Infrared Data Communications Presentation Part 1
November 13,2021 (J. Briante)

Topics

Electromagnetic Spectrum, Devises

IrDA Infrared communication

Infrared Emitting Diode

- Angle of half intensity: ϕ,
- Relative radian power vs wave length

Infrared Receiver

- Series for remote control
- Automatic gain control (AGC), Data format compatibility

Data Encoding Methods

- Pulse distance encoding, Pulse width encoding, Manchester bi-phase encoding

Basic IR System –IR emitter/receiver

- External components/software
- Generating Pulses
  - With PSoC PWM interrupts, Raspberry Pi Pico State Machine
- Receiving Pulse
  - Raspberry Pi Pico using interrupts
  - Single Pulse Application Example

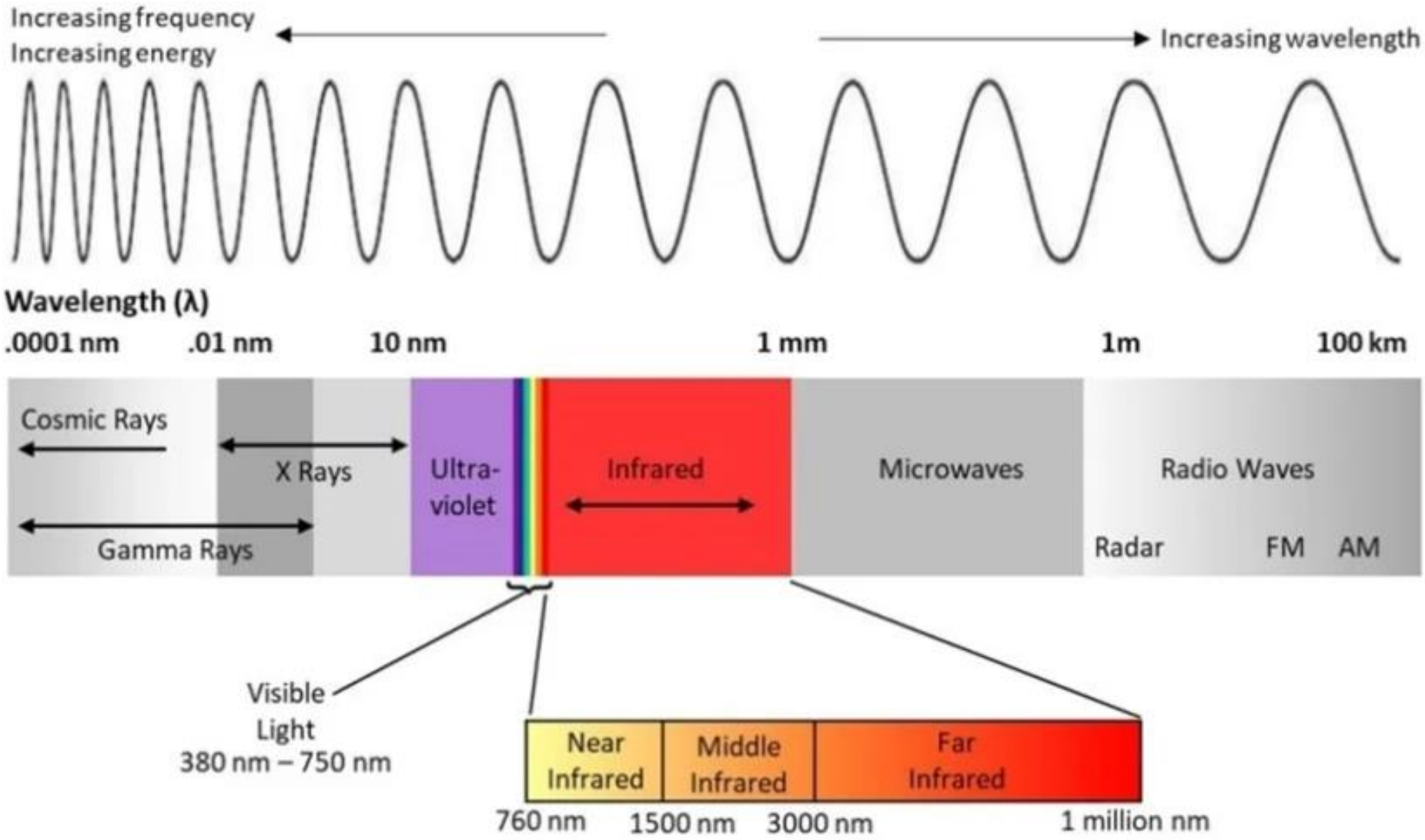
IR Receiver for Continues Data Communication

- What works for RS-232 data transmission and why

Project Utilising IR emitters/Receivers using RS-232 Communication

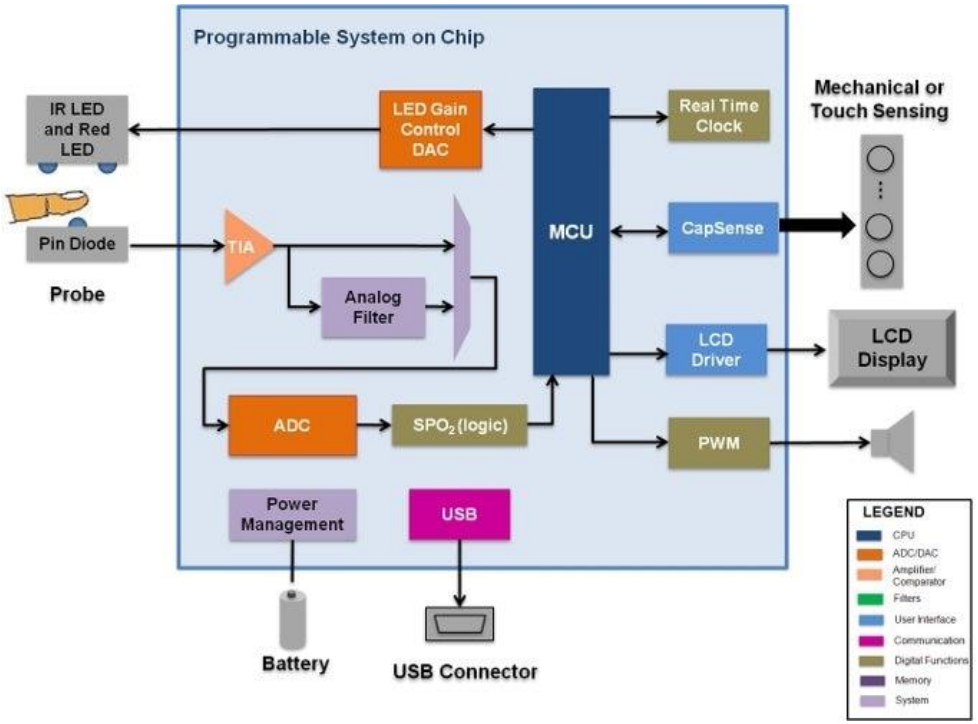
Reference

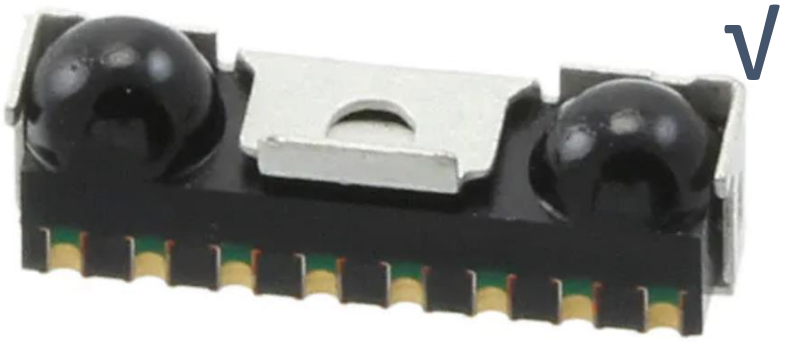
Electromagnetic spectrum



IR Devices

PSoC 6 Pulse Oximeter





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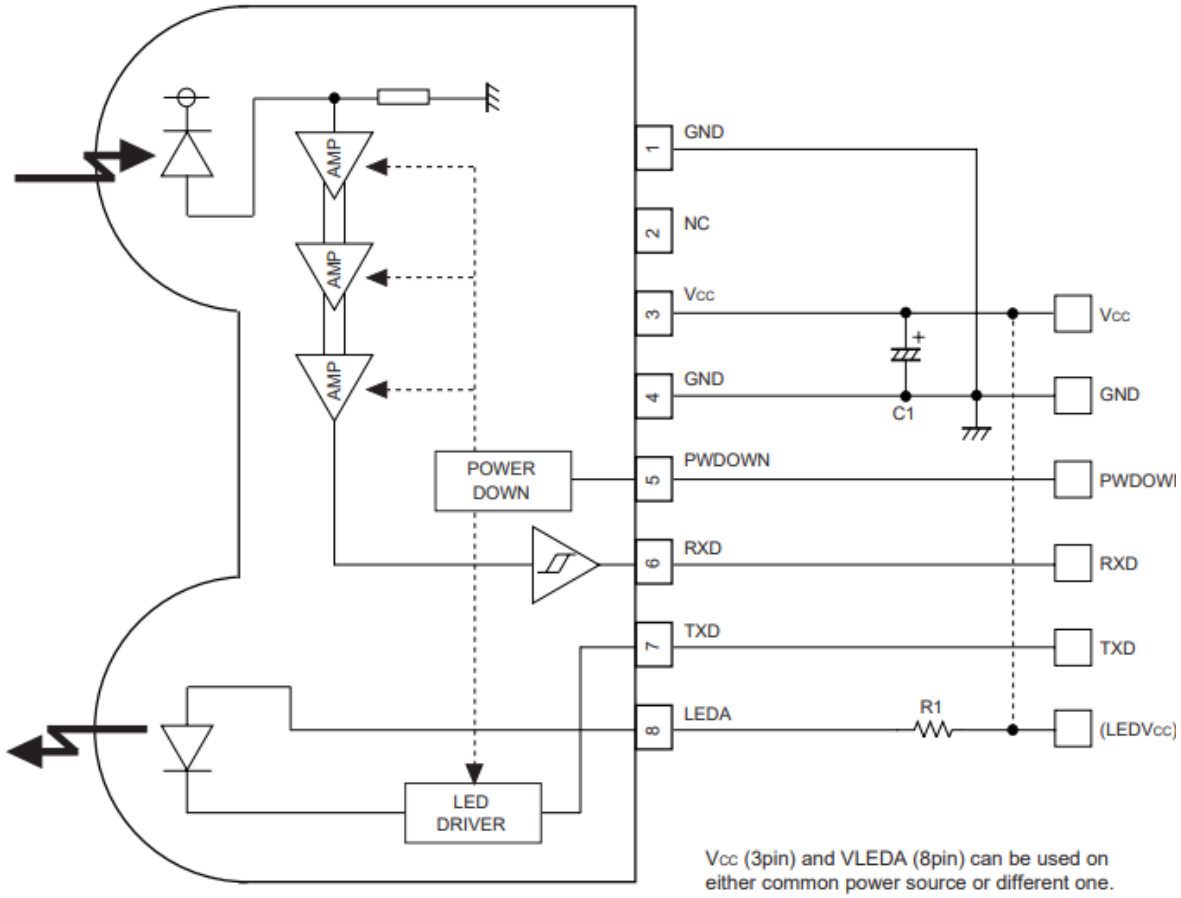
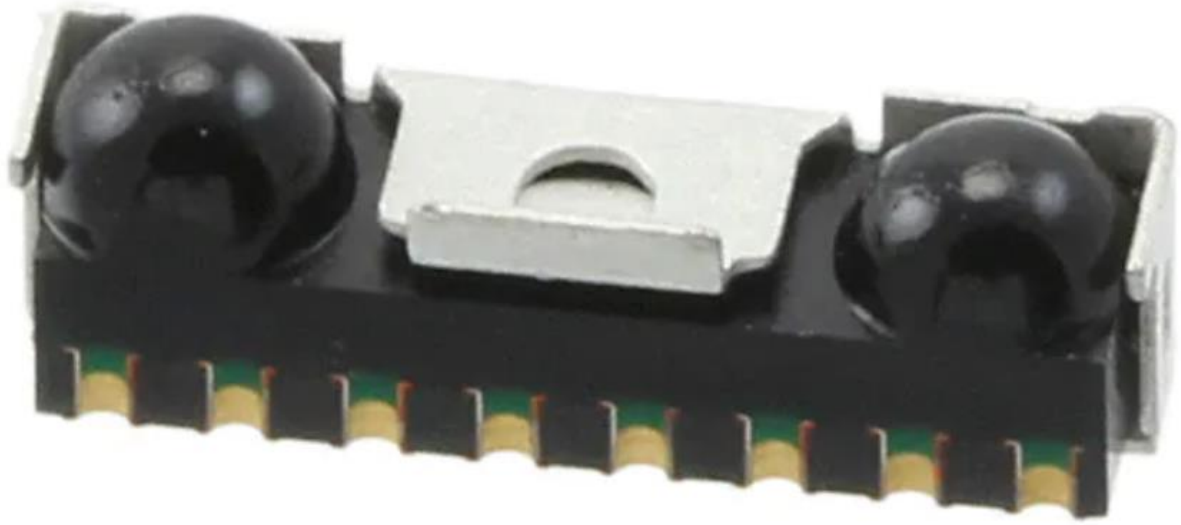
Infrared Data Association (IrDA) Developed in 1993

- wireless data transfer over short rage using point-and-shoot principles
- implemented in portable devices such as mobile telephones, laptops, cameras, printers, and medical devices
- Range :
  - standard: 2 m
  - low-power to low-power: 0.2 m
  - standard to low-power: 0.3 m
- Angle: minimum cone ±15°
- Speed: 2.4 kbit/s to 1 Gbit/s

IrDA Infrared communication Module Rohm Semiconductor RPM871

- Designed for low power consumption at waiting mode (Typ.73µA)
- Suitable for sets driven by battery due to power down control function
- Power supply voltage range : 2.6V to 3.6V 5)
- Constant LED load resistance can change transmission distance. (Approx. 20 to 60cm)





Infrared Emitting Diode With λp = 940 nm

- Vishay, TSAL6100 tsal6100.pdf (vishay.com)
  - Angle of half intensity: ϕ = ± 10°
  - Peak wavelength: λp = 940 nm

- Vishay, VSLY5940 vsly5940.pdf (vishay.com)
  - Angle of half intensity: ϕ = ± 3°
  - Peak wavelength: λp = 940 nm

