Bundesstelle für
Flugunfalluntersuchung

German Federal Bureau of
Aircraft Accident Investigation

Warning-Unit readout and decoding
from
EC135 P2 N62UP

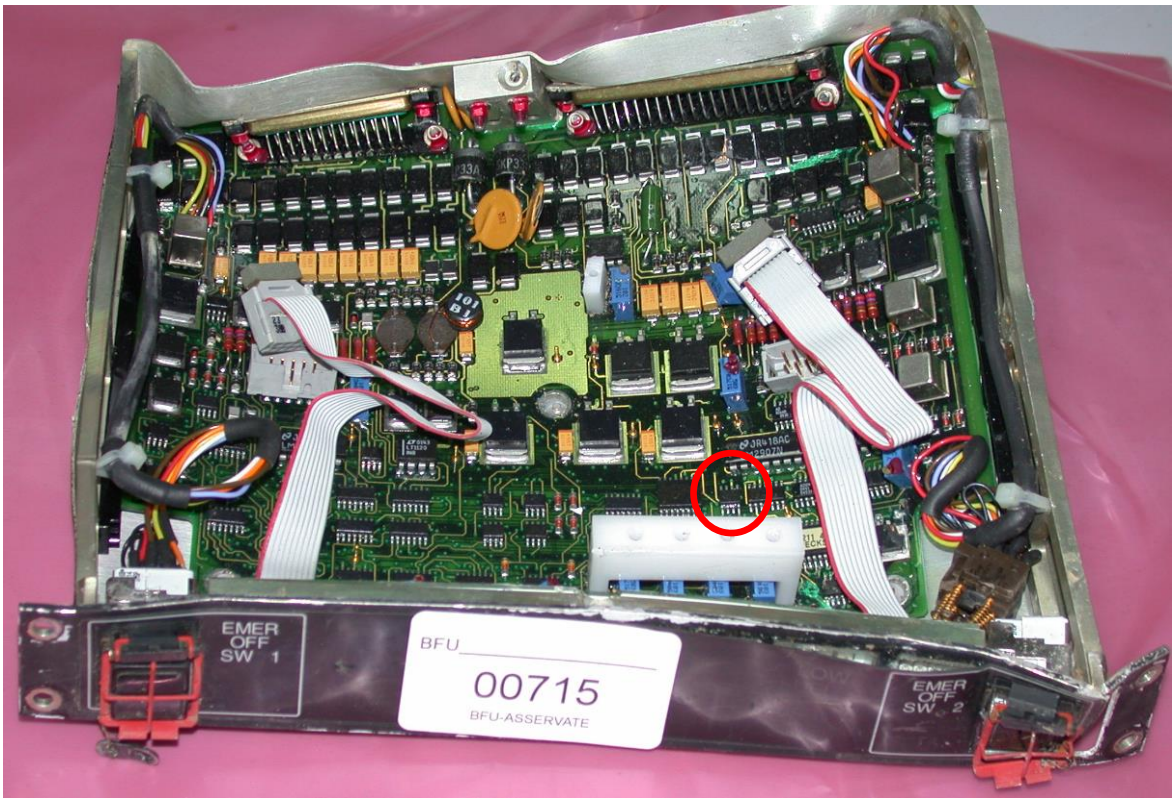
On May 25, 2017 an EC 135 P2 helicopter crashed during a Single Pilot IFR Training Flight near Wimington, New Castle Airport, USA.

The Warning-Unit was salvaged and sent to BFU in Braunschweig, Germany, where the raw data was extracted and decoded.

