mino Pico-Fmeter2 with RP2040
reciprocal frequency counter with 7-digit resolution

This frequency counter is suitable for measuring periodic signals, with the reciprocal measuring method enabling maximum resolution with short measuring times. The basic resolution is 7 digits/s. At higher input frequency, each individual interval is recorded up to 100 kHz and a higher resolution is achieved through statistical evaluation. Increasing the measurement interval to 10 s or higher further increases the resolution.

In addition to the main input F1, which covers the frequency range from approx. 0.01 Hz - 250 MHz, there is an auxiliary input F-Ref with a reduced frequency range of 0.01 Hz – 15 MHz, which, as a subordinate input, enables continuous adjustment using a 1 pps GPS signal or with a 10 kHz, 1 MHz or 10 MHz signal.

Technical specifications:

- Input F1: 0.01 Hz - 250 MHz with 7-digit. result/s; seamless measurements

- Auxiliary input F-Ref: 0.01 Hz - 15 MHz with 7-digit. result/s; for 1 pps GPS signal
- Specification of the measurement time from 0.001 - 100 s in 1 ms steps
- Specification of timeout from 0.001 - 100 s in 1 ms steps
- 5 - 12 digit display of results manually or automatically depending on eff. measurement time
- Frequency display: auto. in 'mHz' – 'GHz' or fixed format in 'MHz'
- Display formats: 1.2345 Hz; 1.2345E+0; 1.2345Hz; 1.2345E+0
- Scale factor for separate prescaler: 1 - 99999
- Adjustable divisor for speed scaling: 1 - 99999
- internal reference frequency (33.25 MHz) from local 12 MHz XO or ext. Reference signal 10 MHz
- manual or automatic adjustment with 1 pps GPS, 10 kHz, 1 MHz or 10 MHz signal or in the simplest case with a trim pot.
- Calibration range +/- 50 ppm with 0.1 ppb resolution
- Storage of all parameters/adjustment values in EEPROM/FRAM
- 2 x LED outputs for "measurement done" and "GPS active"
- 3 x inputs for control buttons (configuration)
- Display with LCD module 2 x 16 -> 4 x 20 with default 16 characters/line
- RS232 connection with 9600 Bd ... 256 kBd for data output
- 5 V supply approx. 100 mA, (without LCD incl. backlight)

Procedure of the measurements:

All measurements are carried out using the reciprocal measuring method. This means that each measurement starts and ends synchronously with the input signal. Since the end time is also the start time of the new measurement, there is no gap between the measurements. With a 1 Hz signal, a new measured value with full resolution/accuracy is delivered every second. With higher input frequencies, all individual intervals are recorded up to 100 kHz, thus increasing the resolution of the measurement results.

Resolution:

The meter readings for the input pulses are always integers and therefore exact, as specified by the measuring method.
In order to obtain the required high resolution, the time measurement must offer a high resolution or high counts must be reached in the time measurement. To ensure this, a minimum measurement time is specified, which only allows an evaluation when this time is reached or exceeded. The measurement channel F1 resolves the time measurement with about 30 ns. Therefore, F1 or F-Ref can resolve the measured values >= 0.3 s measuring time to 7 digits/s. However, the local 12 MHz XO is at best sufficient for 6-digit absolute accuracy. In order to get a higher accuracy for F1, a TCXO must be equipped or alternatively an ext. reference frequency can be used.

Adjustment:
In the simplest case, a trimming potentiometer (2 – 10 k) can be used to adjust the local XO. It is not the frequency itself that is adjusted, but rather the conversion to the final value.