- Other Manufacturers With λp = 940 nm
  - Broadcom, LITEON, Everlight, Lamex, …

Vishay, TSAL6100
$\phi = \pm 10°$

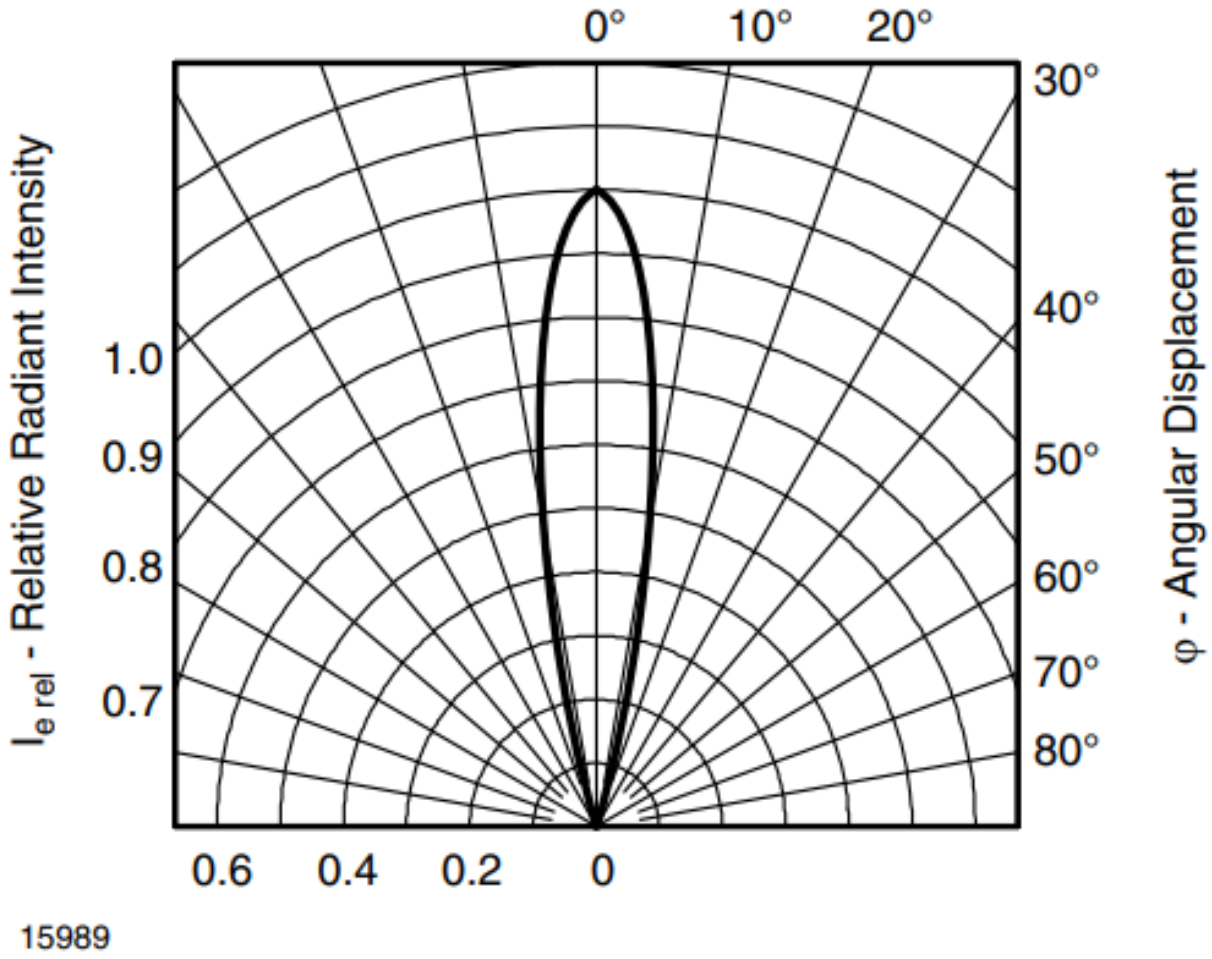


Fig. 9 - Relative Radiant Intensity vs. Angular Displacement

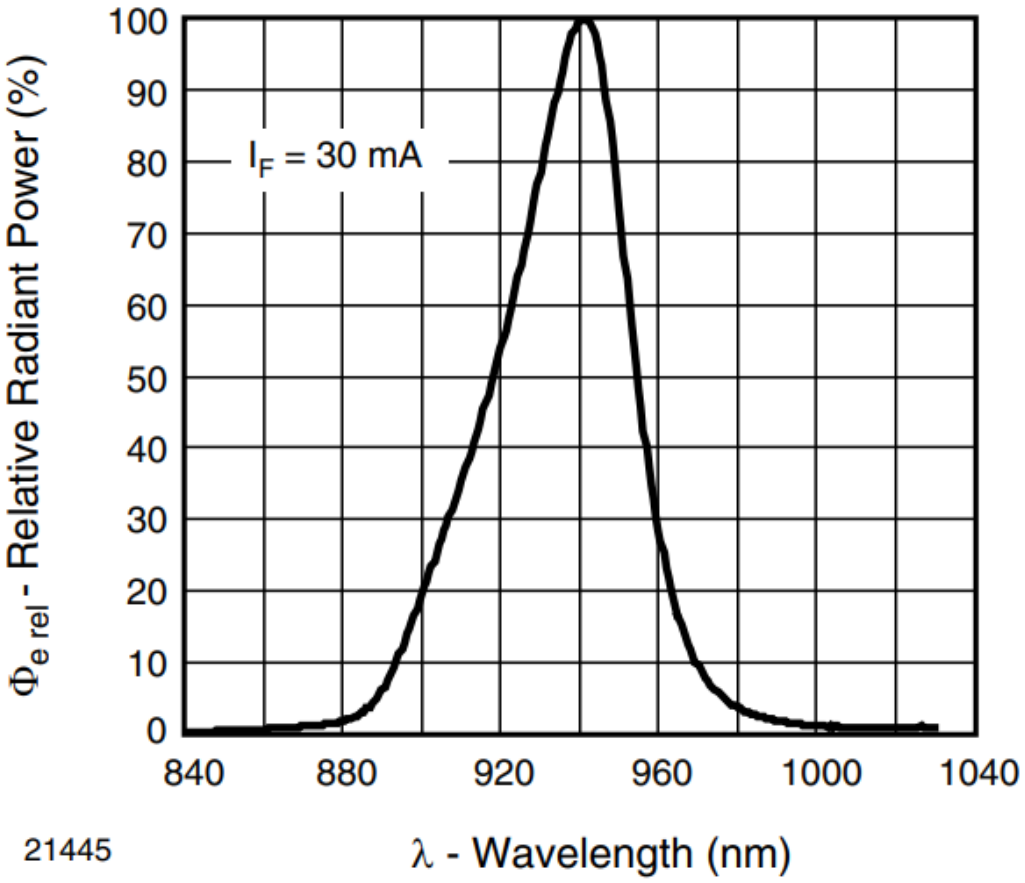


Fig. 8 - Relative Radiant Power vs. Wavelength

Vishay, VSLY5940

$\phi = \pm 3°$

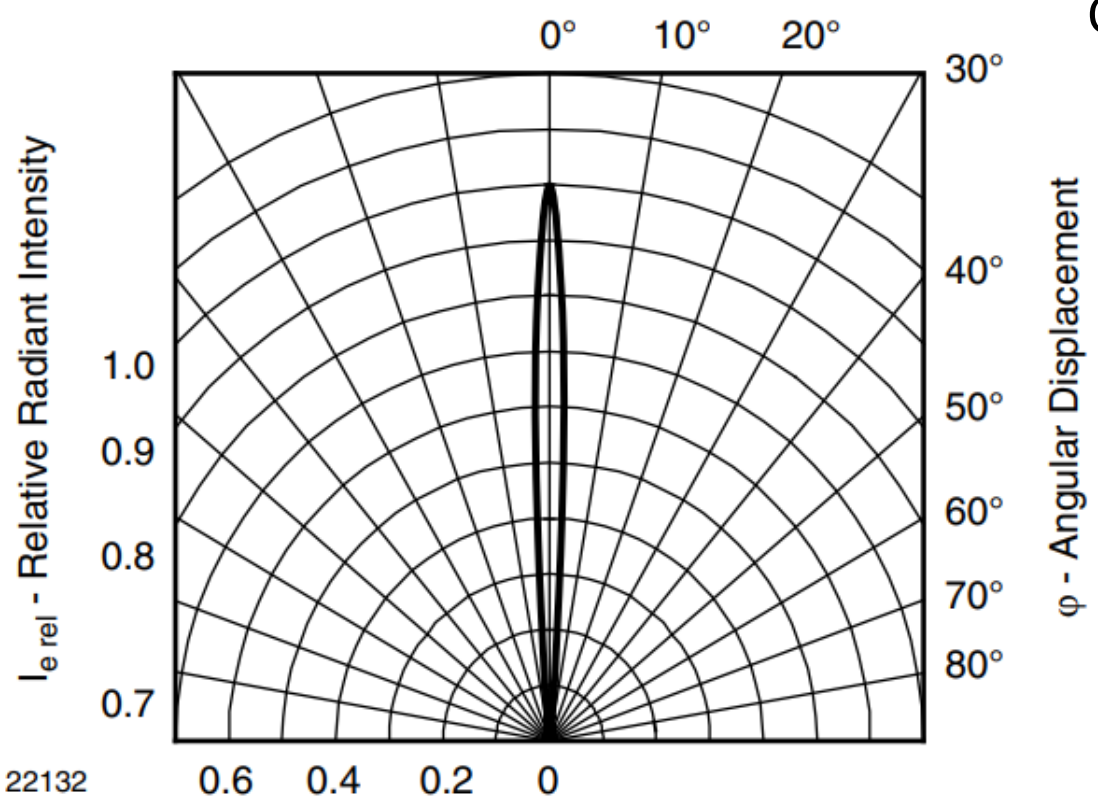


Fig. 8 - Relative Radiant Intensity vs. Angular Displacement

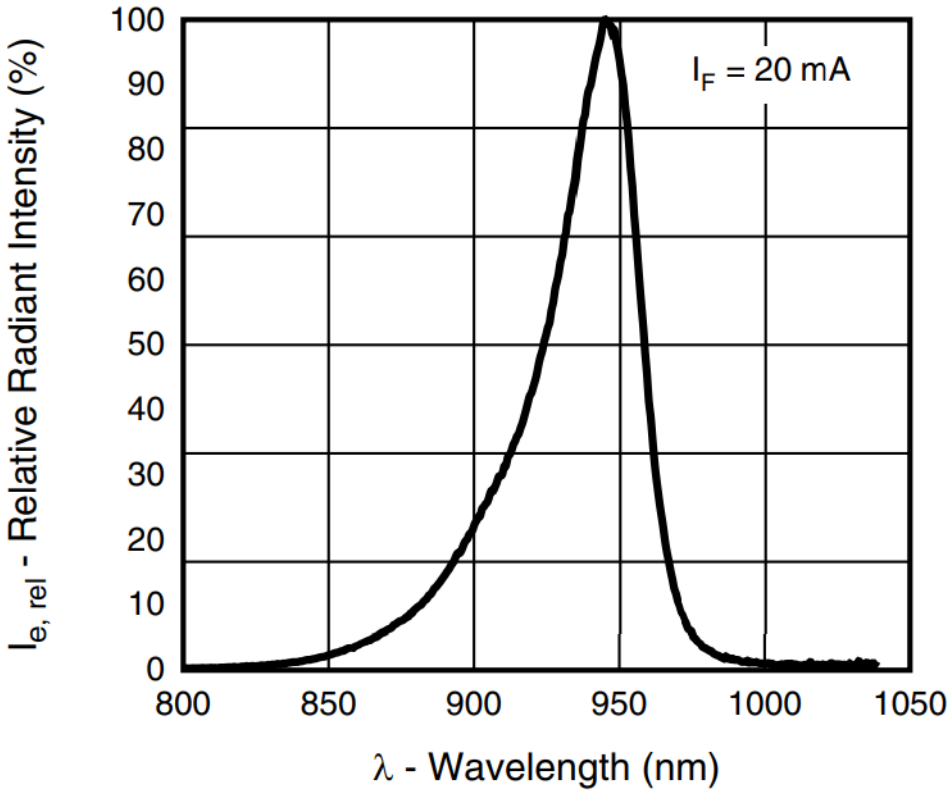
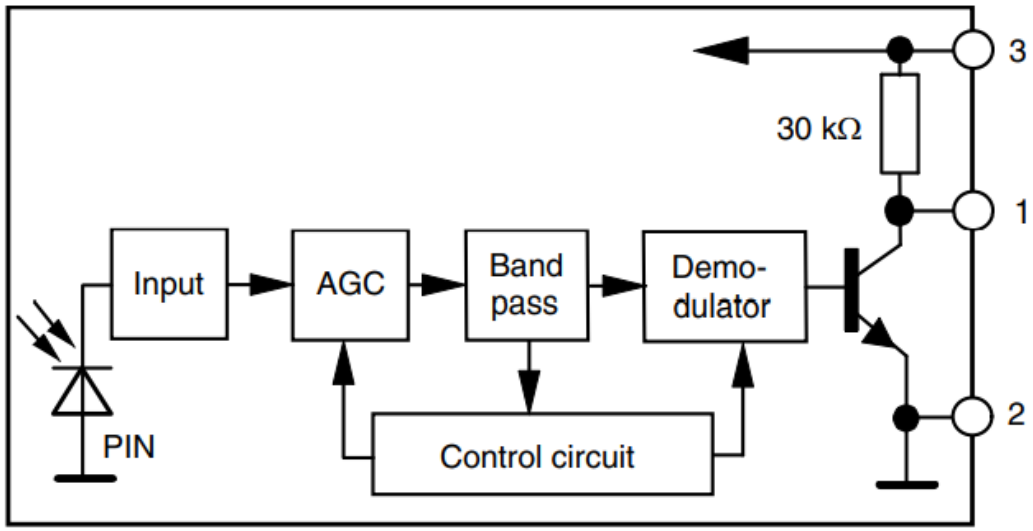
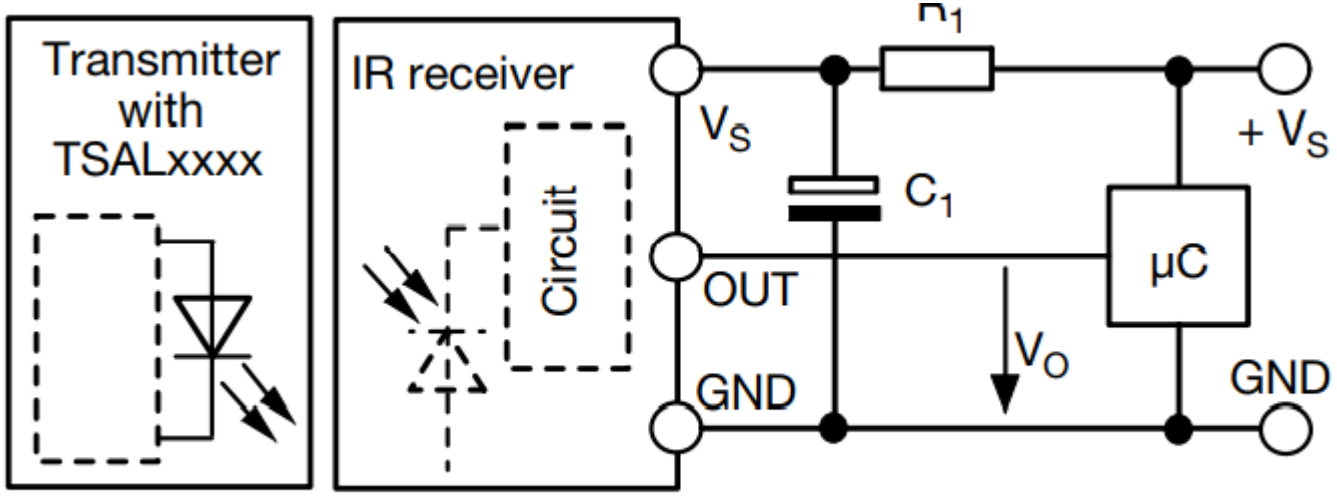


Fig. 7 - Relative Radiant Power vs. Wavelength

Vishay's **Series** for Remote Control
3-Pin Devices





R_1 and C_1 recommended to reduce supply ripple for $V_S < 2.8$ V

Vishay's **Series** for Remote Control

- Basically there are six categories of IR receive based on:
  - Data format (encoding/decoding methods used by various manufacturers)
    - Sonny, RCA, NEC, Panasonic, Sharp, etc.
  - Noise suppression (reduced by AGC) due to environmental factors
    - fluorescent lamps, dimmed LCD panels, emit noise in the infrared spectrum
  - Surface Mounted (8)
  - Through Hole (5)
- Range: ≈20 m
- Frequency: from 30 kHz to 57 kHz

Other Manufacturers:

COMPATIBILITY OF THE TSOP RECEIVER MODULES WITH DATA FORMATS

Vishay offers a variety of IR receiver series in order to supply an optimised solution for each application. Guidelines for selecting the best part for each data format is given here.

