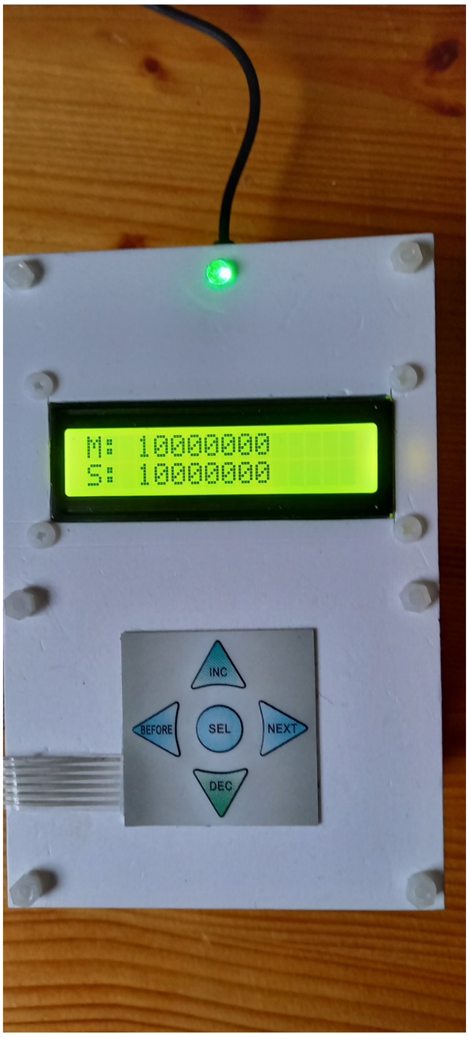
AD9851 sine- and square wave generator with frequency correction versus GPS time base

The requested frequency is the delivered frequency.
High precision frequency: continuously calibrated against GPS time base
Adjustable from 1Hz to 25MHz.
Easy to operate.



M: measurement
S: set point

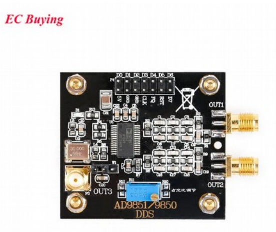
LED:

GREEN GPS module satellite reception, GPS calibrated time base
RED GPS module no satellite reception, no calibrated time base

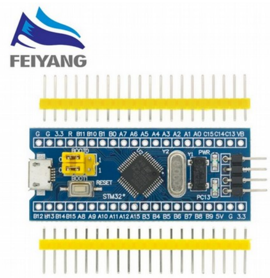
What do we need:

1 x GPS module with pulse output. Ublox compatible. Pulse output is programmed by the program.

1x AD9851



1x STM32F103C8



1x 74HC08

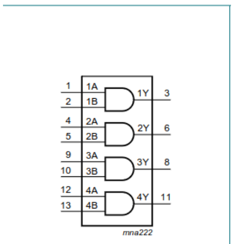
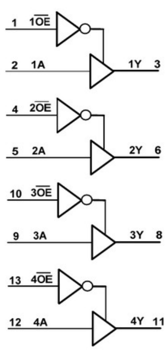
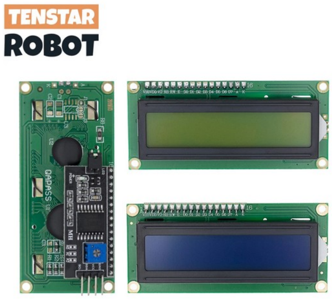


