

## Findings of the Inspection of the Relay of the Rudder Controller M/T Northsea Rational

Order by Prof. Dr.-Ing. Friedrich Wirz (TUHH) on behalf of Bundesstelle für Seeunfalluntersuchung (BSU), Hamburg

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### 1 Purpose of this report

Two relays of Type “finder 60.13.9.024.0040 (Picture 1) have been handed over for inspection. One is labelled with “PORT”, the other one with “STBD”. The STBD-relay shall have failed and shall have caused a damage of the vessel. It is reported, that one of the normal open (NO) contactor pairs did not open after switching off the current of the coil. Both relays are plugged into sockets (Picture 2).



Picture 1: Labels of the relays



Picture 2: One of the relays with socket

It is the purpose of this investigation to help to understand, why this relay has a malfunction in the given situation.

The relays and all data and other information to the plant on the vessel come from Prof. Wirz, TUHH, who has an order from BSU to analyse the technical background of the incident.

## 2 Measurements

### 2.1 Test plan

It was agreed [ 1 ] to do in a first step only non-destructive (without removing the case of the relay) inspections and tests. These are:

- Visual inspection
- Measurement of resistances
- Measurement of closing and opening times

Further steps shall be planned later, if required.

### 2.2 Visual inspection

Both relays are clean and there are no visible damages except that there is some dust or smut inside the case near the contacts (Picture 3, Picture 4). It is much more in the case of the STBD-relay than in the PORT-relay. It is clear that the source of the dust or smut is inside the case.



Picture 3: Dust or smut in PORT-relay



Picture 4: Dust or smut in STBD relay

**2.3 Measurement of resistance**

Equipment:

- HIOK 3532 LCR Tester,  $f = 60 \text{ Hz}$ ,  $U = 1\text{V}$ ; 30 minutes warming-up, open and short condition compensated;
- Standard 24-V-DC-power supply

	<b>PORT-relay</b>	<b>STBD-relay</b>
<u>Coil (21 °C)</u>	425 $\Omega$	432 $\Omega$
<u>NC-contacts</u>		
11 – 12	32 $\text{m}\Omega$	17 $\text{m}\Omega$
21 – 22	28 $\text{m}\Omega$	17 $\text{m}\Omega$
31 – 32	16 $\text{m}\Omega$	32 $\text{m}\Omega$
<u>NO-contacts</u>		
11 – 14	19 $\text{m}\Omega$	16 $\text{m}\Omega$
21 – 24	20 $\text{m}\Omega$	18 $\text{m}\Omega$
31 – 34	15 $\text{m}\Omega$	16 $\text{m}\Omega$

The values are the mean of two measurements. The difference between the two measurements is always lower than 0.3  $\text{m}\Omega$

Result: No significant difference between the relays. All values are in a typical range for relays of this kind and size in a socket.

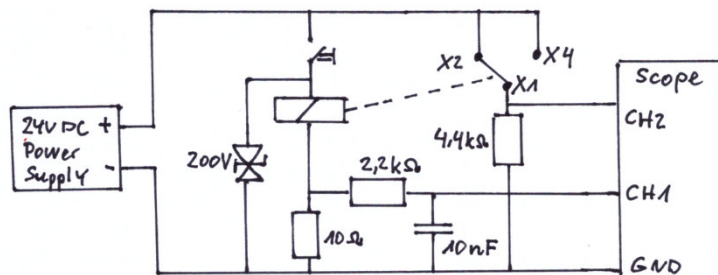
**2.4 Measurement of closing and opening times**

Equipment:

- Standard oscilloscope
- Standard 24-V-DC-power supply

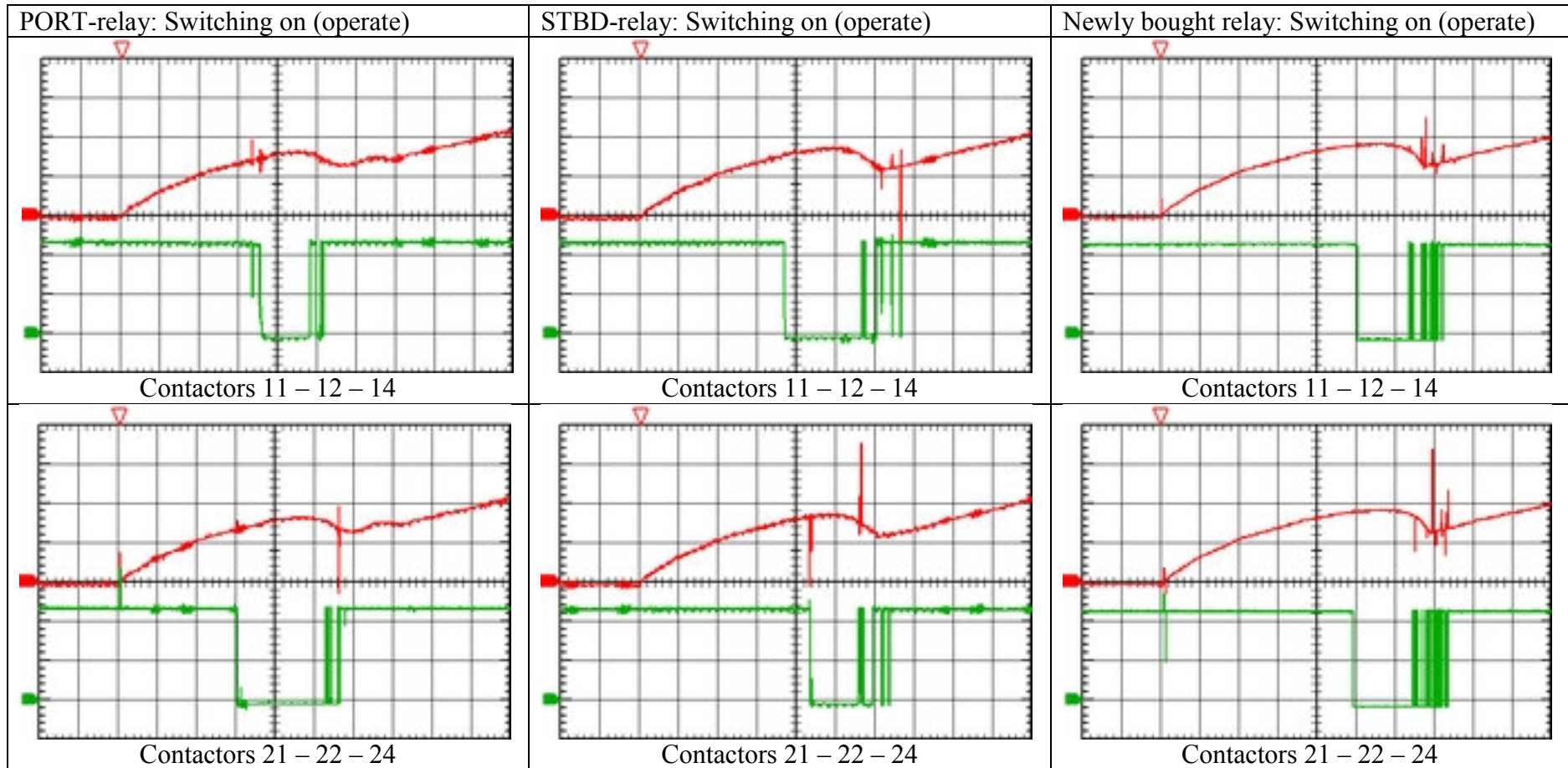
Test circuit

The test circuit is shown in Picture 5.