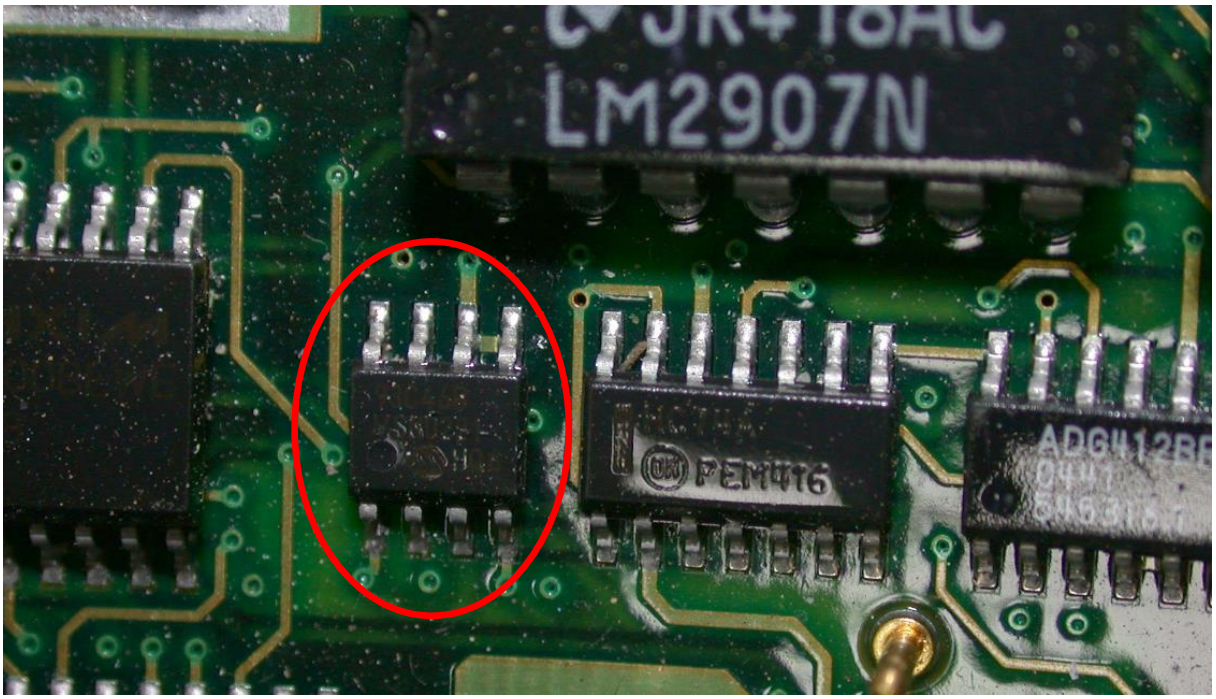
The work was performed by Mr. Philipp Lampert, Avionics-Expert of the BFU

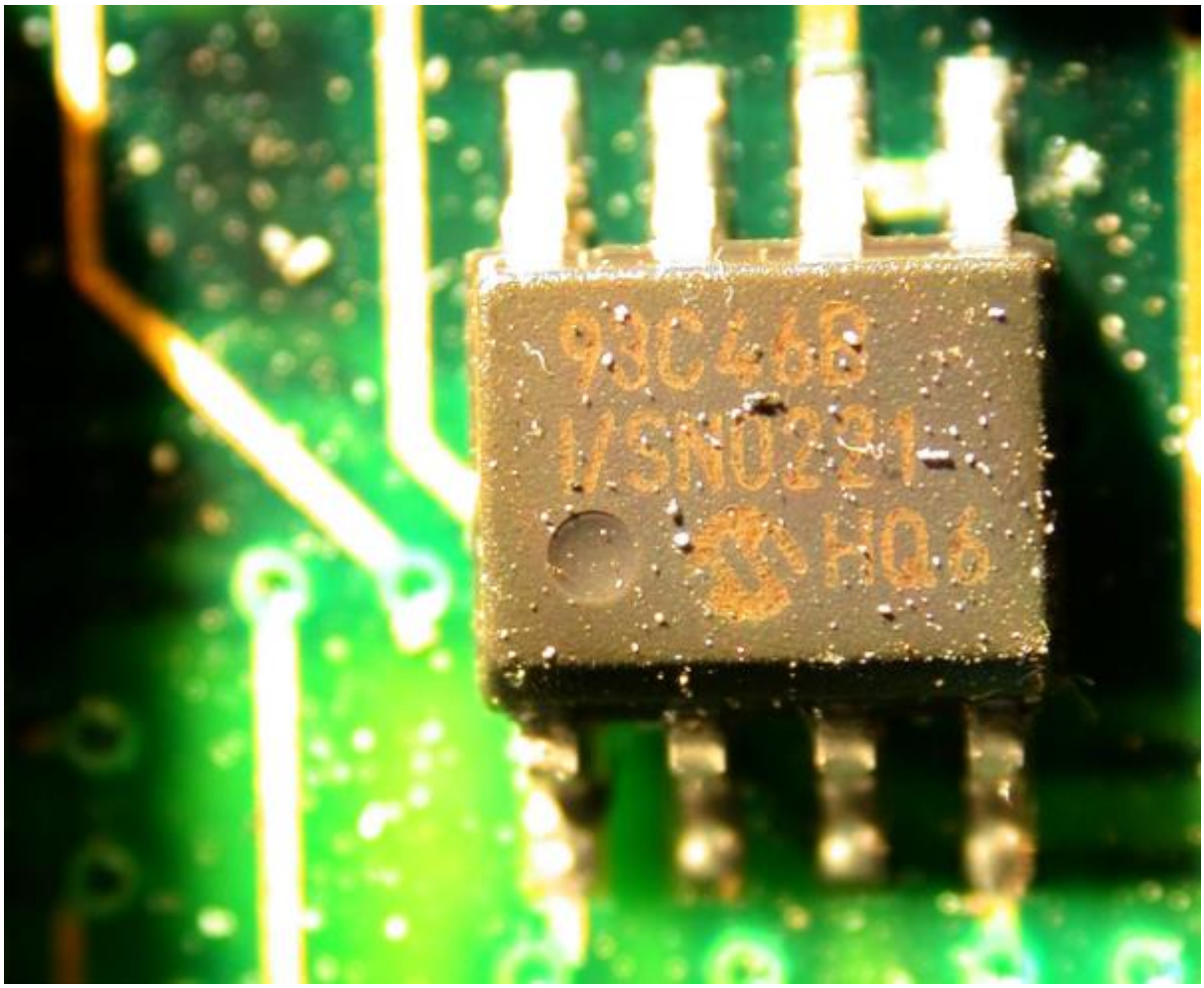
Arrival of the Warning Unit at the BFU End of November 2017