Fig. 1. Logic symbol

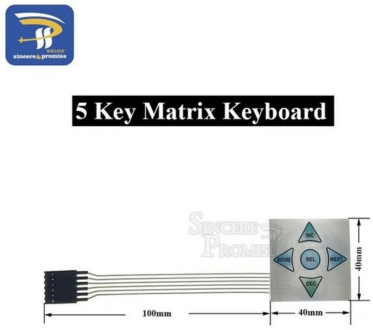
1x 74AHC125



1x LCD screen 2 x 16 lines I2C



1x 5 key matrix board

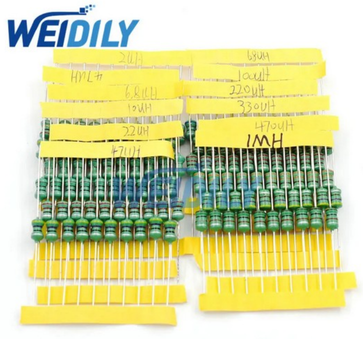


1x ST-link

1x 1N4001
1x 3 kleuren LED
1 x 2K weerstand

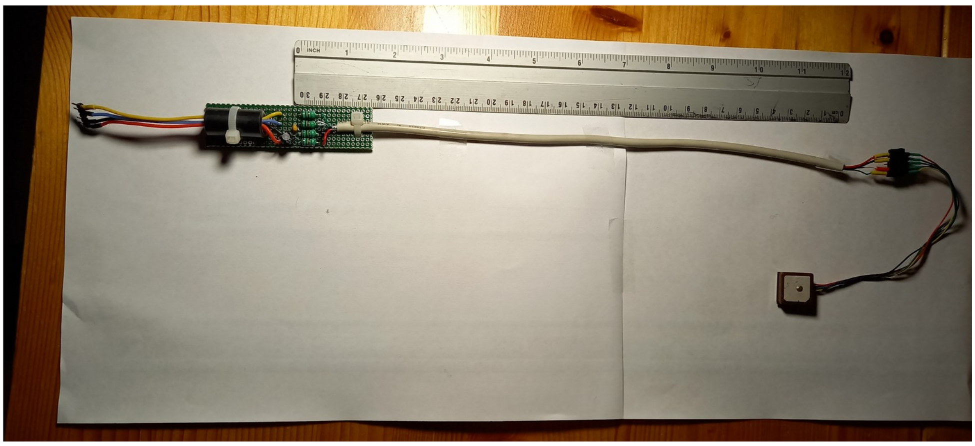
GPS reception interference suppression

3x choke 1mH

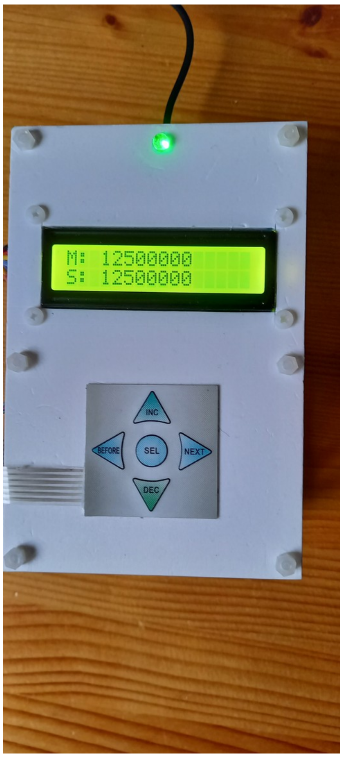


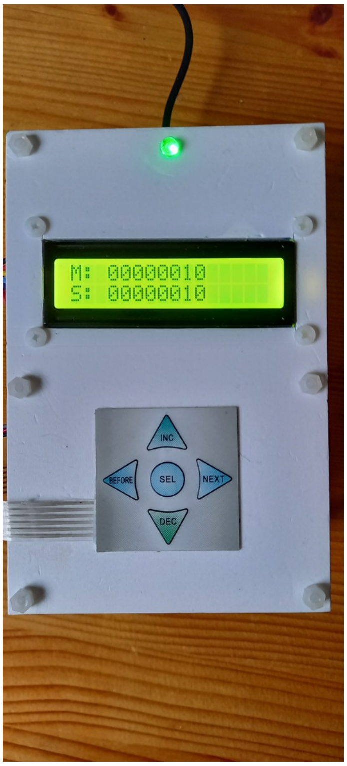
1x Ferrite core (possibly from an old VGA cable)