Basically there are six categories of IR receiver settings regarding noise suppression and data format compatibility. The summary of the features of these AGC types is listed here:

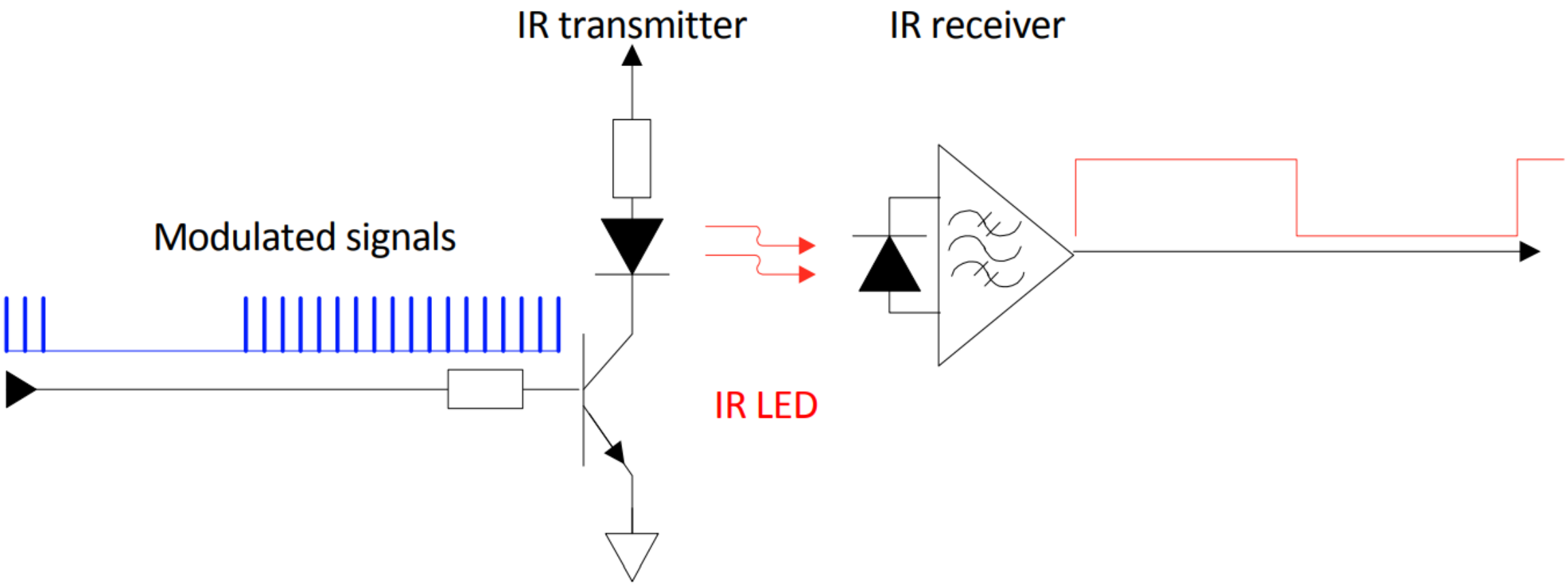
- AGC1 is compatible with any coding scheme, it is optimized for continuous data transmission
- AGC2 is optimized for most common remote control standard applications with typical long burst data formats
- AGC3 is optimized for short burst data formats in noisy environments
- AGC4 is optimized for most common remote control standard applications in very noisy environments (including dimmed LCD backlightings)
- AGC5 is optimized for short burst data formats in very noisy environments
- AGC6 has best sensitivity for NEC and RC5 code in Cyllene series receivers and offers high robustness against smart phone interference in Mneme series receivers
- AGC-S and AGC-C are optimized for Sony code and Cisco code respectively. These AGCs are exclusively designed for Aether series receivers

The tables below provide an overview of which IR receiver

CYLLENE IC (TSOP9...) - COMPATIBILITY FOR DATA FORMATS							
	AGC1	AGC2	AGC3	AGC4	AGC5	AGC6	BEST CHOICE
NEC	yes	yes	yes	yes	yes	yes	AGC6
RC5 code	yes	yes	yes	yes	yes	yes	AGC6
RC6 mode 0	yes	yes	yes	yes	yes	yes	AGC4
RCMM	yes	no	yes	no	yes	no	AGC3
RECS-80 code	yes	no	yes	no	yes	no	AGC3
R-2000 code (33 kHz)	yes	yes	yes	yes	yes	yes	AGC6
Mitsubishi code 38 kHz	yes	yes	yes	yes	yes	yes	AGC6
Sony code SIRCS 12 bit	yes	yes	no	no	no	yes	AGC2
Sony code SIRCS 15 bit	yes	yes	no	no	no	yes	AGC2
Sony code SIRCS 20 bit	yes	yes	no	no	no	no	AGC2
r-map data format 38 kHz	yes	no	yes	no	yes	no	AGC5
r-step data format 38 kHz	yes	no	yes	no	yes	no	AGC3
r-step data format for KB 56 kHz	yes	no	yes	yes	yes	yes	AGC4
XMP code	yes	no	yes	no	yes	no	AGC3
Cisco format 57kHz	yes	yes	no	no	no	yes	AGC2
Cisco format 37kHz	yes	yes	no	yes	yes	yes	AGC6
Low latency protocol - worst case frame 16 bit	yes	yes	yes	yes	yes	yes	AGC6
Low latency protocol - extended frame 24 bit	yes	yes	no	yes	yes	yes	AGC6
Sejin 4PPM format (38 kHz or 56 kHz)	yes	no	yes	yes	yes	no	AGC4
MCIR code keyboard package timing	yes	no	yes	no	yes	no	AGC3
MCIR code pointing device timing	yes	no	yes	no	yes	no	AGC3
MCIR code remote control timing	yes	no	yes	no	yes	no	AGC3
Konka TV data format 2004	yes	yes	yes	yes	yes	yes	AGC6
RCA code 56 kHz	yes	yes	no	yes	yes	yes	AGC4
Panasonic 36.7 kHz	yes	yes	yes	yes	yes	yes	AGC6
Sharp 38 kHz	yes	no	yes	yes	yes	yes	AGC6

MNEME IC (TSOP1...) - COMPATIBILITY FOR DATA FORMATS							
	AGC1	AGC2	AGC3	AGC4	AGC5	AGC6	BEST CHOICE
NEC	yes	yes	yes	yes	yes	yes	AGC4
RC5 code	yes	yes	yes	yes	yes	yes	AGC6
RC6 mode 0	yes	yes	yes	yes	yes	no	AGC4
RCMM	yes	no	yes	no	yes	no	AGC3
RECS-80 code	yes	no	yes	no	yes	no	AGC3
R-2000 code (33 kHz)	yes	yes	yes	yes	yes	yes	AGC4
Mitsubishi code 38 kHz	yes	yes	yes	yes	yes	no	AGC4
Sony code SIRCS 12 bit	yes	yes	yes	no	no	yes	AGC2
Sony code SIRCS 15 bit	yes	yes	yes	no	no	yes	AGC2
Sony code SIRCS 20 bit	yes	yes	no	no	no	no	AGC2
r-map data format 38 kHz	yes	no	yes	no	yes	no	AGC3
r-step data format 38 kHz	yes	yes	yes	yes	yes	no	AGC4
r-step data format for KB 56 kHz	yes	yes	yes	yes	yes	no	AGC4
XMP code	yes	no	yes	no	yes	no	AGC3
Cisco format 57kHz	yes	yes	no	no	no	yes	AGC2
Cisco format 37kHz	yes	yes	yes	yes	yes	yes	AGC6
Low latency protocol - worst case frame 16 bit	yes	yes	yes	yes	yes	yes	AGC6
Low latency protocol - extended frame 24 bit	yes	yes	yes	yes	yes	yes	AGC6
Sejin 4PPM format (38 kHz or 56 kHz)	yes	yes	yes	yes	yes	no	AGC4
MCIR code keyboard package timing	yes	yes	yes	yes	yes	no	AGC4
MCIR code pointing device timing	yes	yes	yes	yes	yes	no	AGC4
MCIR code remote control timing	yes	yes	yes	yes	yes	no	AGC4
Konka TV data format 2004	yes	yes	yes	yes	yes	yes	AGC4
RCA code 56 kHz	yes	yes	yes	yes	no	yes	AGC6
Panasonic 36.7 kHz	yes	no	yes	yes	yes	no	AGC4
Sharp 38 kHz	yes	no	yes	yes	yes	no	AGC4

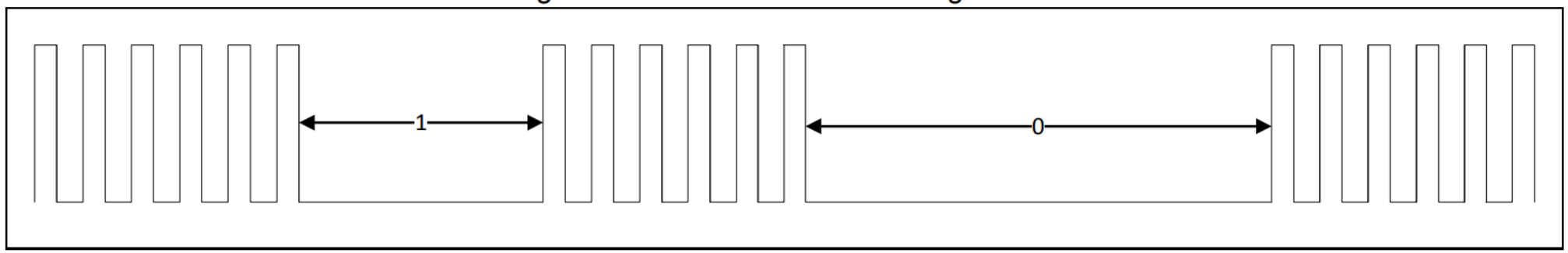
Data Encoding Methods



Pulse Distance Encoding

Figure 2 shows how the distances between bursts of pulses are used to encode (and decode) 0's and 1's. A 0 is encoded with a longer distance between bursts than a 1 in the example shown.

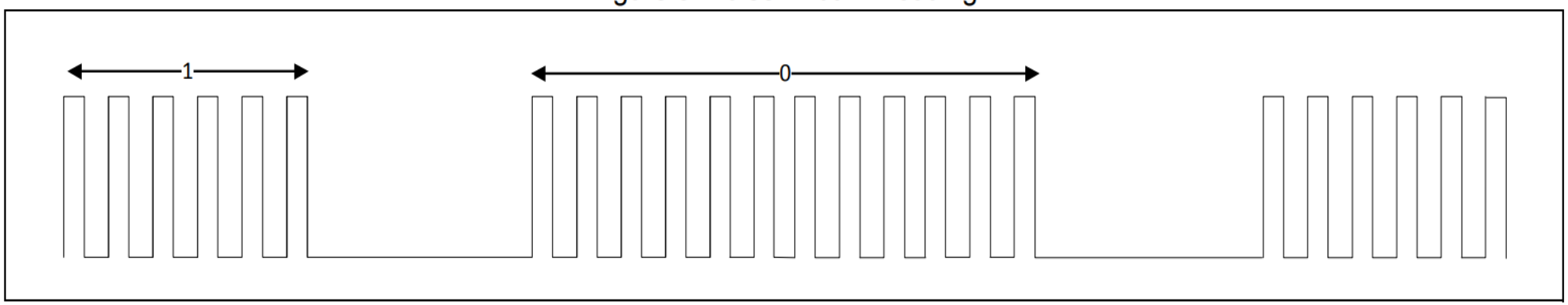
Figure 2. Pulse Distance Encoding



Pulse Width Encoding

Figure 3 shows how the envelope of the pulse bursts (otherwise known as the pulse width) is used to encode data. A 0 is encoded with a wider pulse width than a 1 in the example shown.

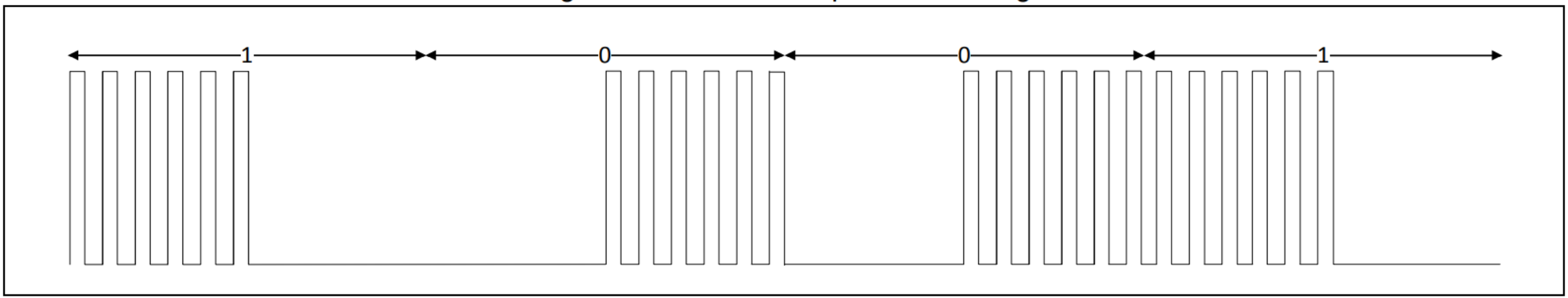
Figure 3. Pulse Width Encoding



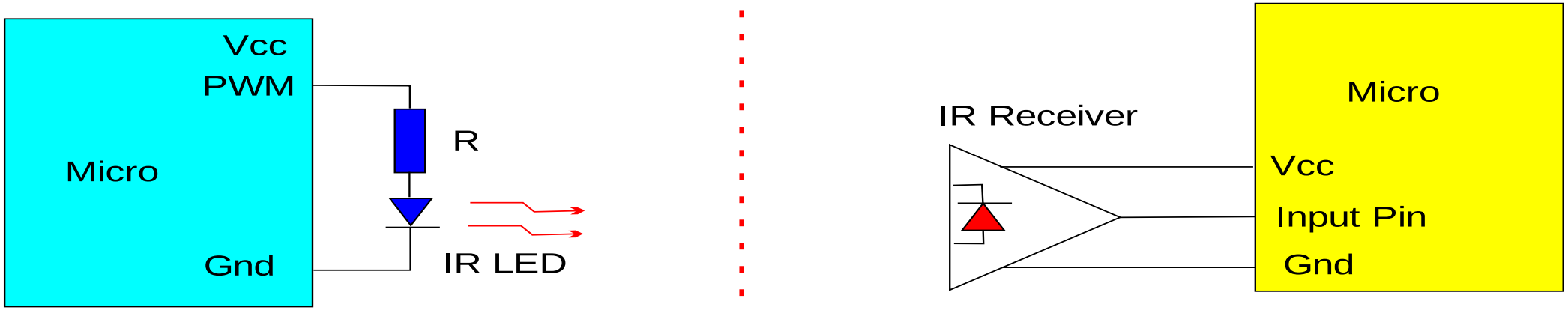
Manchester Biphase Encoding

Figure 4 illustrates manchester biphase encoding. In this example, a 1 is encoded such that the first half of a bit period has pulses and the second half has none. A 0 is encoded such that the first half of a bit period has no pulses and the second half has pulses.

