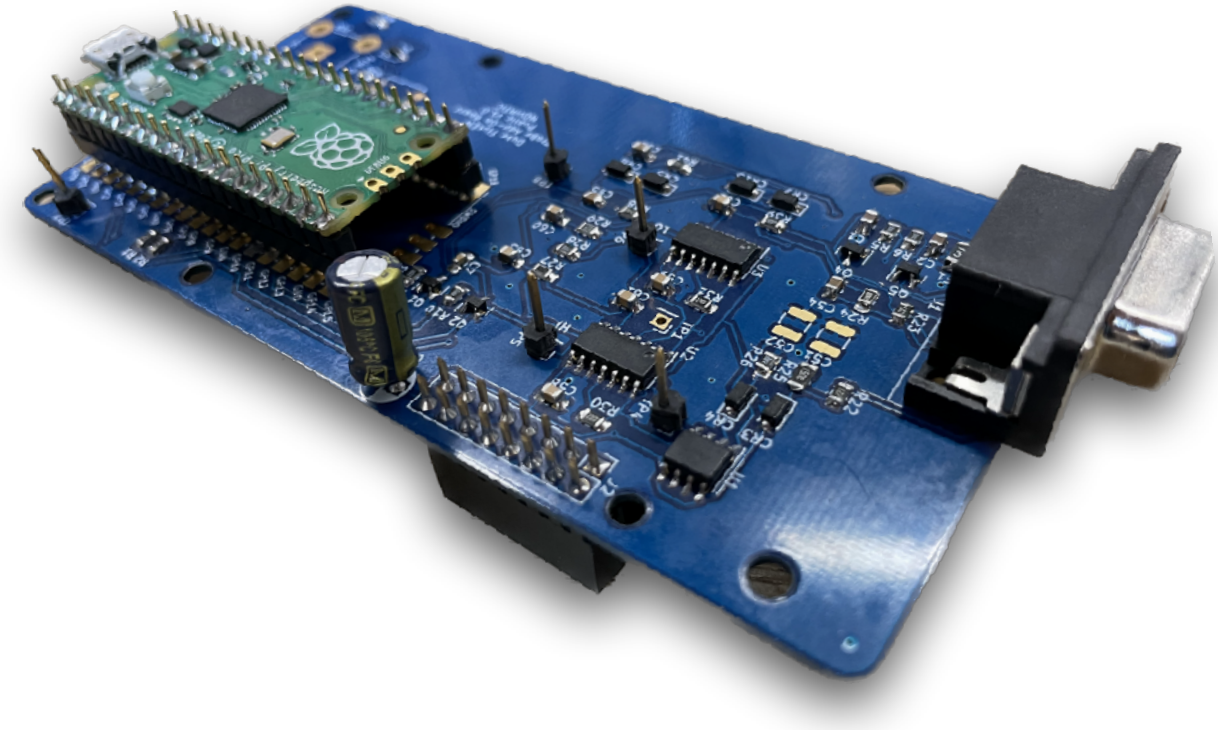
FlukeEmu / FluCom (Duke FlukEM)

Probe Add-on-Board

Build Manual and Bill of Materials



1) Table of Content

2) General description

This add-on board for the FluCom Raspberry Pi HAT provides full probe functionality for the FlukeEmu/ FluCom hardware/software Emulation of the Fluke 9010A Micro-System Troubleshooter.

Basically this makes the Fluke 9010A emulation feature- complete.

As much of the original circuitry as possible was implemented using a Raspberry PICO microcontroller.

However, due to the original design of the probe, a significant amount of analog circuitry had to be reproduced in order to keep the system working with legacy probes.

3) A bit more detailed

The Fluke 9010A Micro-System Troubleshooter's probe provides additional diagnostic features and tools such as:

- Logic level detection
- Signatur analysis
- Event counting
- Pulse generation

It can be used in ‚free run mode' or synced to address or data cycles. It does also provide an external sync signal.

In order to add to the above mentioned functionality to our existing hardware / software solution for 9010A emulation, we decided to take a ‚hybrid'- approach:

The Analog section (probe compensation, high- to low impedance conversion, probe control signals) was kept as close as possible to the original design in order to maintain compatibility to the original probe.
For the rest / majority of the circuits a Raspberry PICO microcontroller was used (especially its PIO state machines) to keep the overall design simple, cheap and flexible.

All in all, our tests suggest that our emulation performs at least as good as the original probe and meets or exceeds the original specifications.

Of course, we did not test our design in all possible / extreme environments or to complete destruction, so please keep that in mind and use it at your own risk. Generally speaking: It is never a good idea to stick your probe where it does not belong.

