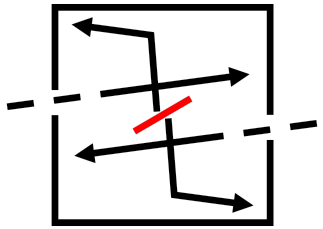
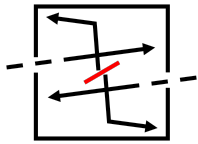
STM32F407VET6 Digital Synthesizer with screen

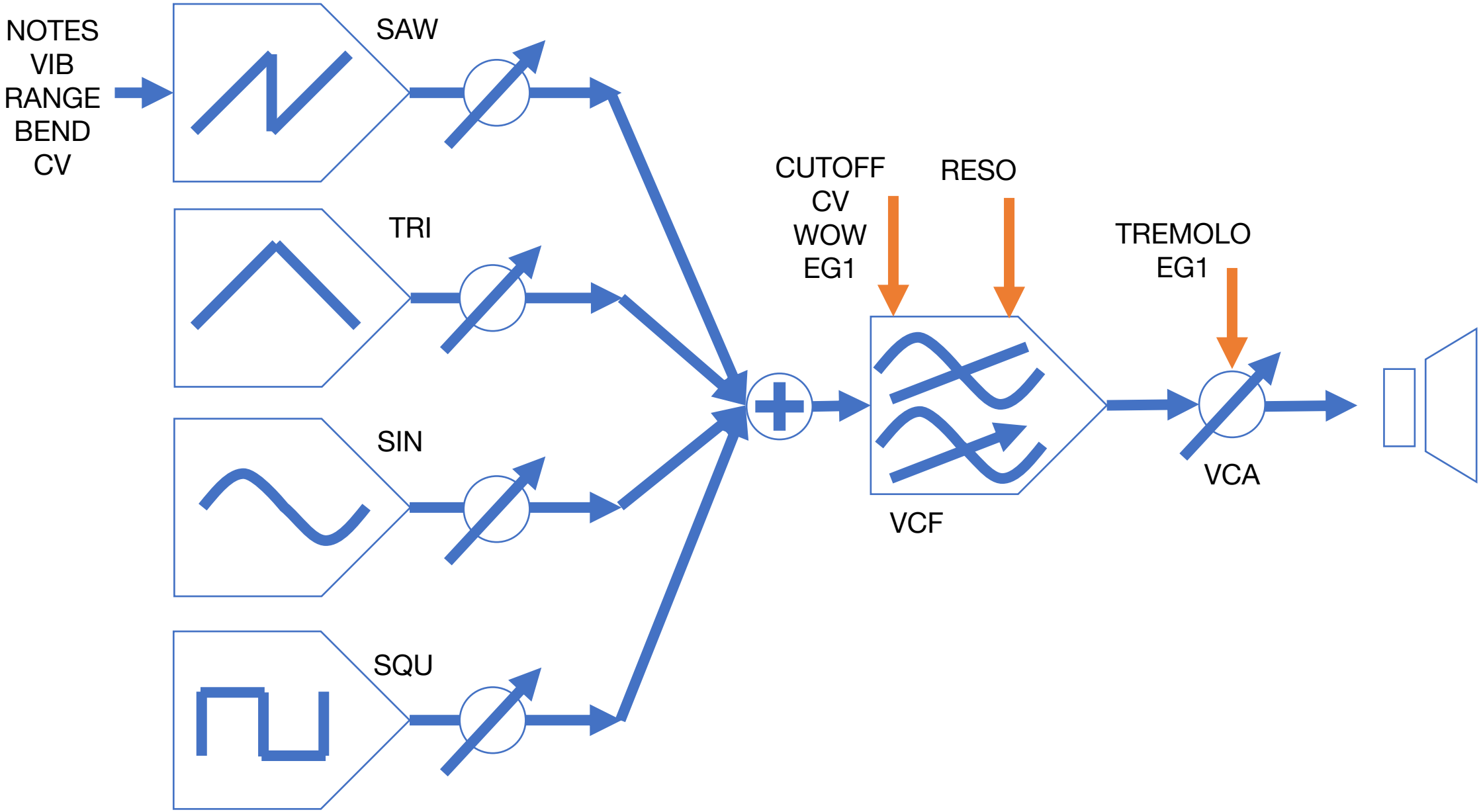
Update: 2020/12/29



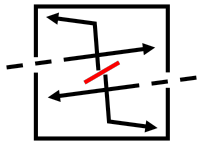


Overview

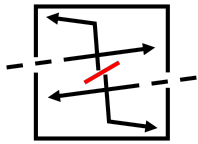
Block diagram



Parameter list (Will be expanded)

