Last modification: Medvode, 27.03.2007

*Dual **Frequency Relay** with dual 3-phase **Voltage Relay***
in modular plug-in housing Hx4 of new Combiflex system

Application

Basic purpose of Frequency-Voltage Protection F3V is operation of private power plant with public electro energetic system.
After disconnection of public network, the protection F3V ensures to local network to continue safety operation, supplied only from private power plant.
Protection F3V is containing Over- and Under-frequency relay in addition to Maximum- and Minimum-voltage relays, which supervise frequency and generated voltage to remain inside the safety limits set by F3V. Frequency-voltage protection relay F3V enables a “safety island operation” of the private power plant with locally connected network.

Properties

- Autonomy self powered supply - no auxiliary batery;
- High reliability;
- High accuracy;
- Very low power consumption, less than 0,7W per phase.

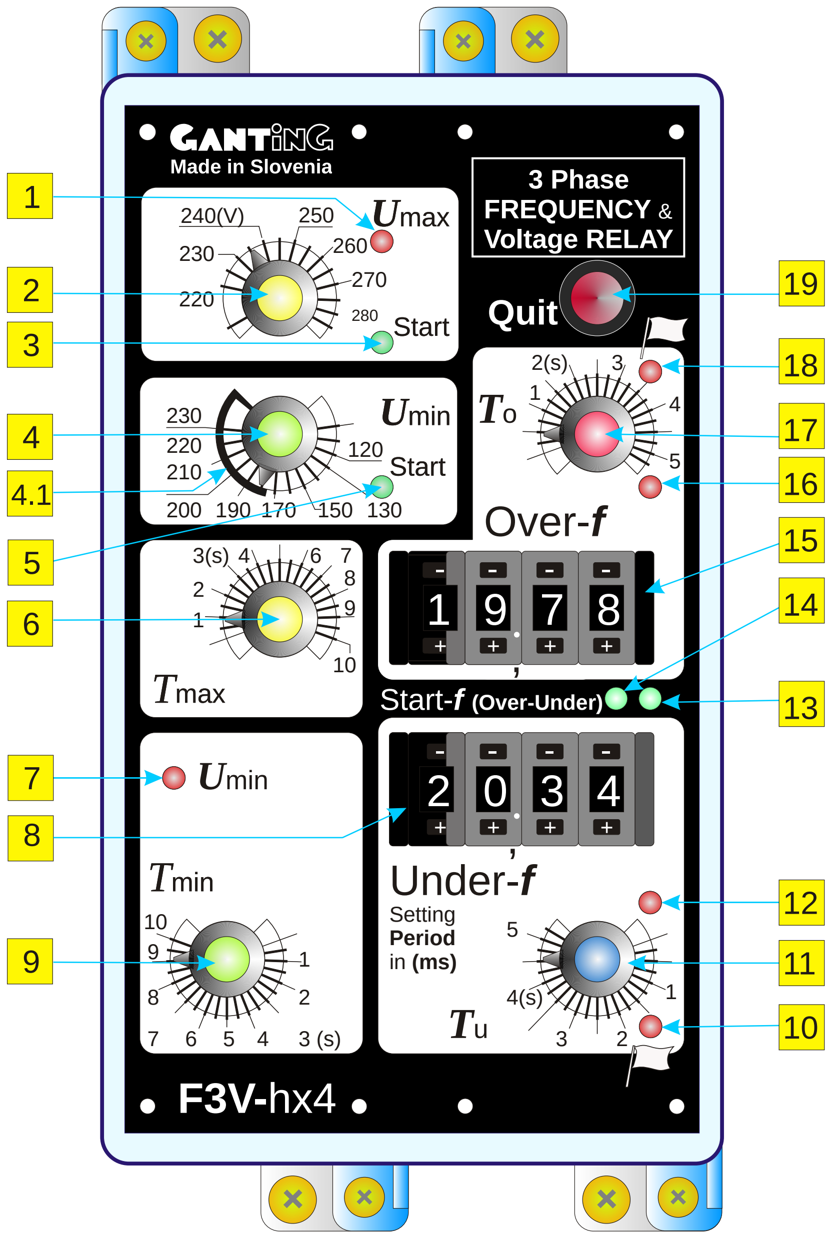
Ordering code

F3V - Hx4

FUNCTIONS

F3V

Front panel settings and signals



1 LED lamp, signalling the trip of delayed Max-voltage relay;

2 Knob for setting the limit of the Max-voltage relay

3 LED lamp of the Max-V starter* triggered by the comparator: (**U**R, **U**S or **U**T) > **U**max,

4 Knob for setting the limit **U**min of the Min-voltage relay;

4.1 Black underlined part of **U**min setting region, in which the Min-voltage relay can operate self-powered, even if all 3 phases decrease at the same time.