Figure 4. Manchester Biphase Encoding



Basic IR System



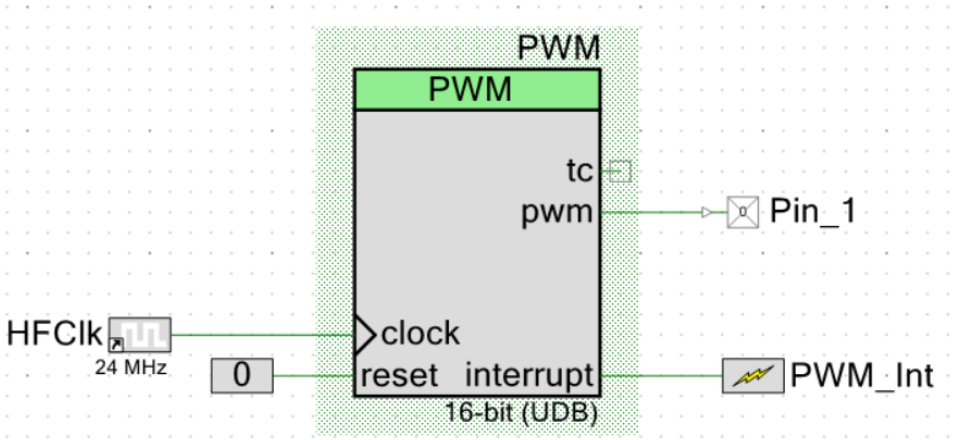
Transmitter End External Components:

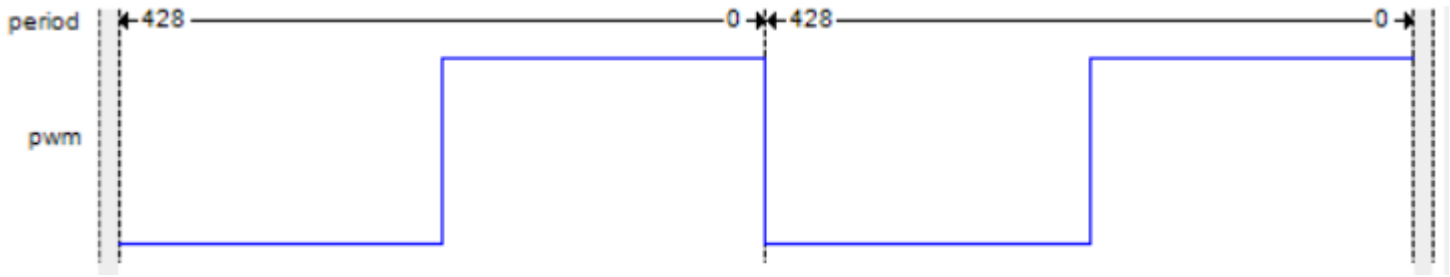
- Microcontroller
  - 8-bit $1.00 micro will do
- Resistor to a GPIO pin to
  - Limit current <20ma
- IR emitter to match λ of IR receiver
  - Like tsal1600
- Software
  - Generate n pulses
    - at frequency of IR receiver

Receiver End External Components:

- Microcontroller or Not
  - Logic gates
    - Do some think
- IR receiver
  - Most type will do
    - No continuous data
- Software
  - Poll pin or generate interrupt
    - Do some think

Generating Pulses Using a PWM and a tsop 4156 56 Kz IR Receiver





Example Calculations Using a Clock of 24 MHz (any other clock frequency can be used)

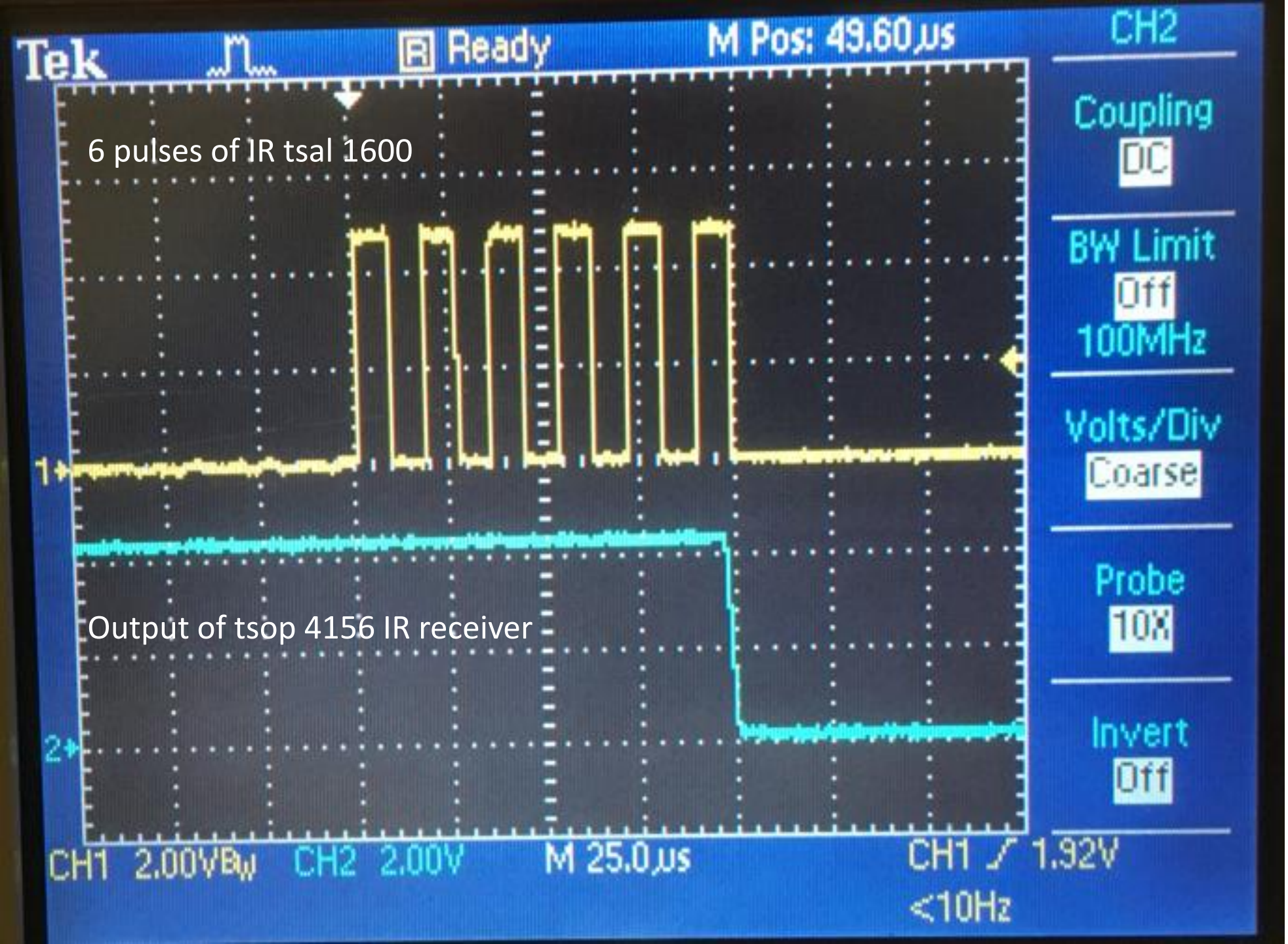
- Using a 56 KZ IR receiver
- 24 MHz / 56 Kz ≈ 429
  - Set the period of the PWM to 428
  - Set the compare value to 428/2 ≈ 214 for 50% duty cycle

Test Program Using Interrupts

```
.
CY_ISR_PROTO(PWM_Interrupt_Handler)
{
    uint8 Temp;
    if ( PulseCount !=0)
        PulseCount --;
    Temp = PWM_ReadStatusRegister();
}
```

```
void Gen_Pulses(void)
{
    if(PulseCount!=0)
    PWM_Start();
    while(PulseCount !=0){}
    PWM_WritePeriod(428);
    PWM_Stop();
}
```

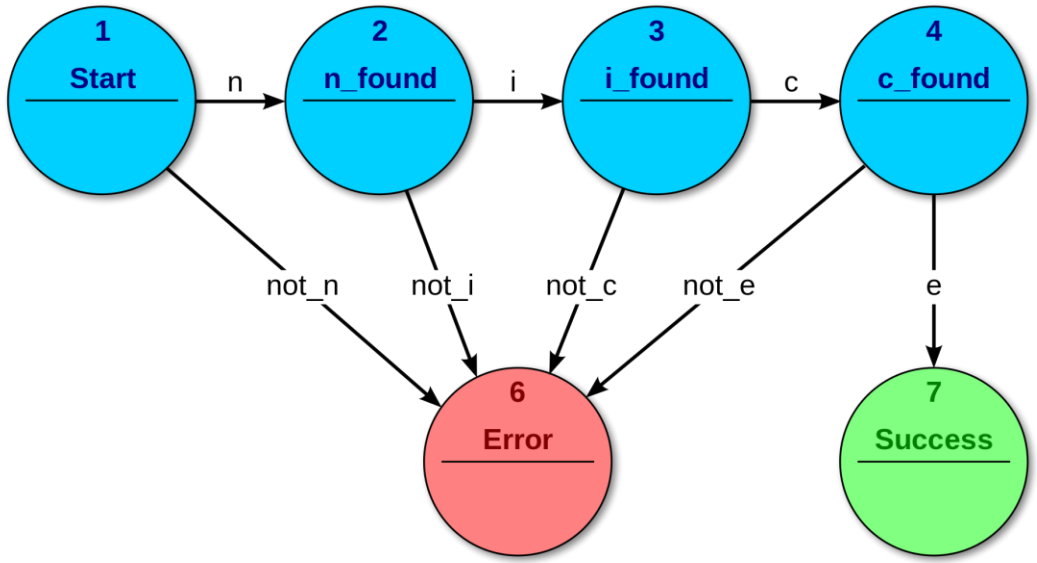
```
int main(void)
{
.
for(;;){
        PulseCount =6;
        Gen_Pulses();
        CyDelay(5000);
    }
}
```

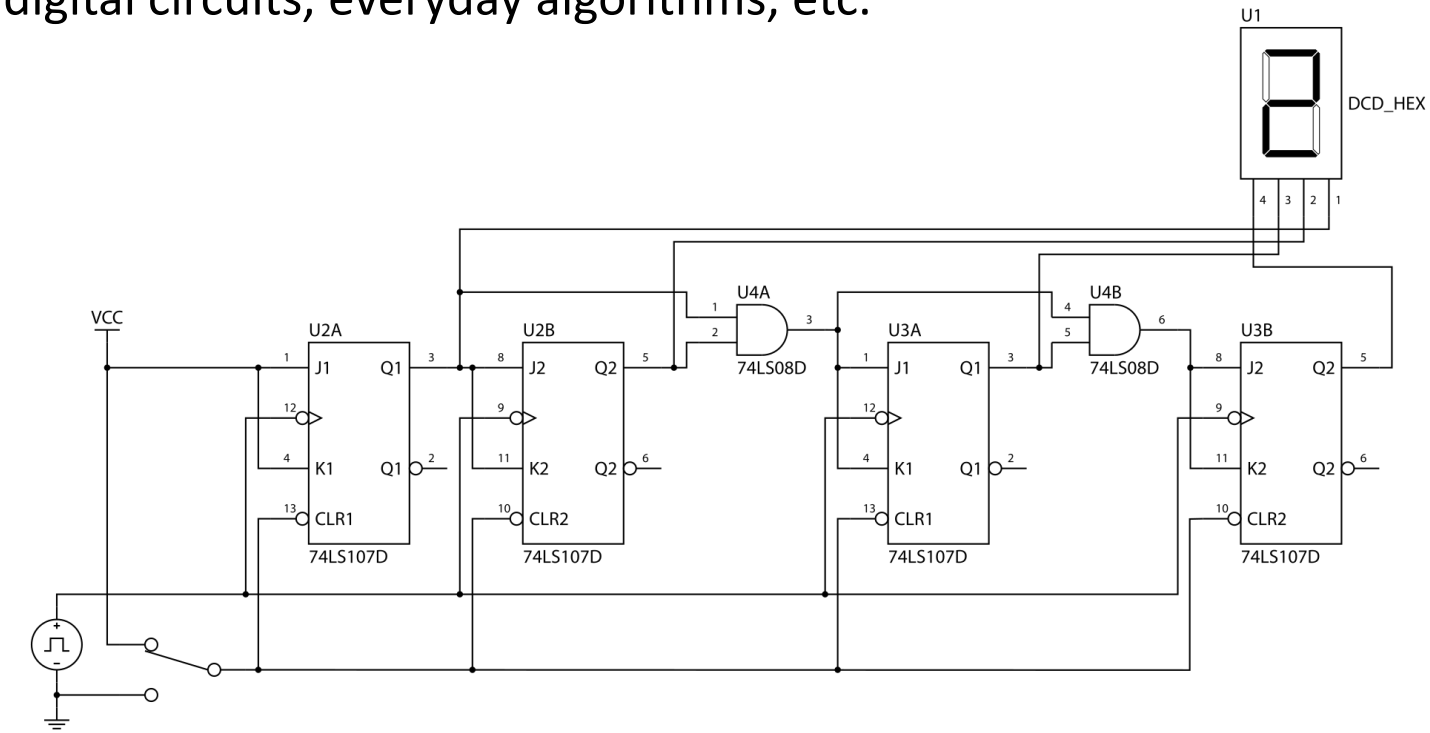

Tek
Ready
M Pos: 49.60µs
CH2
Coupling
DC
BW Limit
Off
100MHz
Volts/Div
Coarse
Probe
10X
Invert
Off
6 pulses of IR tsal 1600
Output of tsop 4156 IR receiver
1
2
CH1 2.00V
CH2 2.00V
M 25.0µs
CH1 1.92V
<10Hz

Generating Pulses Using Raspberry Pi Pico State machine

Finite-State Machines

- A computing system (mathematical mode) that can be in only one of n-states
- Transition from one state to another other state is determined by input to current state
- All around us – computer science theory, digital circuits, everyday algorithms, etc.





