Unit Test PCB1 THD Analyzer

Bob Cordell's article (part 3) describes this as CP1 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:	11-11-'24
PCB1 hardware version:	V0.30
PCB4 firmware version:	V0.24
End-result Test	OK / ~~NOK~~ UNTIL 100 KHZ

PCB1 signal-generator: Unit-Test

Nr.	Description			
0	**Entry-criteria:** - PCB1 board ready for testing, all components are mounted. - Oscilloscope, true-RMS multimeter and frequency-counter are available. - a tested and working µC control-board (PCB4). - A host PC with USB-to-serial adapter is connected to **CON6 (RS232.5V)** of the µC control-board (GND-GND, RXD-TX, TXD-RX). - Communication settings are set to **57600,N,8,1**. Give the **s0** command, a response with version info is returned.			OK/~~NOK~~
1	Connect ±15 V and GND to **+15 V**, **GND** and **-15 V**.			
2	Measure the following DC voltages at the test-pins:	+15.0 V +12.0 V +5.0 V -15.0 V	+14.92 +12.23 +5.16 -14.9	OK/~~NOK~~ BENCH PSU
3	Connect a flatcable from PCB4 **CON10** to PCB1 **CON3 (UC_IO)**. Give the UART command **f10** or use the joystick buttons on PCB4 to select a frequency.	Some PCB1 relays are switched.		OK/~~NOK~~
4	This step tests relays **K1 – K10**. 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 is on 30 Hz – K2 is on 40 Hz – K3 is on 50 Hz – K4 is on 65 Hz – K5 is on 80 Hz – K6 is on 100 Hz – K7 is on 130 Hz – K8 is on 160 Hz – K9 is on 200 Hz – K10 is on	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓	OK/~~NOK~~
5	Use the same procedure to check relays **K11 – K13** and **K17 – K20**.	200 Hz – K11 & K17 are on 250 Hz – K12 & K18 are on 2.5 kHz – K13 & K19 are on 25 kHz – K20 is on	✓ ✓ ✓ ✓	OK/~~NOK~~
6	Use the same procedure to check relays **K14 & K21 – K24**, but now select **Output-level** instead of **Frequency**.	**Output-level**: - **OFF** – K21 is on - **0.15V** – K22 is on - **0.5V** – K23 is on - **1.5V** – K24 is on - **5V** – K14 & K24 are on	✓ ✓ ✓ ✓ ✓	OK/~~NOK~~