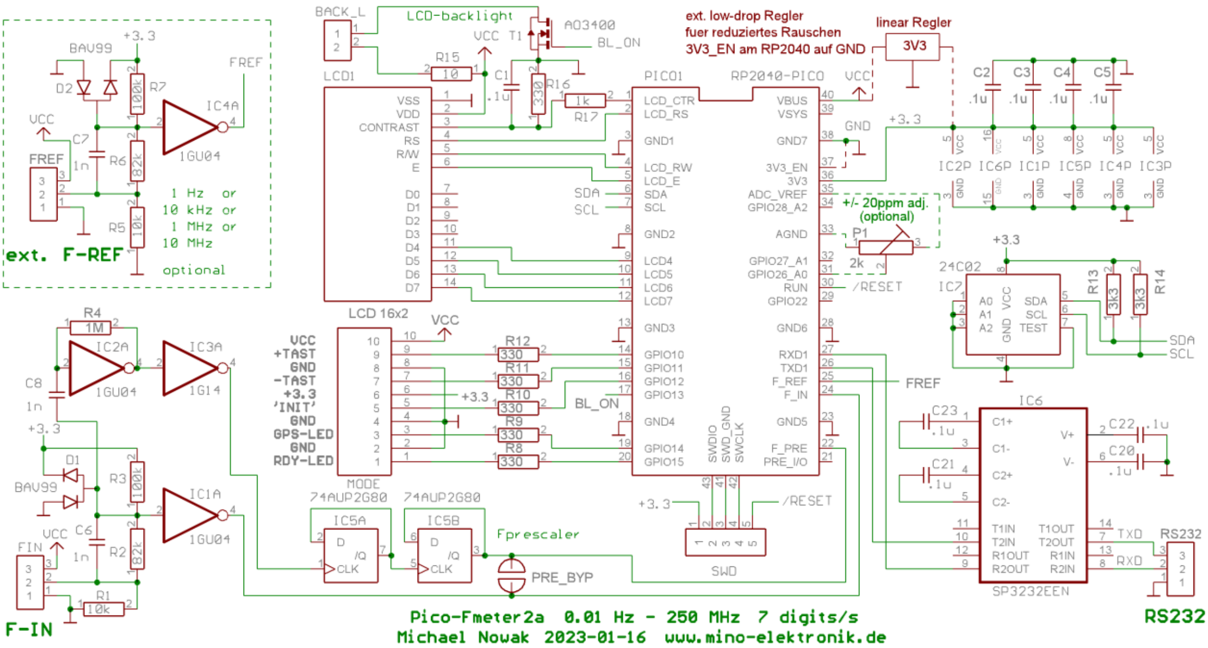
The F-Ref input can be set in such a way that an external, long-term stable 1 Hz signal can precisely determine and correct the existing reference frequency. This signal is supplied by many GPS receivers as a 1 pps signal, but has an annoying jitter of a few 10 ns. So that it can be used for correction, it must be averaged over a longer period of time. If you choose a time of 100 s, this jitter is sufficiently suppressed. However, 10 kHz, 1 MHz or 10 MHz can also be used as the reference frequency. The frequency will be detected automatically.
A match is performed to 0.1 ppb with a local XO capture range of +/- 50 ppm. Correction values can also be set manually in the range of +/- 500000 for a calibration range of +/- 50 ppm. With an external reference frequency, a relatively quick and very precise adjustment is achieved.
When comparing with ext. reference, the first five measured values are discarded. After that, the sliding mean value of the F-Ref signal is formed and only after the integration time (typically 100s) has elapsed the reference frequency is corrected and the correction value saved in the EEPROM. A new correction value is then determined every second and used immediately. However, this value is only saved after the set integration time has elapsed again.

Time-out:
Since the measurements are synchronous with the input signal, a missing input signal would ensure that the measurement would never be completed. Instead, the previous reading would continue to be displayed, even if it is already an hour old.
In order to avoid this, a timeout value is selected in addition to the minimum measurement time, which aborts an incomplete measurement and shows the message "no signal" in the display.

Number of digits:
Depending on the signal source, the input frequencies are very stable (crystal oscillator) or can fluctuate considerably (RC oscillator). It can therefore be useful not always to show the maximum number of digits that can be reached, but rather to round the measured value to a few meaningful digits. Alternatively, a higher number of digits can be set in order to improve the resolution of the last digit, particularly in the case of results with a leading '1...'. Internally, µC calculates with 15 valid digits.

Scales:
For higher input frequencies, input F1 can be operated with a prescaler. For the appropriate scaling, a factor for the correct conversion can be set and switched on if required. A divisor can also be set for RPM measurement, which divides the measured value appropriately if the sensor delivers more than 1 pulse/revolution.

circuit diagram:



2023-01-07 addenda:
Switching regulator of Pico-Board is very noisy. For higher sensitivity of sinusoidal input signals it's a good advice, to stop its function and add an external low-drop 3.3 V linear regulator.
Put input 3V3_EN of Pico-Board to GND (connect Pin37 and Pin38) to disable it and place the additional regulator at the solder side of the board. TO92 package is easy to handle.

Further on you can change R2 and R6 to 82 or 91 kOhm.

Input F1: (Main input)
In the basic circuit, the input stage is DC-coupled and is boosted to about 48% * Vcc by the voltage divider R2-R3. The following inverter IC1 has its switching threshold here and thus the highest signal sensitivity. C6 compensates for the input capacitance at higher frequencies.
The linear inverter IC2, followed by the Schmitt trigger IC3, is used for higher input frequencies > 10 MHz with maximum sensitivity. This provides fast edges, as required by the subsequent 4:1 prescaler IC5. This wiring is suitable for sinusoidal and square-wave signals; the circuit should be adapted accordingly for external prescalers or comparators.
To supply ext. Signal processing (particularly prescalers) + 5 V are brought out at the input socket.
Frequency, period duration and r.p.m. can be displayed as results for F1.
If another prescaler is used, the measured value can be scaled with a switchable factor. When converting for speeds, F1*60 is automatically scaled, with an additional divisor being adjustable if more than one pulse/revolution has to be taken into account.

Input F-Ref: (aux. input)
This input has a similar structure to F1, the measuring range is limited to <= 15 MHz. A 1 pps signal from a GPS receiver is typically connected here for automatic adjustment of the local reference frequency.
In addition, the measured frequency can be shown in lines 3 and 4 of a 4-digit display.