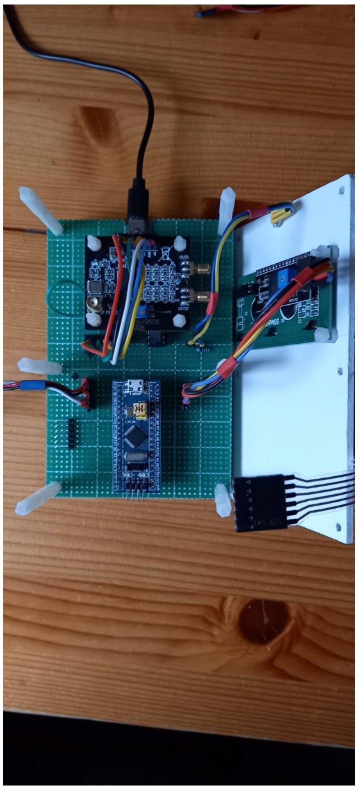
1 x 220 uF
1 x 20 pF
1 x shielded cable 4 conductors +/- 30cm

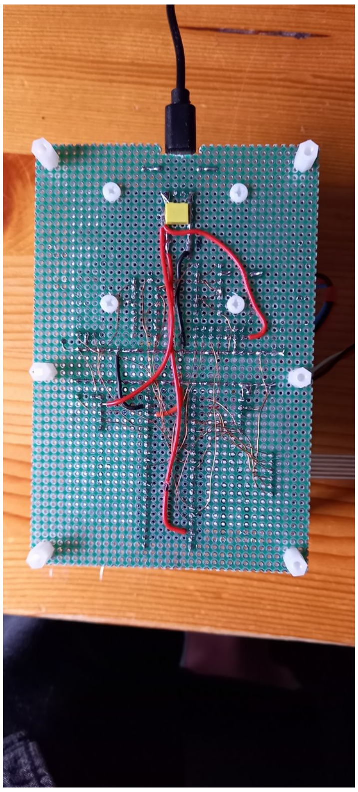


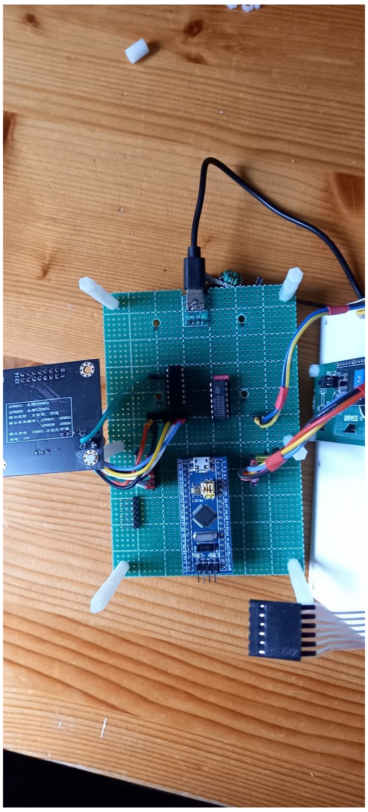
Some photos


M: 12500000
S: 12500000
INC
BEFORE
SEL
NEXT
DEC


M: 00000010
S: 00000010
INC
BEFORE
SEL
NEXT
DEC







How does it work :

GPS module is programmed by the program to send out a pulse of 1Hz or 0.5Hz.
If GPS is not yet connected with satellites 1Hz >> red LED lights up.
If GPS connection with satellites 0.5Hz >> green LED lights up.

GPS pulse is connected to input 74HC08 and input STM32F103C8.

The square wave from AD9851 is converted to a 3.3V signal using a 1N4001 and 1 port 74AHC125.

This 3.3V square wave goes to 1 input of a 74HC08 AND gate.
The other input of the 74HC08 is controlled by the pulse from the GPS module.
The output of the 74HC08 goes to the Timer1 input of the STM32F103C8.