- Parsing the word nice _()

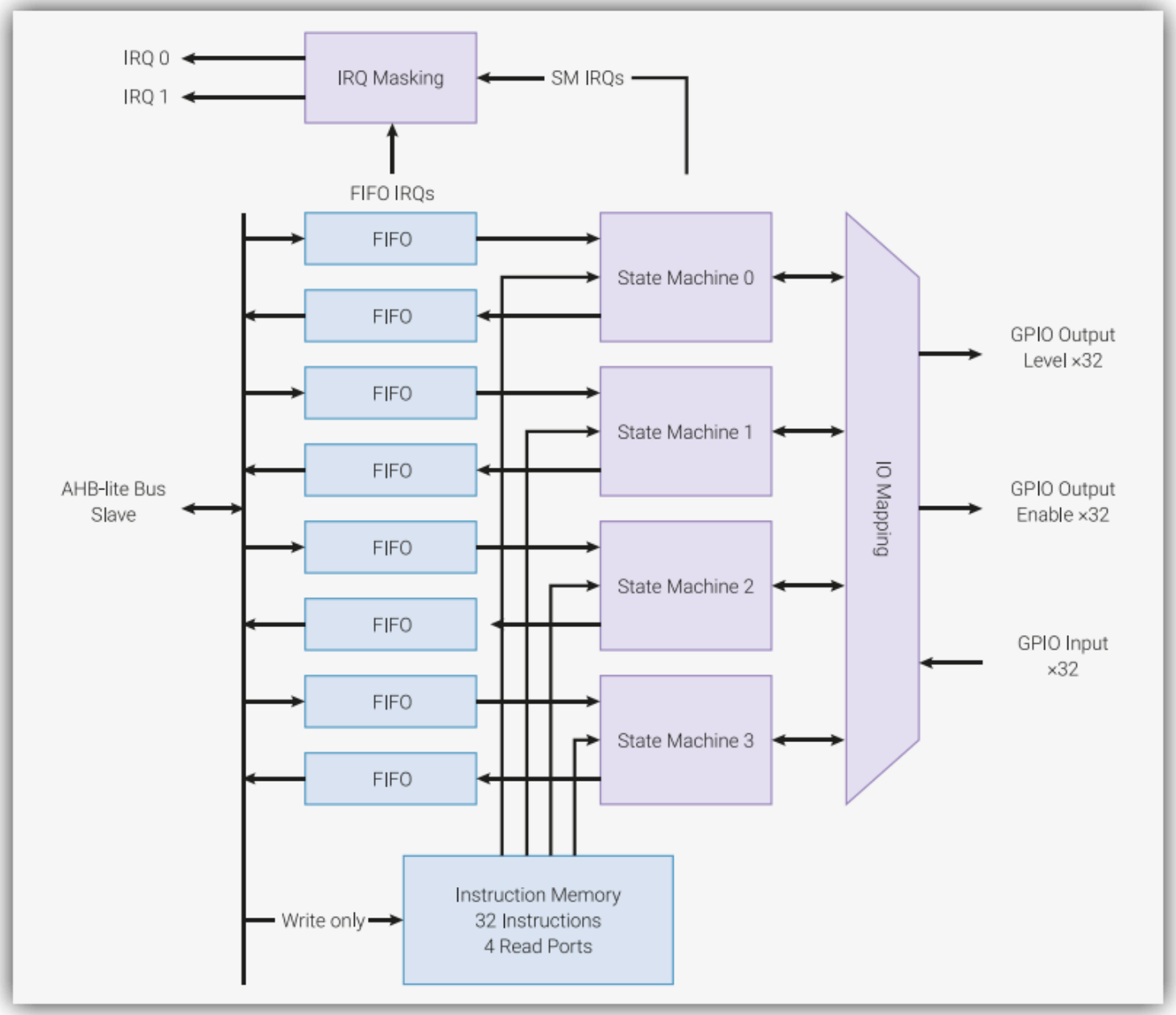
4-bit counter using J k flip flops

Generating Pulses Using Raspberry Pi Pico State machine

Finite-State Machines in Microcontrollers (FSM)

- All arm bases microcontroller may incorporate FSM
  - Including Raspberry Pi Pico
- Cypress PSoC Microcontrollers
  - All Digital Blocks (UDB) are State Machine (reduces libraries)
    - Digital logic –gates, flip flops, registers, mux, de-mux
    - Digital Function – counter, shift register, pwm, quadrature encoders, plus more
    - Digital Communication Blocks

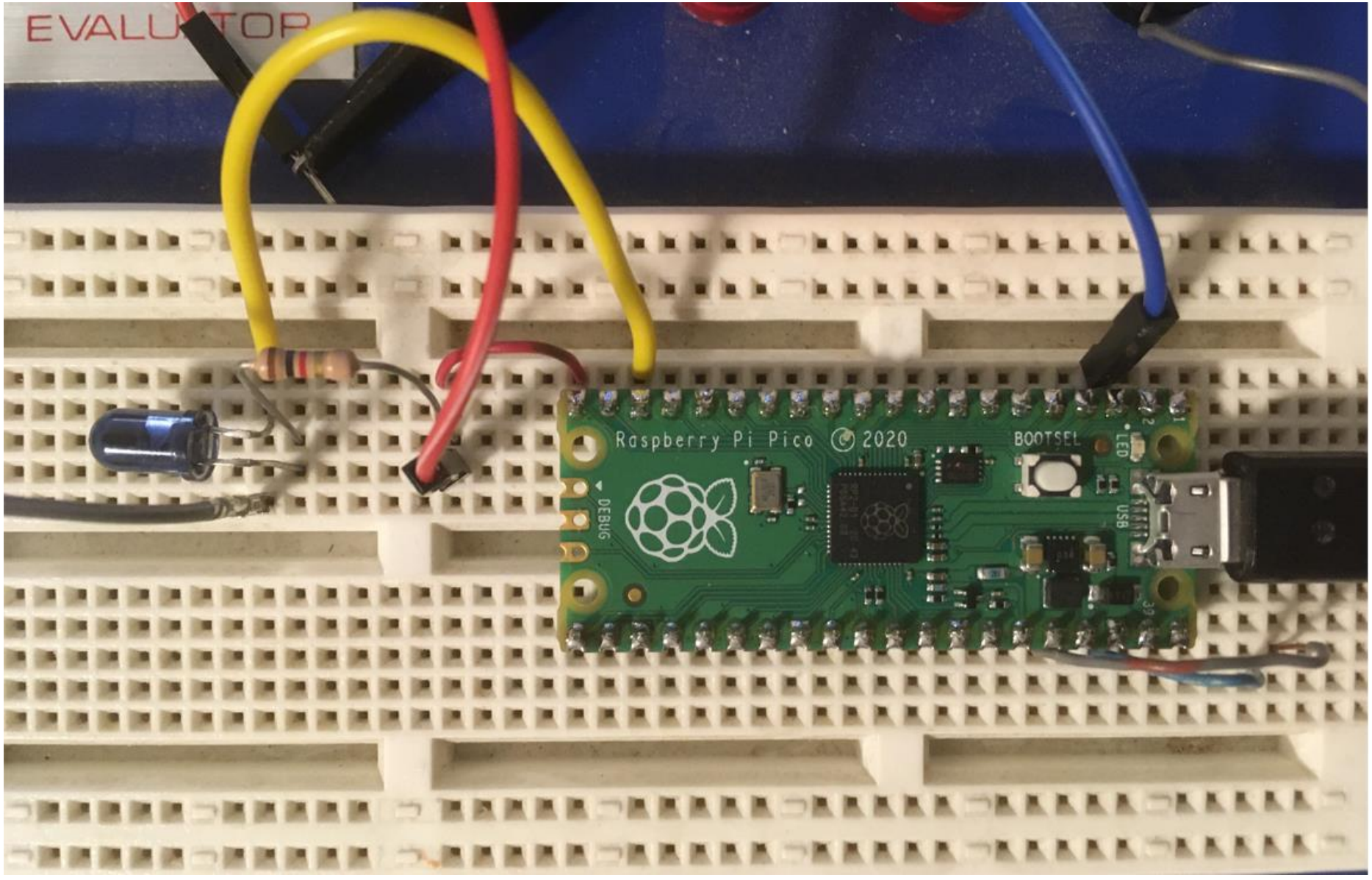
Raspberry Pi Pico State Machine

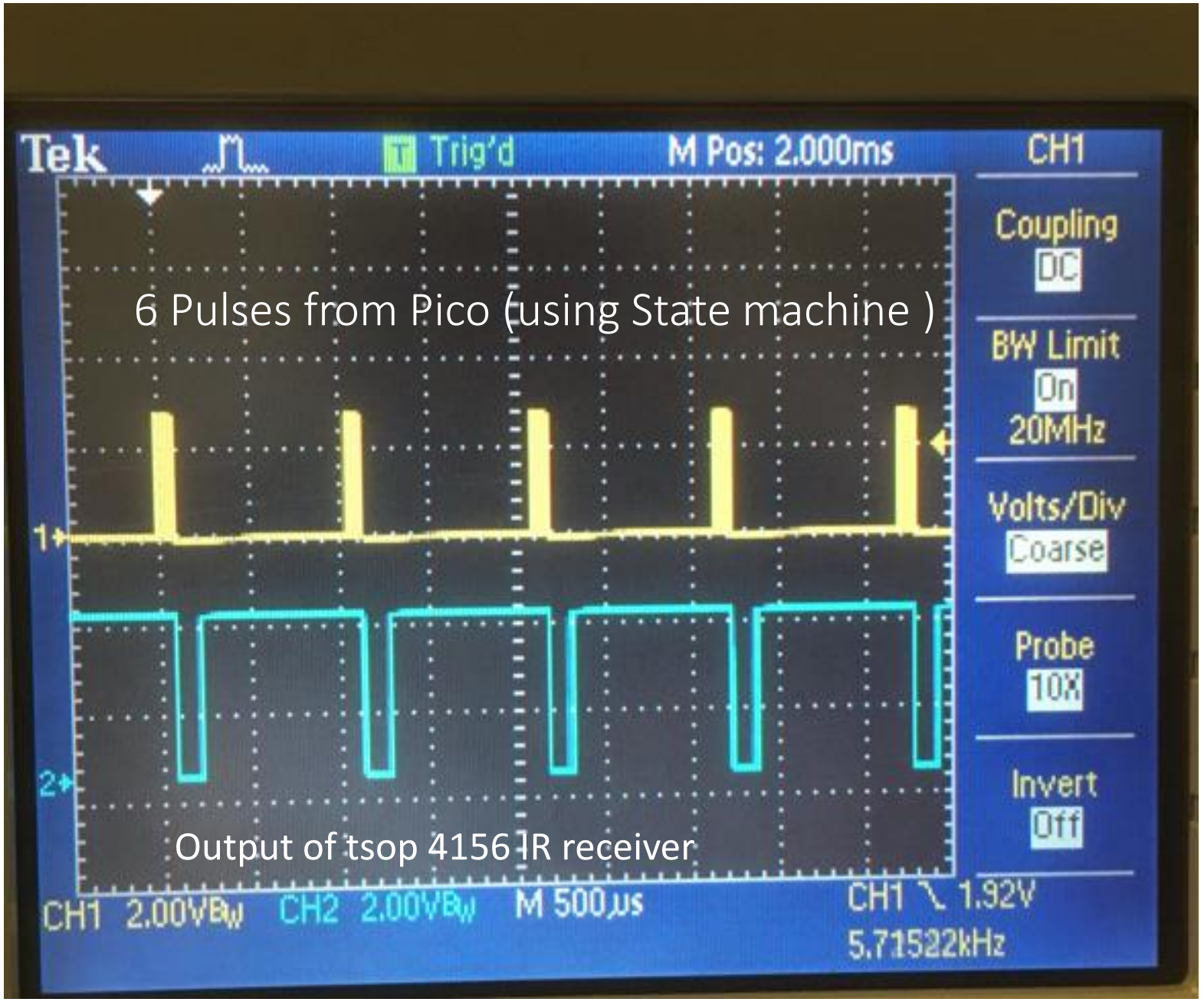


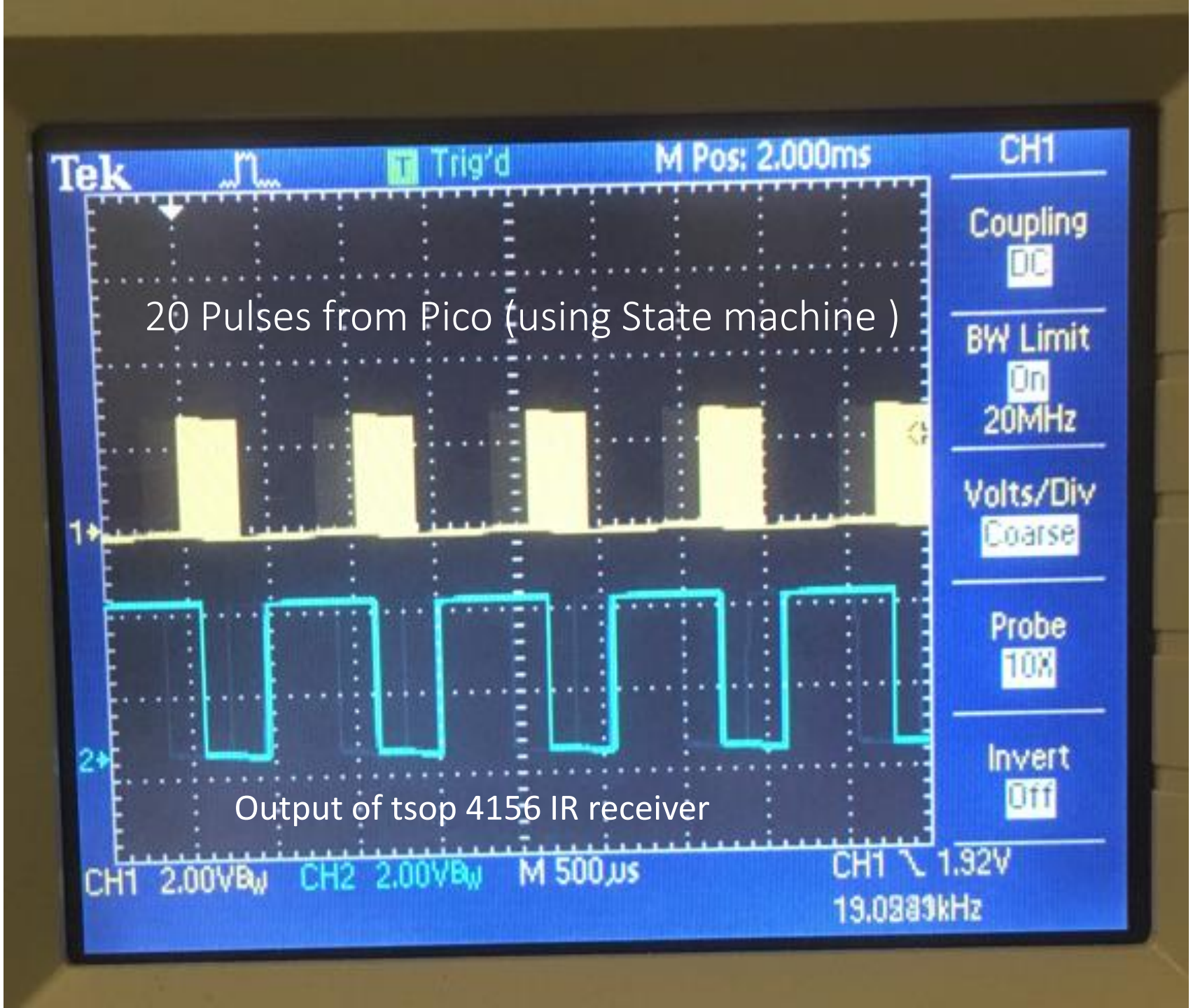
```
# Raspberry Pi Pico outputting n pulses to IR emitter using PIO (State Machine)
import time
from time import sleep
from machine import Pin
import rp2
@rp2.asm_pio(set_init=rp2.PIO.OUT_LOW)
def nPulse_56kz():
    pull()
    mov(x, osr) # num pulses
    label ("start")
    set(pins, 1)      [30]      #31 cycles
    set(pins, 0)      [30]      #31 cycles
    jmp(x_dec, "start")         #2 cycles
                                # calculating frequence: f = 64 x 56000=3564000 hz
# Create the StateMachine 8 pulse @ 57kz, outputting on Pin(25).
sm = rp2.StateMachine(0, nPulse_56kz, freq=3584000, set_base=Pin(15),out_base=Pin(15) )
# Start the StateMachine.
while True:
    sm.put(5)
    sm.active(1)
    time.sleep_ms(1)
    sm.active(0)

