The Tellun Corporation

TLN-428 Voltage Controlled State Variable Filter

User Guide, Rev. 1.1

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Introduction

The TLN-428 is a state variable filter built around a Curtis Electromusic Specialties CEM 3320 chip. Four simultaneous outputs (all with two pole response) are provided: low pass, high pass, band pass, and notch. A built in mixer allows for two audio inputs. The filter frequency can be set using a panel mounted pot, a “one volt per octave” external control voltage, or via two external FM inputs with attenuators (one reversing). Filter resonance can be set using a panel mounted pot or an external control voltage with a reversing attenuator.

Circuit Description

A state variable filter comprises a summing amp and two integrators to create low pass, high pass, and band pass outputs simultaneously. The low pass and high pass outputs are typically combined with a summing amp to provide a notch output. The CEM 3320 provides four gain cell blocks that can be configured into a variety of filters. The TLN-428 uses two of the CEM 3320 gain cell blocks as integrators. A third gain cell block is used as a summing amp and allows use of the onboard Resonance Control Cell for voltage controlled resonance. The CEM 3320 application notes suggest using the fourth gain cell block as a summing amp for the notch output. However, this was not found to be a particularly stable approach and thus an external op amp is used to provide the notch output from the low pass and high pass outputs. The fourth gain cell block is not used in the TLN-428.

Refer to page 3 of the schematic for the following discussion on the filter design. C13 and C14 are bypass caps for the power supply. R38 and TP2 limit the negative supply current and allow trimming the frequency control voltage feed through (see the Calibration section). The summing amp comprises R40 and gain cell block G1-C1-B1. The first integrator comprises R42, C23, and gain cell block G2-C2-B2. The second integrator comprises R23, C24, and gain cell block G3-C3-B3. The audio input signal is fed to the summing amp through R39. The low pass output is fed back to the summing amp through R41 and R25. The band pass output is fed back to the summing amp via C16 and then through two parallel paths, R26 and R27, in order to make use of the onboard Resonance Control Cell. C21 provides phase compensation to prevent the filter from honking too much at high resonance settings. C22 eliminates high frequency oscillations that creep into the high pass output at very low resonance settings.

Refer to page 2 of the schematic for the following discussion on the output design. All four filter outputs are non-inverting with respect to the input signal. This is intentional as it allows any of the four outputs to be fed back to the filter input to further enhance the filter effect. The low pass output is AC coupled through C17 and then fed to a non-inverting amplifier with a gain of one. Similarly, the high pass output is AC coupled through C18 and then fed to a non-inverting amplifier with a gain of one. The band pass output is AC coupled through C16 (on page 3 of the schematic) and then fed to an

inverting amplifier with a gain of one. The notch output is achieved by combining the low pass and high pass outputs with an inverting summing amp set for unity gain and then feeding this combined signal to another inverting amplifier with a gain of one.

Refer to page 1 of the schematic for the following discussion on the input design. The two audio signals appearing at IN1 and IN2 are attenuated by VR6 and VR7 before being mixed by an inverting amplifier with a gain of one. This signal is then AC coupled to the filter via C15. Filter resonance is set either manually via VR1, or externally via the RESM input and VR2 through a reversing attenuator built around U1. Filter frequency can be set manually using VR5, externally via the 1V/OCT input, externally via the FM2 input and attenuator VR3, or externally via the FM1 input and a reversing attenuator built around U2. R10, TP1, and R15 derive an 18 mV/octave frequency control voltage from these combined controls and input signals (see the Calibration section).

Construction Tips

Use a socket for the CEM 3320; this is a rare and expensive chip. Sockets are not necessary for the other chips.

Coax cable should be used for the two audio input signals (J5 and J6) and the four audio output signals (J7, J8, J9, J10). Consider using two-conductor coax (microphone cable) for connecting the two audio input attenuators (VR6, VR7).

R15 is a Tempco resistor and must be mounted on top of the CEM 3320 chip. Use a dab of heat sink compound to thermally connect R15 to the CEM 3320. R15 should be the last component installed on the PCB.

The PCB uses 0.4” spacing for the resistor pads and 0.2” spacing for most of the capacitor pads. The exceptions being C23 and C24 (axially mounted polystyrene caps) which have a 0.6” pad spacing.