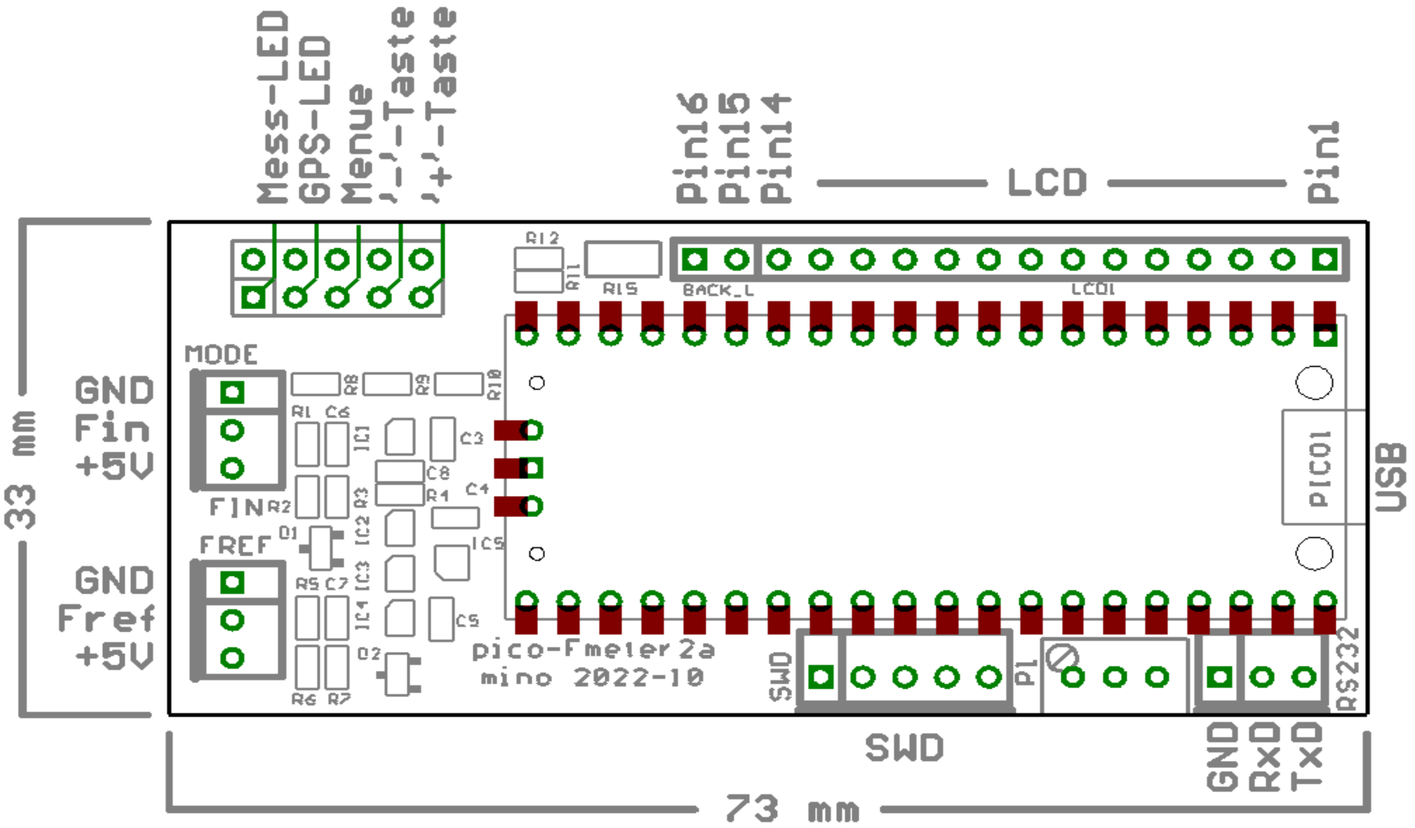
LC-display:
An HD44780-based LCD module with 2 x 16 to 4 x 20 digits can be used to display the measured values. Default: 16 characters/line.
The results of F1 are always displayed in lines 1 and 2, those of F-Ref in lines 3 and 4. If the results of F-Ref are not to be displayed, a two-line display is sufficient. The LCD signals are brought out on a 1 x 16 pin strip, as is usual for these displays (see circuit diagram). The power supply for the backlight is on pins 15 and 16, which correspond to the "LED" connector (see circuit diagram). The series resistor R10 (10 Ohm, type 1206) may have to be adapted to the LCD module used.

ser. Data output RS232:
A result can be output via RS232 for automatic further processing of the measured values.
The following are available for selection: Frequency, period duration and r.p.m. of F1 as well as frequency of F-Ref. Default: Frequency F1
In addition, various parameters can be set via RS232 if manual operation is not intended or the settings are to be made remotely.