```

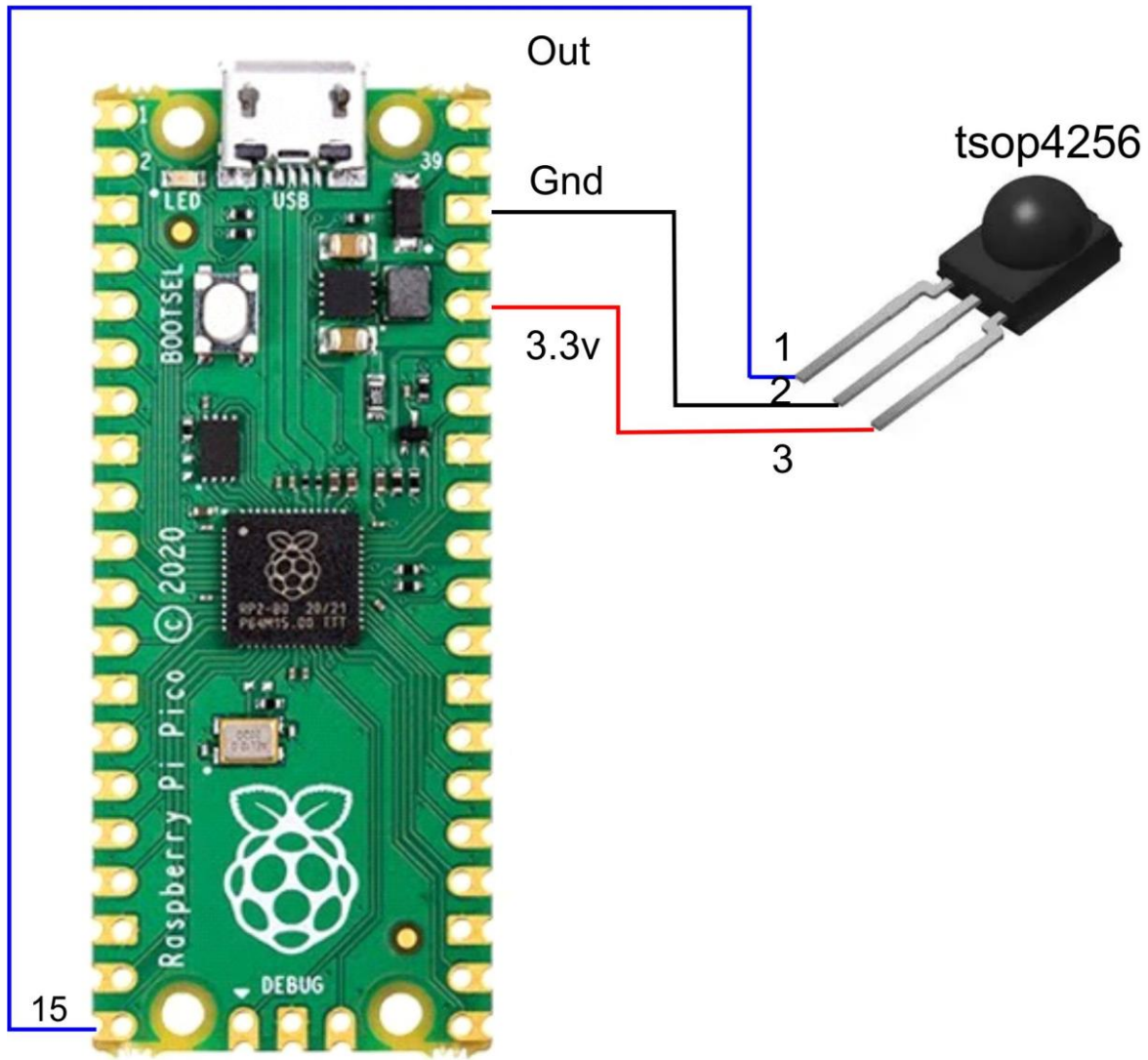
Generating n Pulses Raspberry Pi Pico State Machine



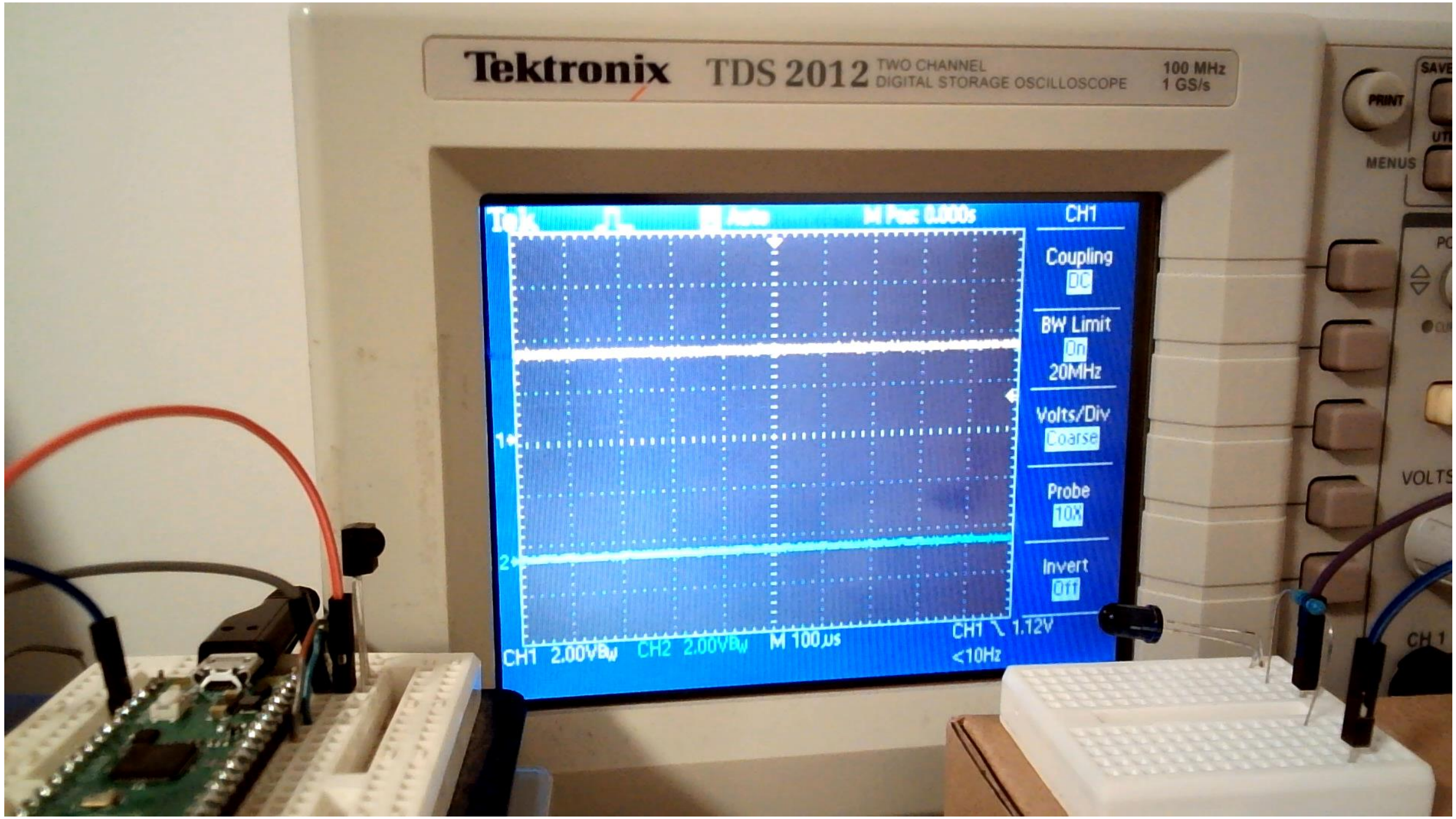

Tek
Trig'd
M Pos: 2.000ms
CH1
Coupling
DC
BW Limit
On
20MHz
Volts/Div
Coarse
Probe
10X
Invert
Off
6 Pulses from Pico (using State machine)
Output of tsop 4156 IR receiver
CH1 2.00V CH2 2.00V M 500µs
CH1 1.92V
5.71522kHz


Tek
Trig'd
M Pos: 2.000ms
CH1
Coupling
DC
BW Limit
On
20MHz
Volts/Div
Coarse
Probe
10X
Invert
Off
20 Pulses from Pico (using State machine)
Output of tsop 4156 IR receiver
CH1 2.00V
CH2 2.00V
M 500µs
CH1 1.92V

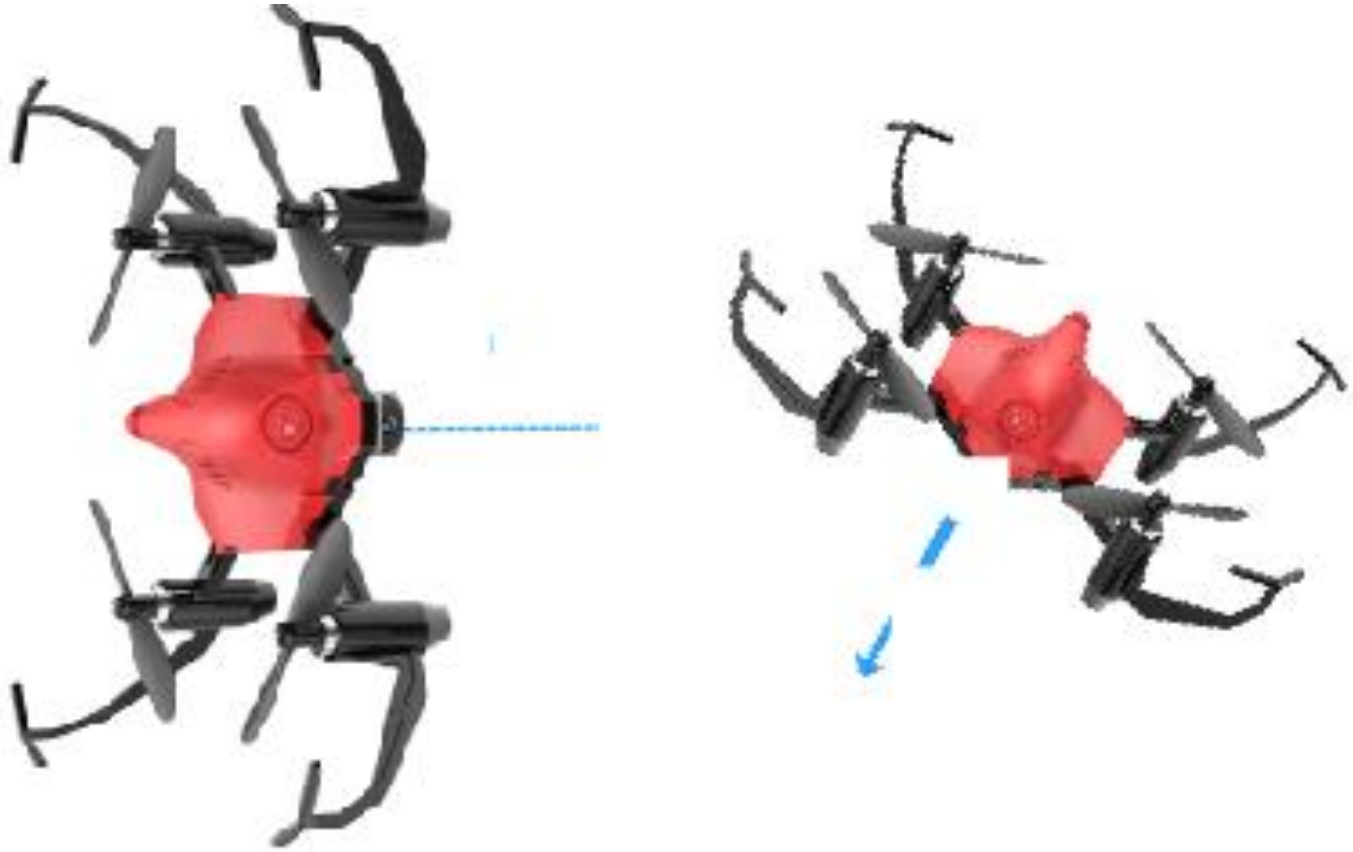
Pico Flashing LED on IR Pulse Received



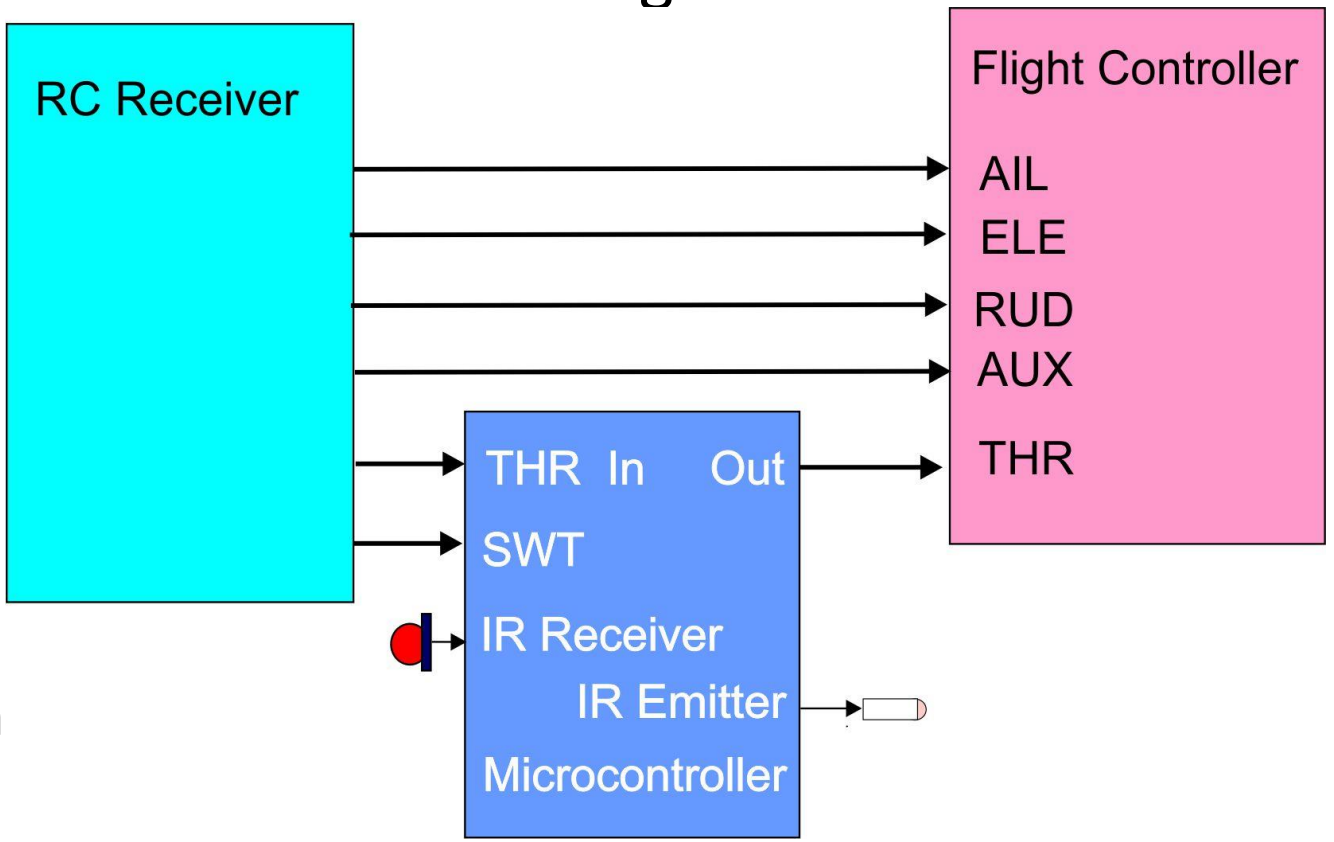

```python
from machine import Pin
import utime
led = Pin(25, Pin.OUT)
IR_Receiver = Pin(15, Pin.IN, Pin.PULL_UP)
global Loop_Count
Loop_Count = 20
global Flag
Flag = False
led.value(0)
def IR_Receiver_callback(pin):
    global Flag
    Flag = True
IR_Receiver.irq(IR_Receiver_callback, Pin.IRQ_FALLING)
while(True):
    if Flag:
        i = Loop_Count
        while i >0:
            led.toggle()
            utime.sleep_ms(50)
            i= i-1
        Flag = False
```


Tektronix TDS 2012 TWO CHANNEL DIGITAL STORAGE OSCILLOSCOPE
100 MHz
1 GS/s
PRINT
MENUS
CH1
Coupling
DC
BW Limit
On
20MHz
Volts/Div
Coarse
Probe
10X
Invert
Off
CH1 2.00V CH2 2.00V M 100µs
CH1 1.12V
<10Hz
VOLTS
CH 1