Having said that, our design does feature the same over/under- voltage protection as the original. The fuse is implemented by a self resetting ‚polyfuse', therefore the ‚fuse blown- circuit' could be omitted because it is obsolete.

Also, If you do not plan to use the trigger out function some parts can be left away: TR2, J10, C71, R52 and R56.

We have tried to keep the symbol references the same as in the original design wherever possible and meaningful (for stuff like Testpoints). This is part of the explanation, why the numbering might seem a bit odd at times.

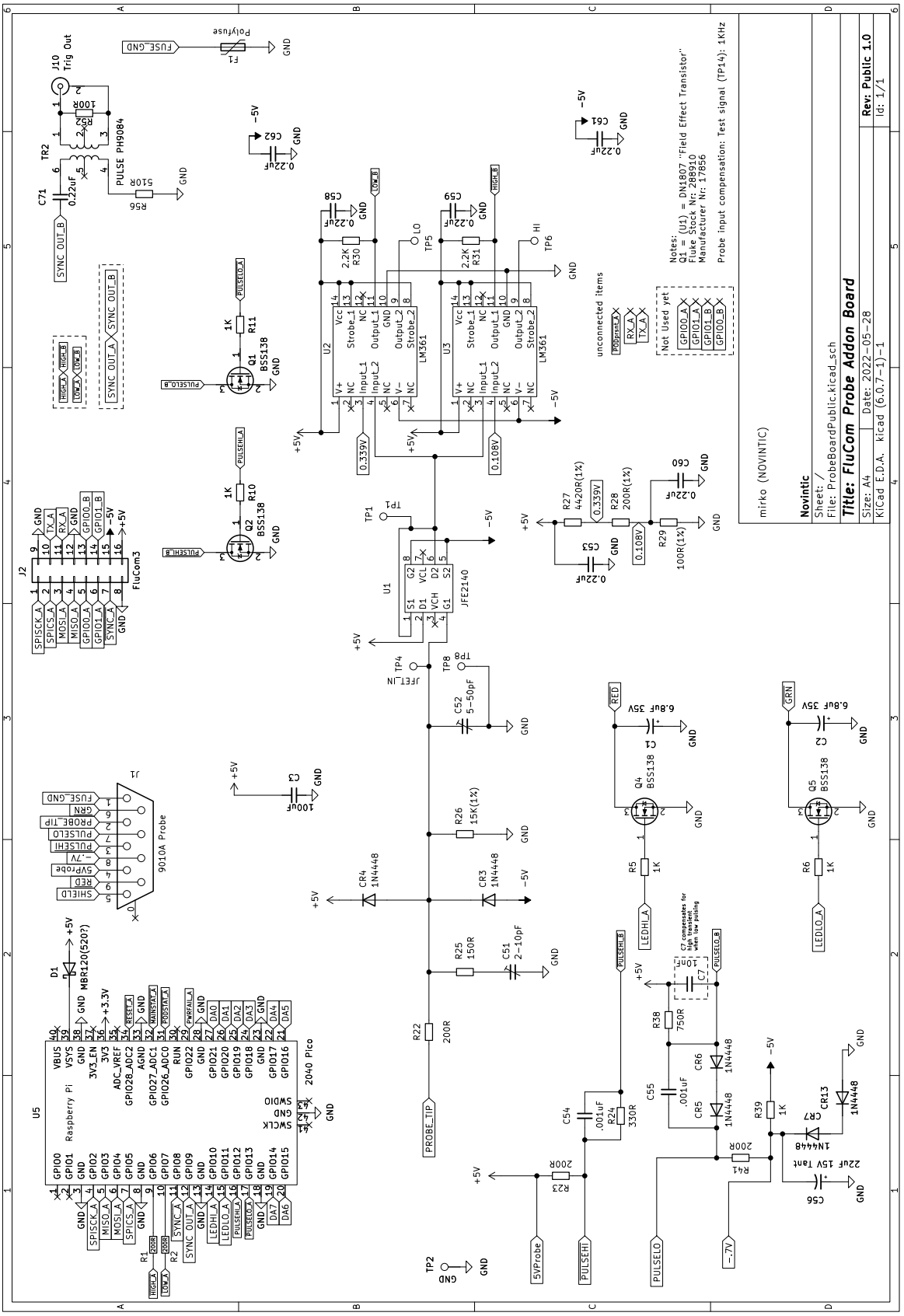
The variable capacitors on the input section can most likely be omitted or replaced by a fixed value too (s. notes below).

In general, building the probe board is a bit more involved than the base FluCom interface; however it can be quite easily done with decent soldering skills and equipment. You will not need to make any changes to the FluCom board or the FlukeEmu software; just stack the probe board on top and you should be ready to go.