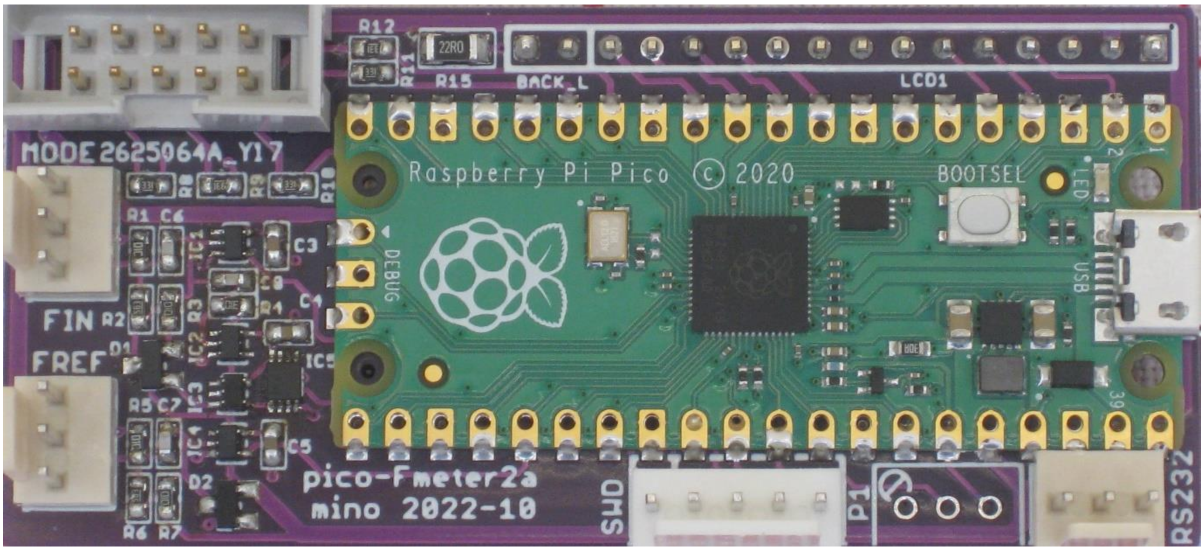
+5 V power supply:
The +5 V power supply can be supplied via a USB cable (pico-board) or via an input socket on F1 or F-Ref.

Storage of the measurement parameters:
All setting and adjustment values are stored in an EEPROM and used when switching on.
With its typical 1x10e6 write cycles, it is sufficient for most applications.
If you choose a permanent adjustment using a 1 pps GPS signal with an integration time of 10 minutes, the maximum write cycles would be enough for around 19 years of uninterrupted operation. In the case of shorter write intervals, an FRAM chip can be used as a substitute.
Memory chips with a capacity of 256 bytes are sufficient.

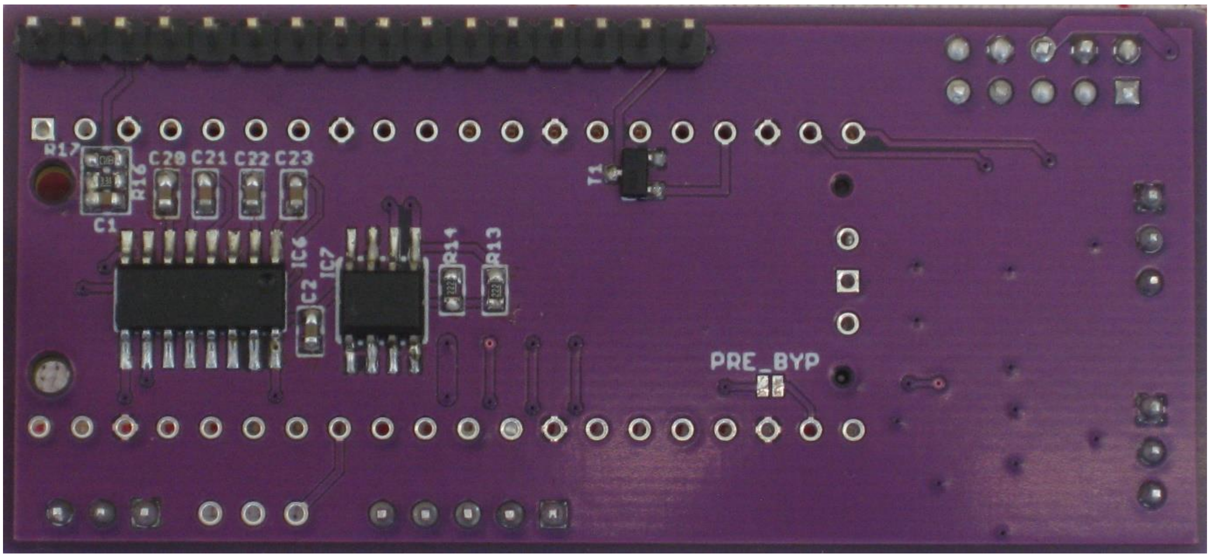
Connections on the circuit board:

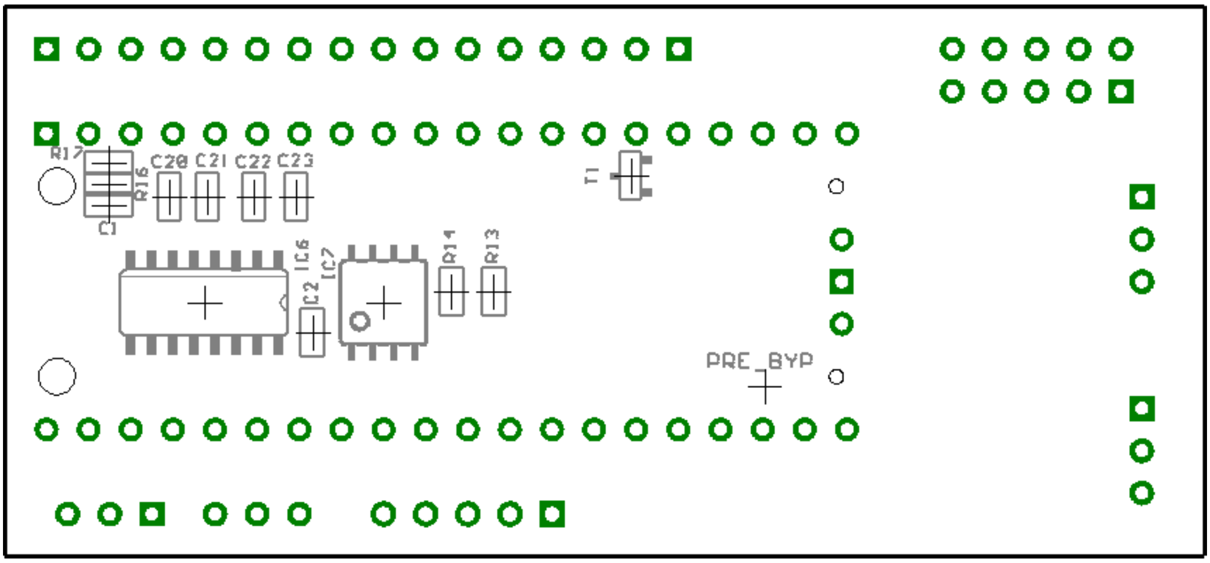


assembled board: top side



assembled board: bottom side





manual operation:

The following instructions do not describe an existing device from which one could show the front panel as a photo, which could make the operation understandable. A little concentration and imagination is therefore necessary so that the meaning and purpose of the operation can be understood.

A total of three control buttons are required, of which one can imagine the left one labeled "-", the right one labeled "+" and the middle one labeled "Menu" or "Setup".
"+" and "-" both have a repeat function and are essentially used to increase or decrease a value. "Menu" calls up a menu item, switches to the next one or cancels the menu with a long press of the button, but the last change is still accepted.
Aborting without changing the settings is achieved by pressing "+" and "-" simultaneously.

The two upper lines of the LC display are required for the settings menu, but the measurements on F1 and F-Ref continue to run in the background during the settings. You can thus follow the effects of the changes directly, if necessary with measured value output per RS232 interface.
During operation, the last menu item called up is remembered. A double short press on the "Menu" button therefore calls up the last selected menu item, so that the setting can be repeated directly there. A long press of the "Menu" button saves the change and returns to the measured value display of F1.

Wiring LEDs
In addition to its supply pins "GND", "+3V" and "+5V", the "Mode" connector (see circuit diagram: "Manu. Operation") offers the direct connection of 2 x LEDs and 3 x buttons. Button and LED signals refer to GND (0 V).

One LED has the function of indicating a finished measurement by lighting up; the other LED shows the status of the alignment using a 1 pps GPS signal. While the "ready LED" (on pin 1 of MODE connector) lights up for an adjustable time, the GPS LED (on pin 3 of MODE connector) flashes according to the progress of the adjustment: first briefly and then longer and longer flashing until the settled state LED stays on constantly.

Wiring button
The buttons for the operating menu are implemented with three buttons:
1st button (on pin 9 of MODE connector): "+" with repeat function
2nd button (on pin 7 of MODE connector): "-" with repeat function
3rd button (on pin 5 of MODE connector): "Menu/next" (short press) and "Cancel" (long press)
Button 1 and button 2 ("+" and "-") simultaneously: Abort the operating menu without saving the last setting. The buttons switch the relevant inputs to GND (0 V).

Basic state of the display:
After switching on, the values are displayed on the LCD as they were last set. If the LCD shows four lines, lines 3 and 4 **always show** the frequency from the F-Ref input. For lines 1 and 2, the display can be set to F1:

frequency+period, frequency only, period only, r.p.m. only.

With the "+" key the selection is shifted to the r.p.m. and with the "-" key to the frequency+period display. This is the only function of "+" and "-" in the ground state.

The settings menu is called up with button 3 "Menu" and switches through the following menu items one after the other:
"Settings input F1", "Settings input F-Ref" and "General settings",
whereby the "+" button in turn switches in the direction of the last and the "-" button in the direction of the 1st menu item. Another short tap on "Menu" then calls up this menu item.

