



MRF3 – Frequency Relay

Manual MRF3 (Revision A)

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1. Introduction and application

The MRF3 is a universal frequency relay and contains the protective functions required by most electrical utilities for mains parallel operation of power stations:

- Four elements for over- or under frequency protection
- Two elements for frequency gradient supervision df/dt
- Fast decoupling of the generator from the grid at mains failure
- Suitable for load shedding systems

2. Features and characteristics

- Microprocessor technology with watchdog
- effective active low pass filter for suppressing of harmonics,
- four elements for frequency supervision, alternatively for under- or over frequency detection,
- adjustable reconnection values for the frequency stages
- independent separate adjustable timers,
- adjustable voltage threshold for blocking and disconnection of the frequency Measurement,
- Reclaim time of output relays after the frequency has been exceeded or fallen short of.,
- display of all measuring values and setting parameters for normal operation and tripping via an alpha-numerical display and LEDs,
- display of actual measuring values, storage and display of tripping values,
- minimum- and maximum measurement of the frequency gradient,
- adjustable tripping window for the df/dt supervision at mains decoupling application,
- the protective functions can be assigned individually to the output relays (relay matrix),
- display of measuring values as primary quantities,
- storage and display of tripping values in a fault memory (voltage-failure safe),
- recording of up to eight fault occurrences with time stamp in the fault recorder,
- External triggering of the fault recorder
- Recording of external functions as digital track in the fault recorder*
- for blocking the individual functions by the external blocking input, parameters can be set according to requirement,
- safe and fast mains decoupling by df/dt supervision,
- suppression of indication after an activation (LED flash),
- display of date and time,
- in compliance with VDE 0435, part 303 and IEC 255,
- serial data exchange via RS485 interface possible; alternatively with RS485 Pro-Open Data Protocol or Modbus Protocol.

* Modbus Protocol only

3. Design

3.1 Connections

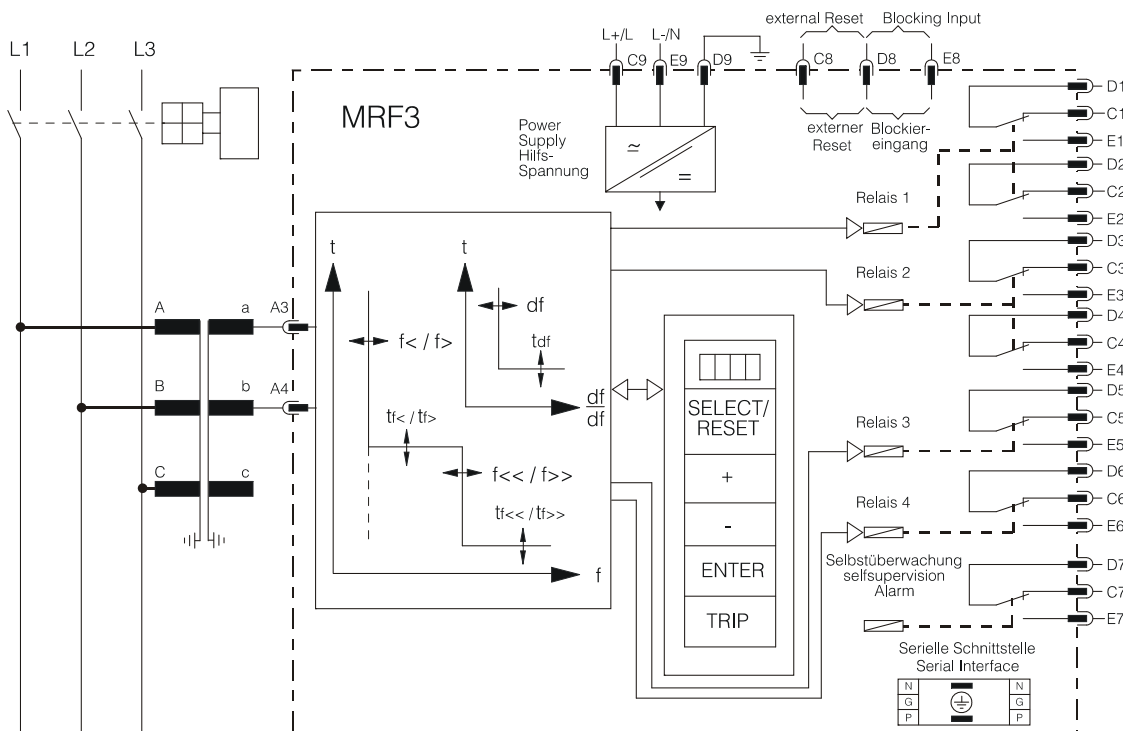


Figure 3.1: Connection diagram MRF3

Note:

Phase voltages can also be connected to A3/A4

3.1.1 Analog input circuits

The analog input voltage is galvanically insulated via the input transformer of the relay and the signal is passed through an active low pass filter. The frequency is detected from the square wave voltages which are formed via comparators. The external wiring of the measuring circuits as well as the auxiliary voltage is shown in the connection diagram.

3.1.2 Output relays

The MRF3 has 5 output relays with change-over contacts:

- Output relay 1: C1, D1, E1 and C2, D2, E2
- Output relay 2: C3, D3, E3 and C4, D4, E4
- Output relay 3: C5, D5, E5
- Output relay 4: C6, D6, E6
- Output relay 5: Self-supervision (internal fault of the relay) C7, D7, E7

All relays are normally off, only the self-supervision re-lay is normally on.

3.1.3 Blocking input

The parameters for the blocking function are free adjustable. Application of the aux. voltage to D8/E8 blocks all protection functions of the device for which the parameters were set previously, refer Table 5.2

3.1.4 External reset input

Refer chapter 5.9.1

3.1.5 Fault recorder

Recording time

There are two possible ways of using the memory capability of the fault recorder:

- **Normal recording time**

The curve shape of the measured analogue voltage value (U) as well as the frequency (f) and the measured df/dt values are scanned and recorded 16 times per period. The maximal memory capacity is 16s at 50 Hz and 13.3s at 60 Hz.

- **Extended recording time**

Measured as an effective value, the voltage (U), the frequency (f) as well as the frequency gradient (df/dt) are recorded in two times per period. By this the total recording time is extended considerably.

The maximal memory capacity is 64s at 50 Hz and 53.3s at 60 Hz.

Sampler rate at rated frequency

| Recording time | 50 Hz | 60 Hz |
|----------------|---------|----------|
| Normal | 1.25 ms | 1.041 ms |
| Extended | 10 ms | 8.33 ms |

Segregation of the memory

Independently of the recording time, the entire memory capacity can be subdivided so that several short fault events can be recorded. The erasing behavior of the fault recorder can also be influenced.

- **not writing over**

When 2, 4 or 8 recordings are chosen, the store is segregated into the corresponding number of sub ranges. If the maximal number of fault events has been recorded, further recordings are blocked by the fault recorder in order to save the stored data. After these have been read-out and erased, the fault recorder is ready for other fault events.

- **overwrite**

When 1, 3 or 7 recordings are chosen, the corresponding number of sub ranges is reserved in the store. If the store is full, the first-in recording will always be written over by the latest one.

Structure of the fault recorder

The memory range of the fault recorder is designed as circulating buffer. The example below explains the storage of 7 fault recordings.

Memory locations 8 to 4 are engaged
Memory location 5 is being written

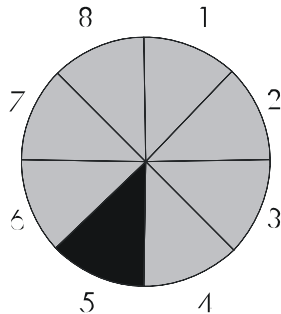


Figure 3.2: Segregation of the memory in e.g. 8 events

This example shows that more than eight recordings are stored because memory locations no. 6, 7 and 8 are engaged. From this follows that no. 6 is the first-in fault recording and no. 4 the latest one. If there are an uneven number of recordings selected, the first-in recording is automatically written over. The fault recorder has to be erased manually if an even number of recordings is chosen because there is no storage location for momentary recording.

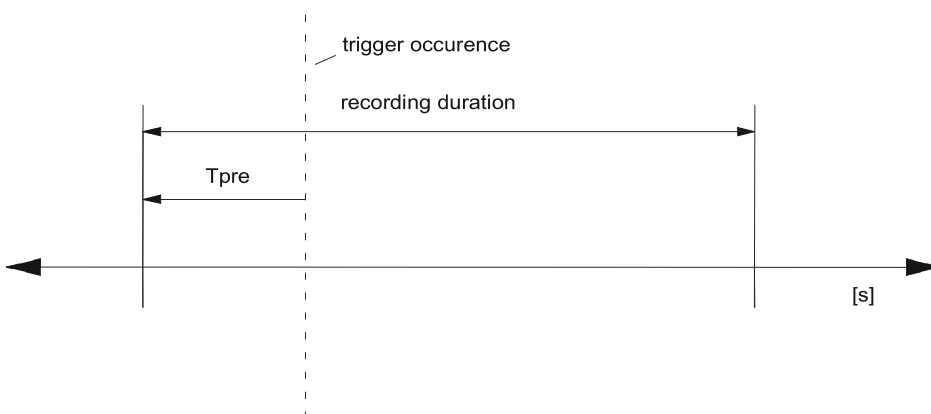


Figure 3.3: Standard structure of fault recording

3.1.6 Parameter settings

System parameters

| | |
|----------------------------------|--|
| $U_{\text{prim}}/U_{\text{sek}}$ | Primary/secondary measured value display of the voltage transformers |
| f_N | Rated frequency |
| LED-Flash | Suppression of LED flashing after pick up |

Protection parameters

| | |
|------------------|--|
| P2 | Parameter set change-over switch |
| T | Measuring repeated for frequency measuring |
| f_1 | Pickup value for frequency stage 1 |
| f_1+R | Reclaim value for frequency stage 1 |
| t_{f1} | Trip delay for frequency stage 1 |
| $t_{f1}+t_R$ | Reclaim time for frequency stage 1 |
| f_2 | Pickup value for frequency stage 2 |
| f_2+R | Reclaim value for frequency stage 2 |
| t_{f2} | Trip delay for frequency stage 2 |
| $t_{f2}+t_R$ | Reclaim time for frequency stage 2 |
| f_3 | Pickup value for frequency stage 3 |
| f_3+R | Reclaim value for frequency stage 3 |
| t_{f3} | Trip delay for frequency stage 3 |
| $t_{f3}+t_R$ | Reclaim time for frequency stage 3 |
| f_4 | Pickup value for frequency stage 4 |
| f_4+R | Reclaim value for frequency stage 4 |
| t_{f4} | Trip delay for frequency stage 4 |
| $t_{f4}+t_R$ | Reclaim time for frequency stage 4 |
| $f_e(df_1)$ | Frequency threshold value for df/dt-stage 1*With setting "vari", two new parameters appear which fix a trip window for the df/dt. |
| $*f_e(df_1+min)$ | Bottom frequency threshold value for the df/dt stage 1 |
| $*f_e(df_1+max)$ | Top frequency threshold value for the df/dt stage 1 |
| df_1 | Pickup value for the frequency changing speed of the df/dt stage 1 |
| dt_1 | Time difference cum value of the trip counter of the df/dt stage 1 |
| $f_e(df_2)$ | Frequency threshold value for the df/dt stage *With setting „vari“, two new parameters appear which fix a trip window for the df/dt. |
| $*f_e(df_2+min)$ | Bottom frequency threshold value for the df/dt stage 2 |
| $*f_e(df_2+max)$ | Top frequency threshold value for the df/dt stage 2 |
| df_2 | Pickup value for the frequency changing speed of the df/dt stage 2 |
| dt_2 | Time difference cum value of the trip counter of the df/dt stage 2 |
| U_{Bmin} | Blocking of frequency measuring |
| U_{Bmax} | Release of frequency measuring |

*min/max setting only if $f_e(df_1)$; $f_e(df_2)$ are set to "vari".