In the STM32F103C8, Timer1, Timer2 and Timer3 are placed in series.

Due to the combination of GPS pulse and square wave from AD9851, the pulses can only be counted if the GPS pulse is high.

With a falling edge of the GPS pulse, the values of the Timers are read in and the Timers are reset.

The number of pulses per second is calculated from the values of the timers and sent to the display.

The read-in frequency is compared with the requested frequency and adjusted if necessary.
If GPS is connected to satellites this should provide a fairly accurate frequency.

The desired frequency can easily be entered using the keyboard.

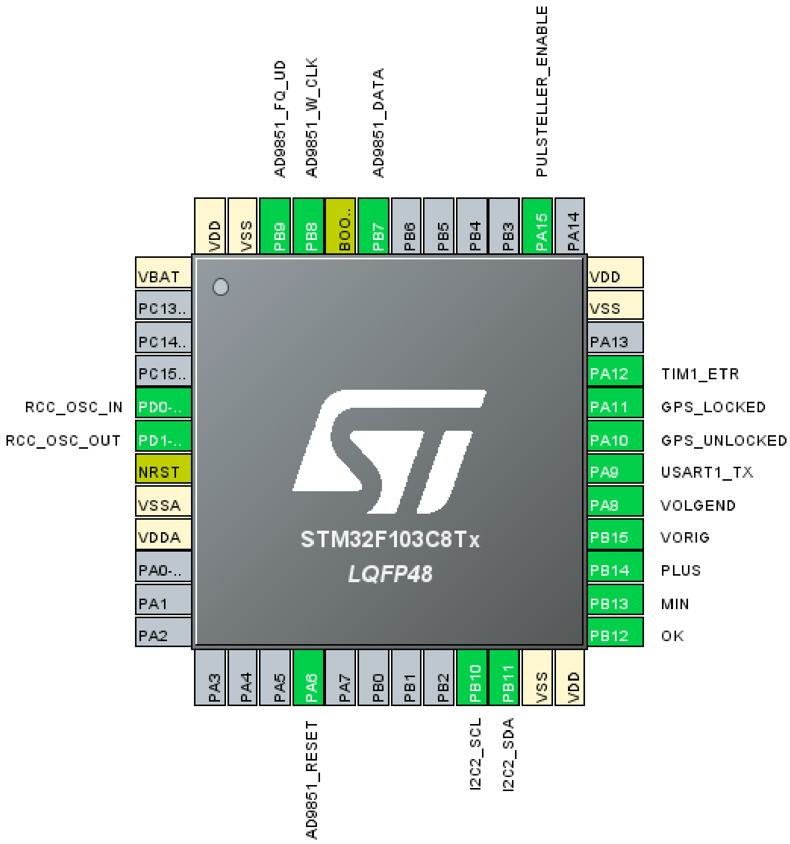
The setpoint (S:) and the measurement (M:) are shown on the display.

Since the accuracy is determined by whether or not the GPS module is connected, this is displayed by a 3-color LED, only 2 colors are used.

GREEN	GPS module connection to satellites.
RED	GPS module not connected to satellites.