Menu item "Settings input F1"
The following values can be changed:

F1 measurement time :	1 ms – 100 s; Default value = 1.000 s
F1 Timeout :	1ms – 100s; Default value = 2.500 s
F1 digits displayed :	5 – 12 digits or "automatic", default value = 8
F1 autom. +/- prescaler:	0 = discard time stamps and continue, 1 = restart test
F1 prescaler :	"off", "active"; Default value = "off"
F1 prescaler factor :	1 – 99999, if prescaler = "active"; Default value = 1
F1 RPM Divisor :	1 – 99999; Default value = 1

Menu item "Settings input F-Ref"
The following values can be changed:

F-Ref *measurement time* :	1 ms – 100 s; Default value = 0.666 s
F-Ref *Timeout* :	1ms – 100s; Default value = 1.300 s
F-Ref *digits displayed* :	5 – 10 digits or "automatic", default value = 8
F-Ref *prescaler* :	"off", "active"; Default value = "off"
F-Ref *prescaler factor* :	1 – 99999, if prescaler = "active"; Default value = 1

"General settings" **menu item**
The following settings can be made here:

ser. Data output :	F1 frequency, F1 period, F1 r.p.m., F-Ref frequency; Default value = F1 frequency
finished LED duty cycle :	1 ms – 10,000 s; Default value 0.100 s (retriggerable)
ser. Baud rate :	9k6, 19k2, 38k4, 57k6, 115k2 (default), 230k4, 256k;
GPS synchronization :	"off", "active"; Default value = "off"
GPS synchronization time internal clock :	10 – 1800 s; Default value 100 s
manual Adjustment internal clock :	-500000 -> +500000; auto. Adaptation with GPS synchronization
manual adjustment ext. Clock :	-*500000* -> +500000; auto. Adaptation with GPS synchronization
LCD line length :	16 or 20; Default = 16
LCD contrast :	0 – 5 0; Default value = 20
format :	1.2345 Hz; 1.2345E+0; 1.2345Hz; 1.2345E+0
Frequency display :	autom. 'mHz' – 'GHz' or fixed format in 'MHz'

An example of how to get from the measurement mode from F1 to the "General settings" menu:
Briefly press the "Menu" button once to call up the settings
1 x "+" button Press until "General settings" is displayed
Briefly press the "Menu" button once to call up the 1st menu item of the general settings.

Control via RS232:

Not only measured values are output via the serial interface, but also parameters for the measurement are entered and permanently stored in the EEPROM. The data format is 8N1 with a baud rate of typically 115.2 kBd. Each command sequence ends with the character '.' initiated; this is followed by an optional decimal number (nnn) in the range 0 – 999999 (–500000 to 500000 for frequency correction). The command sequence ends with the actual command (capital letter or character).
The set values can be queried by simply entering a '.' and the command <character> will be sent. The command <character> and the set numerical value are output as a response.
Instead of the '.' an <ESC> character can also be used.

The following commands are recognized, currently no distinction is made between upper and lower case letters; unknown commands or incorrect numerical values are ignored.
(inserted spaces are for readability only and will not be sent):

.nnn A	Minimum measurement time F1, nnn Range 1 – 100000 in 1 ms steps Example: '.4000A' sets the measurement time for input F1 to 4000 ms (4 s).
.nnn B	As with 'A' but measuring time for input F-Ref
.nnn C	Timeout F1, nnn Range 1 – 100000 in 1 ms increments Example: '.10000C' sets the timeout for input F1 to 10000 ms (10 s).
.nnn D	As with 'C' but timeout for input F-Ref
.nn E	Number of digits displayed for input F1 from 5 to 12. If n = 0 is entered, the digits are dependent on the eff. Measuring time determined automatically: >= 1 s measuring time -> 7 digits
.nn F	Number of digits displayed for input F-Ref as for input F1. If n = 0 is entered, the digits are dependent on the eff. Measuring time determined automatically: >= 1 s measuring time -> 7 digits
.n G	Prescaler active for F1: 1 = with prescaler as set, 0 = no scaling
.nnn I	Prescaler factor for F1; Range 1 - 99999
.nnn K	Contrast voltage for the LCD adjustable in the range 0 - 50; relative value depending on the display used
.nnn L	Lighting duration of the 'measurement ready' LED, range 1 - 10000 in 1 ms steps, retriggerable
.nnn O	Offset value for correcting the currently used reference frequency (internal or external) in 0.1 ppb steps, adjustment range -500000 to 500000 corresponds to +/- 50 ppm of the clock frequency. This value is initially only stored temporarily in RAM. Check the set value with: '.O' "nnn" is a relative value that is added to the existing offset.

With command string '. 0O' the set value is set absolutely to 0.
If an external GPS signal is used for adjustment, the manual offset has no effect and will be overwritten by automatically adjustment.

.nnn P	Divisor for scaling the r.p.m. at F1; Range 1 - 99999
.n R	Selection of the output value via RS232 interface; Values for n: 0 = no output, 1 = frequency F1, 2 = period F1, 3 = speed F1, 4 = frequency F-Ref
.n S	**especially for F-Ref** : 1 = ext. Adjustment per 1 Hz, 10 kHz, 1 MHz or 10 MHz signal possible; 0 = disabled.
.nnn T	Time in seconds for averaging the GPS signal using **internal** reference frequency with typ. 100 s; Setting range: 10 – 1800 seconds
.V	Version request, output "mino Pico-FMeter V2.0 yyyy-mm-dd"
.nn W	Line width of the LC display: 16 or 20
.n Y	Display format for measured values 0: 1.23456789Hz 1: 1.23456789E+0 2: 1.23456789Hz 3: 1.23456789E+0
.n x	0 = discard some time stamps if prescaler is turned on/off 1 = restart test if prescaler is turned on/off
.*	Output of the character '*' as an echo for synchronization (timestamp)
.<Ctrl+S>	This sequence permanently writes the set offset into the internal EEPROM so that it is used automatically the next time the device is switched on. The autom. adjustment via GPS has higher priority and overwrites the manual setting!

