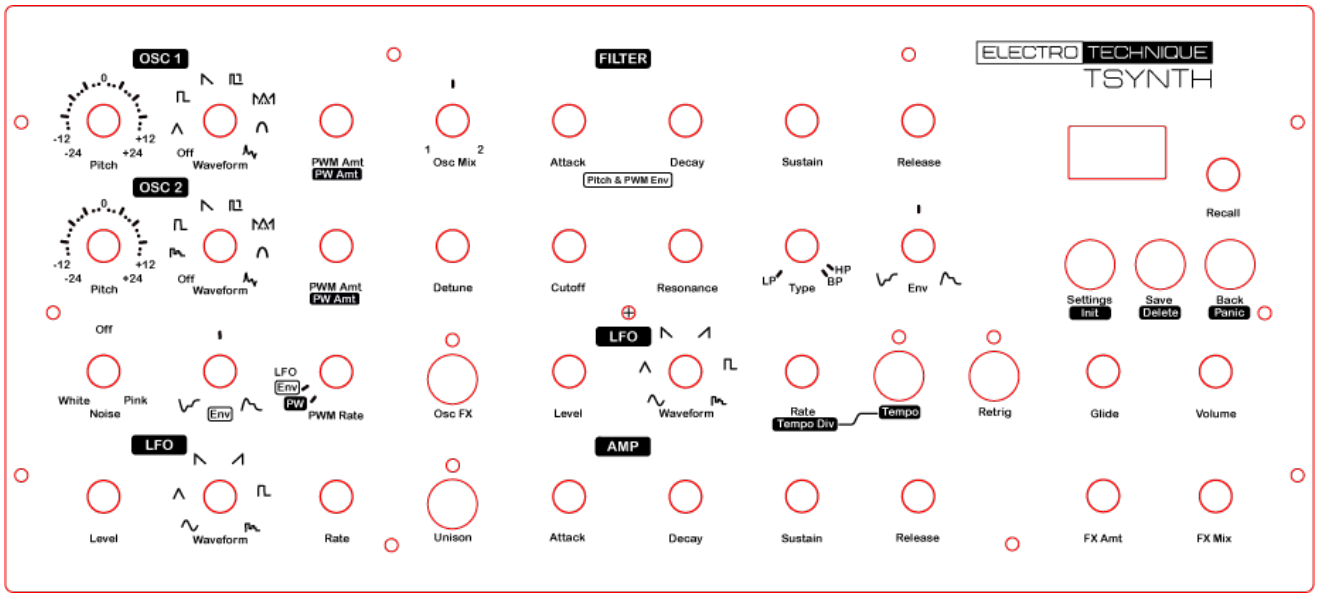
Teensy 4.1
Firmware 2.00 & higher
September 2020

ELECTRO TECHNIQUE
TSYNTH

USER MANUAL



TSynth is a 12 note programmable polyphonic synthesizer based on the Teensy 4.1 microcontroller board. The front panel is divided into distinct regions that should be familiar to anyone who has used an analogue or analogue-like synthesizer.

Oscillators

Both oscillators are identical except for the first and last waveforms. Oscillator 1 has triangle and oscillator 2 has sample & hold (which is an audible random value pulse wave.) Octave sets the pitch of the oscillator relative to the other. It ranges from -24 semitone to +24 semitones with values of -24 and -12 to +12 in semitone intervals, then +24. The waveforms available are the usual triangle, square, sawtooth, the already mentioned sample & hold, plus variable pulse, variable triangle (sawtooth to triangle to ramp waveforms), rectified sine (parabola) and harmonic (these differ on both oscillators for variety).
Pulse width may be set to a fixed value or modulated using the filter envelope or a dedicated LFO - **PWM Rate** (see section on PWM Controls.)

The volumes of each oscillator may be adjusted using **Osc Mix**, which mixes between both oscillators on full (middle) or decreasing one down to zero while the other is full. To turn an oscillator off, the waveform can be set to **Off**.