Save some scrap resistor leads and use them to connect the switching lug of the phone jacks to ground for the inputs (J1-J6).

R43 and R45 are “infinite ohm” resistors, i.e. an open circuit, so don’t install anything there. R44 and R46 are “zero ohm” resistors, i.e. a short circuit, so install a wire jumper there (a scrap resistor lead will work fine). Space is left on the PCB for installing resistors in these locations in order to change the gain of the LP and HP outputs. See the Modifications section for details.

Panel Wiring Guide

Panel Designation	*PCB Designation*	*Wire Length (inches)*	*Wire Type*
RES pot	VR1	2	twisted
RESM pot	VR2	5	twisted
FM 2 pot	VR3	3	twisted
FM 1 pot	VR4	2	twisted
FREQ pot	VR5	4	twisted
IN 1 pot	VR6	4	coax or twisted
IN 2 pot	VR7	4	coax or twisted
RESM jack	J1	8	twisted
1V/OCT jack	J2	7	twisted
FM 2 jack	J3	6	twisted
FM 1 jack	J4	6	twisted
IN 1 jack	J5	5	coax
IN 2 jack	J6	4	coax
LP jack	J7	5	coax
HP jack	J8	5	coax
BP jack	J9	5	coax
NOTCH jack	J10	4	coax

For VR1-VR7, the square pad on the PCB indicates pin 1, the middle pad is pin 2, and the remaining pad is pin 3. The pin out for most pots is (left to right): 3, 2, 1 when viewing the back of the pot with the leads facing down.

For J1-J10, the square pad on the PCB indicates the ground connection.

Calibration

Let the filter warm up for a few minutes before attempting calibration.

TP1 sets the filter's "one volt per octave" tracking. Disconnect any signals from the FM1, FM2, IN1, IN2, and RESM inputs. Set TP1 to the middle of its range. Set the RES control fully clockwise to get the filter to oscillate. Set the FREQ control to the 2 position. Alternately apply 0.000 and 2.000 volts to the 1V/OCT input and adjust TP1 until the filter pitch is two octaves apart at these two voltages. Use a frequency counter or a calibrated reference oscillator for comparison. Don't adjust the FREQ knob on the TLN-428 while setting TP1, adjust the frequency of the reference oscillator instead. Don't worry about trying to get the filter to track perfectly over a wide range; it's just a filter, it's not an oscillator.

TP2 sets the frequency input control voltage rejection. Disconnect any signals from the FM1, FM2, IN1, IN2, and RESM inputs. Set TP2 to the middle of its range. Set the FREQ and RES controls fully counter clockwise. Apply a sawtooth waveform from an oscillator into the 1V/OCT input. The oscillator should be in the audible range. Adjust TP2 for the minimum output signal. Use an oscilloscope or listen to the output.

Modifications

TL072 op amps can be used instead of the MXL1013 and OP275GP op amps.

C21 provides phase compensation to prevent the filter from honking too much at high resonance settings. C22 eliminates high frequency oscillations that creep into the high pass output at very low resonance settings. Both values can be changed to increase or decrease the maximum amount of resonance that the filter can achieve before going into oscillation. Lowering C21 and C22 allows higher resonance to be achieved but increases the risk of high frequency oscillation. Increasing C21 and C22 results in a more stable filter but lowers the maximum resonance achievable. In general, C21 needs to be about twice as large as C22 to keep the filter stable.

The FM2 input has a gain of 2.0 but the FM1 input only has a gain of 1.33. To get a gain of 2.0 with the FM1 input, lower R17 and R18 from 49.9K to 36K. However, this will also lower the input impedance on the FM1 input accordingly.

R11 and R12 can be tweaked to change the filter frequency response. R11 sets the filter frequency when the FREQ knob is at minimum (fully CCW). Increasing the value of R11 will raise the filter frequency when the FREQ knob is at minimum. R12 sets the filter frequency when the FREQ knob is at the maximum (fully CW). Decreasing R12 will decrease the filter frequency when the FREQ knob is at maximum. Note that R11 should always be adjusted before R12 because R11 affects both the minimum and maximum frequency. Thus, changing R11 will likely require changing R12 as well.