Connections

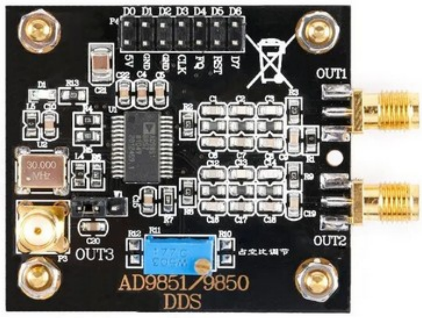
STM32F103C8



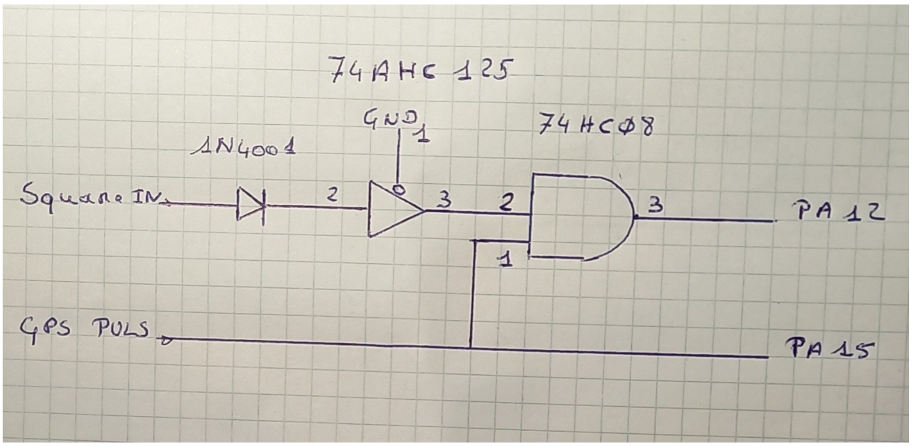
5V	<<	Power 5V IN		
GND	<<	Power GND IN		
PA6	>>	AD9851	RST	
PB7	>>	AD9851	DATA (D7)	
PB8	>>	AD9851	CLK	
PB9	>>	AD9851	FQ	
PB10	>>	LCD Display	SCL	
PB11	>>	LCD Display	SDA	
PA9	>>	GPS module	RX	
PA15	<<	GPS module	Puls uit	
PA12	<<	Pin3	74HC08	AND uit
PA11	>>	LED	GROEN	GPS Locked
PA10	>>	LED	ROOD	GPS Unlocked
PA8	<<	Toetsen	VOLGEND	
PB15	<<	Toetsen	VORIG	
PB14	<<	Toetsen	PLUS	
PB13	<<	Toetsen	MIN	
PB12	<<	Toetsen	OK	

AD9851

EC Buying



5V	<<	Power	5V IN	
GND	<<	Power	GND IN	
CLK	<<	PB8	STM32F108	
FQ	<<	PB9	STM32F108	
RST	<<	PA6	STM32F108	
D7	<<	PB7	STM32F108	
SQUARE OUTPUT	>>	1N4001 ANODE		*Output branched off bottom of PCB to OUT3*



GPS Module

Power in	<<	+3.3V van STM32F103C8		
GND	<<	GND IN		
RX	<<	PA9	STM32F103C8	USART1_TX
PULS UIT	>>	PA15	STM32F103C8	PULSTELLER_ENABLE
	>>	Pin1	74HC08	AND input

74AHC125

Pin 7	<<	GND		
Pin 14	<<	+3.3V van STM32F103C8		
Pin 1	<<	GND	/OE1	
Pin 2	<<	1N4001 kathode		
Pin 3	>>	Pin2	74HC08	AND input

verbind alle niet gebruikte ingangen met GND

74HC08

Pin 7	<<	GND		
Pin 14	<<	+3.3V STM32F103C8		
Pin 1	<<	Puls Uit GPS module		
Pin 2	<<	Pin 3	74AHC125	
Pin 3	>>	PA12	STM32F103C8	TIM1_ETR

verbind alle niet gebruikte ingangen met GND

LCD Display

VCC	<<	+5V In		
GND	<<	GND In		
SDA	<<	PB11	STM32F103C8	I2C2_SDA
SCL	<<	PB10	STM32F103C8	I2C2_SCL

LED

GROEN Anode	<<	PA11	STM32F103C8	GPS_LOCKED
ROOD Anode	<<	PA10	STM32F103C8	GPS_UNLOCKED
Kathode common	<<	R 2K		

Kathode common LED >> **R 2K** << **GND**

5 Key Matrix

INC	>>	PB14	STM32F103C8
DEC	>>	PB13	STM32F103C8
BEFORE	>>	PA8	STM32F103C8
NEXT	>>	PB15	STM32F103C8
SEL	>>	PB12	STM32F103C8
Common	>>	+3.3V STM32F103C8	