5 LED lamp of the Min-V starter* triggered by the comparator: (**U**R, **U**S or **U**T) < **U**min; .

6 Knob for setting time delay **T**max of the Max-voltage Relay;

7 LED lamp, signalling the trip of the delayed Min-voltage relay;

8 BCD switches for setting of the Under-frequency limit period;

9 Knob for setting the time delay **T**min of the Min-voltage Relay;

10 LED lamp flag, which is set at the first trip, caused by Under-frequency Relay;

11 Knob for setting time delay "**T**u" of the Under-frequency Relay;

12 LED lamp, signalling the trip of the delayed Under-ferequency Relay;

13 LED green lamp, Under-frequency Starter*, displaying present status of the Under-***f*** comparator: ON=(***f*** < Under-***f***);

14 LED green lamp, Over-frequency Starter*, displaying present status of the Over-***f*** comparator: ON=(***f*** > Over-***f***);

15 BCD switches for setting of the Over-frequency limit period;

16 LED lamp, signalling the trip of the delayed Over-ferequency Relay;

17 Knob for setting the time delay "**T**o" of the Over-frequency Relay;

18 LED lamp flag, which is set at the first trip, caused by Over-frequency Relay;

19 Push button for manual reset of both flags.

Note: * The tripping of all starter´s relay is momentary.