Detune detunes oscillator 2 relative to oscillator 1 and is useful for giving a thicker, chorus-like effect. This also works with **Unison**, which will detune all the voices relative to the others, up to the maximum set by **Detune**.

Noise will allow **White** or **Pink** noise to be introduced. The centre setting is **Off** and adjusting each side will increase the volume of either **White** or **Pink**.

Env is a pitch modulation applied by the filter envelope. Centre setting is none and this may be adjusted to increase a negative or postive envelope. Negative (anticlockwise) goes down then up. Positive (clockwise) goes up then down.

The oscillators have their own dedicated **LFO**. This has a **Level** control for the amount. A **Waveform** choice and a **Rate** (speed) setting. The Waveforms are sine, triangle, sawtooth, ramp (or reverse sawtooth), square and sample & hold.

Osc FX applies a choice of two effects to the oscillators:

- A Korg MS20 style, **XOR** type 'ring modulation' effect. This introduces harmonics to the sound and may not work with certain combinations of waveforms such as two pulse types.
- Cross Modulation (**X Mod**) - (*press and hold* **Osc FX** *button for 1 second*) modulates one oscillator with the other, depending on the postion of the **Osc Mix** control. Turning past the centre to the left increase modulation of oscillator 1 by oscillator 2. Turning towards the right increases modulation of oscillator 2 by 1.

Unison has two types:

- **Dynamic Unison** sounds all the oscillators together when up to four notes are played. This is *dynamic* and will divide up the 24 oscillators between one, two, three or four notes. As mentioned, **Detune** will set all the oscillators slightly detuned from each other up to the maximum set by the **Detune** control.
- **Chord Unison** - (*press and hold* **Unison** *button for 1 second*) will play all 24 oscillators on one note, divided up into pitches corresponding to the notes in various chords. The **Detune** control will set the chord type (major, minor, augmented...)

PWM Controls

Both oscillators feature variable pulse and variable triangle waveforms that can be manually adjusted or modulated by the filter envelope or a dedicated LFO.

Fixed Pulse Width / Triangle shape

Set the **PWM Rate** control to zero where it's marked **PW**. The two controls above - **PW Amt** will set the pulse width / triangle shape. The central middle setting corresponds to a square wave (50% duty cycle) or a triangle waveform depending on the oscillator waveform.

Pulse Width / Triangle shape modulation by filter envelope

Set the **PWM Rate** control to where it's marked **Env**. The two controls above - **PWM Amt** will set the amount of modulation pulse width / triangle shape receive from the filter envelope.

Pulse Width / Triangle shape modulation by LFO

Set the **PWM Rate** control to **LFO** and above. The two controls above - **PWM Amt** will set the amount of modulation the pulse width / triangle shape receive from the a dedicated LFO. **PWM Rate** will adjust the rate (speed) of this LFO. The LFO waveform is a sine wave.

Filter

The Filter section features an ADSR envelope with **Attack**, **Decay** and **Release** times from 1ms up to almost 12s, which is also used by the oscillators pitch envelope and by the PWM control, as outlined in the Oscillators section. The envelope modulates the cutoff frequency of the filter and the amount of the effect is by the **Env** control, which allows a positive (clockwise) or negative (anticlockwise) modulation of the cutoff.

The cutoff frequency is controlled by the **Cutoff** control, with resonance level set by the **Resonance**

control. The **Type** control will vary the filter type between low pass (LP) through to high pass (HP) acting as a notch filter, to band pass (BP). This is known as a state variable filter and has a 12dB per octave cutoff response. Resonance may produce distortion when set to full with the cutoff at the resonant frequencies of particular waveforms.