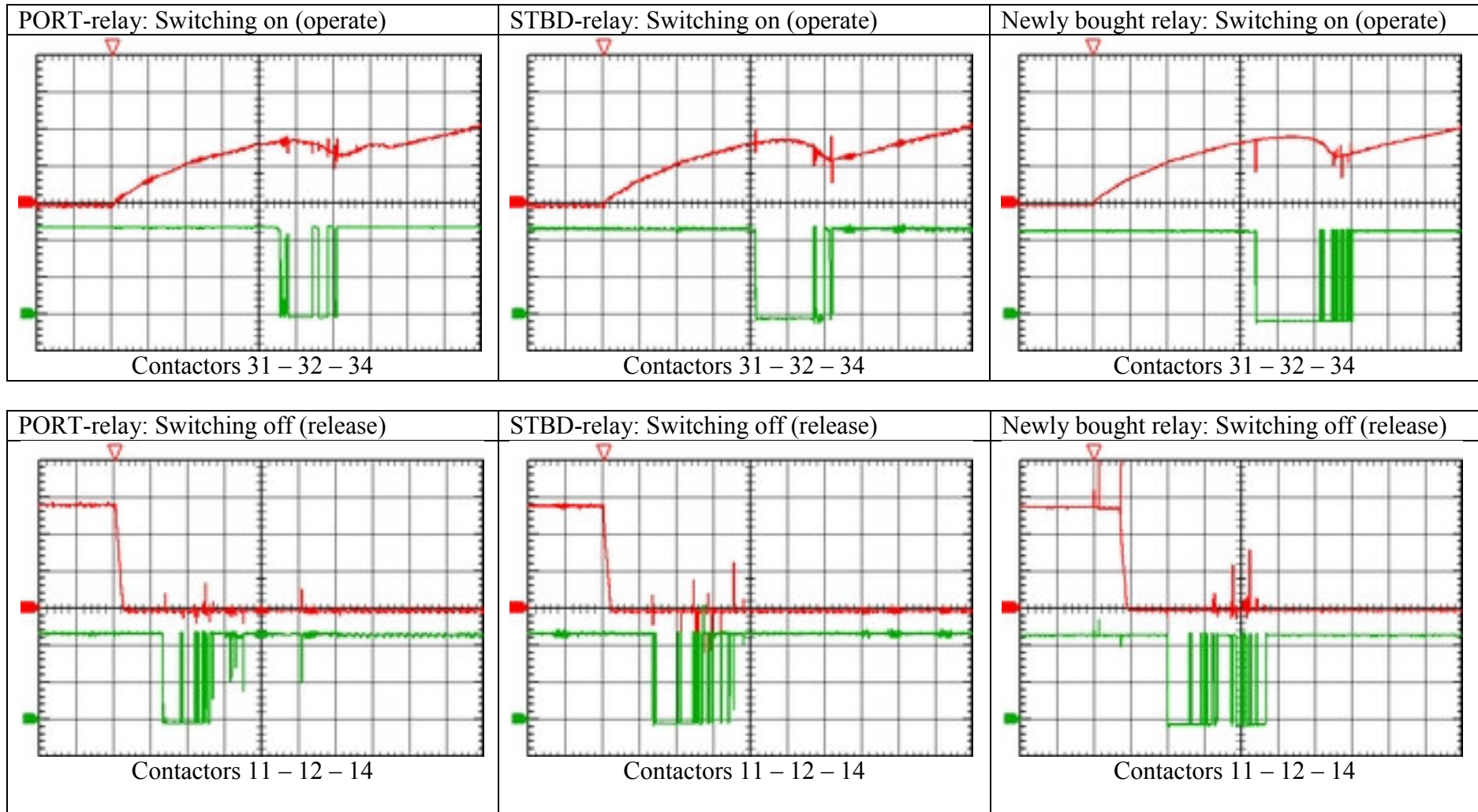


**Picture 5: Test-Circuit**

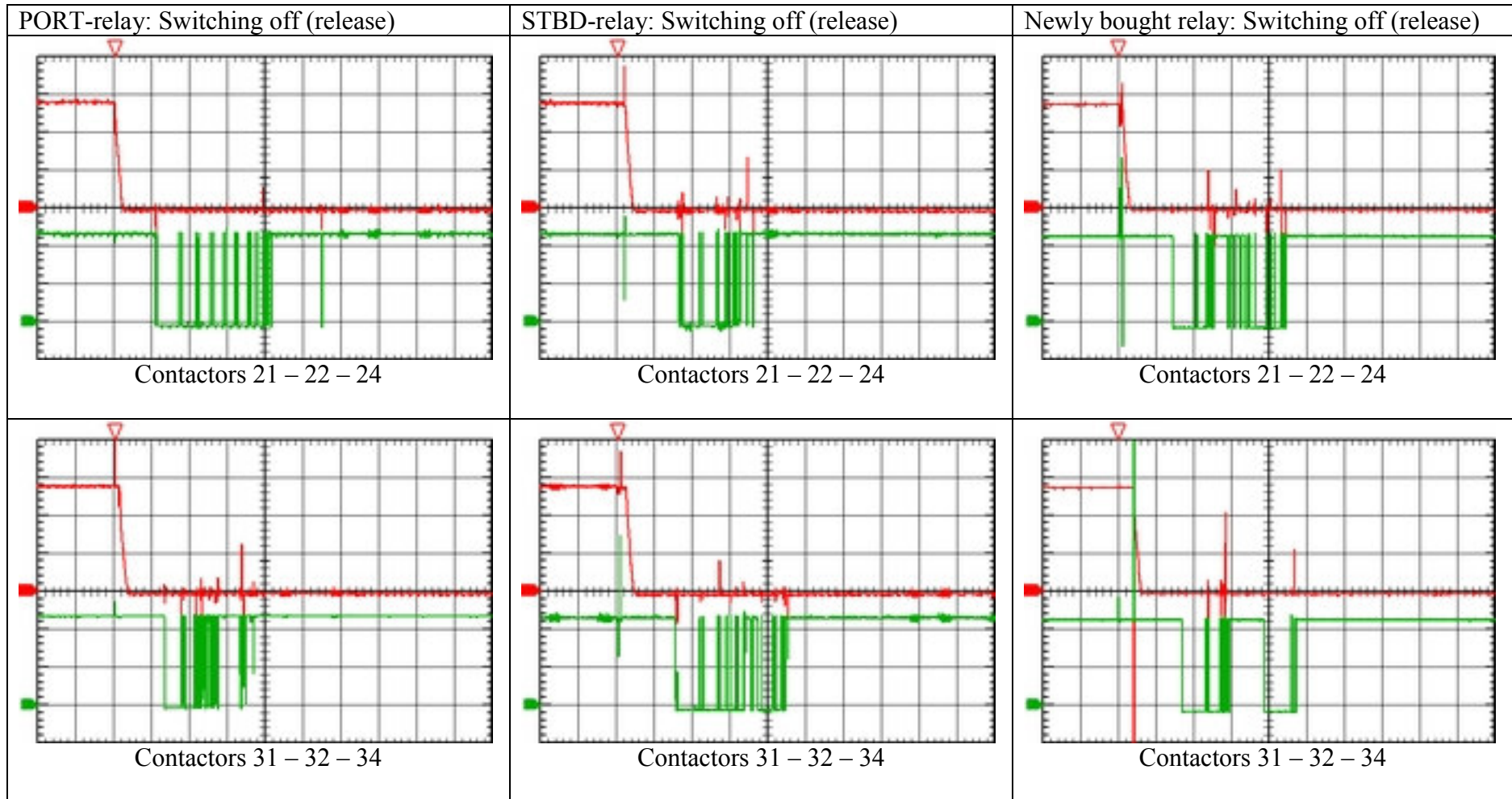
For comparison a new relay of the same type and maker as the two other is bought and measured.