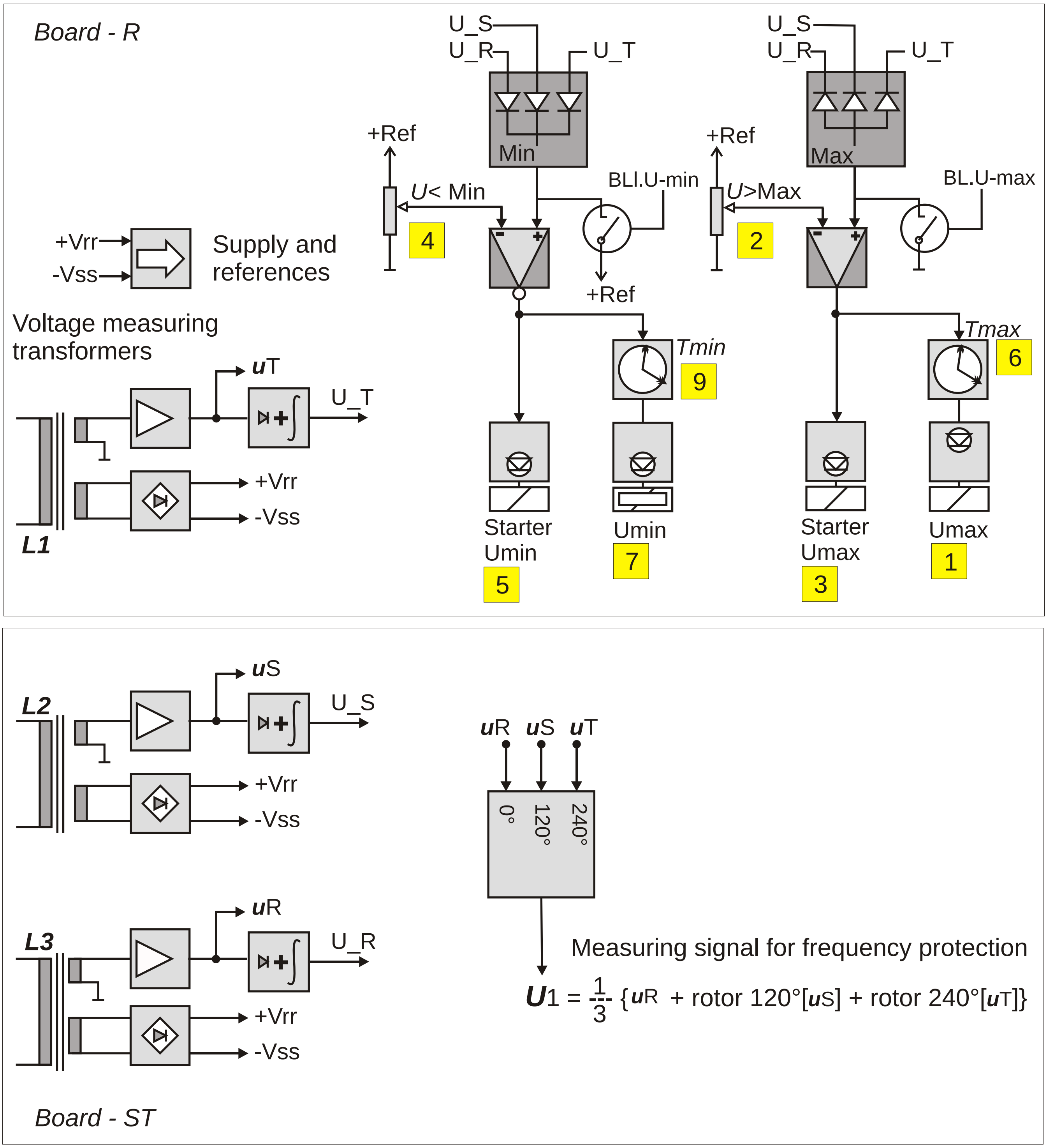


Figure 1:
Tree phase Voltage protection
including the supply and real time filter of positive sequence signal of symmetric components.

Self-powered supply system

Voltage measuring transformers ***L1***, ***L2*** and ***L3*** contains 2 secondary windings, one for supply and the other for measuring signal. The supply windings are connected via bridges to a common accumulating capacitor, storing the energy sufficient for the worst case time delay of the Min-voltage relay, which has in addition a duty to alarm the loss of supply. For the most reliable requirements, there is an additional input for the auxiliary supply. The quiescent power consumption is 350 mW. Each tripped relay requires additional 160mW. The same additional power dissipates each active starter.

Three phase Voltage protection

consists of Min-voltage and Max-voltage relay, which are shown in the Figure 1. Each line phase voltage measuring transformer (***L1***, ***L2*** and ***L3***) can be used for the nominal voltage (230V) or for half of mentioned value at the middle tap.
Measuring secondary windings are connected to the operational amplifiers with sinusoidal output (***u***R, ***u***S and ***u***T). Mentioned outputs are rectified and integrated to the values (U_R, U_S and U_T), which are exactly proportional to the original inputs.

Minimum Voltage Relay /unit **"Min"/**

is an operational circuit, which is selecting the minimum of the incoming values (U_R, U_S and U_T). The output of this unit is entering to the comparator of the Min-voltage Relay.

Maximum Voltage Relay /unit **"Max"/**

is the maximum detector, selecting the maximum of incoming voltages (U_R, U_S and U_T). The output of unit "Max" is compared to the limit set by the Max-voltage Relay.

Starter of Voltage Relays

In standard model both comparators Umax and Umin are connected to the common "Voltage starter" with momentary relay output..
On a request there is a model with two starters, alarming separately Umin and Umax comparator´s status.
The basic purpose of the starter is, to alarm the countdown sequence of particular voltage tripping relay.

Timer *T*min and *T*max

Standard model is using constant time delay, set by linear knobs scale ***T***min and by ***T***max. On a request we deliver inverse timer. The inverse time delay is related to hyperbolic equation:

$$t = (k \cdot T_{max})/(u - U_{max}),$$

{t= time delay; k= scale range factor; T_{max}= time seting;
($u - U_{max}$)= differece of input voltage and scale setting}.

Input signal "*U1*" for frequency measurement

Figure 1 is showing generation of analogue signal ***U1***, used for frequency relay measurement. Signal ***U1*** is the output from the positive sequence filter. Positive sequence filtering is the most reliable source for the frequency information. Disappearance of one phase reduces the amplitude of signal ***U1*** only for 33%, while the collapse of two phases still offers 1/3 of the nominal signal ***U1***. The under-voltage blocking of frequency measuring circuit is set to 25% of nominal ***U1***. The signal ***U1*** disappearance is alarmed by PNB relay of the frequency board.