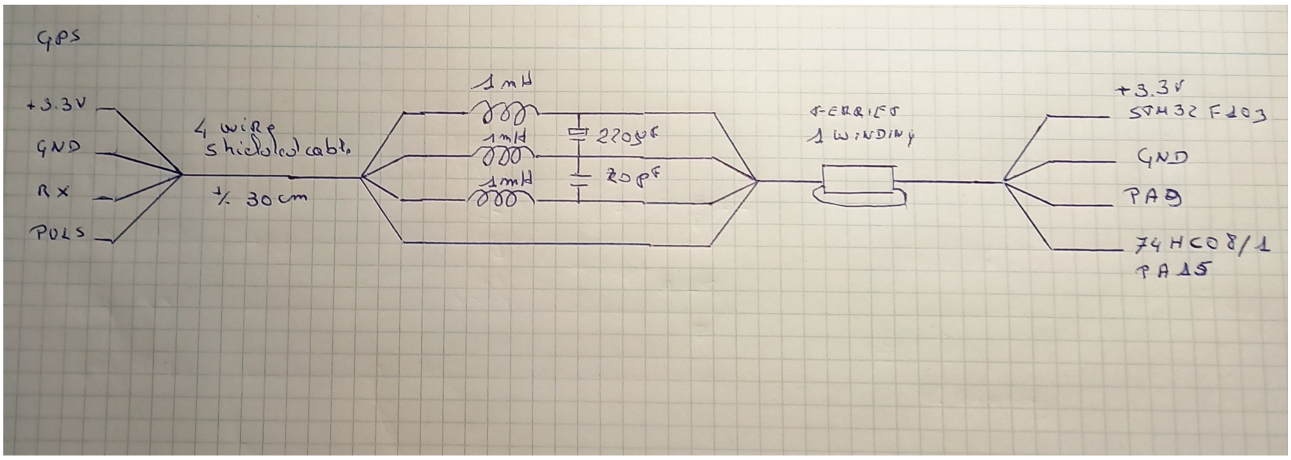
Interference suppression

To function smoothly, this circuit must be built in a shielded housing with the GPS module shielded from the rest. So not the way this test setup was built.
Suppressing the cable with an LC Low Pass Filter helps, but the radiation from the AD9851 goes quite far.
Without a Low Pass Filter on the connection between the GPS module and the circuit, the GPS module has no reception.

Frequencies between 12.3MHz and 12.7MHz are the most difficult to get interference-free.

This setup gives me the best result, not very professional but it works.

GPS shielded from the electronics with aluminum foil.



How to use

Start frequency is 10MHz.
Display shows 2 numbers.
Top row
M: xxxxxxxx MEASUREMENT in Hz
S: 10000000 SETPOINT in Hz
GPS not yet connected to satellites, red LED is on.
Frequency generator can already be used, but time base is incorrect.
After some or more time >> GPS module connection with satellites, green LED lights up.
Time base in now OK

To change desired frequency.
* Press a key
    The desired frequency appears in the bottom line
    A “*” appears in the top row
    You can move “*” with the “BEFORE” “NEXT” keys
    The “*” shows which number can change with
    You can change using the “INC” and “DEC” keys
    When desired frequency is selected, press “SEL”
* The program does the rest and adjusts the frequency to the desired frequency

Everything can be found on Github.
https://github.com/thieu-b55/AD9851-automatic-frequency-correction-vs-GPS-timebase

zip file contains the complete STM32CubeIDE project.

If STM32CubeIDE is not installed, the following files can be used to program the STM32F103C8.

AD9851_frequency_control_GPS_timebase.hex
AD9851_frequency_control_GPS_timebase.bin
AD9851_frequency_control_GPS_timebase.elf

Windows
https://www.st.com/en/development-tools/stsw-link004.html

Linux
https://github.com/stlink-org/stlink

groeten,
thieu-b55
november 2023