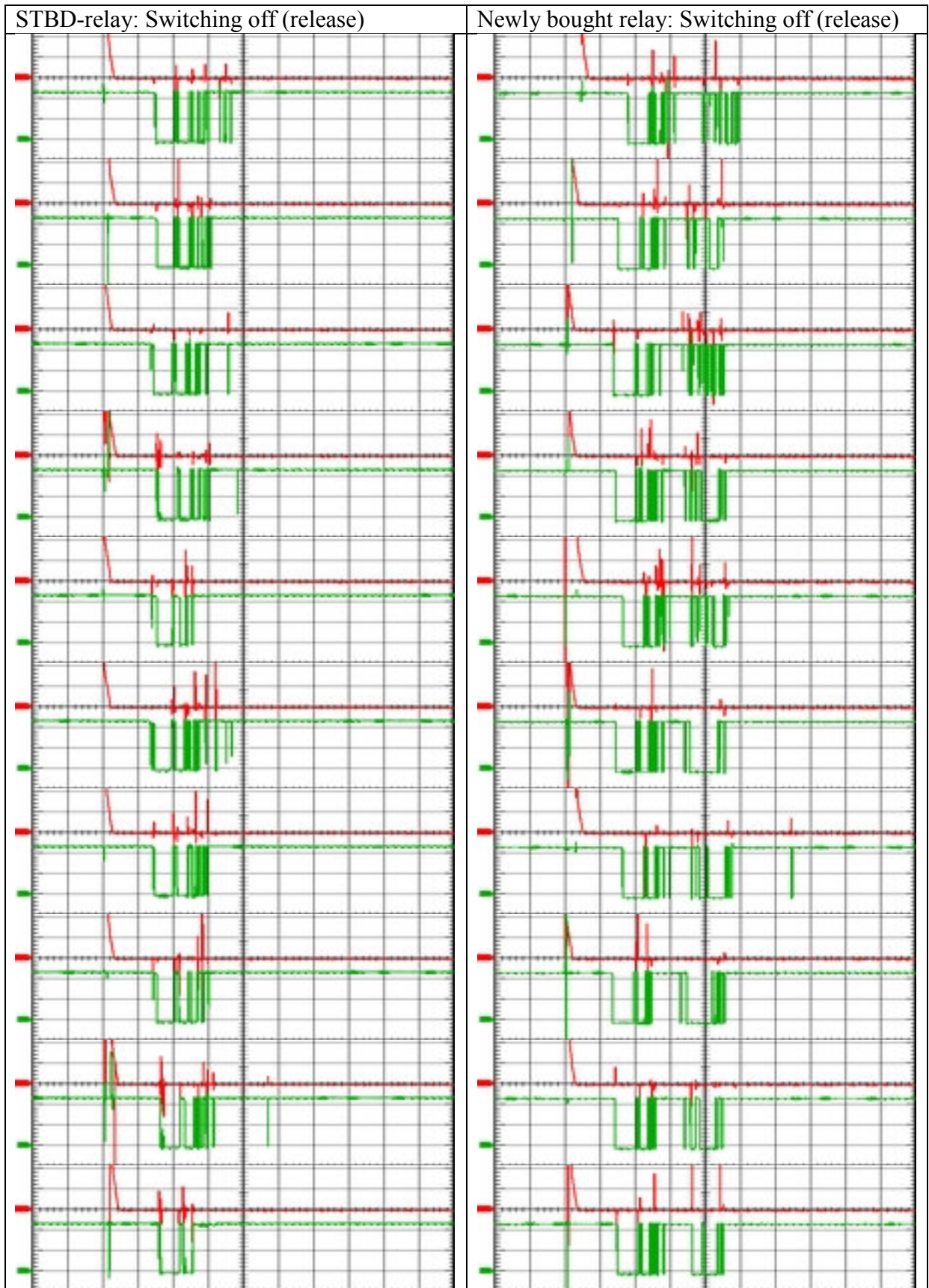
Picture 6: Operate times and bounce times: Horizontal: 2 ms/div; upper curve (red): Current in coil 20 mA/div; lower curve (green): Center contact connected to 24 V, low means, contactor is flying or bouncing. Specification [ 2 ]: Operate time 11 ms, bounce time 1 ms; (continue Picture 7)



Picture 7: (Continuation of Picture 6) Operate times, release times and bounce times: Horizontal: 2 ms/div; upper curve (red): Current in coil 20 mA/div; lower curve (green): Center contact connected to 24 V, low means, contactor is flying or bouncing. Specification [ 2 ]: Operate time 11 ms, bounce time 1 ms; Release time 4 ms, bounce time 4 ms; (continue Picture 8)



Picture 8: (Continuation of Picture 7) Release times and bounce times: Horizontal: 2 ms/div; upper curve (red): Current in coil 20 mA/div; lower curve (green): Center contact connected to 24 V, low means, contactor is flying or bouncing. Specification [ 2 ]: Release time 4 ms, bounce time 4 ms



Picture 9: Reproducibility of release times and bounce times: Horizontal: 2 ms/div; upper curve (red): Current in coil 20 mA/div; lower curve (green): Center contact connected to 24 V, low means, contactor is flying or bouncing. Contactors 31-32-34

The measurement results shown in Picture 6, Picture 7 and Picture 8 show that there are no significant differences between the three relays. Operate time, release time and bouncing times are reasonable with respect to the specification. It is reasonable to assume that the specified [ 2 ] times are maximum values. The times when closing and opening are lower than the specified values, some bouncing times are slightly higher.

Picture 9 shows the result of 10 measurements for the STBD-relay and the newly bought relay. It shows that there are clear differences between the bouncing in the 10 trials, but this is the case for both relays. There is no significant difference in the reproducibility between both relays.

### **3 Conclusion**

Neither the measurement of the resistance nor the measurement of closing and opening of the contacts show a significant difference between the Port-, STBD- and newly bought relays and the values are within the specified values respectively typical. No reason for a malfunction can be identified.

Due to the dust or smut in the case there is the suspicion that a heavy overcurrent or short circuit current has been switched off. It has to be emphasized that this must not have caused a serious damage to the contactors, but it is possible. This could be found out after disassembling the relay and inspecting the contact surface with a microscope.

### **4 Resources**

[ 1 ] Meeting with Prof. Wirz, TUHH, 11.01.2021

[ 2 ] Finder, General purpose relays 6 . 10 A, serie 60, I-2018ABB