Application of Single Burst IR Pulses Force Landing a Quadcopter Following an IR Hit

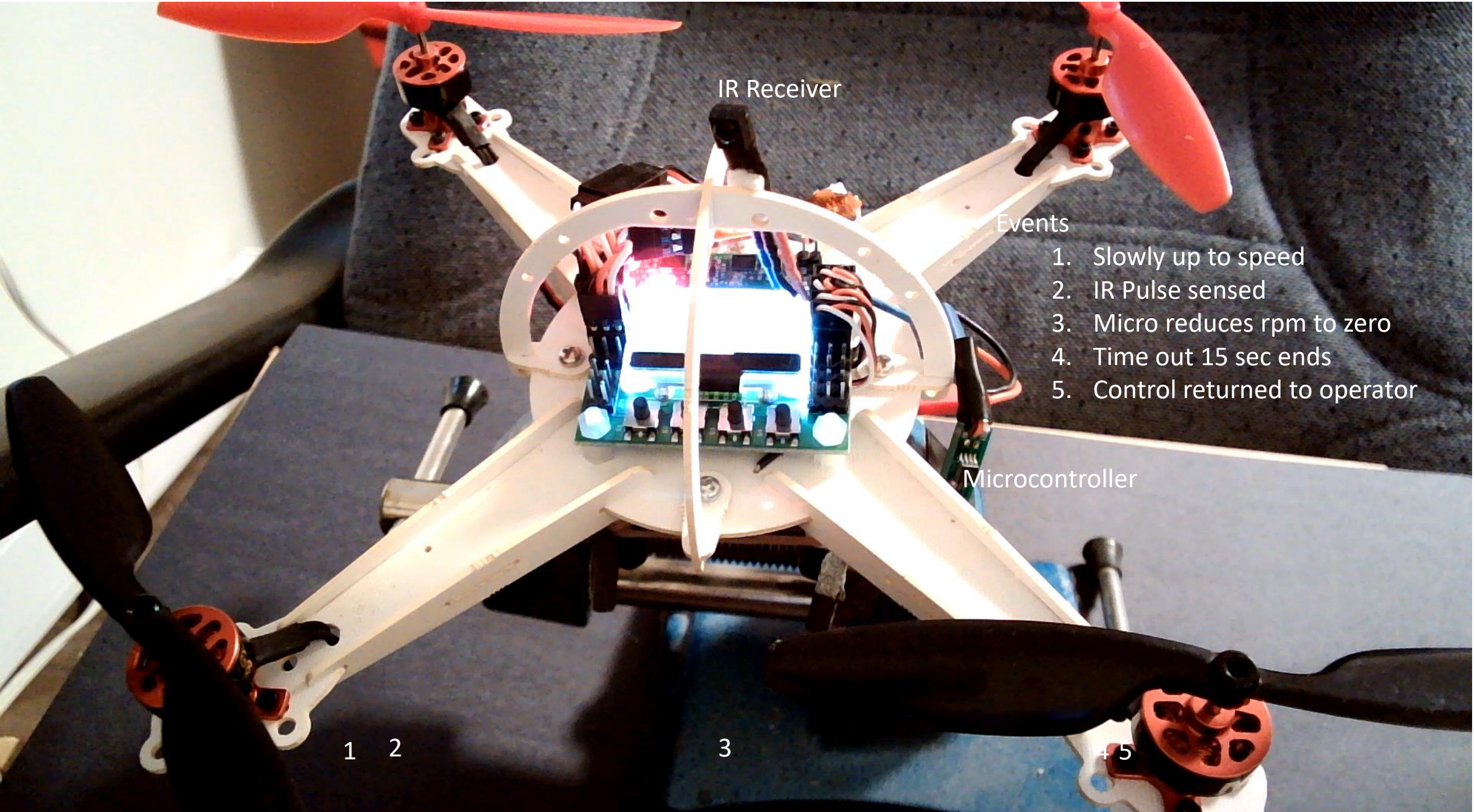


Force Landing a Quadcopter Following an IR Hit



The throttle signal from RC receiver

- is connected to the micro and passed on flight controller of the quadcopter
- If an IR hit is sensed by the micro
  - operator loses throttle control only
  - micro slowly reduces throttle signal forcing the quadcopter to land
  - Following a time out throttle control restores


IR Receiver
Events
1. Slowly up to speed
2. IR Pulse sensed
3. Micro reduces rpm to zero
4. Time out 15 sec ends
5. Control returned to operator
Microcontroller
1
2
3
4
5

Vishay’s TSDP Receiver Series for Infrared RS232 Communication

TSDP Series:

- TSDP series devices differ from standard infrared receivers for remote control
- frequencies are tuned to the needs of RS-232 communication
- pulse-width accuracy has been improved
- 1200 bps to 9600 bps over a range of up to 35 meters
- either 38.4 kHz or 57.6 kHz

TSDP34138 IR Receiver:

- Frequency : 38.4 kHz
- Data Rate: 4800 bps

TSDP devices may be used for RS-232 Data Communications (AGC1 low-noise/ AGC3 typical-noise environment)

DATA RATE (bps)	CARRIER FREQUENCY (kHz)	CYCLES PER MARK / SPACE	AGC1 LOW-NOISE ENVIRONMENTS	AGC3 TYPICAL-NOISE ENVIRONMENTS
9600	57.6	6	TSDP34156, TSDP37156, TSDP36156	TSDP34356, TSDP37356, TSDP36356
4800	57.6	12	TSDP34156, TSDP37156, TSDP36156	
4800	38.4	8	TSDP34138, TSDP37138, TSDP36138	TSDP34338, TSDP37338, TSDP36338
2400	38.4	16	TSDP34138, TSDP37138, TSDP36138	

TSDP34138 special case : 4800 bps, 38.4 kHz, and AGC1

- any possible data pattern can be received indefinitely
- In all other combinations in the table, data patterns exist that will trigger the AGC
  - data patterns exist that data transmission may need to be interrupted periodically to allow the AGC to recover

Explanation of Why AGC Triggers

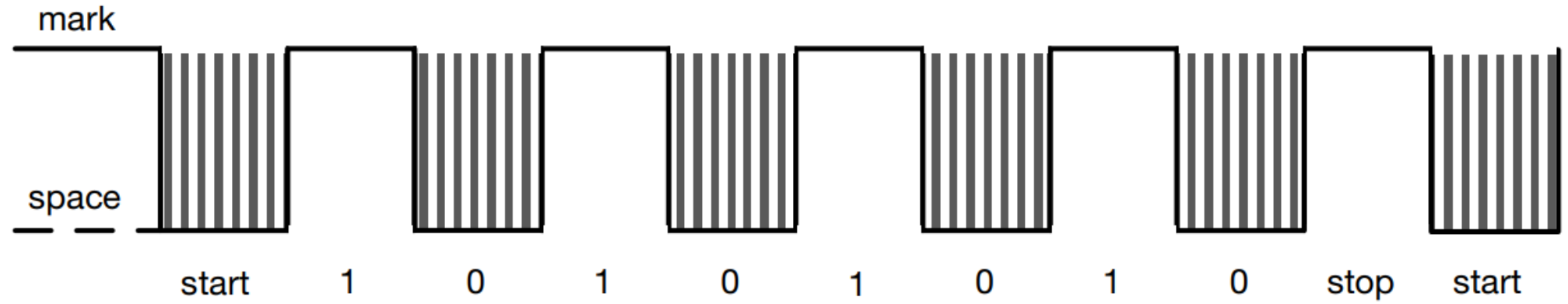
tB : burst length

Dt : envelope duty cycle

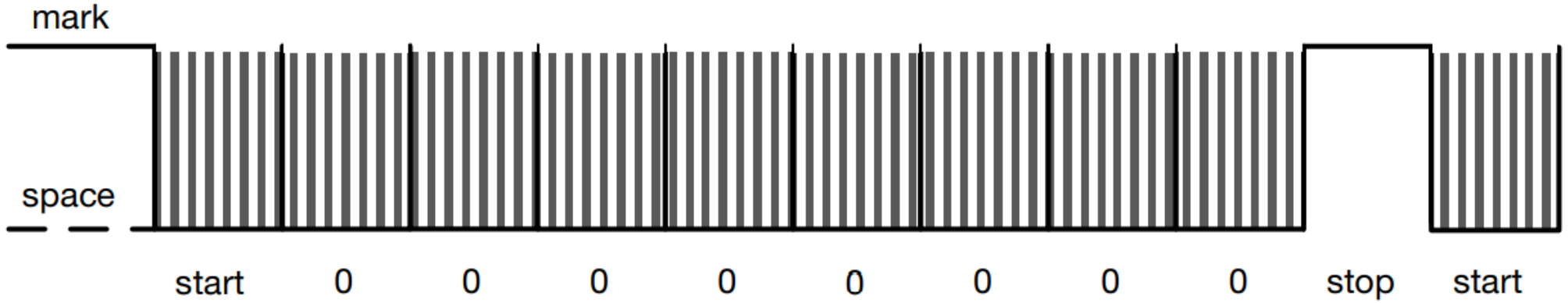
Dt = tB/TB : burst time divided by the burst repetition time

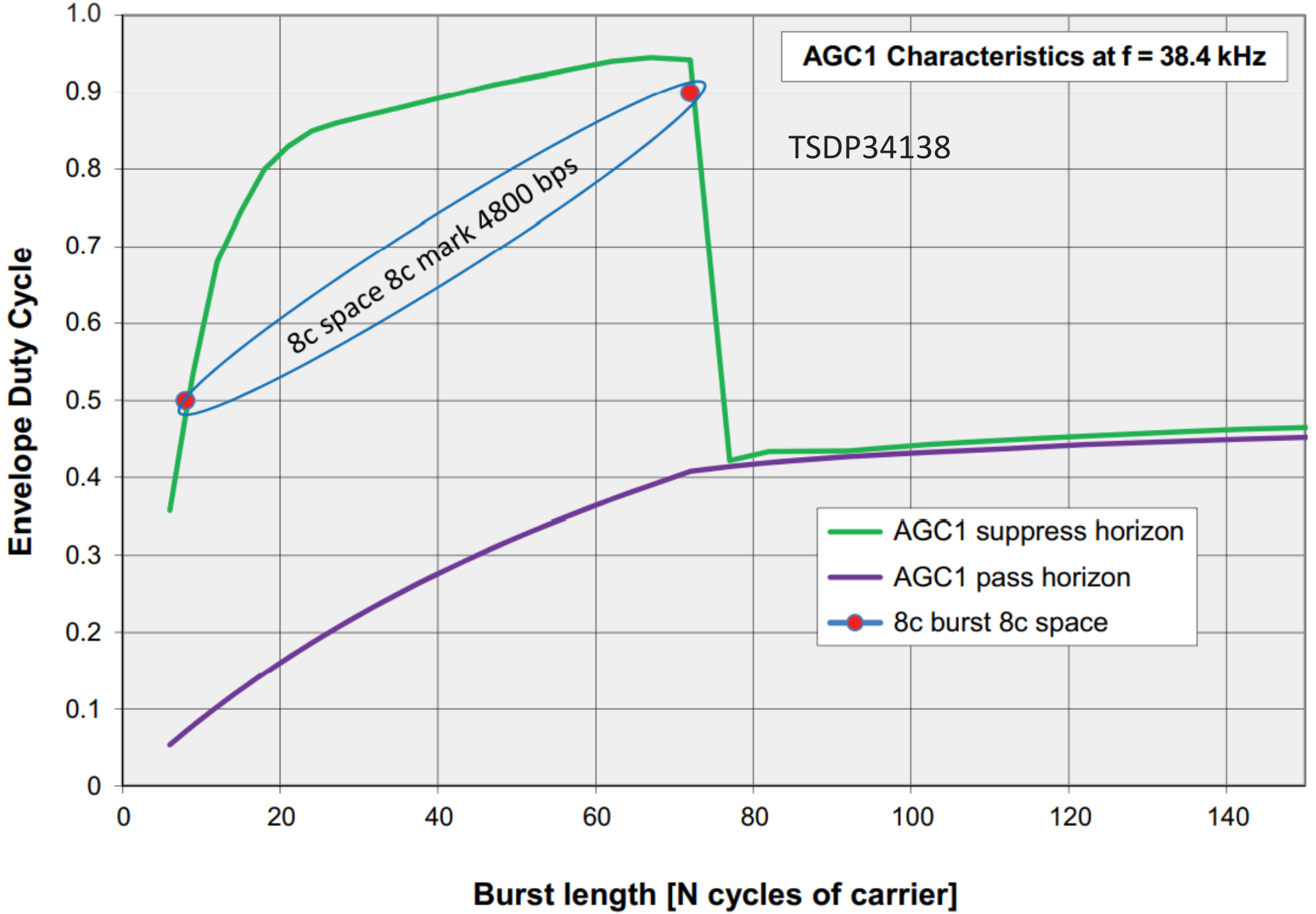
Two Worst-Case Data Patterns

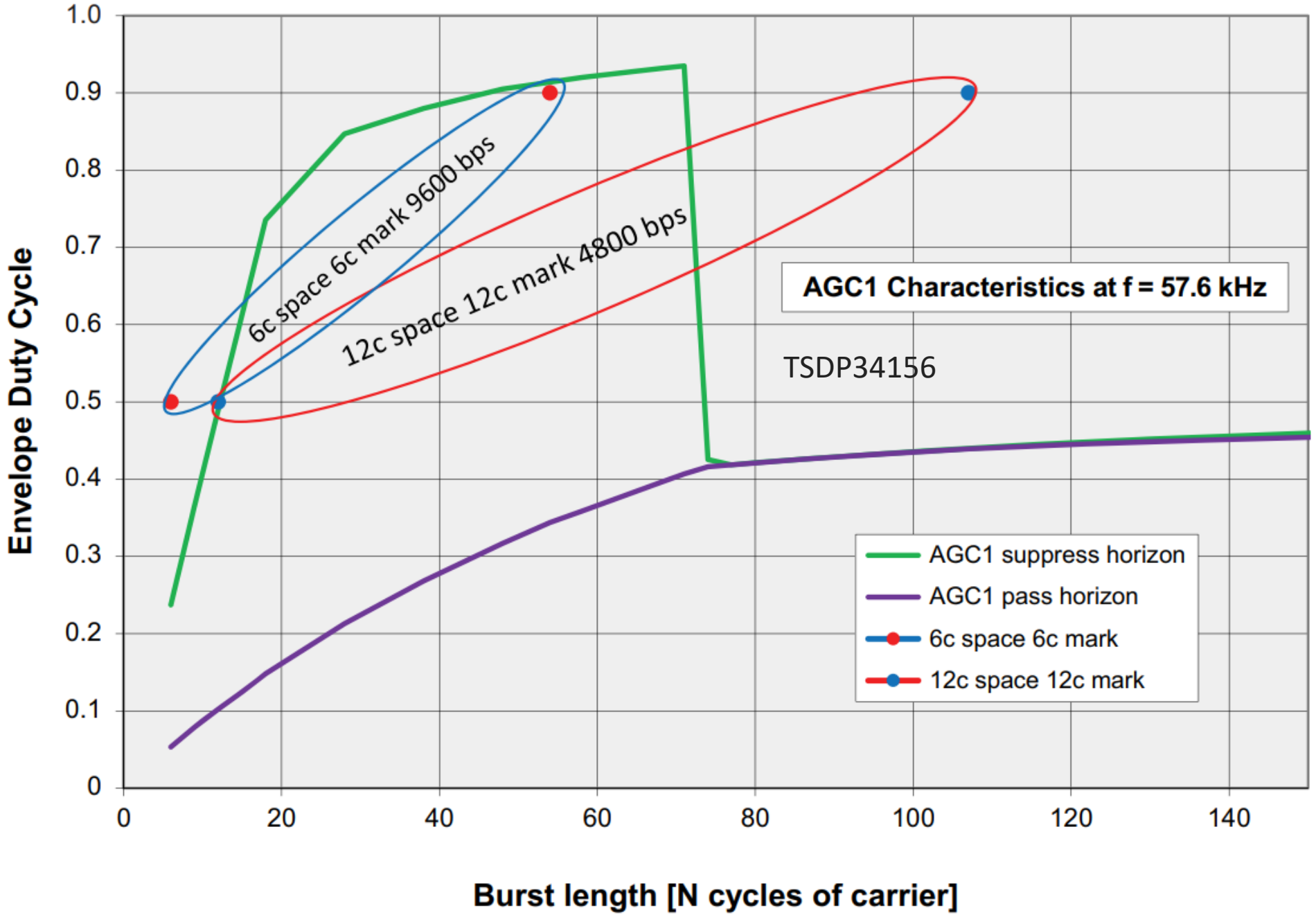
alternating 1-0-1-0: Dt =0.5



data bursts of 0: Dt =0.9




AGC1 Characteristics at f = 38.4 kHz
TSDP34138
8c space 8c mark 4800 bps
AGC1 suppress horizon
AGC1 pass horizon
8c burst 8c space
Envelope Duty Cycle
Burst length [N cycles of carrier]
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
80
100
120
140