R27 sets the point where the filter will oscillate. The suggested value of 240K will allow the filter to oscillate when the RES control is at the 8 position. The filter oscillates more easily at higher frequencies. Lowering R27 will allow the filter to oscillate at a lower RES control setting. R27 can be increased to prevent the filter from oscillating at any RES control setting.

The input and output amplifiers are designed to provide unity gain through the filter. This should provide sufficient output drive. More gain can be achieved by changing a few resistors. Be warned that when the filter oscillates, it will output a 12 Vpp signal at unity gain; increasing the gain will provide an even larger output signal. Decrease R29 to get more gain out of the BP output; the gain equation is “R30/R29”. Decrease R32 to get more gain out of the NOTCH output; the gain equation is “R31/R32”. Put resistors in for R43 and R44 to get more gain out of the LP output; the gain equation is “1 + R44/R43”. Put resistors in for R45 and R46 to get more gain out of the HP output; the gain equation is “1 + R46/R45”.

TLN-428 Parts List

Resistors

Quantity	*Description*	*Part No.*	*Notes*
13	100 K	R20, R21, R22, R23, R29, R30, R31, R32, R33, R35, R37, R40, R42	5% or better, Mouser #291-100K
4	1 K	R24, R28, R34, R36	5% or better, Mouser #291-1K
2	91 K	R39, R41	5% or better, Mouser #291-91K
1	220 K	R26	5% or better, Mouser #291-220K
2	240 K	R25, R27	5% or better, Mouser #291-240K
1	820 ohm	R38	5% or better, Mouser #291-820
1	3.3 M	R8	5% or better, Mouser #291-3.3M
1	300 K	R5	1%, Mouser #271-300K
8	100 K	R1, R2, R3, R4, R9, R14, R16, R19	1%, Mouser #271-100K
5	49.9 K	R6, R7, R13, R17, R18	1%, Mouser #271-49.9K
1	44.2 K	R10	1%, Mouser #271-44.2K
1	1 K	R15	1% Tempco, PT146 or similar
1	180 K	R11	1%, Mouser #271-180K
1	150 K	R12	1%, Mouser #271-150K
2	infinite ohm	R43, R45	see Construction Tips and Modifications
2	zero ohm	R44, R46	see Construction Tips and Modifications

Capacitors

Quantity	*Description*	*Part No.*	*Notes*
4	4.7 uF 35V electrolytic	C15, C16, C17, C18	can substitute 3.3 uF, or use bipolar, Mouser #140-XRL35V4.7
2	33 pF ceramic	C19, C20	can substitute 22 pF, Mouser #140-50N5-330J
1	18 pF ceramic	C21	Mouser #140-50N5-180J
1	10 pF ceramic	C22	Mouser #140-50N5-100J
2	150 pF polystyrene	C23, C24	axial lead, Mouser #23PS115
12	0.1 uF ceramic	C3 – C14	Mouser #147-72-104
2	22 uF 25V electrolytic	C1, C2	can use 35V, Mouser #140-XRL25V22

Semiconductors

Quantity	*Description*	*Part No.*	*Notes*
2	MXL1013 (or LT1013) dual op amp	U1, U2	can substitute TL072, Allied #735-3671
3	OP275GP dual op amp	U3, U4, U5	can substitute TL072, Allied #630-9295
1	CEM 3320 filter	U6	

