Unit Test PCB3 THD Analyzer

Bob Cordell's article (part 3) describes this as CP3 bench-testing. The PCB itself is tested slightly different from Bob's bench-test. This is because we use the µC board (PCB4) to control all the switches.

Date test conducted:	24-10-'24
PCB3 hardware version:	V0.21
End-result of test	~~OK~~/ NOK TEST 5.1 FAILS, typo?

PCB3 Auto-Tune Circuits

Nr.	Description			
	Entry-criteria: - a tested and working µC control-board (PCB4) is needed for these tests. - PCB3 board ready for testing, all components are mounted. - Two flat-cables, one for the connection to PCB4 and one for the connection to PCB2. - Function-generator, oscilloscope, true-RMS multimeter.			
0	Preparations for **Auto-Tune circuits** and **Filter, Meter and Status Circuits** test - Connect a flat-cable between PCB4 and PCB3, do NOT connect the PCB3-PCB4 flat-cable yet. - Solder a **10 kΩ** resistor between **E29** (**DIST.IN**) and **GND**. - Center trimpots **R135** and **R157**. - Connect ±15 V and GND to **+15 V**, **GND** and **-15 V**.			
	Description	**Result**		
		Expected	**Measured**	**OK?**
1.1	This step tests relays **K1 – K10** and relays **K15 – K24**. Use the following procedure to check if a relay on PCB3 is switched: - A relay is **ON** when the voltage level on pin 8 of the relay is equal to approx. **0 Volts** (DC). - A relay is **OFF** when the voltage level on pin 8 of the relay is equal to approx. **12 Volts** (DC). - Use the joystick-buttons on PCB4 to select a **Frequency** and use that to check the relays. - When a relay is **NOT** mentioned under expected test-results, it should be **OFF**! Test this as well.	20 Hz – all relays off 25 Hz – K1 & K15 are on 30 Hz – K2 & K16 are on 40 Hz – K3 & K17 are on 50 Hz – K4 & K18 are on 65 Hz – K5 & K19 are on 80 Hz – K6 & K20 are on 100 Hz – K7 & K21 are on 130 Hz – K8 & K22 are on 160 Hz – K9 & K23 are on 200 Hz – K10 & K24 are on	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓	OK/~~NOK~~
1.2	Use the same procedure to check relays **K11 – K14** and **K25 – K27**.	200 Hz – K11 & K25 are on 250 Hz – K12 & K26 are on 2.5 kHz – K13 & K27 are on 25 kHz – K14 & K27 are on	✓ ✓ ✓ ✓	OK/~~NOK~~
1.3	Use the same procedure to check relays **K28 & K29**, but now select **Sensitivity** instead of **Frequency**.	Sensitivity: - **0.3%** - K28 is on - **0.03%** - K28 & K29 are on - **0.01%** - K29 is on	 ✓ ✓ ✓	OK/~~NOK~~
2	Measure the following DC-voltages with a **10 kΩ** resistor in series:	**IC25-6**: +2.5 mV **IC26-1** and **IC26-4**: -7.6 V **IC26-2** and **IC26-3**: -8.2 V **IC26-5**: -14.0 V **IC26-6**: +5.6 V **IC26-10**: -2.2 mV **IC26-12**: +5.6 V **IC27-5**: +1.3 V **IC27-7**: 0.0 V **IC28-6**: +7.2 mV **IC29-10**: -10.4 mV **IC29-12**: +5.6 V **IC30-5**: +1.4 V	-2.6 mV -6.82 V -7.5 V -12.7 V +5.59 V -5.8 mV +5.55 V +1.32 V +12 mV +4.2 mV -24 mV +5.52 V +1.31 V	OK/~~NOK~~
3.1	Turn **R135** in both positive and negative directions.	Integrator output **E23** drifts slowly in positive or negative direction,	✓	OK/~~NOK~~