There is a dedicated LFO for the filter with a **Level** control, a selection of **Waveform**s and a **Rate** (speed) control. Setting the **Tempo** switch to on, makes the LFO sync with incoming MIDI clock signals from a sequencer (like Ableton Live, Logic Pro etc) This also allows the **Rate** control to set the tempo divisions for a particular tempo. The **Tempo Div** control will allow the LFO to sync to a frequency that is a division of a bar 1/16, 3/32, 1/8, 3/16, 1/4 .... for a particular tempo, in beats per minute (bpm).

Retrig will retrigger the LFO to start from the same point in the waveform every time a new note is pressed regardless of whether other notes are still held. This can be useful if you want to play a series of notes and have the filter modulate each note in the same way.

Amplifier

This is a standard ADSR envelope with **Attack**, **Decay** and **Release** times from 1ms up to almost 12s. Velocity sensitivity is set in the **Settings** menu.

Saving and Naming Patches

Back button will cancel and move back to previous screen. If you make a mistake naming patches, press back button.

Save a new patch

Save ⇨ **Recall** ⇨ Turn the **Recall** encoder to select letters and numbers. Press **Recall** to select each character and move to the next one to select. Press to select final character. ⇨ **Save**

Overwriting an existing patch

Save ⇨ Turn the **Recall** encoder to select the patch to overwrite. ⇨ **Save**

Renaming an existing patch

Save ⇨ Turn the **Recall** encoder to select the patch to rename and press **Recall**. ⇨ Turn the **Recall** encoder to select letters and numbers. Press **Recall** to select each character and move to the next one to select. Press to select final character. ⇨ **Save**

Settings

Pressing **Settings** allows access to a number of patch and global level settings for TSynth. These are:

MIDI Ch. - The MIDI channel TSynth will accept incoming MIDI data on, including All (Omni on). This is global.
Key Tracking - This modulates the filter cutoff frequency as you go up the keyboard to higher notes. The idea is that the cutoff increases to allow higher frequencies to sound clearer. It can be set to None (cutoff doesn't change) Half (some effect) and Full (full effect). This is saved with the patch.
Velocity Sens - This sets the velocity sensitivity of the amplifier and has four curves:

1 - Linear, velocity value corresponds directly to the loudness.
2 - Curve to maximum loudness.
3 - Curve to maximum loudness at 70 and then flatten.
4 - Curve up to maximum loudness.

Choose an appropriate curve for the keyboard response. This is saved with the patch.
Pitch Bend - this sets the pitch bend range in semitones. This is global.
MW Depth - this sets the modulation wheel maximum depth. This is like the level control in the oscillator LFO section but allows lower levels of modulation (vibrato in this case) to be applied. This is global.
MIDI Out Ch. - The channel MIDI out will transmit on. Can be switched off. Only works over USB host and client and is useful for recording parameter changes while recording a sequence. This is global.
Encoder - Choose Type 1 or Type 2 depending on how your encoder produces pulses when turning. If your encoder decrements when turning clockwise, change the type here. This is global.
Pick-up - An experimental feature that only allows a panel control and the corresponding MIDI CC control, to start changing the parameter value when it matches the current patch value. This is to prevent jumps when the control suddenly changes the parameter value. Turn the control slowly and smoothly, and the control will pick-up the current value when it gets to it and change it. An icon of a knob appears on the display when changing parameters, when this is on. This is global.
Bass Enh. - This enhances the bass frequencies using the SGTL5000 codec chip on the audio board and doesn't involve the Teensy. This will only affect audio from the headphone socket. This is global.
Oscilloscope - An experimental feature that shows what the waveforms look like. This is taken just before the stereo chorus effect. This is global.
VU Meter - This is a linear meter that shows the amplitude of the audio signal - not really VU standard. This is global.

The **Settings** menu allows scope for expansion; for example, velocity sensitivity could be set for the modulation of the filter cutoff frequency. You could set different types of filter, user waveforms, effects...

Initialisation

Pressing and holding the **Settings** button for one second invokes **Init,** which will re-read all the panel controls and set TSynth to the current panel settings.