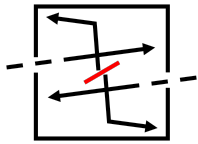


Parameter	Description
T_1_FREQ	First signal frequency
T_1_SIN	Sine amplitude of the first signal
T_1_SQU	Square amplitude of the first signal
T_1_SAW	Saw amplitude of the first signal
T_1_TRI	Triangle amplitude of the first signal
F_CUTOFF	Cutoff frequency of Low-Pass filter
F_Q	Q value of Low-Pass filter



Design

Sampling specifications

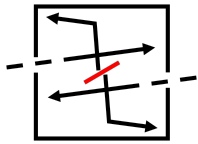


	Freq domain	Time domain
Sound max freq	20kHz	50us
Sound min freq	20Hz	50ms
Sampling freq	40kHz	25us

Note

- Create a waveform by dividing into 1024 samples
- 12bit DAC → audio level 0 = 2048
- DAC Clock source 84MHz
  - ✓ Prescaler 100(840kHz, 1.19us), Period 21(21*1.19us=25us)

Sampling specifications



DMA Circular

DAC start

12.8ms

Generate waveform for next cycle (1.5ms)

Half of the buffer is complete

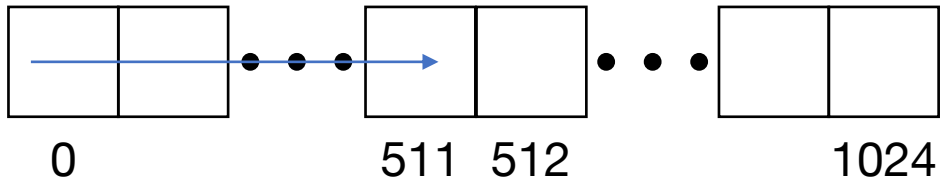
12.8ms

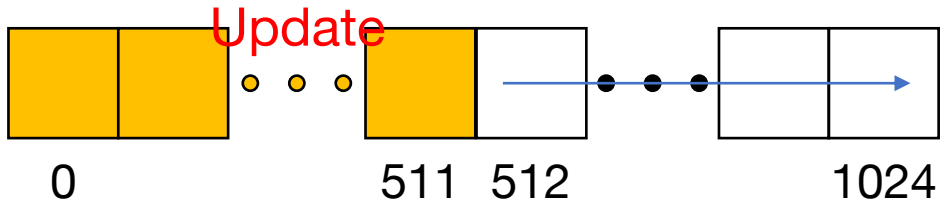
Display time waveform on LCD

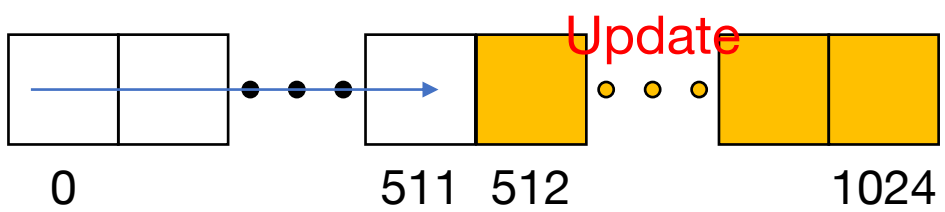
All of the buffer is complete

Structure of DAC buffer

DAC position



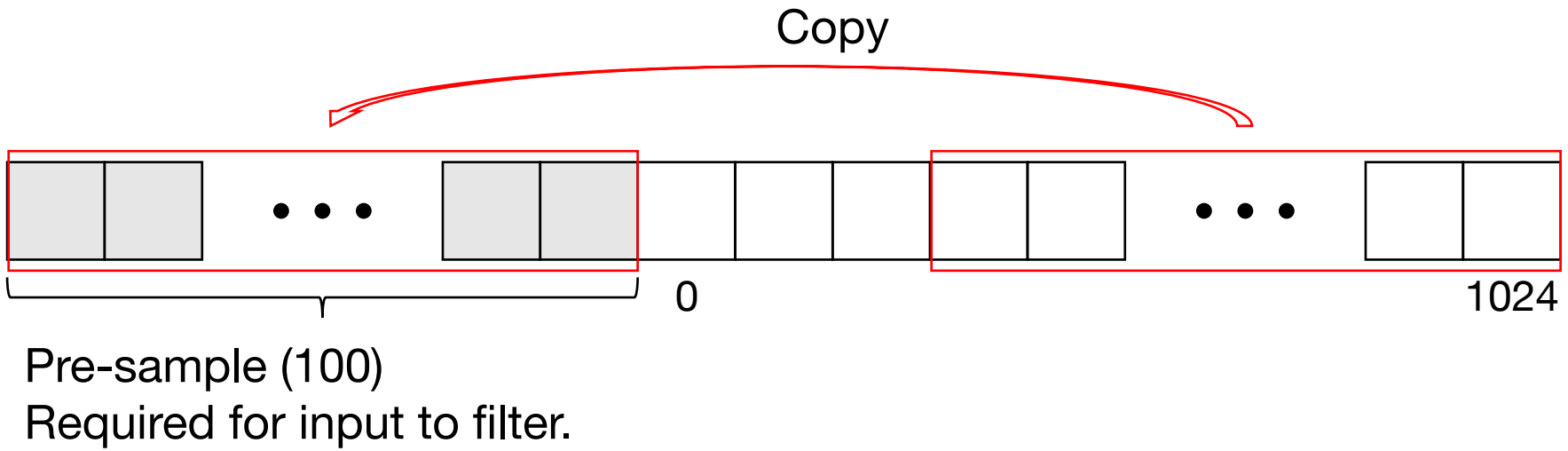




Sampling specifications

Structure of sampling array

- Reserve a buffer of size 100 + 1024
- Only 1024 parts are used in DAC