		between -12 V and +0.3 V.		
3.2	Turn **R157** in both positive and negative directions.	Integrator output **E22** drifts slowly in positive or negative direction, between -12 V and +0.3 V.	✓	OK/~~NOK~~
4.1	- Select a **Sensitivity** of **0.01 %** on the display. - Connect a sinewave (**100 mV_{rms} / 2 kHz**) to **E29 (DIST.IN)**.	- **IC31 pin 6** carries the same signal. - **IC25 pin 6** carries a soft-clipped **1.5 V_{pp}** version of this signal.	✓ 944 mV_{pp}	OK/~~NOK~~
4.2	Select a **Sensitivity** of **0.03 %** on the display.	- **1 V_{rms}** at **IC31 pin 6** - **2.5 V_{pp}** rounded square wave at **IC25 pin 6**.	✓ 2.62 V_{pp}	OK/~~NOK~~
4.3	- Connect a sinewave (**100 mV_{rms} / 2 kHz**) to **E21**. - Increase the amplitude to **1V_{rms}**.	- Soft-clipped **0.8 V_{pp}** version of this signal at **IC28 pin 6**. - Hard-clipped **1.0 V_{pp}** signal at **IC28 pin 6**.	0.736 V_{pp} ✓ 1.0 V_{pp} ✓	OK/~~NOK~~

Nr.	Description		
	The following tests need a fully functional PCB2 board. If any problems remain on PCB2, correct them now before proceeding. Preparations for the **Auto-Tune circuits** tests: - Connect the flatcable between PCB2 CON1 and PCB3 CON1. This connects **E21 (QREF)**, **E29 (DIST)**, **E32 (IREF)**, **E22 (ACONT)** and **E23 (FCONT)**. Test these interconnections (PCB2 – PCB3) prior to power-up! - Center trimpots **R135** and **R157** on PCB2. - Connect both **PCB2** and **PCB3** with their flatcables to PCB4 (3 flatcables in total: PCB4-PCB2, PCB4-PCB3 and PCB2-PCB3).		

	Description	Result		OK?
		Expected	Measured	
5.1	- Connect a sinewave of **1 V_{rms}** and **2 kHz** to the PCB2 input pin. - Select a **Sensitivity** of **3 %**. - Select an **Input-level** of **3 V**.	1) A **3 V_{pp}** rounded square wave should be visible at **IC25 pin 6**. If the level is very small, the analyzer may have tuned itself. In this case, changing the frequency by about 10% so that it is well out of the tuning range should yield the square wave. 2) A **1 V_{pp}** square wave should be visible at **IC28 pin 6**.	AT 2.1 kHz THIS IS 4.5 V_{pp} IF f=2.2 kHz THEN 13.2 V_{pp} 980 mV_{pp} ✓	OK/NOK CAN NOT get 3 V_{pp} none. Typo in article 2 2 ✓
5.2	- Adjust the input frequency for a minimal output at **E29** and measure the DC voltage at **E22**. Set the input frequency to yield a voltage equal to one-half the pinch-off voltage for **Q5** (default: -3.5 V). - Now adjust R62 on PCB2 for a DC voltage of one-half the pinch-off voltage (default: -3.5 V) of **Q6** at E23.	A complete null of the fundamental should now be present at **E29**, with only distortion and noise visible.	± 8 mV_{pp} AT E29 f = 2.032 kHz → -3.536 VE E22 E22 = -3.53 V	OK/~~NOK~~
5.3	- Remove the flat-cable between PCB2 and PCB3 and make manual connections for **E21 (QREF)**, **E32 (IREF)**, **E22 (ACONT)** and **E23 (FCONT)**. - Place a 100-to-1 attenuator between **E29 (DIST)** on PCB2 and **E29 (DIST.IN)** on PCB3 (**100 kΩ** series with **1 kΩ** shunt will do). - Alternately adjust **R135** and **R157** for the best possible fundamental null as observed at **E29 (DIST.IN)** on PCB2. These adjustments should be made slowly, as the time-constants in the auto-tune control circuits are long.	**E31 E21 GND E23** **E32 E29 GND E22** ***PCB2_IO connector*** 	8 mV_{pp} → 4 mV_{pp} SOME EFFECT OF R135/R157, BUT NOT TOO MUCH.	OK/~~NOK~~