Parameters for the fault recorder

| | |
|----|------------------------------|
| FR | Number of disturbance events |
| FR | Trigger events |
| FR | Pre-Trigger time T_{pre} |

Date and time

| | |
|--------|--------|
| Year | Y = 00 |
| Month | M = 04 |
| Day | D = 18 |
| Hour | h = 07 |
| Minute | m = 59 |
| Second | s = 23 |

Additional functions:

Blocking function
Relay configuration (relay matrix)
Fault memory

3.2 LEDs

All LEDs (except LEDs FR, RS and min., max. P2) are two-colored. The LEDs left next to the alphanumeric display light up green during measurement and red at fault signals.

The LEDs below the <SELECT/RESET> push button light up green during setting and reading out the setting values printed on the left side next to the LEDs. The LEDs light up red when the setting values printed on the right side next to them are activated.

The LED marked with the letters RS lights up green during setting of the slave address for the serial interface (RS485) of the unit.

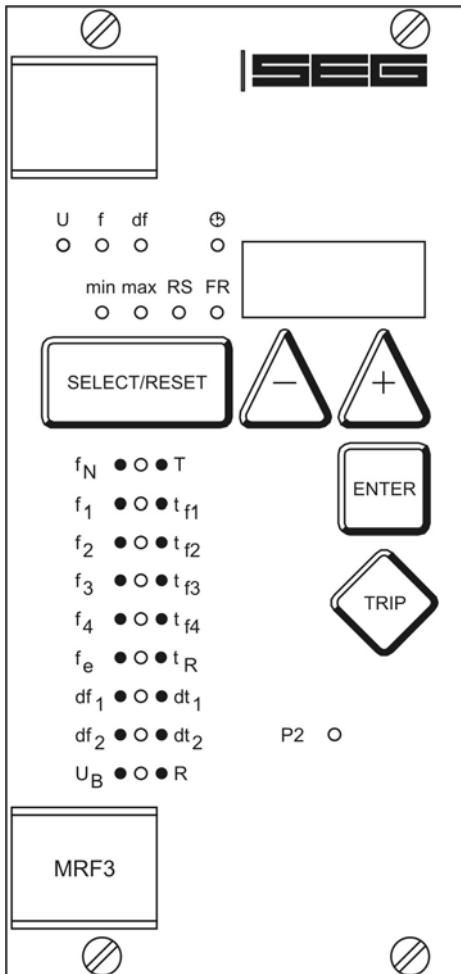


Figure 3.4: Front plate MRF3

4. Working principle

4.1 Analog circuits

The input voltage is galvanically insulated via the input voltage transformer. The noise signals caused by the influence of inductive and capacitive couplings are then suppressed by RC-analog filter circuits. The analog voltage signals are fed to the A/D-converter of the microprocessor and then transformed into digital signals via sample- and hold-circuits. These digital values are then used for further processing. The analog signals are sampled with a sampling frequency of $16 \times f_N$, namely, a sampling rate of 1.25 ms for every measuring quantity (at 50 Hz). The input voltage is also passed through an analog filter for frequency measurement and is then converted into square wave signals via comparators. The frequency is determined by measuring complete cycles.

4.2 Digital part

The essential element of the protection relay is a powerful microcontroller. All functions - from the analog digital conversion to the relay tripping decision are carried out by the microcontroller digitally.

The relay program is located in an EPROM (Electrically-Programmable-Read-Only-Memory). With this program the microcontroller's CPU calculates the value of the measured voltage of the fundamental frequency. Harmonics are suppressed by an efficient digital filter based on the Fourier transformation (DFFT = Discrete Fast Fourier Transformation) When the measured voltage falls below the voltage threshold U_B , all frequency functions are blocked.

The frequency is established from the time difference of two similar voltage zero passages. The microprocessor compares continuously the frequency measured values and df/dt measuring values with the preset pickup values (setting value) stored in the parameter memory (EPROM). If a fault occurs an alarm is given and after the set tripping delay has elapsed, the corresponding tripping relay is activated.

The relay setting values for all parameters are stored in a parameter memory (EPROM - Electrically Erasable Programmable Read Only Memory), so that the actual relay settings cannot be lost, even if the power supply is interrupted. The microprocessor is supervised by a built-in "watchdog" timer. In case of failure the watchdog timer resets the microprocessor and gives an alarm signal via output relay "self supervision".

4.3 Principle of frequency supervision

Frequency relay MRF3 protects electrical generators, consumers or electrical operating equipment in general against over- or under frequency.

The relay has independent from each other, four frequency elements $f_1 - f_4$ with a free choice of parameters, with separate adjustable pickup values and delay times as well as two elements for supervision of frequency gradient df/dt . With the aid of the frequency gradient sign both frequency increase and frequency decrease can be supervised.

The measuring principle of the frequency supervision is based in general on the time measurement of complete cycles, whereby a new measurement is started at each voltage zero passage. The influence of harmonics on the measuring result is thus minimized.

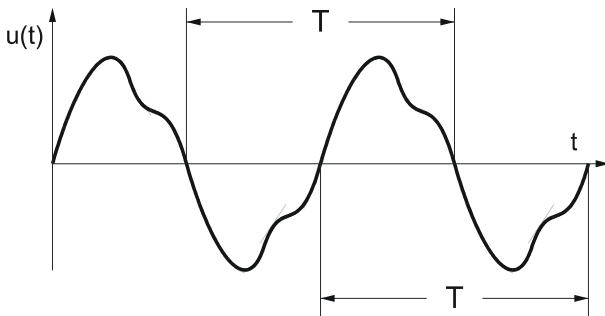


Figure 4.1: Determination of cycle duration by means of zero passages.

In order to avoid false tripping during occurrence of interference voltages and phase shifts the relay works with an adjustable measuring repetition (see chapter 5.2.2)

Frequency tripping is sometimes not desired by low measured voltages which for instance occur during alternator start-up.

All frequency supervision functions can be blocked with the aid of an adjustable voltage threshold UB in case the measured voltage value is below this value.

4.4 Measurement of the frequency gradient (rate of change of frequency)

Supervision of the frequency gradient df/dt is applied to the following applications:

- As additional criteria for under frequency supervision at load shedding systems
- For fast decoupling of mains parallel electrical generators at mains failure (mains Decoupling)
- With frequency limiting function top and/or bottom (setting-up of a trip window)

The df/dt elements can be set accordingly depending on the type of application.

4.4.1 Load shedding

In the event of large interferences in the power generation grid, the failure of several power generators may endanger the stability of the entire grid. The created power deficit causes the mains frequency to drop rapidly.

The MRF3 can be used for defined load shedding in order to restabilise the grid.

For this purpose, the parameters of the four frequency stages are set for immediate load shedding.

After grid stabilization the shed load can be connected again after a reclaim time.

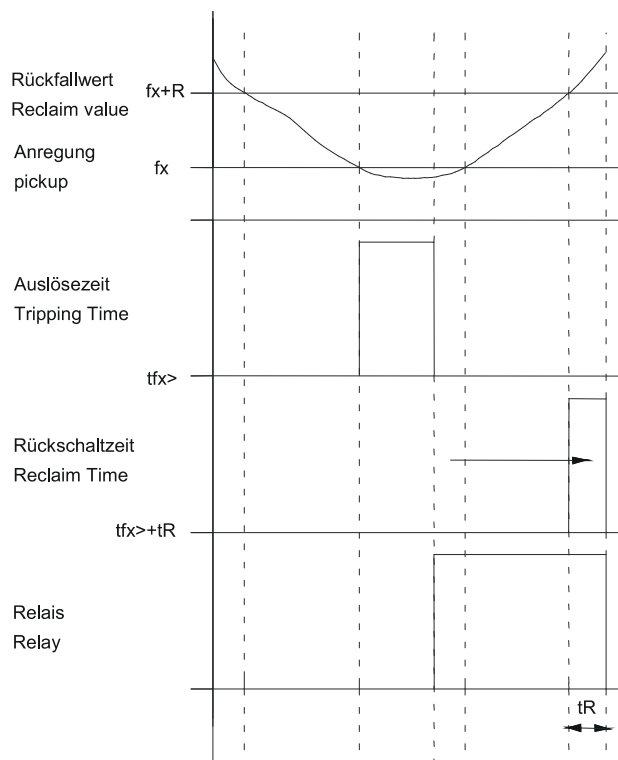


Figure 4.2: Reclaim time after mains recovery

In addition, the MRF3 offers two measuring stages for the frequency gradient df/dt . The amount of power deficit can be determined by way of the frequency change speed and this way appropriate load shedding can be initiated.

The conventional method of supervising the frequency gradient by using "load shedding" shows the following disadvantages in practical application:

- At the beginning of a mains failure the frequency gradient may differ greatly from one substation to the next and is, from a time point of view, not constant in most cases. This depends on the power required by the individual substations. This makes selective shut-down of consumers more difficult.
- During a frequency decrease in the grid the power between the individual power stations may fluctuate. In this situation the frequency gradient is not constant which makes a safe decision for tripping on the basis of the momentary value of the frequency gradient impossible.

On account of the above-mentioned disadvantages only the consideration of the average value of the frequency gradient makes sense for a df/dt supervision with load shedding systems.

Since the frequency gradient supervision of the MRF3 can work on this principle, the above-mentioned problems can be excluded.