Due to the command structure, several commands can also be transferred as a coherent character chain (string) by computer. An example: '.1000C.333A.500L'
For input F1, the timeout is set to 1.000 s, the minimum measurement time to 0.333 s and the (retriggerable) lighting duration of the 'Ready' LED to 0.500 s. If a frequency >= 3 Hz is present at input F1, 3 measurements/s are carried out and the LED remains permanently on.

An example for querying a set value (measuring time F-Ref):
.B Response: B666 <CR><LF> for 0.666 seconds

Notes on operation:

So far, the properties have been listed, but some of their meaning still requires an explanation. Furthermore, there are a few points to consider when using it.

Active edges at inputs F1 and F-Ref:
The negative edge is always evaluated by the RP2040. Due to the inverters at the inputs F1 and F-Ref, the positive edge of the input signal is required in order to obtain a new result. The active edge is unimportant for the HF branch of F1.

Settings measurement time and timeout:
The measuring time can be increased accordingly for higher resolutions, for smoothing the measured values or for a compressed long-term recording.
At inputs F1 and F-Ref, the timeout refers to the period of the input signal. Each input pulse resets timeout-counter. This means that the measuring time may well be longer than the set timeout, which is only triggered if the signal fails.

Alignment of internal and external reference frequency:

The local crystal oscillator (XO) used in the circuit offers an accuracy or stability of
<= 10 ppm at room temperature. In the adjusted state, this is sufficient for 6-digit results at best. In order to achieve maximum accuracy, either a local TCXO must be retrofitted, the automatic correction activated using an F-Ref signal, or an external reference frequency of typically 10 MHz is absolutely necessary.

The adjustment range is limited to +/- 50 ppm; imprecise clock sources should not and therefore cannot be used. During adjustment, a correction factor is determined or set, with which the measured value can be precisely converted to the target value. The actual clock frequency is not changed!

There are the following options for adjusting the frequency counter:

1. by adjustment with trimming potentiometer P1. P1 should not be assembled for the following options so that turning it does not lead to errors.
2. by manually specifying an offset relative to the existing correction value with RS232 commands
3. by manually specifying an absolute correction value via ext. control button
4. by automatic correction with 1Hz, 10 kHz, 1 MHz or 10 MHz signal
5. Use of a highly accurate, highly stable ext. reference clock with 10 MHz.

During the adjustment, separate correction values for the internal and external clock are determined, used and also saved. You should wait for the warm-up phase of the reference clock before making an adjustment.

concerning 1 .) manual setting with trim pot
If only the local XO and a trimpot are fitted, this is the simplest type of adjustment without any further additions. A known frequency is applied to F1 and the potentiometer turned so that the correct value is displayed.

concerning 2.) The adjustment via RS232 command is somewhat more time-consuming and only ever supplies a fixed value for frequency correction. Furthermore, an exactly known frequency must be applied to F1, on the basis of which the adjustment can be made. Frequencies of 10 MHz, 1 MHz, 1 kHz or 1 Hz are preferably suitable. The LC display must be set in such a way that the frequency and period of F1 are displayed simultaneously. Under certain circumstances, you can also increase the displayed digits manually in order to achieve better resolution.

With an F1 frequency of 10MHz, the goal is to get 10.0000000 MHz and 100.000000 ns as simultaneously displayed results. Smaller deviations are immediately visible because one of the values jumps to '9' in all places.

A too low displayed frequency is corrected by a positive offset (.nnnnO) and a too high frequency with a negative offset (.-nnnnO). The entered offset is added to the current correction value. If necessary, reset this to '0' at the beginning of the comparison with '.0O' or display it with the query '.O'.

Example: the input signal at F1 is exactly 10.0000000 MHz and an OCXO is used as an external reference clock. The displayed value is 9.99999989 MHz. You can see that the displayed value is displayed ___11 too low. With the 10-digit display, the last digit provides the resolution of 0.1 ppb. The correction value (offset) must be entered with 11.
Command: '.11O'
Then check the displayed value again and correct it if necessary, which can be done in small steps of 5, for example: '.5O' to increase or '.-5O' to decrease the offset. As mentioned before, the alignment is perfect when "10.0000000 MHz" and "100.000000 ns" are displayed at the same time.
For the first time, the settings are only temporarily stored in RAM, so that the last setting is not initially 'destroyed'. You can therefore also make the adjustment empirically without having set anything incorrectly.
In order to be able to use the new setting again the next time the device is switched on, the new correction value must be written to the EEPROM/FRAM with '.<Ctrl-S>' after the adjustment is complete.

concerning 3.) The manual setting of the correction values needs, as with 2.), a precisely known ext. input frequency at F1, but otherwise does not require a GPS signal or RS232 terminal. The operation is therefore somewhat more time-consuming.