The firmware (APPLICATION.uf2) for the Raspberry PICO can just be copied to its root directory which can be accessed by pressing and holding it's button while plugging in the micro- USB- cable. It will then be recognized as an external USB storage device.

Good luck with building and have fun!

4) Schematics



5) Bill of Materials

Component Count:	63			
Ref	Qnty	Value	Cmp name	KiCAD Footprint
C1, C2,	2	6.8uF 35V	C_Small	Capacitor_SMD:C_0805_2012Metric_Pad1.18x1.45mm_HandSolder
C3,	1	100uF	C_Polarized	Capacitor_THT:CP_Radial_D5.0mm_P2.50mm
C7,	1	10nF	C_Small	Capacitor_SMD:C_0805_2012Metric_Pad1.18x1.45mm_HandSolder
C51,	1	2-10pF	C_Trim_Small	Capacitor_SMD:C_1210_3225Metric
C52,	1	5-50pF	C_Trim_Small	Capacitor_SMD:C_1210_3225Metric
C53, C58, C59, C60, C61, C62, C71,	7	0.22uF	C_Small	Capacitor_SMD:C_0805_2012Metric_Pad1.18x1.45mm_HandSolder
C54, C55,	2	.001uF	C_Small	Capacitor_SMD:C_0805_2012Metric_Pad1.18x1.45mm_HandSolder
C56,	1	22uF 15V	C_Small	Capacitor_SMD:C_0805_2012Metric_Pad1.18x1.45mm_HandSolder
CR3, CR4, CR5, CR6, CR7, CR13,	6	1N4448	1N4448	Diode_SMD:Nexperia_CFP3_SOD-123W
D1,	1	MBR120(520?)	MBR0520	Diode_SMD:Nexperia_CFP3_SOD-123W
F1,	1	Polyfuse	Polyfuse	Capacitor_SMD:C_1206_3216Metric_Pad1.33x1.80mm_HandSolder
J1,	1	9010A Probe	DB9_Female	Connector_Dsub:DSUB-9_Female_Horizontal_P2.77x2.84mm …
J2,	1	FluCom3	Conn_02x08	Connector_PinHeader_2.54mm:PinHeader_2x08_P2.54mm_Vertical
J10,	1	Trig Out	Conn_Coaxial	Connector_Coaxial:BNC_TEConnectivity_1478035_Horizontal
Q1, Q2, Q4, Q5,	4	BSS138	BSS138	Package_TO_SOT_SMD:SOT-23
R1, R2, R22, R23, R41,	5	200R	R_Small	Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
R5, R6, R10, R11, R39,	5	1K	R_Small	Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
R24,	1	330R	R_Small	Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
R25,	1	150R	R_Small	Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
R26,	1	15K(1%)	R_Small	Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
R27,	1	4420R(1%)	R_Small	Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
R28,	1	200R(1%)	R_Small	Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
R29,	1	100R(1%)	R_Small	Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
R30, R31,	2	2.2K	R_Small	Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
R38,	1	750R	R_Small	Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
R52,	1	100R	R_Small	Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
R56,	1	510R	R_Small	Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
TP1,	1	TP1	TestPoint	Connector_PinHeader_2.54mm:PinHeader_1x01_P2.54mm_Vertical
TP2,	1	GND	TestPoint	Connector_PinHeader_2.54mm:PinHeader_1x01_P2.54mm_Vertical
TP4,	1	JFET_IN	TestPoint	Connector_PinHeader_2.54mm:PinHeader_1x01_P2.54mm_Vertical
TP5,	1	LO	TestPoint	Connector_PinHeader_2.54mm:PinHeader_1x01_P2.54mm_Vertical
TP6,	1	HI	TestPoint	Connector_PinHeader_2.54mm:PinHeader_1x01_P2.54mm_Vertical
TP8,	1	TP8	TestPoint	Connector_PinHeader_2.54mm:PinHeader_1x01_P2.54mm_Vertical
TR2,	1	PULSE PH9084	ADTT1-6	Transformer_SMD:Pulse_P0926NL
U1,	1	JFE2140	JFE2140	Package_SO:SOIC-8_3.9x4.9mm_P1.27mm
U2, U3,	2	LM361	LM361_1	Package_SO:SOIC-14_3.9x8.7mm_P1.27mm
U5,	1	2040 Pico	Pico	MCU_RaspberryPi_and_Boards:RPi_Pico_SMD_TH

6) Notes, ToDos and known issues

- The probe compensation implemented in the original circuit uses 2 variable capacitors to calibrate the circuit to individual probes: C51 (2-10pF) and C52 (5-50pF). A 1kHz Square wave is used in the calibration process (as described in the Service Manual for the 9010A).