Remark:

The jumper J3, which is located behind the display panel, must not be plugged in (automatic reset of the relays).

The function of the jumper J3 is that all energized relays go into self-holding position and are only deenergized by manual resetting. This would prevent resetting of the trip relay.

Application example: f_{\min} :

The df/dt function of the MRF3 for load shedding is only active as from an adjustable frequency threshold value f_e . If the measured system frequency drops below f_e , a time counter is started (adjustment value dt in periods). If the measured system frequency drops below the tripping value f_T within the time dt , the MRF3 switches off immediately. The tripping value f_b results from the settings

$$df \frac{f_e - f_t}{dt} = f_e - dt * dt$$

If the tripping value f_T is not achieved within time d_t , no tripping will take place.

Only when the frequency rises above the threshold value f_e will the MRF3 be reset automatically.

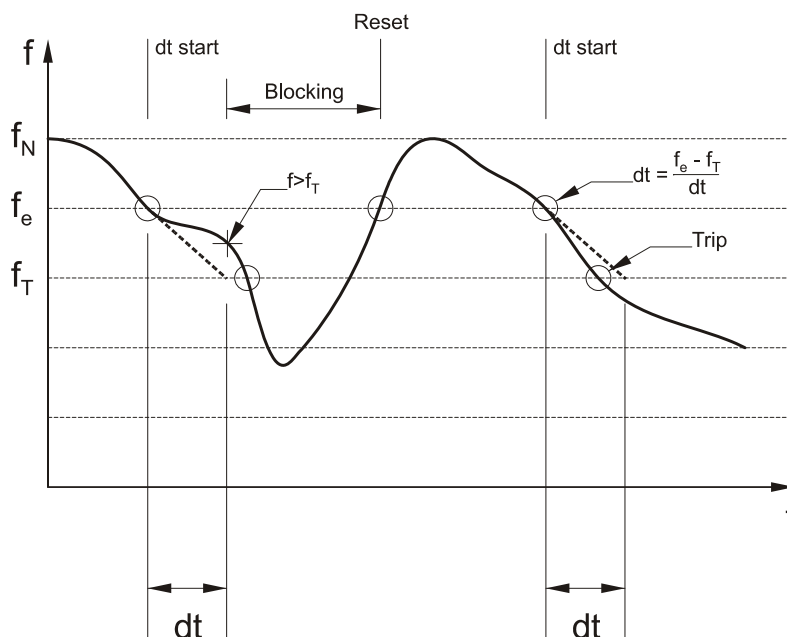
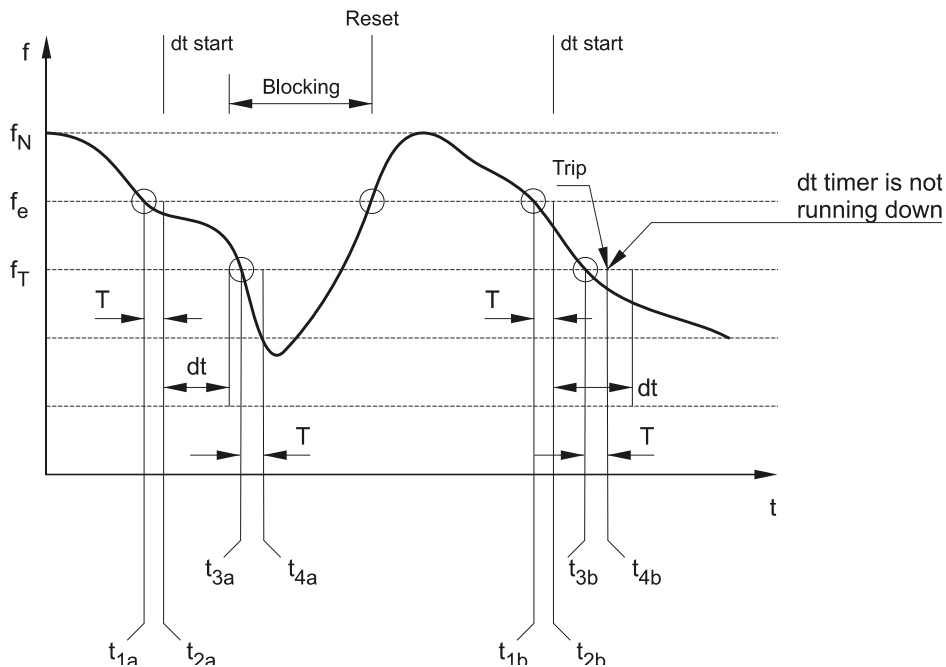


Figure 4.3: Working principle of the df /measuring

This is to be considered as a simplified description.

The following functional description applies for an exact trip mode at load shedding:

For thresholds f_e and f_T this frequency timer is connected in series as measuring repetition timer as de-scribed for frequency elements $f_1 - f_4$ (see chapter 5.4.2). Thus Figure 4.3 only applies when compared to dt the setting value of T is smaller, otherwise an additional trip delay has to be used (see Figure 4.4).



4.1: Working principle of the df measuring

- t1 threshold f_e is fallen short of
- t2 measuring repetition delay T for f_e has elapsed
- t3 threshold f_T is fallen short of
- t4 measuring repetition delay for f_T has elapsed

The frequency value f_e is not reached at the instant t_{1a} or t_{1b} and the measuring repetition timer T is started. At the instant t_{2a} or t_{2b} the time has elapsed and time dt starts.

The frequency value f_e is not reached at the instant t_{3a} or t_{3b} and the measuring repetition timer T is restarted by a second timer. If its time has run down and time dt has not elapsed yet (time t_{4b}), tripping is initiated. There is no tripping if time dt has elapsed before the time of the second timer has run down (time t_{4a}).

5. Operation and settings

5.1 Display

| Function | Display shows | Pressed pushbutton | Corresponding LED | Color of LED |
|---|---|---|--|--|
| Normal operation: | WW | | | |
| Measured operating values | meas. value of voltage | <SELECT/RESET> | U | green |
| | meas. value of frequency | <SELECT/RESET> | f | green |
| | Min./Max. frequency measuring values before last reset | <SELECT/RESET> one time for each value | f + (min or max) | green |
| | Measuring value df/dt | <SELECT/RESET> one time for each value | df/dt | green |
| | Min./Max. measuring value of frequency gradient before last reset | <SELECT/RESET> one time for each value | df/dt + (min or max) | green |
| Setting values: Rated frequency f_N | f=50 f=60 | <SELECT/RESET><+><-> | f_N | green |
| LEDs flash after excitation | FLSH / NOFL | <SELECT/RESET><+><-> | | |
| Parameter change-over switch Function assignment of digital inputs | SET1; SET2; B_S2; R_S2; B_FR; R_FR; S2FR; B_EX ³⁾ ; R_EX ³⁾ ; EXS2 ³⁾ ; EXFR ³⁾ ; EXEX ³⁾ | <SELECT/RESET><+><-> | P2 | yellow |
| Measuring repetition | Setting value in periods of nominal frequency | <SELECT/RESET><+><-> | T | red |
| Frequency pickup value f_1 Reclaim value for f_1 Tripping delay time for f_1 Reclaim time for f_1 | Setting value in Hz setting value in seconds setting value in seconds setting value in seconds | <SELECT/RESET><+><-> one time for each value one time for each value one time for each value | f_1 f_1+R t_{f1} $t_{f1} + t_R$ | green green red red |
| Frequency pickup value f_2 Reclaim value for f_2 tripping delay time for f_2 Reclaim time for f_2 | Setting value in Hz setting value in seconds setting value in seconds setting value in seconds | <SELECT/RESET><+><-> one time for each value one time for each value one time for each value | f_2 f_2+R t_{f2} $t_{f2} + t_R$ | green green red red |
| Frequency pickup value f_3 Reclaim value for f_3 tripping delay time for f_3 Reclaim time for f_3 | Setting value in Hz Setting value in seconds setting value in seconds setting value in seconds | <SELECT/RESET><+><-> one time for each value one time for each value one time for each value | f_3 f_3+R t_{f3} $t_{f3} + t_R$ | green green red red |
| Frequency pickup value f_4 Reclaim value for f_4 tripping delay time for f_4 Reclaim time for f_4 | Setting value in Hz Setting value in seconds setting value in seconds setting value in seconds | <SELECT/RESET><+><-> one time for each value one time for each value one time for each value | f_4 f_4+R t_{f4} $t_{f4} + t_R$ | green green red red |
| 1. Frequency threshold value f_e for df/dt measuring | Setting value in Hz or „VARI ¹⁾ “ | <SELECT/RESET><+><-> | $f_e + df_1$ | green |
| ¹⁾ Lower frequency threshold value f_e for df/dt measuring ¹⁾ Higher frequency threshold value f_e for df/dt measuring | Setting value in Hz | <SELECT/RESET><+><-> | $f_e + df_1$ + min $f_e + df_1$ + max | green yellow green yellow |
| 2. Frequency threshold value f_e for df/dt measuring | Setting value in Hz or „VARI ¹⁾ “ | <SELECT/RESET><+><-> | $f_e + df_2$ | green |
| ¹⁾ Lower frequency threshold value f_e for df/dt measuring ¹⁾ Higher frequency threshold value f_e for df/dt measuring | Setting value in Hz | <SELECT/RESET><+><-> | $f_e + df_2$ + min $f_e + df_2$ + max | green yellow green yellow |
| Setting value df_1/dt Different time or value of the | Setting value in Hz /s Setting value in periods | <SELECT/RESET><+><-> one time for each value | df_1 dt_1 | green red |