Other Specifications

Power - 5V 180mA from USB
Digital Audio - 16 bit, 44.1Hz - headphone jack and audio interface recommended for recording.

Known Issues

Plugging in a MIDI controller may alter current patch settings. Arturia Minilab for example, sends its current panel control settings when plugged in, causing MIDI CC messages to be received by TSynth, altering settings.

Low cost (sub $10) USB to MIDI converters can have problems handling clock signals and SysEx, which get mixed up with note on/off and CC messages. Use quality converters made by a known brand name.

There is a significant latency (delay) between TSynth receiving a MIDI note and hearing it on a computer via USB audio - about 100ms. For recording, use the headphone output and send through a quality audio interface featuring low latency ASIO drivers.

Troubleshooting

No sound

- Check Waveforms are not set to off and volume is mid way.
- Check filter cutoff and filter type will allow sound through.
- Pulse Width of Pulse waveforms will be quiet if set to maximum (very narrow!)
- If using digital audio via USB, check your computer. Windows sometimes doesn't pass the audio through - Go into the Control Panel, Manage Audio Devices and the Recording tab. Double-click the digital audio device and go into the Listen tab and set the Listen to this device to on - you may find it's already on and you have to toggle it off and on so it works again.

Pressing **Init** to set TSynth to the panel control current settings and with the controls set to make sound, will show if there is a problem.

Digital noises

This may happen occasionally when using the USB digital audio. The analogue audio is fine.
The chorus / ensemble effect may also introduce some noise when a low FX Amount is set.

Humming Noises

This could be attributable to ground or mains noise through the USB port if connected to a pc or an external amplifier and needs action by you see what configuration works. TSynth can be powered from a USB powerbank and played by a small MIDI controller without an attachment to the mains or a pc, this would show if noise is from the mains or possibly your computer.

SD Card problems

Use a low value (1GB is more than enough!) SD card. It doesn't need to be particularly fast and cheaper, older cards are fine. Ensure that the card is formatted as FAT16/32 before using it and the SDFormatter application from the SD Association is recommended:

www.sdcard.org/downloads/formatter/

Other problems

If there are intermittant problems, check the hardware. Are there dry solder joints, is the Teensy properly seated in the header socket if you used one, are the potentiometers smooth. TSynth is a DIY project and it is up to the individual to build it properly.

MIDI CC	Controller	MIDI CC	Controller
1	Mod Wheel	77	Filter LFO Amount
3	Pitch LFO Amount	79	Sustain Level
5	Glide	80	Filter Attack Time
7	Volume	81	Filter Decay Time
14	Osc 1 Waveform	82	Filter Sustain Level
15	Osc 2 Waveform	83	Filter Release Time
16	Filter Envelope Amount	85	Osc 1 Pulse Width
19	Filter Type	86	Osc 2 Pulse Width
20	Osc 1 Level	87	PWM Rate
21	Osc 2 Level	88	PWM Amount
23	Noise Level (0 White, 63 Off, 127 Pink)	89	Key Tracking
24	Osc FX (0 off, >0 On)	90	Filter LFO Waveform
26	Osc 1 Pitch	91	FX Amount
27	Osc 2 Pitch	93	FX Mix
28	Pitch Envelope Amount (63 Off)	94	Detune
30	Osc LFO Retrig (0 off, >0 On)	102	Pitch LFO Rate
31	Filter LFO Retrig (0 off, >0 On)	103	Pitch LFO Waveform
71	Resonance	104	Filter LFO MIDI Clock Sync (0 Off, >0 On)
72	Release Time	105	Pitch LFO MIDI Clock Sync (0 Off, >0 On)
73	Attack Time	106	PWM Source (0 LFO, >0 Filter Env)
74	Cut Off Frequency	123	All Notes Off
75	Decay Time	126	Unison (0 Off, >0 On)
76	Filter LFO Rate		