Potentiometers & Trimmers

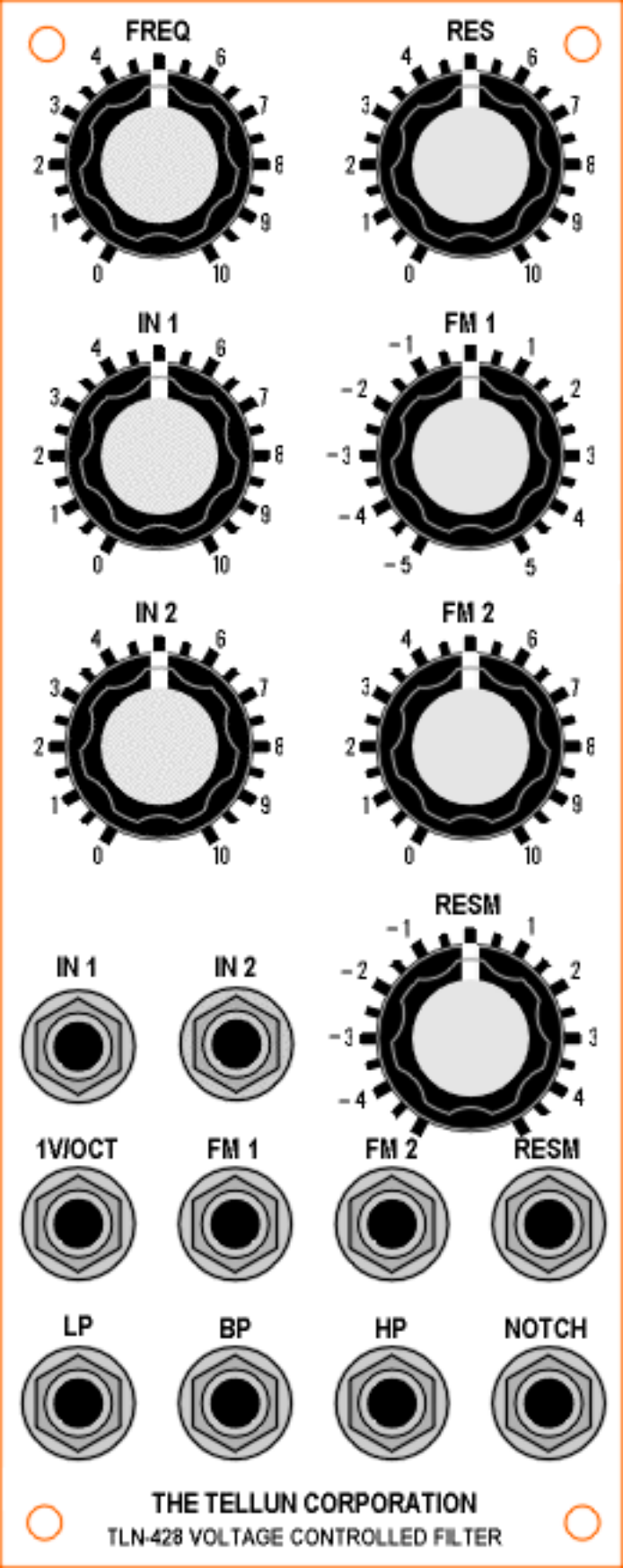
Quantity	*Description*	*Part No.*	*Notes*
2	100 K log pot	VR6, VR7	Bournes 91 series, Allied #754-9820
5	100 K linear pot	VR1, VR2, VR3, VR4, VR5	Spectrol 149 series, Allied #970-1791, or Bournes 91 series, Allied #754-9420
1	25 K trimmer (multi-turn)	TP1	Mouser #72-T93YA-25K
1	1 K trimmer (multi-turn)	TP2	Mouser #72-T93YA-1K

Miscellaneous

Quantity	*Description*	*Part No.*	*Notes*
10	phone jack	J1 – J10	Switchcraft 112A, Allied #932-9391
1	18 pin DIP socket		for U6
5	8 pin DIP socket		for U1 – U5 (optional)
2	axial ferrite beads	L1, L2	Active #MURJP2141, or Mouser #623-2743002112
1	MTA-156 power connector	JP1	Mouser #571-6404454

Hardware

Quantity	*Description*	*Notes*
7	knobs	ALCO PKES90B1/4
1	TLN-428 panel	front panel
1	TLN-428 pcb	printed circuit board
1	4 pot short Stooge bracket	Stooge bracket
4	#6-32 screw, spacer, and nut	for mounting circuit board to Stooge bracket
4	pot nut	for mounting Stooge bracket to front panel
4	#8-32 black screw	for mounting module to cabinet
1	power cable	with MTA-156 connectors
	heat shrink cable	
	wire ties	
	coax cable	
	hookup wire	
	solder	both organic and no clean
	heat sink compound	


FREQ
RES
IN 1
FM 1
IN 2
FM 2
RESM
IN 1
IN 2
1V/OCT
FM 1
FM 2
RESM
LP
BP
HP
NOTCH
THE TELLUN CORPORATION
TLN-428 VOLTAGE CONTROLLED FILTER