| Function | Display shows | Pressed pushbutton | Corresponding LED | Color of LED |
|--|---|--|--|--|
| trip counter for df_1/dt | of rated frequency | | | |
| Setting value df_2/dt Different time or value of the trip counter for df_2/dt | Setting value in Hz /s Setting value in periods of rated frequency | <SELECT/RESET><+><-> | df_2 dt_2 | green red |
| Function blocking | EXIT | <SELECT/RESET><+><-> | LED of blocked parameters | green |
| Blocking for the frequency measuring | Setting value in Volt | <SELECT/RESET><+><-> | U_B t_{min} | green yellow |
| Releasing threshold for frequency measuring | Setting value in volt | <SELECT/RESET><+><-> | $UB + max$ | green yellow |
| Assignment of blocking function | BLOC; NO_B | SELECT/RESET><+><-> | $f_1 - f_4, df_1, df_2$ | |
| Assignment of output relays | 1 - 4 | <ENTER> + <TRIP> <SELECT/RESET><+><-> | R $f_1 - f_4, tf_1 - tf_4, dt_1, dt_2$ | red green red |
| Recorded fault data: voltage | Tripping value in Volt | <SELECT/RESET><+><-> | U | red |
| Slave address of serial interface | 1 - 32 | <SELECT/RESET><+><-> | RS | yellow |
| Baud-Rate ²⁾ | 1200-9600 | <SELECT/RESET><+><-> | RS | yellow |
| Parity-Check ²⁾ | even odd no | <SELECT/RESET><+><-> | RS | yellow |
| Frequency | Tripping value in Hz | <SELECT/RESET><+><-> | f, f_{min} , f_{max} | red, yellow |
| Frequency changing speed | Tripping value in Hz/s | <SELECT/RESET><+><-> | df, df_{min}, df_{max} | |
| Fault memory | FLT1; FLT2..... | <SELECT/RESET><+><-> | U, f, f_{min} , f_{max} , df, df_{min}, df_{max} , $tf_1 - tf_4, dt_1, dt_2, \text{Ⓜ}$ | red, yellow red red, green |
| Delete failure memory | wait | <-> <SELECT/RESET> | | |
| Number of fault occurrences | S = 1N to S = 8N or S = 1L to S = 8L | <SELECT/RESET> <+><-> | FR | yellow |
| Trigger signal for the fault recorder | TEST, P_UP, A_PI, TRIP | <SELECT/RESET> <+><-> | FR | yellow |
| Display of date and time | Y = 99, M = 10, D = 1, h = 12, m = 2, s = 12 | <SELECT/RESET> <+><-> | Ⓜ | green |
| Save parameter? | SAV? | <ENTER> | | |
| Save parameter! | SAV! | <ENTER> for about 3 s | | |
| Software Version | | <TRIP> time for each part | | |
| Manual tripping | TRI? | <TRIP> three times | | |
| Inquire password | PSW? | <SELECT/RESET>/ <+>/<->/<ENTER> | | |
| Relay tripped | TRIP | <TRIP> or fault tripping | | |
| Secret password | XXXX | <SELECT/RESET>/ <+>/<->/<ENTER> | | |
| System reset | WW | <SELECT/RESET> for about 3 s | | |

Table 5.1: Possibilities for indications by the display

¹⁾ The MRF3 is operating with the df/dt function

²⁾ Setting is only possible in case of dt/df trip

³⁾ Only in conjunction with Modbus Protocol

²⁾ only Modbus Protocol

5.2 Setting procedure

Before changing a parameter a password has to be entered first (see chapter 4.4 of description "MR-digital multifunctional relay")

The parameter setting procedure is guided by two-colored illuminated LEDs. During setting of the frequency setting values f_N , $f_1 - f_4$, f_e , d_{f1} and d_{f2} the LEDs light up green. During setting of the tripping delays, differential periods or counters these LEDs light up red.

The desired pickup values, nominal values and tripping delays can be adjusted by pressing push buttons <+> and <-> and stored with <ENTER>.

5.3 System parameter

5.3.1 Display voltage U as primary quantity (U_{prim}/U_{sek})

The voltage can be shown as primary measuring value. For this parameter the transformation ratio of the VT has to be set accordingly. If the parameter is set to "sec", the measuring value is shown as rated secondary voltage.

Example:

The voltage transformer used is of 10 kV/100 V. The transformation ratio is 100 and this value has to be set accordingly. If still the rated secondary voltage should be shown, the parameter is to be set to 1.

5.3.2 Setting of nominal frequency

For proper functioning it is necessary to first adjust the rated frequency (50 or 60 Hz).

First the nominal frequency (50 or 60 Hz) has to be set before unit MRF3 is put into operation. All frequency functions are determined by setting the nominal frequency, i.e. whether the set frequency thresholds are evaluated as over- or under frequency (see also chapter 5.2.3). Also the cycle duration (20 ms at 50 Hz and 16.67 ms at 60 Hz) derives from this setting which determines the minimum tripping delay for frequency elements $f_1 - f_4$ with an adjustable multiplier (see also chapter 5.4.4).

During setting of the nominal frequency a value in Hz is shown on the display.

5.3.3 Display of the activation storage (FLSH/NOFL)

If after an activation the existing current drops again below the pickup value, e.g. f_1 , without a trip has been initiated, LED f_1 signals that an activation has occurred by flashing fast. The LED keeps flashing until it is reset again (push button <RESET>). Flashing can be suppressed when the parameter is set to NOFL.

5.4 Protection parameters

5.4.1 Parameter change-over switch

Parameter change-over switch/function assignment of digital inputs

The parameter change-over switch permits selection between two parameter sets. Parameter change-over switching can be done by software or via the external inputs for reset or blocking. Furthermore, the inputs can be assigned to function as external triggering for the fault recorder and as external inputs* 1 and 2. The function of the external inputs is setting digital tracks in the fault recorder by means of external functions. For example circuit breaker check-back.

| Software-Parameter | Blocking input used as | RESET input used as |
|--------------------|---------------------------------------|---------------------------------------|
| SET1 | Blocking input | RESET input |
| SET2 | Blocking input | RESET input |
| B_S2 | Parameter switch | RESET input |
| R_S2 | Blocking input | Parameter switch |
| B_FR | External triggering of fault recorder | RESET input |
| R_FR | Blocking input | External triggering of fault recorder |
| S2FR | Parameter change-over switch | External triggering of fault recorder |
| B_EX | External input* 1 | RESET input |
| R_EX | Blocking input | External input* 2 |
| EXS2 | External input* 1 | Parameter change-over switch |
| EXFR | External input* 1 | External triggering of fault recorder |
| EXEX | External input* 1 | External input* 2 |

* external inputs are only applicable in conjunction with Modbus-Protocol

By means of a change over facility, two different parameter sets can be activated. This change over procedure can be realized either over touch panel by software or by using the external inputs RESET or BLOCKING:

For settings SET1 or SET 2 the parameter set is activated by software. Terminals C8/D8 and D8/E8 can then be used as external RESET or BLOCKING inputs.

At setting B_S2 the BLOCKING input (D8/E8) can be used as parameter set change-over switch. At setting R_S2 the RESET input (D8/E8) can be used as parameter set change-over switch. At setting B_FR immediate activation of the fault recorder by using the BLOCKING input. During the recording time the LED "FR" lights up at the front plate.

Setting R_FR is used for activating the fault recorder via the RESET input. At setting S2_FR the parameter set 2 can be activated via the BLOCKING input and/or via the RESET input recording of a fault event can be activated.

The setting B_EX causes the blocking input to be used for recording an external function as digital track in the fault recorder.

The setting R_EX causes the reset input to be used for recording an external function as digital track in the fault recorder.

The setting EXS2 causes the blocking input to be used for recording an external function as digital track in the event recorder and the reset input to be used as parameter change-over switch.

The setting EXFR causes the blocking input to be used for recording an external function as digital track in the fault recorder and the immediate activation of the fault recorder by using the reset input. The setting EXEX causes the blocking and reset inputs to be used for recording two external functions as digital track in the fault recorder.

By applying the aux. voltage to one of the external in-puts the respective function will be activated.

Important information:

The respective external inputs RESET or BLOCKING used as parameter set change-over switch or to trigger off the fault recorder are then not available. If, for in-stance, the external BLOCKING input is used as parameter set change-over switch, the protective functions have to be blocked separately by software (see chapter 5.7.1).

5.4.2 Number of measuring repetitions (T)

In order to avoid false tripping of the unit at short volt-age drops of the system voltage or interference volt-ages, MRF3 works with an adjustable measuring repetition. When the instantaneous frequency measuring value exceeds (at over frequency) or falls below (at under frequency) the set reference value, the counter is incremented, otherwise the counter is decremented down to the minimum value of 0. Only when the counter exceeds the value adjusted at T, alarm is given and after the tripping delay of the frequency element has elapsed the tripping command is given.

The setting range for T is between 2 - 99.

Recommendation for setting:

For short tripping times, e.g. for machine protection or for mains decoupling T should be set in the range from 2 - 5. At precision measurements, e.g. exact measurement of the system frequency a setting of T in the range from 5 - 10 is recommended.

5.4.3 Threshold of frequency supervision

The frequency supervision of MRF3 has three frequency elements independent from each other. Acc. to setting the pickup value above or below the nominal frequency, these elements can be used for over- or under frequency supervision.

Dependent on the preset nominal frequency f_N the pickup values from 30 Hz up to 70 Hz at $f_N = 50$ Hz and from 40 Hz to 80 Hz at $f_N = 60$ Hz can be set.

During setting of the pickup values $f_1 - f_4$ the display shows the values in Hz. A value of for in-stance

49.8 Hz is indicated with "4980".

The function of the individual frequency elements can be deactivated by setting the pickup values to "EXIT".

The setting value "EXIT" corresponds to the rated frequency. For this purpose the frequency adjustment value must be set to the rated frequency f_N .

5.4.4 Tripping delays for the frequency elements

Tripping delays $t_{f1} - t_{f4}$ of the four frequency elements can be set independently from $t_{f1min} - 120$ s. The mini-mum tripping delay t_{f1min} of the relay depends upon the number of set measuring repetitions T (periods) and amounts to:

| T | $t_{f,min}$ |
|----------|-------------------------------|
| 2....49 | $(T+1) \cdot 20$ ms |
| 50....69 | $(T - 49) \cdot 50$ ms + 1 s |
| 70....99 | $(T - 69) \cdot 100$ ms + 2 s |

When setting the tripping delay to "EXIT" by pressing push button <+> up to the maximum setting value, the corresponding tripping relay is blocked. Pickup of the frequency element is however displayed on the front plate by the corresponding LED, an assigned alarm re-lay is also activated.

5.4.5 Disengaging value for the frequency stages with mains stabilization

If the excitation points for frequency supervision are exceeded or fallen short of, the disengaging value can be separately adjusted for each frequency stage. The disengaging values can never be set greater or smaller than the appertaining tripping value.

Example: $f_1 < = 49 \text{ Hz} \geq f_1 + R = > 49.01 \text{ Hz}$
 $f_2 > = 51 \text{ Hz} \leq f_2 + R = < 50.99 \text{ Hz}$

see chapter 7.3

5.4.6 Reclaim time upon mains stabilization

If the mains frequency is exceeded or fallen short of, the trip relay is reset (refer to chapt. 4.4.1). The reclaim time is separately adjustable for every tripping stage. The adjustment can be changed if LED $t_R + t_{f1} - t_{f4}$ lights up and by means of the <+> , <-> keys.