Again the LC display should show the frequency and the period of F1 in the first two lines. As described above, three control buttons for 'Menu', '+' and '-' must be connected, with which the settings are made.
Since the setting menu requires the first two lines of the display, setting the correction value and checking the measured value must take place alternately.

A frequency of 10.0000000 MHz applied to F1 is measured. If the displays of frequency or period are not displayed with sufficient accuracy, the menu item 'General settings' is called up via the control buttons. Further keystrokes on 'Menu' lead to the items 'manu. Internal adjustment: xxxx' or 'manu. External adjustment: xxxx'. 'xxxx' shows the currently set, absolute correction value. The value that corresponds to the reference clock source used must now be selected.

The correction value is increased or decreased with the '+' or '-' control buttons, with the changes taking place in ever-increasing steps if the button is held down. The new correction value can either be calculated or only roughly estimated and then adjusted. The setting is completed with a long press of the 'Menu' button, which saves the new correction value and also shows the measured values for F1 in the display again. As long as the adjustment is unsatisfactory, pressing 'Menu' twice brings you back to the last setting of the correction value and you can change it again. A long press of the 'Menu' button returns you to the frequency display with a new correction value.

concerning 4.) Automatic synchronization with the GPS signal is the recommended method, which is why it is described first. To do this, it is necessary to apply an exact reference signal (1 Hz, 10 kHz, 1 MHz or 10 MHz) to the F-Ref input and to set the autom. GPS synchronization ‘on’ (manually via button or via RS232 command). The comparison is only carried out if the ext. signal and the active reference clock differ by less than +/- 50 ppm. Otherwise the frequency at F-Ref is only measured and displayed. A single exposure of the F-Ref signal breaks the autom. alignment and starts it again when a stable signal is present.

The 1 Hz signal from a GPS receiver can fluctuate slightly at the beginning. Therefore, the first five pulses are ignored. The moving average value is then formed from the pulses arriving at F-Ref over the period (GPS adjustment time), as set for the internal or external clock frequency. As long as the ring memory for the moving average is not yet full, the GPS LED (if connected) flashes in such a way that, starting with a small duty cycle at the beginning and increasing duty cycle as the averaging progresses, the LED remains on continuously as soon as the first valid mean value is available. At this point in time, the correction value is calculated for the first time, used and also written to the EEPROM/FRAM. The automatic synchronization is finished at this point. The next time the device is switched on, this correction value will be restored even if no GPS signal is available.

However, it is of great advantage to leave the GPS signal connected. As a result, a new mean value and, from this, a new correction value are determined every second. In this way, slow changes in the reference clock (due to drift, heating) are continuously compensated. The correction value is always written to the EEPROM/FRAM after the set integration time has elapsed.

Depending on the short-term stability of the reference clock, a good compromise must be found for the integration time, which enables the highest possible accuracy with the shortest possible adjustment time.
Suppose the GPS signal has a typical jitter of 30 ns. In order to reduce this clock inaccuracy to <= 10 ns, as required to achieve an 8-digit. accuracy, an averaging over >= 100 s makes sense.

If the local XO is used, the short-term stability is at best sufficient for 7 digits. A slight warming of the circuit board or a short draught are enough to change the output frequency significantly.

concerning 5.) When using a highly accurate, highly stable ext. reference clock , no adjustment is necessary.
Channel F-Ref is used for signal processing and its output is given via 22 pF to Xin of the RP2040. The signal of the XO becomes ineffective. In addition, input GPIO28 must be set to ADC_VREF when switching on: bridge pins 34-35. The frequency measurement at F-Ref remains switched off and the RP2040 runs with a 10 MHz base clock, which is why an USB connection does not work.
It must be noted that the correction value under "manu. external adjustment:” is set to '0', which can be done either with the control button or with an RS232 command.

experimental increase of the input frequency:
The maximum input frequency depends directly on the clock frequency of the µC internal timer. If the maximum measuring range of 250 MHz is not enough, it can optionally be doubled if the input stage is equipped with fast components. The internal clock frequency is increased from 133 MHz to 266 MHz, which is outside the specification but can be helpful if it works.

For activation, a resistor of 3.3 kOhm is connected between the LCD lines RS (pin 4) and R/W (pin 5). This is checked once for presence when switching on and, if necessary, the increased clock frequency is used. Due to the higher clock frequency, the power consumption increases by approx. 10 mA, which does not lead to excessive heating of the µC.
If this is not required, leave it at the default setting.

assembled ICs:
For simple applications you only need the pico board itself and either the RS232 output or the LC display. The signal inputs can be applied directly to the RP2040 as digital signals: F1 and F_Ref.

If the input stages are equipped, the inverters IC1 or IC4 and the corresponding wiring are sufficient for low input frequencies <= 15 MHz. 74AUP1GU04 or 74LVC1GU04 can be fitted.
The HF channel of F1 should be equipped with fast components. In particular, the prescaler 74AUP2G80 from the manufacturer Nexperia with a maximum of 600 MHz is best suited.