- Add 100 samples at the beginning to obtain stationary filter output
- Copy the end of the previous buffer to the beginning



Filter specifications

Note
- biquad filter
- Normalize as a_0=1

$$H(z) = \frac{b_0 + b_1 z^{-1} + b_2 z^{-2}}{a_0 + a_1 z^{-1} + a_2 z^{-2}} \qquad \omega_c = \frac{2\pi f_c}{f_s} \qquad \alpha = \frac{\sin \omega_c}{Q}$$

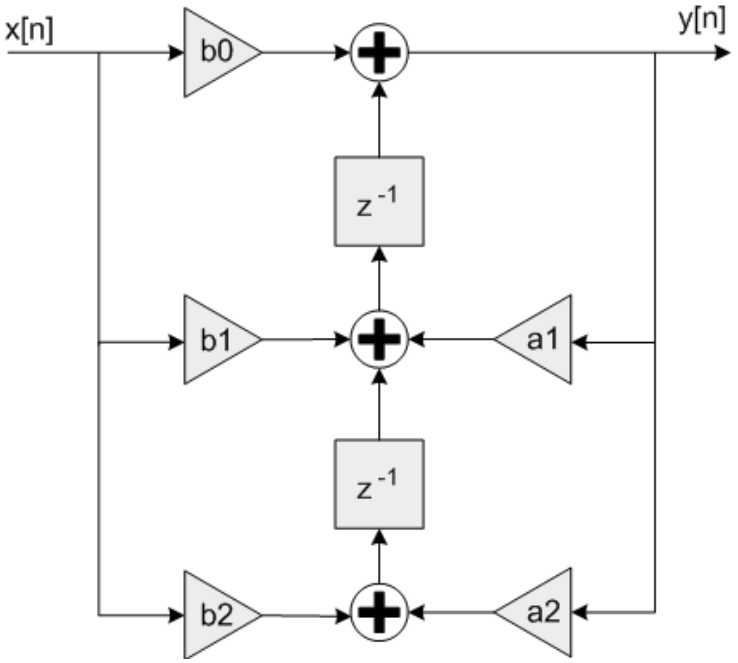
LPF

Time domain

$$b_0 = \frac{1 - \cos \omega_c}{2} \qquad a_0 = 1 + \alpha$$

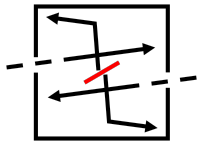
$$b_1 = 1 - \cos \omega_c \qquad a_1 = 2\cos \omega_c$$

$$b_2 = \frac{1 - \cos \omega_c}{2} \qquad a_2 = -(1 - \alpha)$$



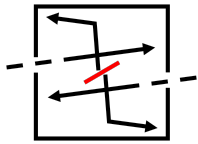
Freq domain

$$|H(\omega)| = \frac{\omega_c^2}{\sqrt{(\omega_c^2 - \omega^2)^2 + \left(\frac{\omega_c}{Q}\omega\right)^2}} = \frac{\frac{\omega_c}{\omega}}{\sqrt{\left(\frac{\omega_c}{\omega}\right)^2 + \left(\frac{\omega}{\omega_c}\right)^2 + \frac{1}{Q^2} - 2}}$$



Communication

Controller connection specifications



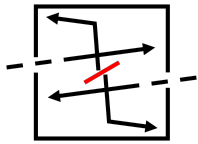
SPI

- SPI3 as slave

Data format

- Unsigned 4 byte

uint8_t[0]	Lower byte	Parameter
uint8_t[1]	Higher byte	
uint8_t[2]	Lower byte	Value
uint8_t[3]	Higher byte	



Implementation

Spectrum of DAC output at 100Hz(Sine)