5.4.7 Parameter for frequency gradient supervision df/dt at load shedding

Table 7.1 in chapter 7.3 shows the possible setting parameters with their setting ranges. For the frequency gradient supervision df/dt at load shedding the following parameters are important:

fe+df₁: Frequency threshold value as from which excitation of the df/dt stages below f_N begins.
fe+df₂: Frequency threshold value as from which excitation of the df/dt stages above f_N begins.
df₁ + df₂: Tripping values of the df/dt stages are set in Hz/s (refer also to 4.4.1 "Load shedding").
dt₁ + dt₂: Time interval in periods of the rated frequency.

Setting example:

df/dt measurement is to be started when the frequency falls below the pickup value of $f_e = 49.2 \text{ Hz}$. Tripping of MRF3 is to follow when a mean frequency gradient of $df_1/dt_1 = 1 \text{ Hz/s}$ is exceeded before the critical frequency dt_1 of 48.9 Hz is reached, this comes to a time interval df_1 to be set of:

$$dt_1 = \frac{49.2 \text{ Hz} - 48.9 \text{ Hz}}{1.0 \text{ Hz/s} \cdot 0.02 \text{ s}} = 15(\text{Periods})$$

5.4.8 Parameters for frequency gradient supervision df/dt for mains decoupling

With this application threshold f_e+df_1 or f_e+df_2 must be set to „VARI“. With this setting two additional parameters will appear by means of which a bottom ($f_e+df+min$) and/or a top ($f_e+df+max$) limit value can be adjusted. This way it is possible to set up a tripping window each for both df/dt stages.

The parameters df_1 and df_2 are response values in Hz/s. Normally df_1 and df_2 are adjusted in the same way, but with different prefixes (e.g. $df_1 = -2$ Hz/s and $df_2 = +2$ Hz/s). This way it is possible to detect an impermissible frequency increase as well as a drop in frequency.

Measuring repetition counters dt_1 and dt_2 are for checking the monotony of the frequency increase or - decrease and can be set in the range from 1 - 64 cycles.

For mains coupling a setting from 2 - 4 is recommended. Setting of 2 cycles corresponds to an interval evaluation of 4 measuring cycles and resulting from this a tripping delay of 2×20 ms = 40 ms. The df/dt stages can be blocked by setting the tripping value of the frequency gradient to 0. The display will show the word "EXIT".

5.4.9 Blocking for frequency measuring

If the system voltage is lowered, correct frequency measuring may no longer be possible as from a certain value. In order to prevent faulty tripping of the MRF3 in such cases, there is an adjustable voltage threshold value U_{Bmin} . If the system voltage lays below this threshold value, all frequency functions of the MRF3 are blocked.

5.4.10 Voltage threshold for frequency measurement

At very low system voltage, e.g. during alternator start-up or voltage failure the frequency measurement cannot be done correctly. An adjustable voltage threshold U_{Bmax} prevents a false tripping of the MRF3 in such cases. When the system voltage drops below this threshold, all frequency functions of unit MRF3 are blocked. See chapter 5.10

5.4.11 Adjustment of the slave address

By pressing push buttons <+> and <-> the slave address can be set in the range of 1 - 32. During this adjustment the LED RS lights up.

5.4.12 Setting of Baud-rate (applies for Modbus Protocol only)

Different transmission rates (Baud rate) can be set for data transmission via Modbus Protocol. The rate can be changed by push buttons <+> and <-> and saved by pressing <ENTER>.

5.4.13 Setting of parity (applies for Modbus Protocol only)

The following three parity settings are possible :

- "even" = even parity
- "odd" = odd parity
- "no" = no parity check

The setting can be changed by push buttons <+> and <-> and saved by pressing <ENTER>.

5.5 Parameter for the fault recorder

5.5.1 Adjustment of the fault recorder

The MRF3 is equipped with a fault recorder (see chapter 3.1.5). Three parameters can be determined.

5.5.2 Type of fault recorder

The normal or extended recording time can be selected by parameter "Number of Recordings".

5.5.3 Number of the fault recordings

The max. storage time for the normal recording time is 16s at 50 Hz and 13.2 at 60 Hz. For the extended recording time the storage time is 64s at 50 Hz and 53.2s at 60Hz.

| Software parameter | Parameter | Time per recording at the set rated frequency of | | Auto writing over |
|---------------------------|-----------|--|------------|-------------------|
| | | 50 Hz | 60Hz | |
| Normal U; f; df | S=1N | 1 x 8 s | 1 x 6.65 s | yes |
| | S=3N | 3 x 4 s | 3 x 3.30 s | |
| | S=7N | 7 x 2 s | 7 x 1.65 s | |
| | S=2N | 2 x 8 s | 2 x 6.65 s | no |
| | S=4N | 4 x 4 s | 4 x 3.30 s | |
| | S=8N | 8 x 2 s | 8 x 1.65 s | |
| Extended URMS f; df | S=1L | 1 x 64 s | 1 x 53.2 s | yes |
| | S=3L | 3 x 32 s | 3 x 26.4 s | |
| | S=7L | 7 x 16 s | 7 x 13.2 s | |
| | S=2L | 2 x 64 s | 2 x 53.2 s | no |
| | S=4L | 4 x 32 s | 4 x 26.4 s | |
| | S=8L | 8 x 16 s | 8 x 13.2 s | |

5.5.4 Adjustment of trigger occurrences

There is a choice between four different occurrences:

| | |
|---------------------|---|
| P_UP (Pickup) | Storage is initiated after recognition of a general activation. |
| TRIP | Storage is initiated after a trip has occurred. |
| A_PI (After Pickup) | Storage is initiated after the last activation threshold was fallen short of. |
| TEST | Storing is activated by simultaneous actuation of the keys <+> and <->. During the recording time the display shows "Test". |

5.5.5 Pre-trigger time (T_{pre})

By the time T_{pre} it is determined which period of time prior to the trigger occurrence should be stored as well. It is possible to adjust a time between 0.05s and the max. recording interval. With keys <+> and <-> the values can be changed and with <ENTER> be saved.

5.6 Date and time

5.6.1 Adjustment of the clock

When adjusting the date and time, LED \oplus lights up. The adjustment method is as follows:

| | | |
|--------|--------|------|
| Date : | Year | Y=00 |
| | Month | M=00 |
| | Day | D=00 |
| Time : | Hour | h=00 |
| | Minute | m=00 |
| | Second | s=00 |

The clock starts with the set date and time as soon as the supply voltage is switched on. The time is safe-guarded against short-term voltage failures (min. 6 minutes).

Note:

The window for parameter setting is located behind the measured value display. The parameter window can be accessed via the <SELECT/RESET> key.

5.7 Additional functions

5.7.1 Setting procedure for blocking the protection functions

The blocking function of the MRF3 can be set according to requirement. By applying the aux. voltage to D8/E8, the functions chosen by the user are blocked. Setting of the parameter should be done as follows:

- When pressing push buttons <ENTER> and <TRIP> at the same time, message "BLOC" is displayed (i.e. the respective function is blocked) or "NO_B" (i.e. the respective function is not blocked). The LED allocated to the first protection function U< lights red.
- By pressing push buttons <+> <-> the value displayed can be changed.
- The changed value is stored by pressing <ENTER> and entering the password.
- By pressing the <SELECT/RESET> push button, any further protection function which can be blocked is displayed.
- Thereafter the menu is left by pressing <SELECT/RESET> again.
- If the <SELECT/RESET> key is actuated again, the blocking menu is left and the assignment mode is accessed[^].

| Function | Description | Display | LED |
|----------|----------------------|---------|-------|
| f1 | Frequency step 1 | BLOC | green |
| f2 | Frequency step 2 | BLOC | green |
| f3 | Frequency step 3 | NO_B | green |
| f4 | Frequency step 4 | NO_B | green |
| df/dt1 | Frequency gradient 1 | BLOC | green |
| df/dt2 | Frequency gradient 2 | BLOC | green |

Table 5.2: Blocking function for two parameter sets

Assignment of the output relays:

Unit MRF3 has five output relays. The fifth output relay is provided as permanent alarm relay for self supervision is normally on. Output relays 1 - 4 are normally off and can be assigned as alarm or tripping relays to the voltage functions which can either be done by using the push buttons on the front plate or via serial interface RS485. The assignment of the output relays is similar to the setting of parameters, however, only in the assignment mode. The assignment mode can be reached only via the blocking mode.

By pressing push button <SELECT/RESET> in blocking mode again, the assignment mode is selected.

The relays are assigned as follows:

LEDs f_1 , f_2 , f_3 , f_4 , df_1 and df_2 are two-colored and light up **green** when the output relays are assigned as **alarm relays** and LEDs tf_1 , tf_2 , tf_3 , tf_4 , dt_1 and dt_2 red as **tripping relays**.

Definition:

Alarm relays are activated at pickup.

Tripping relays are only activated after elapse of the tripping delay.

After the assignment mode has been activated, first LED U< lights up green. Now one or several of the four output relays can be assigned to under voltage element U< as alarm relays. At the same time the selected alarm relays for under voltage element 1 are indicated on the display. Indication "1 _ _ _" means that output relay 1 is assigned to this under voltage element. When the display shows " _ _ _ _", no alarm relay is assigned to this under voltage element. The assignment of output relays 1 - 4 to the current elements can be changed by pressing <+> and <-> push buttons. The selected assignment can be stored by pressing push button <ENTER> and subsequent input of the password. By pressing push button <SELECT/RESET>, LED U< lights up red. The output relays can now be assigned to this voltage element as tripping relays.

Relays 1 - 4 are selected in the same way as described before. By repeatedly pressing of the <SELECT/RESET> push button and assignment of the relays all elements can be assigned separately to the relays. The assignment mode can be terminated at any time by pressing the <SELECT/RESET> push button for some time (abt. 3 s).

Note:

- The function of jumper J2 described in general description "MR Digital Multifunctional Relays" does not apply for MRF3. For relays without assignment mode this jumper is used for parameter setting of alarm relays (activation at pickup or tripping).

A form is attached to this description where the setting requested by the customer can be filled-in. This form is prepared for telefax transmission and can be used for your own reference as well as for telephone queries.

| Relay function | Output relays | | | | Display-Indication | Corresponding LED |
|--------------------|---------------|---|---|---|--------------------|-------------------|
| | 1 | 2 | 3 | 4 | | |
| f_1 Alarm | X | | | | 1 _ _ _ | f_1 green |
| tf_1 Tripping | X | | | | 1 _ _ _ | tf_1 red |
| f_2 Alarm | X | | | | 1 _ _ _ | f_2 green |
| tf_2 Tripping | X | | | | 1 _ _ _ | tf_2 red |
| f_3 Alarm | | X | | | _ 2 _ _ | f_3 green |
| tf_3 Tripping | | X | | | _ 2 _ _ | tf_3 red |
| f_4 Alarm | | | X | | _ _ 3 _ | f_3 green |
| ff_4 Tripping | | | X | | _ _ 3 _ | tf_3 red |
| df/dt_1 Tripping | | | | X | _ _ _ 4 | dt_1 red |
| df/dt_1 Tripping | | | | X | _ _ _ 4 | dt_2 red |

Table 5.3: Example of assignment matrix of the output relay (default settings)

5.8 Measuring values

5.8.1 Instantaneous values

The indication of the instantaneous measuring values is described in the general description "MR - Digital Multifunctional Relays", chapter 4.1.