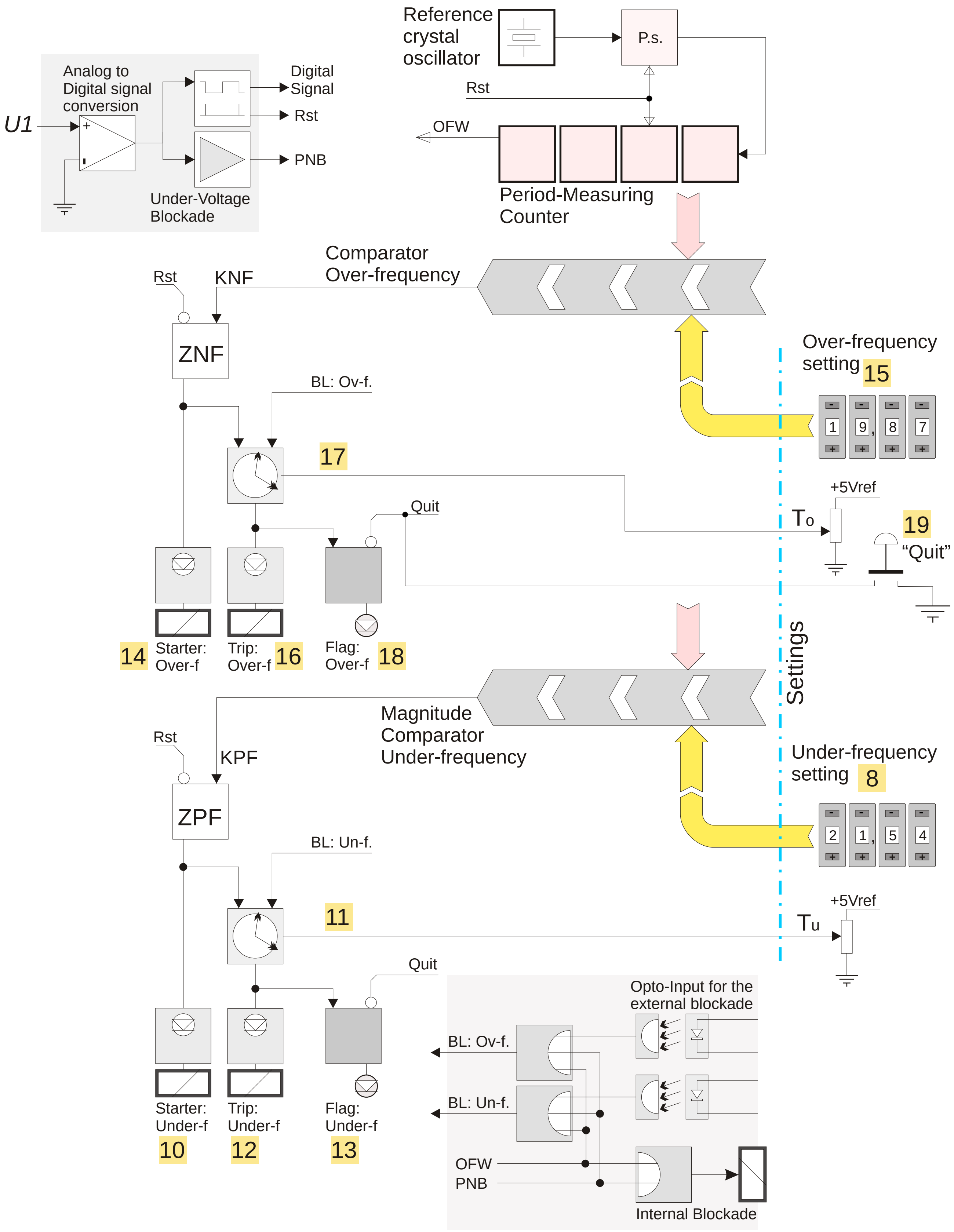


Figure 2:
Dual frequency relay on board F3V.

Converter of analog signal “*U1*” to digital “Rst”

The input signal ***U1*** is converted by zero crossing comparator and by front edge generator to reset signal at the output **Rst**. Pulse duration of **Rst** is in the range of 10 ns. For each measured period the Rst pulse has a duty to accomplish the present period and to initiate the next period to be measured.

Period measuring Counter and Oscillator

consists of the next 3 parts:
Pre-scaler, enables the application of the most stabile quartz oscillator. The best stability of the crystal oscillator is at the frequency range 2 to 8 MHz, first harmonic. For the best operation the reference quartz oscillator has to operate sinusoidal at low level in linear region. The central part of period counter consists of 4 decade counters, which is connected to two magnitude comparators. One for Under-frequency and the other for Over-frequency limit comparison.
The third part of measuring counter is the overflow detector, with alarming output “OWF”. This is an indication that the frequency is out of range or that the signal is no more present.