PCB3 Filter, Meter and Status Circuits

6.1	- Remove the connections made between PCB2 and PCB3 in test-step 5.3. - Connect a **10 kΩ** resistor between **E29 (DIST.IN)** and **GND**. - Center trimpots **R180** and **R192**. - Apply power and measure the following DC voltages through a **10 kΩ** isolating resistor at the end of the meter probe to prevent oscillations:	**E29**: -10 mV **IC31-6** & **IC32-6**: -14 mV **IC33-6**: -0.6 mV **IC34-6**: +13.6 mV **IC35-6**: +110 mV **IC36-6**: 0.0 mV **IC37-6**: +1.7 V **IC38-3**: +3.3 V **IC38-6**: -3.5 V **IC38-13**: -12.1 V **IC38-14**: +13.3 V **E47**: +12.8 V	0 mV -16, -5.1 mV -2.9 mV -2 mV -23.8 mV -9 mV 0.217 V +3.46 V -3.42 V -11.8 V +13.51 V 11.54 V, BLUE LED!	OK/~~NOK~~
6.2	- Apply a **300 mV_{rms} 2 kHz** sinewave to **E29 (DIST.IN)**. - Select a **Sensitivity** of **0.3 %**. - Select a **Frequency** of **2 kHz**. - Adjust **R180** to set **IC34 pin 6** to 1/3rd of the voltage at IC33 pin 6. - Drop the input level at **E29 (DIST.IN)** to **30 mV_{rms}** and select a **Sensitivity** of **0.1 %**. - Adjust the input level of the 2 kHz sinewave at **E29 (DIST.IN)** so that **IC35-6** is exactly **500 mV_{rms}**. - Adjust **R192** to a reading of "0.050 %" on the distortion seven-segment display (SSD4).	- **300 mV_{rms}** at **IC32 pin 6** - **150 mV_{rms} at IC33 pin 6.** - **50 mV_{rms}** at **IC34 pin 6**. - **500 mV_{rms}** at **IC35 pin 6**. - 50 **mV_{rms}** at **IC34 pin 6**. - **500 mV_{rms}** at **IC35 pin 6**. - **500 mV_{rms}** at **IC35 pin 6**. - **Distortion** SSD4 should read "**0.050 %**".	300 mV_{RMS} 158 mV_{RMS} 50 mV_{RMS} 500 mV_{RMS} 51 mV_{RMS} 500 mV_{RMS} 500.8 mV_{RMS} 2501 ON SSD4 WITH V0.22 FIRMWARE	OK/~~NOK~~
7	- Connect 4 LEDs (D24-D27) from terminals **E43** through **E46** to **E49 (+15V)**. - Reconnect the flatcable between **PCB2** and **PCB3**. - Select an **Input-level** of **3V**. - Select a **Frequency** of **2 kHz**. - Connect a sinewave of **1 V_{rms}** and **2 kHz** to the input at PCB2. - Increase the frequency of the input sinewave - Decrease the frequency of the input sinewave - Tune for a good notch at **E29 (DIST.IN)**. - Drop input level to **0.25 V_{rms}** - Raise input level to **4 V_{rms}**	**E43/D24**: freq. too high **E44/D25**: freq. too low **E45/D26**: level too high **E46/D27**: level too low - **D26** and **D27** are off - **D24** is on, **D25** is off - **D24** is off, **D25** is on - **D24** and **D25** are off - **D27** is on, **D26** is off - **D26** is on, **D27** is off	ß ß ß ß ß ß ß ß → 2.01 KHZ FOR INPUT FREQ. ß ß ß ß	OK/~~NOK~~