5.8.2 Tripping memory

The indication of the measuring values in case of a trip is described in the general description "MR - Digital Multifunctional Relay", chapter 4.5.2.

5.8.3 Display of measuring values

During normal operation the following measuring values can be displayed:
Displayed measuring values:

| | |
|-------------------|---|
| U: | System voltage in Volt |
| f: | System frequency in Hz |
| df: | Frequency gradient in Hz/s |
| $f_{\min/\max}$: | Min. and Max. value of system frequency in Hz |
| $d_{\min/\max}$: | Min. and Max. value of frequency gradient in Hz/s |

5.8.4 Unit of the measuring values displayed

The measuring values can optionally be shown in the display as a multiple of the "sec" rated value (x ln) or as primary current (A). According to this the units of the display change as follows:

| Indication as | Range | Unit |
|-----------------|-------------|------|
| sec. voltage | 000V - 999V | V |
| primary voltage | .00V – 999V | V |
| | 1k00 – 9k99 | kV |
| | 10k0 – 99k0 | kV |
| | 100k – 999k | kV |
| | 1M00 – 3M00 | MV |

Table 5.4: Units of the display

5.8.5 Minimum and maximum values

The MRF3 offers a minimum/maximum storage each for the measuring values of the frequency gradient. These min./max. values are mainly used to appraise the system quality. Always the highest and lowest values of **each cycle** are measured and stored until the next reset.

Min./max. measurement of the frequency:

Unit MRF3 calculates from each cycle of the mains voltage the instantaneous frequency. These measuring values are written into the min./max.-storage. Hereby only a new minimum- or maximum value overwrites older stored values. According to the setting of T and the tripping delay it can happen that the stored min./max.-values are far above the tripping thresholds, but tripping does not occur. This is established by the storage of instantaneous values.

Min./max.-measurement of the frequency gradient

The before described is valid in the same way for storage of min./max. values of the df/dt measurement. Because every instantaneous df/dt value is stored, high values can occur which however do not lead to tripping. This can for instance occur due to switching transients where high positive and negative df/dt values occur. Because of the special measuring procedure the relay does not trip.

Very helpful are the min./max.- measurements for long time study of the mains quality.

Operation:

At each reset (see chapter 5.4) the stored min./max.- values are deleted. From this time the min./max.-storage runs without time limitation until the next reset.

The measuring values of the min./max.-storage can be called by pressing push button <SELECT> several times. Simultaneously the respective LEDs light up, for instance LEDs "f" and "min" light up at the indication of the minimum frequency.

5.9 Fault memory

When the relay is energized or is energized or trips, all fault data and times are stored in a non-volatile memory manner. The MRF3 is provided with a fault value recorder for max. five fault occurrences. In the event of additional trippings always the oldest data set is written over.

For fault indication not only the trip values are recorded but also the status of LEDs. Fault values are indicated when push buttons <-> or <+> are pressed during normal measuring value indication.

- Normal measuring values are selected by pressing the <SELECT/RESET> button.
- When then the <-> button is pressed, the latest fault data set is shown. By repeated
- pressing the <-> button the last but one fault data set is shown etc. For indication of fault data sets abbreviations FLT1, FLT2, FLT3, ... are displayed (FLT1 means the latest fault data set recorded). At the same time the parameter set active at the occurrence is shown.
- By pressing <SELECT/RESET> the fault measuring values can be scrolled.
- By pressing <+> it can be scrolled back to a more recent fault data set. At first FLT8, FLT7, are al-ways displayed. When fault recording is indicated (FLT1 etc), the LEDs flash in compliance with the stored trip information, i.e. those LEDs which showed a continuous light when the fault occurred are now blinking to indicate that it is not a current fault. LEDs which were blinking during trip conditions, (element had picked up) just briefly flash.
- If the relay is still in trip condition and not yet reset (TRIP is still displayed), no measuring values can be shown.
- To delete the trip store, the push button combination <SELECT/RESET> and <->, has to be pressed for about 3s. The display shows "wait".

Recorded fault data:

| Measuring | Displayed value | Corresponding LED |
|-------------------------|--------------------------|-------------------|
| Voltage | 1-phase measuring | U |
| Frequency | f, f_{min}, f_{max} | f; min; max |
| Frequency changing rate | df, df_{min}, df_{max} | df; min; max |
| Time stamp | | |
| Date: | Y = 99 | 🕒 |
| | M = 03 | 🕒 |
| | D = 10 | 🕒 |
| Time: | h = 17 | 🕒 |
| | m = 21 | 🕒 |
| | s = 14 | 🕒 |

5.9.1 Reset

MRF3 has the following 3 possibilities to reset the display as well as the output relays at jumper position J3 = ON.
(see also chapter 4.2 of description "MR-Digital Multi-functional Relays").

Manual reset

- by pressing push button <SELECT/RESET> for some time (abt. 3 secs.).

Electrical reset

- by applying aux. voltage to C8/D8.

Software reset

- software reset has the same effect as the <SELECT/RESET> push button. Please also
- refer here to the communication protocol of RS 485 interface.

Resetting the display is only possible when there is no pickup anymore (otherwise signal "TRIP" will still remain in the display and the relays remain activated). Resetting the relay does not change the preset parameters.

5.10 Dynamic behavior of the relay functions

The following table shows the dynamic behavior of the relay functions under various system conditions.

| System condition/ event | Function | | | |
|--|------------------------------|------------------------------|------------------------------|-------------------------------|
| | f> | f< | df/dt for load shedding | df/dt for mains decoupling |
| Applying auxiliary voltage | active after 1 s | active after 1 s | active after 1 s | active after 1 s |
| Applying auxiliary voltage to the external blocking input | not blocked* | Blocked* | Blocked* | Blocked* |
| Disconnecting the auxiliary voltage from the external blocking input | no influence | active after 1.5 s | active after 1.5 s | active after 1.5 s |
| Applying auxiliary voltage to the external reset input | reset of the relay (Display) | reset of the relay (Display) | reset of the relay (Display) | reset of the relay (Display) |
| Applying the system voltage to the frequency measuring input | active after 1.5 s | active after 1.5 s | active after 1.5 s | active after 1.5 s |
| Applying a voltage <U _B to the frequency measuring input | blocked | blocked | blocked | blocked |
| Applying a voltage with a frequency <f _e to the frequency measuring input | active after 1.5 s | active after 1.5 s | no tripping | no tripping |
| Disconnecting system voltage from the frequency measuring input | blocked | blocked | blocked | blocked |
| Voltage drops below U _B min | blocked | blocked | blocked | blocked |
| Recovering of system voltage U _B max | active after 1.5 s | active after 1.5 s | active after 1.5 s | active after 1.5 s |
| Voltage vector surge | no tripping | no tripping | no tripping | no tripping |
| Short time voltage drop | no tripping | no tripping | no tripping | no tripping |

Table 5.5: Dynamic behavior of MRF3-Functions

*There is a fre of parameters for the setting (see chapter 5.7.1)

6. Relay testing and commissioning

The following test instructions should help to verify the protection relay performance before or during commissioning of the protection system. To avoid a relay damage and to ensure a correct relay operation, be sure that:

- the auxiliary power supply rating corresponds to the auxiliary voltage on site.
- the rated frequency and voltage of the relay corresponds to the plant data on site.
- the voltage transformer circuits are connected to the relay correctly.
- all signal circuits and output relay circuits are connected correctly.

6.1 Power-on

NOTE!

Prior to switch on the auxiliary power supply, be sure that the auxiliary supply voltage corresponds to the rated data on the type plate.

Switch on the auxiliary power supply to the relay and check that the message "WW" appears on the display and the self supervision alarm relay (watchdog) is energized (Contact terminals D7 and E7 closed).

6.2 Testing the output relays

NOTE!

Prior to commencing this test, interrupt the tripping circuit to the circuit breaker if tripping is not desired.

By pressing the push button <TRIP> once, the display shows the first part of the software version of the relay (e.g. „D01-“). By pressing the push button <TRIP> twice, the display shows the second part of the software version of the relay (e.g. „7.00“). The software version should be quoted in all correspondence. Pressing the <TRIP> button once more, the display shows "PSW?". Please enter the correct password to proceed with the test. The message "TRI?" will follow. Confirm this message by pressing the push button <TRIP> again. All output relays should then be activated and the self supervision alarm relay (watchdog) is deenergized one after another with a time interval of 1 second. Thereafter, reset all output relays back to their normal positions by pressing the push button <SELECT/RESET>.

6.3 Checking the set values

By repeatedly pressing the push button <SELECT>, all relay set values may be checked. Set value modification can be done with the push button <+><-> and <ENTER>.

6.4 Secondary injection test

6.4.1 Test equipment

- Voltmeter and frequency meter with class 1 or better
- Auxiliary power supply with the voltage corresponding to the rated data on the type plate
- AC voltage supply with frequency regulation (Voltage: adjustable from 0 to $\geq 2 \times U_N$; Frequency: adjustable from 40 - 70 Hz)
- Timer to measure the operating time (Accuracy class ± 10 ms)
- Switching device
- Test leads and tools

6.4.2 Test circuit

For testing MRF3 the connection of a voltage source with adjustable frequency is required. Fig. 6.1 shows a simple example of a test circuit. For checking the df/dt function a voltage source is needed which can generate a constant rate of change of frequency.

