concatenate((pulse10, pulse10, pulse05, pulse10, pulse10, pulse10, pulse10, pulse10, si-
lence), axis=None)
plt.plot(series)
plt.ylabel('3L- 20ms series 8x 1.0ms +silence')
plt.show()
second3L=repeat48x(series)
plt.plot(second3L)
plt.ylabel('3L-1s- 20ms series 8x 1.0ms +silence')
plt.show()

#second4L
series=np.concatenate((pulse10, pulse10, pulse10, pulse05, pulse10, pulse10, pulse10, pulse10, si-
lence), axis=None)
plt.plot(series)
plt.ylabel('4L- 20ms series 8x 1.0ms +silence')
plt.show()
second4L=repeat48x(series)
```

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```
plt.plot(second4L)
plt.ylabel('4L-1s- 20ms series 8x 1.0ms +silence')
plt.show()
#second5L
series=np.concatenate((pulse10, pulse10, pulse10, pulse10, pulse05, pulse10, pulse10, pulse10, si-
lence), axis=None)
plt.plot(series)
plt.ylabel('5L- 20ms series 8x 1.0ms +silence')
plt.show()
second5L=repeat48x(series)
plt.plot(second5L)
plt.ylabel('5L-1s- 20ms series 8x 1.0ms +silence')
plt.show()
#second6L
series=np.concatenate((pulse10, pulse10, pulse10, pulse10, pulse10, pulse05, pulse10, pulse10, si-
lence), axis=None)
plt.plot(series)
plt.ylabel('6L- 20ms series 8x 1.0ms +silence')
plt.show()
second6L=repeat48x(series)
plt.plot(second6L)
plt.ylabel('6L-1s- 20ms series 8x 1.0ms +silence')
plt.show()
#second7L
series=np.concatenate((pulse10, pulse10, pulse10, pulse10, pulse10, pulse10, pulse05, pulse10, si-
lence), axis=None)
plt.plot(series)
plt.ylabel('7L- 20ms series 8x 1.0ms +silence')
plt.show()
second7L=repeat48x(series)
plt.plot(second7L)
plt.ylabel('7L-1s- 20ms series 8x 1.0ms +silence')
plt.show()
#second8L
series=np.concatenate((pulse10, pulse10, pulse10, pulse10, pulse10, pulse10, pulse10, pulse05, si-
lence), axis=None)
plt.plot(series)
```

Servo Demultiplexer

```
plt.ylabel('8L- 20ms series 8x 1.0ms +silence')
plt.show()
second8L=repeat48x(series)
plt.plot(second8L)
plt.ylabel('8L-1s- 20ms series 8x 1.0ms +silence')
plt.show()
```

```
w=wave.open("servo.wav", 'wb')
w.setnchannels(1)
w.setsampwidth(1)
w.setframerate(48000)
#w.setnframes(24000)
#w.setcomptype('NONE', 'wav')
w.writeframesraw(100*second10.astype(np.int8))
w.writeframesraw(100*second10.astype(np.int8))
w.writeframesraw(100*second10.astype(np.int8))
w.writeframesraw(100*second10.astype(np.int8))
w.writeframesraw(100*second1L.astype(np.int8))
w.writeframesraw(100*second2L.astype(np.int8))
w.writeframesraw(100*second3L.astype(np.int8))
w.writeframesraw(100*second4L.astype(np.int8))
w.writeframesraw(100*second5L.astype(np.int8))
w.writeframesraw(100*second6L.astype(np.int8))
w.writeframesraw(100*second7L.astype(np.int8))
w.writeframesraw(100*second8L.astype(np.int8))
w.writeframesraw(100*second10.astype(np.int8))
w.writeframesraw(100*second10.astype(np.int8))
w.writeframesraw(100*second10.astype(np.int8))
w.writeframesraw(100*second10.astype(np.int8))
w.close()
#servoMUX.py#####END#
```


Revision History

Revision	Date	Description
1.0	17-May-2019	Initial Version

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