PCB1 signal-generator: Unit-Test

Nr.	Description	Result		OK?
		Expected	Measured	
10	- Center trim pot **R24**. - Select a **frequency** of **2 kHz**. - Connect a scope to **E5**.	**4.5 V_{pp}** sine-wave of approx. **2 kHz**.	4.36 Vpp 2.02 kHz	OK/~~NOK~~
11	Measure the following DC voltages:	IC1-6: +2.9 mV IC2-6: +0.8 mV IC3-3: +0.1 mV IC3-6: -4.3 mV IC4-6: +1.0 mV IC5-6: -4.6 mV BQ3: +602 mV EQ3: +2.2 V E7 : +2.2 V IC6-6: +13 mV E8 : -2.5 V GQ1 : -2.5 V	-36.0 mV -36.0 mV -0.1 mV +3.9 mV -35 mV -35 mV +620 mV +2.17 V +2.15 V 10-15 mV varying -3.49 V -3.50 V	OK/~~NOK~~
12	- Set **output-level** to **1.5V**. - Connect scope channel A to **E5** and channel B to **E9**. - Measure the amplitude with a true-RMS multimeter of both V_{E11} and V_{E5}. - Set **output-level** to **5V**. - Measure both amplitudes again.	V_{E11} / V_{E5} ≈ 1.0 X V_{E11} / V_{E5} ≈ 3.0 X	V_{E11}: 1.62 Vrms V_{E5}: 1.53 Vrms $\frac{V_{E11}}{V_{E5}} = 1.06X$ V_{E11}: 4.89 Vrms V_{E5}: 1.53 Vrms $\frac{V_{E11}}{V_{E5}} = 3.2X$	OK/~~NOK~~
13	- Select a **frequency** of **200 Hz**. - Connect scope channel A to test-pin **IC6.6**. Adjust **R24** for perfect symmetry: adjacent peaks are of equal level.	- 4.5 Vpp sine-wave of approx. **200 Hz**. - Signal is full-wave rectified	✓ ✓	OK/~~NOK~~
14	Select a frequency of **20 Hz** on PCB4. Adjust **R24** if necessary.	- 4.5 Vpp sine-wave of approx. **20 Hz**. - Stable level within 15 seconds	✓ ✓	OK/~~NOK~~
15[1]	- Connect a scope to **E9** and select frequency measurement on the scope (or use a frequency-counter). - Select a frequency of **650 Hz** and adjust frequency trimmer **R2** for a source frequency of exactly 650 Hz. - Select a frequency of **65 Hz** and adjust frequency trimmer **R1** for a source frequency of exactly 65 Hz. - Select a frequency of **6.5 kHz** and adjust frequency trimmer **R3** for a source frequency of exactly 6.5 kHz. - Select a frequency of **65 kHz** and adjust frequency trimmer **R4** for a source frequency of exactly 65 kHz.	 - frequency = 650 Hz - frequency = 65 Hz - frequency = 6.5 kHz - frequency = 65 kHz	TEKTRONIX CFC 250 650 Hz 65 Hz 6501 Hz 64996 Hz	OK/~~NOK~~
16	- Use the µC control-board and select every possible frequency. - Connect a scope to **E9** and check for a stable sine-wave. Measure the actual frequency. - Connect a multimeter to **E8** and measure the DC-voltage.	Fill in table 1 with actual measured frequency and **E8** DC voltage. - Frequency within 10% - 0.5V ≤ **-E8** ≤ 8V		OK/~~NOK~~ 130 kHz 160 kHz 200 kHz } FAIL

[1] Test-step 15 is taken from Bob's "Test and Calibration" paragraph, since it felt more appropriate here as a Unit-Test.

Frequency	Measured	E8 (V_{DC})	Frequency	Measured	E8 (V_{DC})
20 Hz	19.96	−3.21			
25 Hz	24.80	−3.15	2.5 kHz	2477	−1.27
30 Hz	31.0	−3.11	3.0 kHz	3028	−1.09
40 Hz	40.18	−3.03	4.0 kHz	4015	−0.86
50 Hz	50.23	−2.97	5.0 kHz	5024	−0.64
65 Hz	65.02	−2.89	6.5 kHz	6510	−0.39
80 Hz	79.47	−2.82	8.0 kHz	7963	−0.17
100 Hz	99.65	−2.73	10 kHz	9996	+0.06
130 Hz	129.66	−2.62	13 kHz	13002	+0.31
160 Hz	159.33	−2.53	16 kHz	16018	+0.45
200 Hz	201.2	−2.42	20 kHz	20256	+0.56
250 Hz	248.1	−3.62	25 kHz	24797	−7.09
300 Hz	303.2	−3.62	30 kHz	30306	−6.83
400 Hz	401.5	−3.62	40 kHz	40144	−6.22
500 Hz	501.9	−3.63	50 kHz	50200	−5.19
650 Hz	649.5	−3.62	65 kHz	64993	−3.21
800 Hz	793.8	−3.63	80 kHz	79434	−1.16
1.0 kHz	995.2	−3.64	100 kHz	99595	+0.65
1.3 kHz	1295	−3.64	130 kHz	—	+0.73
1.6 kHz	1591	−3.65	160 kHz	165020	−13.59
2.0 kHz	2008	−3.67	200 kHz	90016	−13.57

Table 1: results from test-step 15

Test-step 13: IC6.6 output at f = 200 Hz

Test-step 14: IC6.6 output at f = 20 Hz