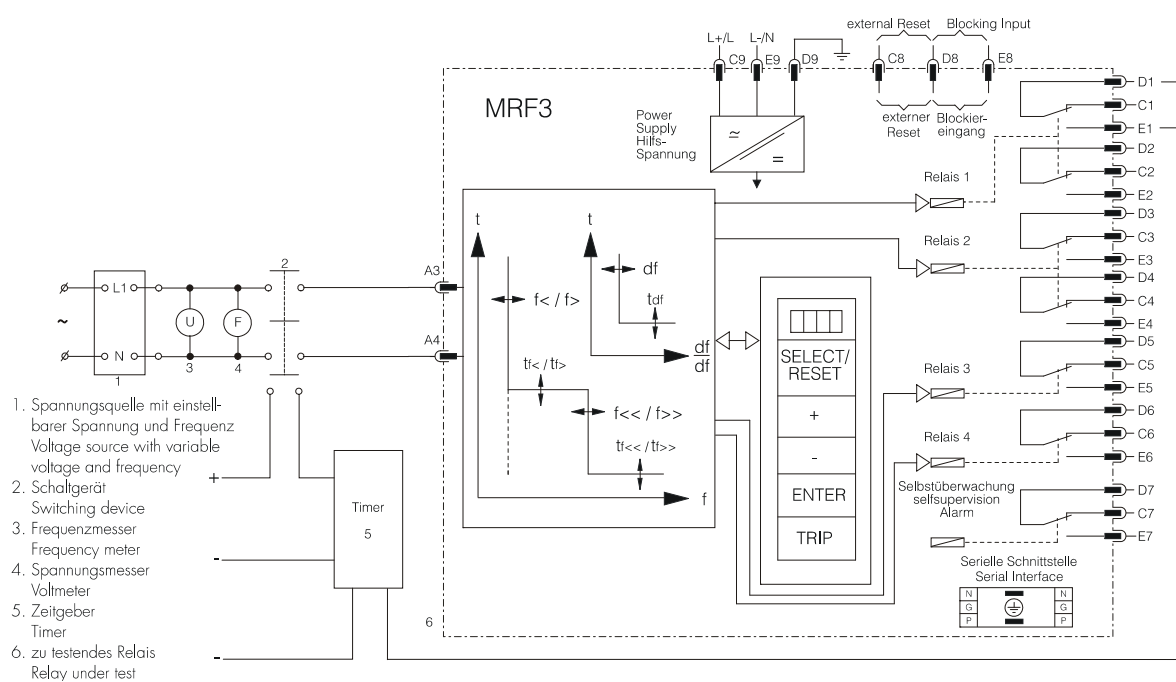


Figure 6.1: Test circuit

6.4.3 Checking the input circuits and measuring values

First the measuring voltage as high as the nominal voltage is to be connected to terminals A3 and A4. Then the actual measuring values of the frequency can be read by pressing push button <SELECT/RESET>. The measured frequency is indicated on the display by the simultaneous illumination of LED f as follows:5001; corresponds to 50.01 Hz. The rate of change of frequency is indicated on the display when LED df (indication in Hz/s) lights up. Example 3.1 corresponds to 3.1 Hz/s.

6.4.4 Checking of operating- and resetting values of the over-/under frequency functions

Note!

During frequency test each of the four frequency elements should be checked. To guarantee a trouble-free test run the other frequency elements of the unit have therefore to be blocked at the beginning by adjusting the corresponding frequency operating values $f_1 - f_4$ to "EXIT".

To check the operating- and reset values the test frequency must be increased or decreased until the relay picks up. This is signaled when LEDs $f_1 - f_4$ light up.

When comparing the values indicated on the display with those of the frequency meter, the deviation must not exceed more than 0.01 Hz.

The reset values are detected by increasing or decreasing the test frequency slowly till the output relay releases.

The reset value for over frequency must be smaller than the setting value of f_x+R , for Under frequency it must be larger than the setting value of f_x+R .

6.4.5 Checking of operating- and resetting values of the df/dt elements

Note!

During testing the df/dt function the two frequency elements should be checked individually. Therefore the other frequency functions must be blocked by adjusting the pickup values to "EXIT".

Frequency threshold f_e and the df/dt function can, however, only be tested with a function generator which can generate a definite frequency gradient.

6.4.6 Checking the tripping delays

For checking the tripping delays t_r a voltage source is needed which changes the frequency in a defined quantity at a certain time and at the same time generates an output signal.

While checking the tripping delay a timer can be connected with the contact of the tripping relay.

The timer is simultaneously started with the change of the frequency and stopped when the relay trips. Hereby the test frequencies have to be selected so that the relay detects a safe under- or over frequency. The tripping time measured with the aid of the timer should not deviate more than 3%, or more than 20 ms (at short trip-ping delay), from the set tripping delay.

It is to be observed that the measured time till tripping is longer by the number of the measuring periods (T) to be evaluated than the set tripping delay.

6.4.7 Checking the reclaim time of the frequency stages

The reclaim time are checked the same way as the trip delays. The difference in the tests is that the set frequency must lie above the excitation point and is rest below the excitation point after tripping has occurred in order to be able to determine the switch-off time.

6.4.8 Checking the external blocking- and reset functions

The external blocking input blocks the under frequency and df/dt functions of the MRF3 which are selected in the assignment mode (please refer to tab. 5.2 , page 16)

At the beginning of the test the auxiliary voltage is connected to terminals D8/E8 of the unit. Then a test frequency has to be set which normally leads to tripping of one of the frequency functions. Neither an alarm nor tripping must take place.

After this the auxiliary voltage has to be removed from the blocking input. Changing the frequency again by the same amount, the relay trips and the signal "TRIP" appears on the display. After this the test frequency must be set again to a value which does not lead to tripping. By applying auxiliary voltage to the reset input (C8/D8), the LED indication extinguishes and the display resets.

6.5 Primary injection test

Generally, a primary injection test could be carried out in the similar manner as the secondary injection test described above. With the difference that the protected power system should be, in this case, connected to the installed relays under test "on line", and the test voltages should be injected to the relay through the voltage transformers with the primary side energized. Since the cost and potential hazards are very high for such a test, primary injection tests are usually limited to very important protective relays in the power system.

Because of its powerful combined indicating and measuring functions, the MRF3 relay may be tested in the manner of a primary injection test without extra expenditure and time consumption.

In actual service, for example, the measured voltage and frequency values on the MRF3 relay display may be compared phase by phase with the concerned indications of the instruments of the switchboard to verify that the relay works and measures correctly.

6.6 Maintenance

Maintenance testing is generally done on site at regular intervals. These intervals vary among users depending on many factors: e.g. the type of protective relays employed; the importance of the primary equipment being protected; the user's past experience with the relay, etc.

For electromechanical or static relays, maintenance testing will be performed at least once a year according to the experiences. For digital relays like MRF3, this interval can be substantially longer. This is because:

- The MR-relays are equipped with very wide self-supervision functions, so that many faults in the relay can be detected and signaled during service. Important: The self-supervision output relay must be connected to a central alarm panel!
- The combined measuring functions of MR-relays enable supervision the relay functions during service.
- The combined TRIP test function of the MR-relay allows to test the relay output circuits.

A testing interval of two years for maintenance will, therefore, be recommended.

During a maintenance test, the relay functions including the operating values and relay tripping times should be tested.

7. Technical Data

7.1 Measuring input circuits

| | |
|-----------------|--|
| Rated data: | Nominal voltage U_N : 100 V, 230 V, 400 V Nominal frequency f_N : 50/60 Hz Operating range: $0.05...2.0 \times U_N$ Power consumption: <1 VA at U_N $f = 30 - 80$ Hz |
| Thermal rating: | continuously $2 \times U_N$ |

7.2 Common data

| | |
|--|--|
| Dropout to pickup ratio: | $f>: > 99.97\%$ $f<: < 100.03\%$ |
| Dropout time: | 60 ms |
| Time lag error class index E: | ± 10 ms |
| Minimum operating time: | 30 ms |
| Max. allowed interruption of the auxiliary supply without influence to the function of the device: | 50 ms |
| Influences on frequency measuring: | |
| Aux. voltage: | in the range $0.8 < U_H/U_{HN} < 1.2$ not additional influences to be measured |
| Frequency: | no influences |
| Influences on delay time: | no additional influences to be measured |

For additional common data of all MR-relays please refer to manual "MR - Digital Multifunctional relays".

7.3 Setting ranges and steps

| Function | Parameter | Setting range | Steps | Tolerance |
|---|---------------------|--|---|-----------------|
| Display shows primary measured values | U | Sec. 1.01 - 6500 | 0,01; 0,02; 0,05; 0,1; 0,2;0,5; 1; 2; 5; 10; 20; 50 | None |
| Rated frequency | f_N | 50 Hz/60 Hz | 50 Hz/60 Hz | None |
| LEDs flash after excitation | | FLSH / NOFL | | None |
| Parameter change-over switch Function assignment of digital inputs | P2 | SET1; Set2; B_S2; R_S2; B_FR; R_FR; S2FR; B_EX; R_EX; EXS2; EXFR; EXEX | | None |
| Frequency measuring periods | T | 2...99 (periods) | 1 | None |
| Frequency measuring step 1 | f_1 | 30...49.99; EXIT; 50.01...70 Hz ¹ 40...59.99; EXIT; 60.01...80 Hz ² | 0.1; 0.01 Hz | 0.03 Hz |
| | f_1+R | (40 Hz... f_1^5 / f_1^6 ...60 Hz) ¹ (50 Hz... f_1^5 / f_1^6 ...70 Hz) ² | 0.1; 0.01 Hz | 0.03 Hz |
| | t_{f1} | $t_{f,min}$600 s; EXIT | 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0 s | ±1% bzw. ±20 ms |
| | t_R+t_{f1} | 0.06s...600s | 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0; 5.0; 10s | |
| Frequency measuring step 2 | f_2 | 30...49.99; EXIT; 50.01...70 Hz ¹ 40...59.99; EXIT; 60.01...80 Hz ² | 0.1; 0.01 Hz | 0.03 Hz |
| | f_2+R | (40 Hz... f_2^5 / f_2^6 ...60 Hz) ¹ (50 Hz... f_2^5 / f_2^6 ...70 Hz) ² | 0.1; 0.01 Hz | 0.03 Hz |
| | t_{f2} | $t_{f,min}$600 s; EXIT | 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0 s | ±1% bzw. ±20 ms |
| | t_R+t_{f2} | 0,06s...600s | 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0; 5.0; 10s | |
| Frequency measuring step 3 | f_3 | 30...49.99; EXIT; 50.01...70 Hz ¹ 40...59.99; EXIT; 60.01...80 Hz ² | 0.1; 0.01 Hz | 0.03 Hz |
| | f_3+R | (40 Hz... f_3^5 / f_3^6 ...60 Hz) ¹ (50 Hz... f_3^5 / f_3^6 ...70 Hz) ² | 0.1; 0.01 Hz | 0.03 Hz |
| | t_{f3} | $t_{f,min}$600 s; EXIT | 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0 s | ±1% bzw. ±20 ms |
| | t_R+t_{f3} | 0.06s...600s | 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0; 5.0;10s | |
| Frequency measuring step 4 | f_4 | 30...49.99; EXIT; 50.01...70 Hz ¹ 40...59.99; EXIT; 60.01...80 Hz ² | 0.1; 0.01 Hz | 0.03 Hz |
| | f_4+R | (40 Hz... f_4^5 / f_4^6 ...60 Hz) ¹ (50 Hz... f_4^5 / f_4^6 ...70 Hz) ² | 0.1; 0.01 Hz | 0.03 Hz |
| | t_{f4} | $t_{f,min}$120 s; EXIT | 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0 s | ±1% bzw. ±20 ms |
| | t_R+t_{f4} | 0.06s...600s | 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0; 5.0; 10s | |
| Thresholds and tripping values for df/dt-measuring | $f_e + df_1$ | 40...49.999; VARI ³ ; 50.001...60Hz ¹ 50...59.999; VARI ³ ; 60.001...70Hz ¹ | 0.1; 0.01 Hz | 0.03 Hz |
| ⁴⁾ Bottom limit value for df/dt measuring | $f_e + df_1 + \min$ | EXIT; 40... 60Hz ¹ EXIT; 50... 70Hz ² | 0.1; 0.01 Hz | 0.03 Hz |
| ⁴⁾ Top limit value for df/dt measuring | $f_e + df_1 + \max$ | 40...60 Hz ¹ ; EXIT 50...70 Hz ² ; EXIT | 0.1; 0.01 Hz | 0.03 Hz |
| df/dt – step 1 | df_1 | -10...-0.2 Hz/s; EXIT; 0.2...10 Hz/s | 0.1; 0.2; 0.5 Hz/s | 0.1 Hz/s |
| | dt_1 | 2...64 (periods) | 1 | |
| Thresholds and tripping values for df/dt-measuring | $f_e + df_2$ | 40...49.999; VARI ³ ; 50.001...60Hz ¹ 50...59.999; VARI ³ ; 60.001...70Hz ¹ | 0.1; 0.01 Hz | 0.1 Hz/s |
| ⁴⁾ Bottom limit value for df/dt measuring | $f_e + df_2 + \min$ | EXIT; 40...60Hz ¹ EXIT; 50...70Hz ² | 0.1; 0.01 Hz | 0.03 Hz |
| ⁴⁾ Top limit value for df/dt measuring | $f_e + df_2 + \max$ | 40...60 Hz ¹ ; EXIT 50...70 Hz ² ; EXIT | 0.1; 0.01 Hz | 0.03 Hz |