  We have tested our board using variable capacitors of approximately same values; these do not really appear to have the desired effect.

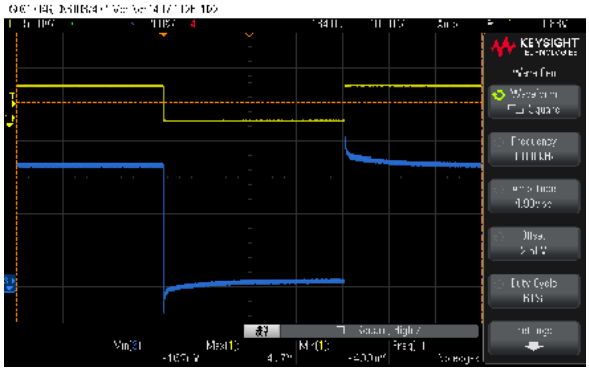
  However, as the over/undershoot is not very high in the first place and can be corrected using a bit higher values we did not try any other values for those variable capacitors (they are quite expensive).

  Also, by adding too much capacitance to the input section, you will loose high frequency performance.

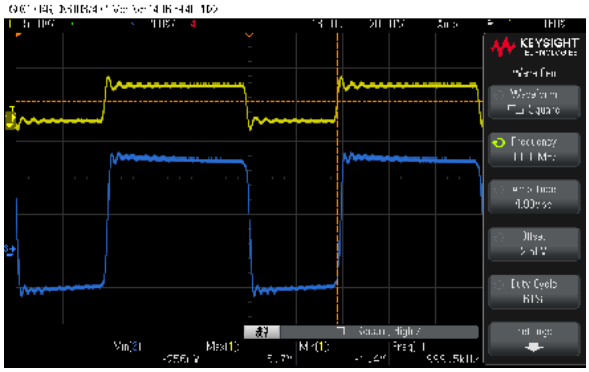
  So, as long as you are not servicing nuclear ICBMs or something the like, not populating C51 / C52 or just using a capacitor around 50-100pF should be just fine (s. images to the right).

- We have tried to use a dual comparator IC (NE521) instead of the two LM361s to reduce the component count; however this design would prove to be unreliable at higher frequencies.

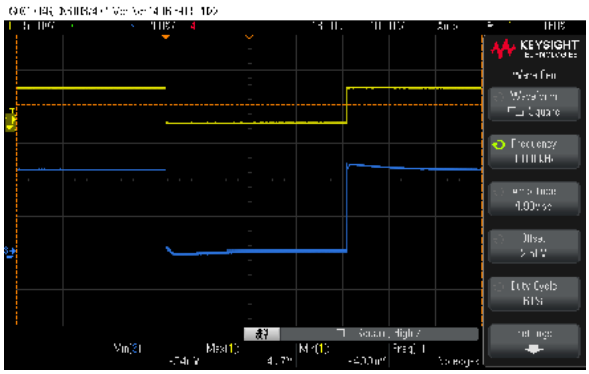
Yellow: Probe tip, Blue: TP4



1kHz, No compensation (C51 / 52 not populated)



1MHz, No compensation (C51 / 52 not populated)



1kHz, C52 = 100pF, C51 not populated

- IMPORTANT CHANGE FOR ‚OLDER' FLUCOM INTERFACE BOARD BUILDS:
In order to get the Probe Board to work properly R8 and R9 had to be changed (with the 10K/20K voltage divider the edges were too ‚slow'). So if you have an older Version of the base interface board and want probe functionality you will have to change these 2 Resistors on the FluCom3 Board (R8 to 1K and R9 to 2K).

7) DigiKey Parts list

By ‚popular demand'. It is incomplete as some parts that were used we had laying around or were bought at a local store

1) Resistors:
   All resistors are 1/8W, 0805. For example:
   RNCP0805FTD1K00CT-ND

2) Capacitors:
   All SMD capacitors used in our builds were ceramic, 0805, 25V. For example:
   1276-1244-1-ND

3) Cap Trimmers (C51, C52) (please read notes below)
   3-15pF: 1674-1018-1-ND
   8-40pF: 1674-1021-1-ND

4) MBR 120 (520)
   Just used an appropriate Schottky diode to protect the USB port if unit is powered (did not have DigiKey part..)

5) 1N4448 Gen Purpose Diodes
   1N4448W-E3-08GICT-ND

6) PTC Polyfuse 100mA
   18-1206L010/60WR-ACT-ND

7) LM361
   296-47682-1-ND

8) JFE 2410 Dual JFET
   296-JFE2140DRCT-0

9) BSS138BK MOSFET
   1727-1141-1-ND