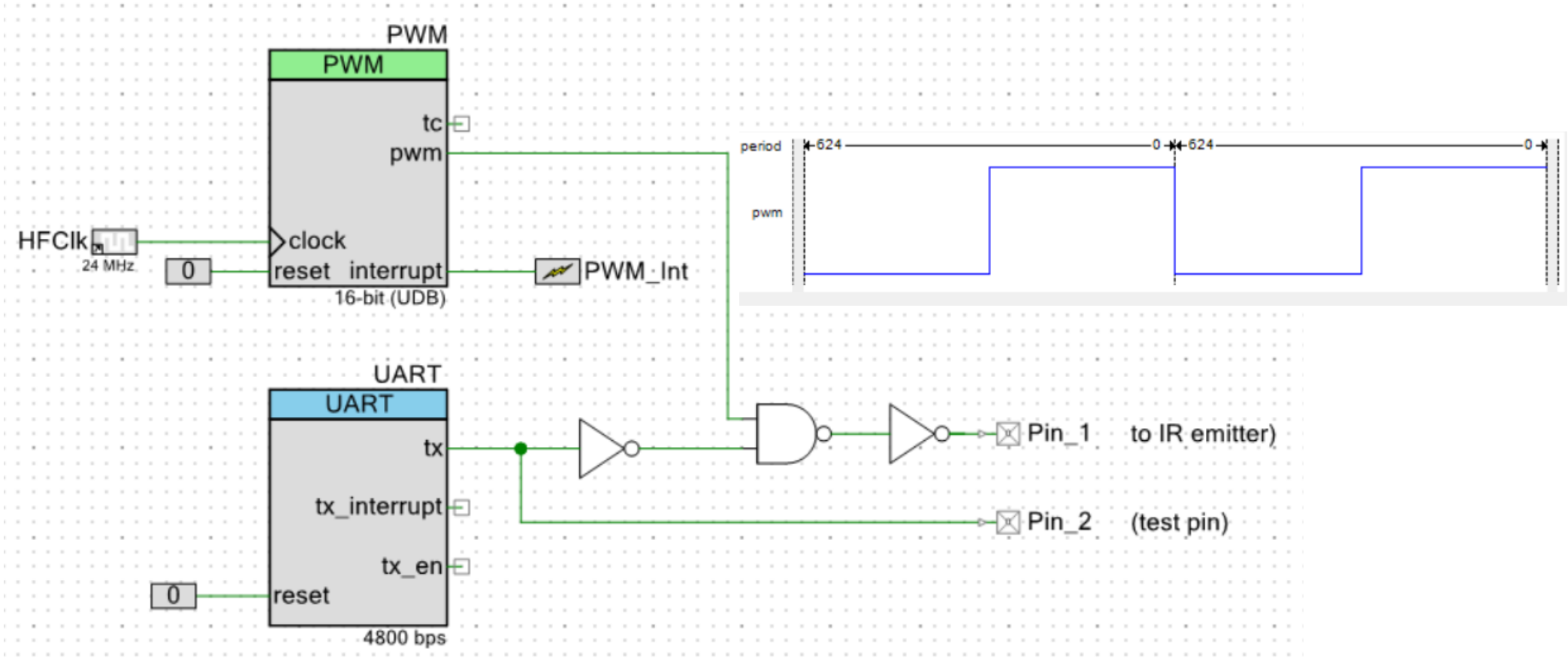

AGC1 Characteristics at f = 57.6 kHz
TSDP34156
6c space 6c mark 9600 bps
12c space 12c mark 4800 bps
AGC1 suppress horizon
AGC1 pass horizon
6c space 6c mark
12c space 12c mark
Envelope Duty Cycle
Burst length [N cycles of carrier]
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
80
100
120
140

Generating Mark/Space Pulses in RS-232 Data Stream
(AGC1 typical-noise environment)

Solutions

- **Cypress PSoC Devices**
  - Simple solution
- **Raspberry Pi Pico**
  - State Machine ?
  - External Nand Gates
  - Other

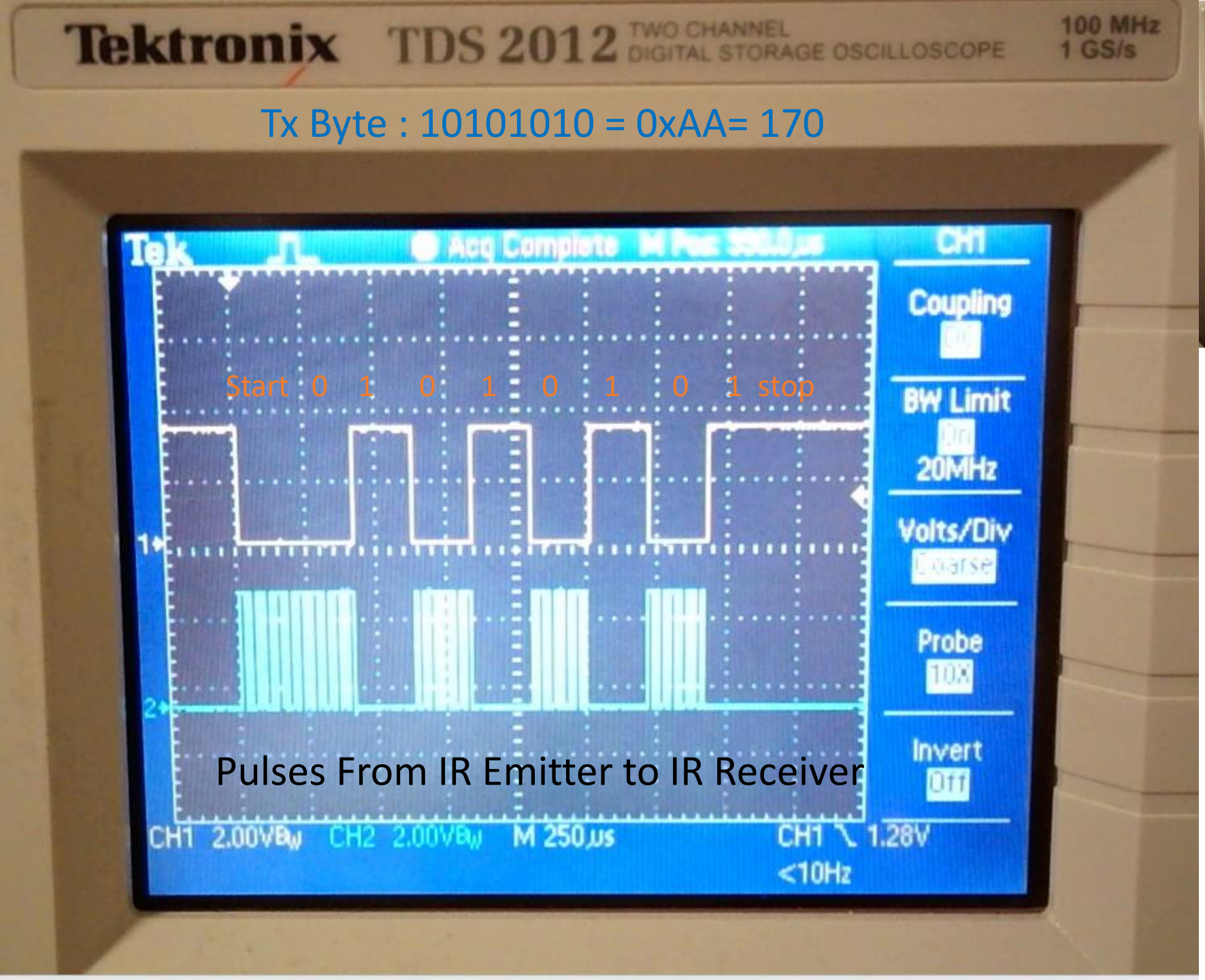
Solution Using PSoC 4 Microcontroller

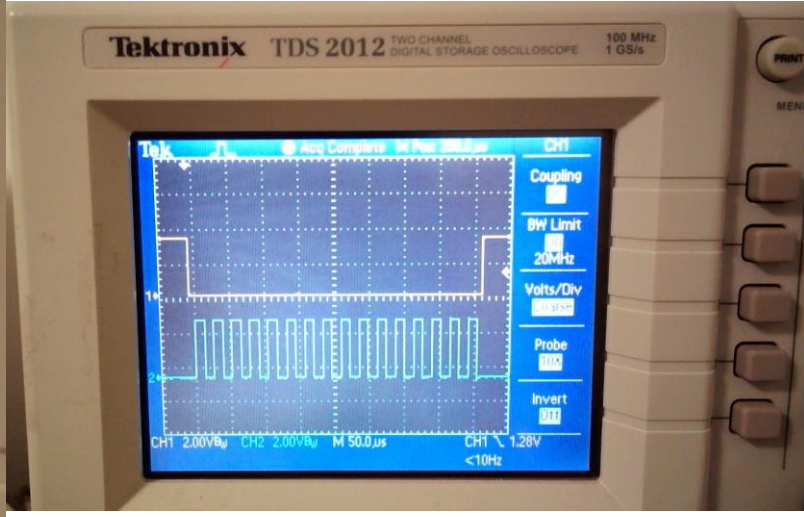


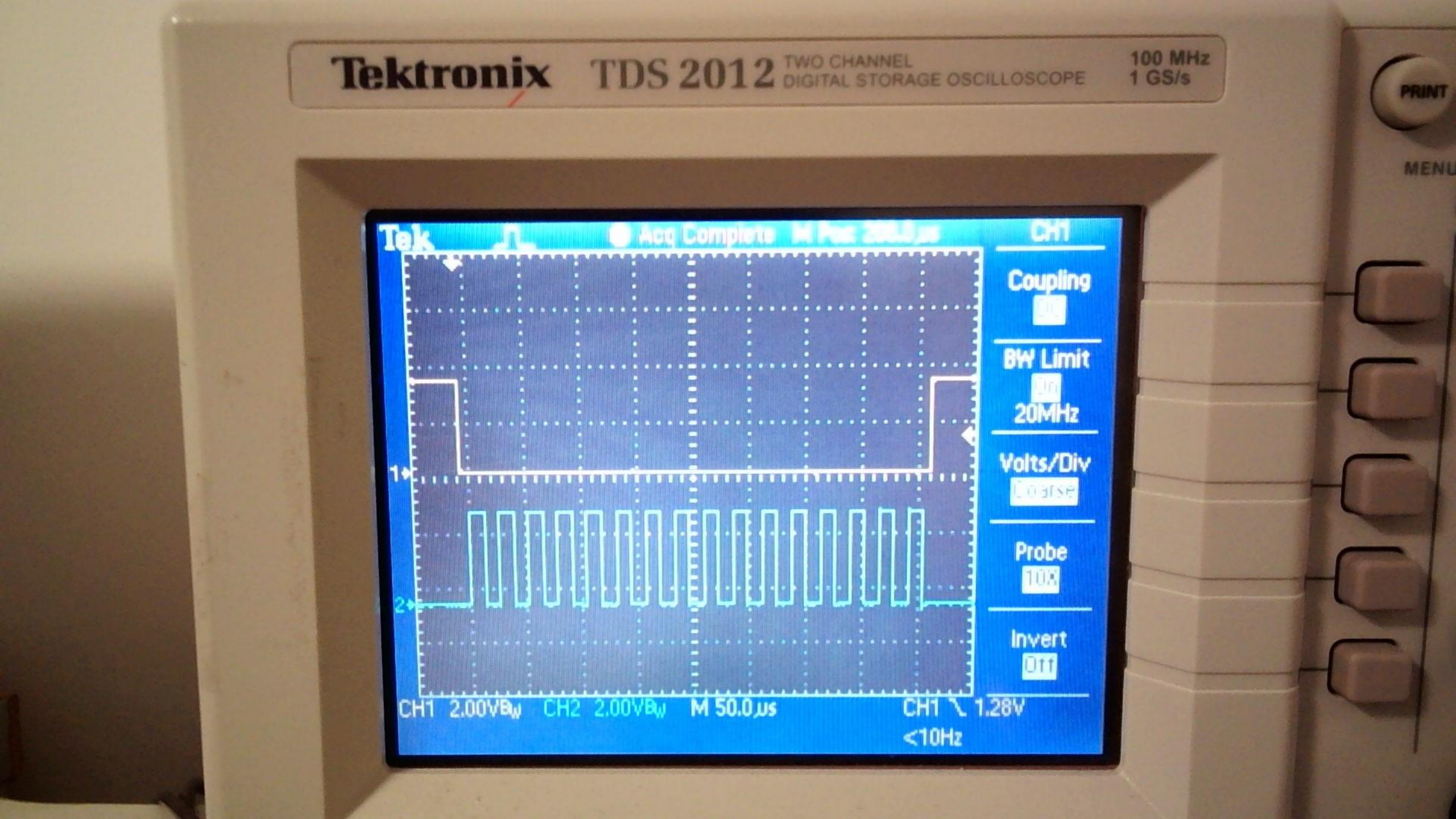
Example Calculations Using a Clock of 24 MHz (any other clock frequency can be used)

- Using a 38.4KZ IR receiver
- 24 MHz / 38.4 KZ ≈ 625
  - Set the period of the PWM to 624
  - Set the compare value to 624/2 ≈ 312 for 50% duty cycle

Tx Byte : 10101010 = 0xAA= 170






Tektronix
TDS 2012
TWO CHANNEL
DIGITAL STORAGE OSCILLOSCOPE
100 MHz
1 GS/s
PRINT
MENU
Tek
Acq Complete
CH1
Coupling
BW Limit
20MHz
Volts/Div
Probe
10X
Invert
CH1 2.00V
CH2 2.00V
M 50.0µs
CH1 1.28V
<10Hz

References

Finite-state machine - Wikipedia

Vishay Data Formats for IR Remote Control

- untitled (vishay.com)

TSDP34138: RS232 Communication

- tsdp341.pdf (vishay.com)

Tsop4156 IR Receiver(s)

- tsop45.pdf (vishay.com)

ROHM: IrDA Infrared communication Module RPM871

- RPM871 : IrDA Infrared Communication Modules (digikey.com)

IR Emitters

- Vishay TSAL6100 tsal6100.pdf (vishay.com)
  - Angle of half intensity: φ = ± 10°
  - Peak wavelength: λp = 940 nm

- Vishay VSLY5940 vsly5940.pdf (vishay.com)
  - Angle of half intensity: φ = ± 3°
  - Peak wavelength: λp = 940 nm

End Part1