| Function | Parameter | Setting range | Steps | Tolerance | |
|---------------------------------------|-----------------|-------------------------------------|--------------------|---------------------|-----|
| df/dt – step 2 | df ₂ | -10...-0.2 Hz/s; EXIT;0.2...10 Hz/s | 0.1; 0.2; 0.5 Hz/s | 0.1 Hz/s | |
| | dt ₂ | 2...64 (periods) | 1 | | |
| Blocking the frequency measuring | UBmin | 5 – 100 V | 1 V | 1% from rated value | |
| Releasing for the frequency measuring | | 12 – 230 V | 1 V | | |
| | | 20 – 400 V | 2 V | | |
| | | UBmax | 5 – 100 V | | 1 V |
| | | | 12 – 230 V | | 1 V |
| | | 20 – 400 V | 2 V | | |

7.1: Setting ranges and steps

1 for setting $f_N = 50$ Hz 2 for setting $f_N = 60$ Hz

3 f_e setting „VARI“:df/dt – measurement for mains decoupling „Setting values“:df/dt – measurement for load shedding schemes

4 Parameters appear with setting "VARI"/ 5 at over frequency setting / 6 at under frequency setting

7.4 Order form

| Frequenzrelais | | MRF3- | |
|-----------------------|--------------|--------------|---|
| Nennspannung: | 100 V | 1 | |
| | 230 V | 2 | |
| | 400 V | 4 | |
| Bauform (12TE): | 19"-Einschub | | A |
| | Türeinbau | | D |

Technical data subject to change without notice!

Setting list MRF3

Project: _____ Woodward-job.-no.: _____

Function group: _____ Location: + _____ Relay code: - _____

Relay functions: _____ Password: _____

Setting of the parameters

System parameter

| Function | | Unit | Default settings Set 1/Set 2 | Actual settings Set 1/Set 2 |
|----------------------------------|--|------|---------------------------------|--------------------------------|
| $U_{\text{prim}}/U_{\text{sek}}$ | Voltage transformer ratio | | SEK | |
| f_N | Rated frequency | Hz | 50Hz | |
| LED Flash | Display of the activation storage | | FLSH | |
| P2/FR | Parameter set change-over switch/ Trigger off from external/ recording of external functions * | | SET1 | |

* Recording of external functions in the fault recorder is only possible with Modbus Protocolcol (refer to Chapt. 5.4.1)

Protection parameter

| Function | | Unit | Default settings Set 1/Set 2 | Actual settings Set 1/Set 2 |
|------------------------------|--|----------|---------------------------------|--------------------------------|
| f_N | Nominal frequency | Hz | 50 | |
| T | Measuring repetition for frequency measurement | | 4 | |
| f_1 | Pickup value of the first frequency element | Hz | 48.00 | |
| t_{f1} | Tripping delay of the first frequency element | s | 0.1 | |
| f_1+R | Reclaim value of the first frequency stage | Hz | 48.01 | |
| $t_{f1}+t_R$ | Reclaim time of the first frequency stage | s | 0.06 | |
| f_2 | Pickup value of the second frequency element | Hz | 49.00 | |
| t_{f2} | Tripping delay of the second frequency element | s | 0.1 | |
| f_2+R | Reclaim value of the second frequency stage | Hz | 49.01 | |
| $t_{f2}+t_R$ | Reclaim time of the second frequency stage | s | 0.06 | |
| f_3 | Pickup value of the third frequency element | Hz | 51.00 | |
| t_{f3} | Tripping delay of the third frequency element | s | 0.1 | |
| f_3+R | Reclaim value of the third frequency stage | Hz | 50.99 | |
| $t_{f3}+t_R$ | Reclaim time of the third frequency stage | s | 0.06 | |
| f_4 | Pickup value of the fourth frequency element | Hz | 52.00 | |
| t_{f4} | Tripping delay of the fourth frequency element | s | 0.1 | |
| f_4+R | Reclaim value of the fourth frequency stage | Hz | 51.99 | |
| $t_{f4}+t_R$ | Reclaim time of the fourth frequency stage | s | 0.06 | |
| $f_e(df_1)$ | Frequency threshold for df/dt-element 1 | Hz | VARI** | |
| $f_e(df_1) \text{ min}^{**}$ | Bottom limit value for the df/dt stage 1 | Hz | EXIT | |
| $f_e(df_1) \text{ max}^{**}$ | Top limit value for the df/dt stage 1 | Hz | EXIT | |
| df_1 | Pickup value for rate of change of frequency df/dt of the first frequency element | Hz/s | -0.2 | |
| dt_1 | Differential period or value of the tripping timer for the first df/dt element | Perioden | 4 | |
| $f_e(df_2)$ | Frequency threshold for df/dt-element 2 | Hz | VARI** | |
| $f_e(df_2) \text{ min}^{**}$ | Bottom limit value for the df/dt stage 2 | Hz | EXIT | |
| $f_e(df_2) \text{ max}^{**}$ | Top limit value for the df/dt stage 2 | Hz | EXIT | |
| df_2 | Pickup value for rate of change of frequency df/dt of the second frequency element | Hz/s | +0.2 | |
| dt_2 | Differential period or value of the tripping timer for the second df/dt element | Perioden | 4 | |

| | | | | |
|-------------------|---------------------------------------|---|-----------|--|
| U _{Bmin} | Blocking of the frequency measurement | V | 10/23/40* | |
| U _{Bmax} | Releasing for the frequency measuring | | | |
| RS | Slave address of the serial interface | | 1 | |

*threshold dependent on rated voltage 100 V/230 V/400 V

**Parameters appear with setting „VARI“

Fault recorder

| Function | Unit | Default settings | Actual settings |
|----------|---|------------------|-----------------|
| FR | Number of recordings | 4N | |
| FR | Saving of the recording at the occurrence | TRIP | |
| FR | Time prior to trigger impulse | s | 0.05 |
| ⌚ | Year setting | year | Y=00 |
| ⌚ | Month setting | month | M=01 |
| ⌚ | Day setting | day | D=01 |
| ⌚ | Setting of the hour | hour | h=00 |
| ⌚ | Setting of the minute | minute | m=00 |
| ⌚ | Setting of the second | second | s=00 |

Blocking function

| Parameter set | Default settings | | | | Actual settings | | | |
|---------------|------------------|-------|--------------|-------|-----------------|-------|--------------|-------|
| | Blocking | | Not blocking | | Blocking | | Not blocking | |
| | Set 1 | Set 2 | Set 1 | Set 2 | Set 1 | Set 2 | Set 1 | Set 2 |
| f1 | X | X | | | | | | |
| f2 | X | X | | | | | | |
| f3 | | | X | X | | | | |
| f4 | | | X | X | | | | |
| df/dt1 | X | X | | | | | | |
| df/dt2 | X | X | | | | | | |

Assignment of the output relays

| Function | Relay 1 | | Relay 2 | | Relay 3 | | Relay 4 | |
|---|------------------|-----------------|------------------|-----------------|------------------|-----------------|------------------|-----------------|
| | Default settings | Actual settings | Default settings | Actual settings | Default settings | Actual settings | Default settings | Actual settings |
| f ₁ pick-up | X | | | | | | | |
| f ₁ tripping | X | | | | | | | |
| f ₂ pick-up | X | | | | | | | |
| f ₂ tripping | X | | | | | | | |
| f ₃ pick-up | | | X | | | | | |
| f ₃ tripping | | | X | | | | | |
| f ₄ pick-up | | | | | X | | | |
| f ₄ tripping | | | | | X | | | |
| df ₁ /dt ₁ tripping | | | | | | | X | |
| df ₂ /dt ₂ tripping | | | | | | | X | |

Setting of the code jumpers

| Code jumper | J1 | | J2 | | J3 | |
|-------------|------------------|-----------------|------------------|-----------------|------------------|-----------------|
| | Default settings | Actual settings | Default settings | Actual settings | Default settings | Actual settings |
| Plugged | | | | | | |
| Not plugged | X | | No function | | X | |

| Code jumper | Low/High-range for Reset input | | Low/High-range for blockage input | |
|------------------|--------------------------------|-----------------|-----------------------------------|-----------------|
| | Default settings | Actual settings | Default settings | Actual settings |
| Low=plugged | X | | X | |
| High=not plugged | | | | |

This technical manual is valid for

Software version number: D01-8.12 (MRF3)

Modbus version number: D51-1.13 (MRF3-M)

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