Frequency comparator´s pulse chain integrators “ZNF and ZPF”

The output of frequency comparator has 2 typical output patterns. If measured period of the under-f comparator is longer regarding set reference limit period, than the output contains the sequence of short pulses. Duration of mentioned pulses is proportional to the excess of limit period. In the other case, when measured period is shorter compared to reference setting, the output is continuously low.
Both pulse integrating circuits “**ZNF**” and “**ZPF**” has a property to output the continuous “high” state, until the comparator send continuous chain of pulses, regardless a duration of pulses.
The integration is an interaction of Rst and ZNF pulse sequences. The characteristic case is shown in **Figure 3**.

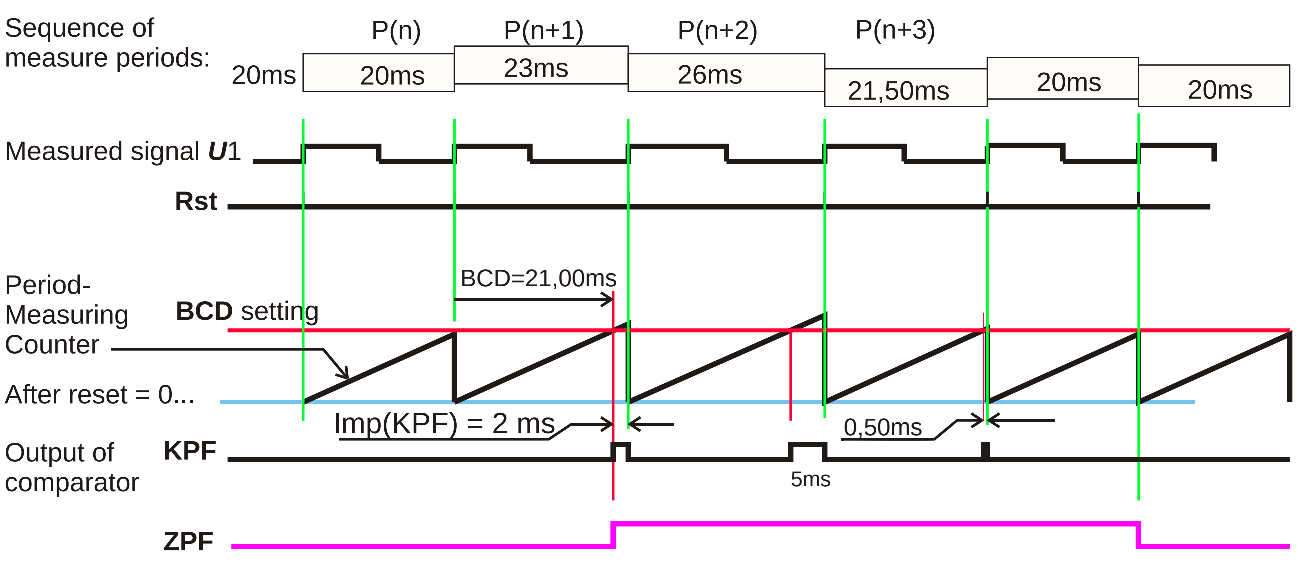


Figure 3:
Oscillogram showing the measuring principle of frequency relay.
Numerical operation of the magnitude comparator is done for the setting case BCD = 21,00ms.

Starters, timers and flags of f-relays

The output of Under-frequency pulse chain integrator KPF drives directly the starter (13), announcing the beginning of under-f count down sequence, set by timer ***T***u (11). The first trip of under-f tripping relay (12) turn on the flag (10). Both flags (10) and (18) are reset manually by button **Quit** (19). Both timers (11) and (17) are re-triggable, to avoid uncertain situation, when the frequency is on the edge of the limit (8) or (15).
The output of Over-f pulse chain integrator ZNF is taken from the inverted output, to obtain the opposite, it means the Over-frequency operation.

Blockade of f-relays

Each of Under-f and Over-f relay has separated blocking input. Both are photo coupled. The frequency relay internal system is watching the credibility of measured data. The frequency is expected to be inside of the expected frequency range and the amplitude of the input signal U1 has to be at least 25% of nominal value, otherwise internal blocking condition is alarmed and via internal blocking relay, which has to inform the superior level.

Blockade of U-relays

Voltage relay has an option, that each part Umin and Umax can be blocked separately. The purpose of individual external blocking of each of 4 relays inside F3V is giving an option, to build the effective automat protection. For the same reason each of 4 relays has its own starter.