Overview of damages to the Warning-Unit, Opening December 23, 2017

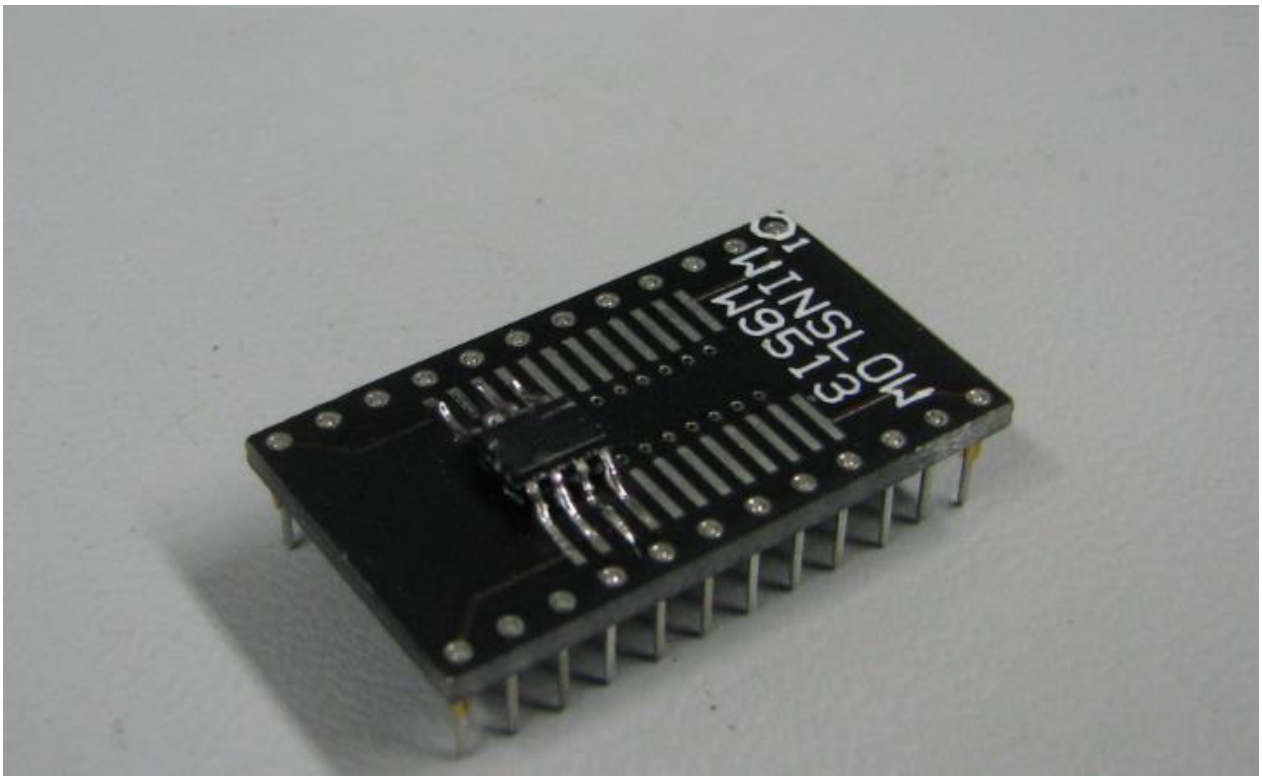


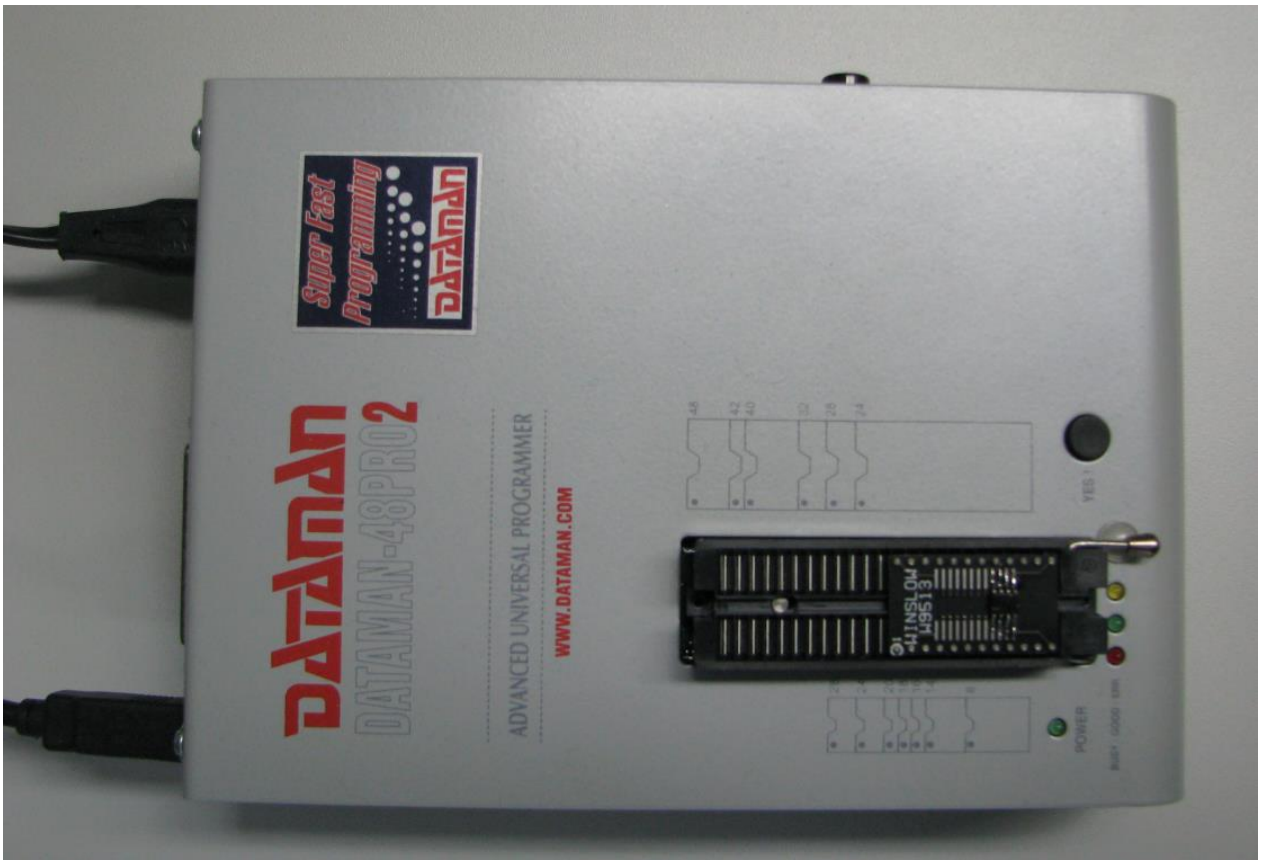
Unsoldering of memory chip





Preparing of memory chip for readout





Readout raw data and swapped for decoding:

93c46b_run1.bin

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	ANSI ASCII
00000000	37	C0	37	C0	02	C0	02	00	02	80	02	02	02	82	02	00	7À7À À € ,
00000010	02	80	02	01	02	81	02	41	02	C1	02	01	02	81	02	03	€ A Á
00000020	02	83	00	43	00	C3	00	03	00	83	00	01	00	81	00	00	ƒ C Ã ƒ
00000030	00	80	00	01	00	81	00	00	00	80	00	01	00	81	00	00	€ €
00000040	00	80	00	00	00	C0	02	00	02	C0	00	00	00	C0	02	00	€ À À À
00000050	02	C0	00	00	00	C0	20	00	20	C0	00	00	00	C0	00	00	À À À À
00000060	20	C0	20	00	20	C0	60	00	60	C0	00	00	00	40	02	43	À À` `À @ C
00000070	02	C3	02	03	02	83	02	02	02	82	02	42	02	C2	02	40	Ã ƒ , B Â @

93c46b_run1_swapped.bin

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	ANSI ASCII
00000000	C0	37	C0	37	C0	02	00	02	80	02	02	02	82	02	00	02	À7À7À € ,
00000010	80	02	01	02	81	02	41	02	C1	02	01	02	81	02	03	02	€ A Á
00000020	83	02	43	00	C3	00	03	00	83	00	01	00	81	00	00	00	ƒ C Ã ƒ
00000030	80	00	01	00	81	00	00	00	80	00	01	00	81	00	00	00	€ €
00000040	80	00	00	00	C0	00	00	02	C0	02	00	00	C0	00	00	02	€ À À À
00000050	C0	02	00	00	C0	00	00	20	C0	20	00	00	C0	00	00	00	À À À À
00000060	C0	20	00	20	C0	20	00	60	C0	60	00	00	40	00	43	02	À À `À` @ C
00000070	C3	02	03	02	83	02	02	02	82	02	42	02	C2	02	40	02	Ã ƒ , B Â @

After readout decoding of the raw data with use of a BFU-program

Record	Flight Marker	Audio	Visual	BFU remark
0	1	GONG GONG PERMANENT TONE	Auto Pilot 1 Alarme Gong 1 Rotor > 112 %	last entry prior accident
1	1	GONG GONG GONG	Auto Pilot 1 Rotor > 106 % Alarme Gong 1	
2	1	GONG GONG	Auto Pilot 1 Alarme Gong 1	
3	1	GONG GONG PULSED TONE	Auto Pilot 1 Alarme Gong 1 Rotor < 95 %	
4	1	GONG PULSED TONE	Auto Pilot 1 Rotor < 95 %	
5	1	GONG	Auto Pilot 1	
6	1	GONG GONG	Auto Pilot 1 Alarme Gong 1	
7	1	GONG	Auto Pilot 1	
8	1	GONG GONG	Auto Pilot 1 Rotor > 106 %	
9	1	GONG PERMANENT TONE	Auto Pilot 1 Rotor > 112 %	
10	1	GONG GONG	Auto Pilot 1 Rotor > 106 %	
11	1	GONG GONG GONG	Auto Pilot 1 Rotor > 106 % Alarme Gong 1	
12	1	GONG PERMANENT TONE	Alarme Gong 1 Rotor > 112 %	
13	1	GONG GONG	Rotor > 106 % Alarme Gong 1	
14	1	GONG	Rotor > 106 %	
15	1			
16	1	GONG	Rotor > 106 %	
17	1			
18	1	GONG	Rotor > 106 %	
19	1			normal flight
20	1		Rotor < 95 %	
21	1	GONG	Auto Pilot 1 Rotor < 95 %	AP-test in idle
22	1		Rotor < 95 %	
23	1	GONG	Auto Pilot 1 Rotor < 95 %	AP-test in idle
24	1		Rotor < 95 %	
25	1	GONG	BAT DISCH Rotor < 95 %	
26	1		Rotor < 95 %	
27	1		BAT DISCH Rotor < 95 %	
28	1	GONG	BAT DISCH Rotor < 95 %	
29	1	GONG GONG	BAT DISCH XMSN (oil pressure) Rotor < 95 %	start up accident flight
30	0		Rotor < 95 %	end of last flight

The BFU proposed an additional decoding by the BEA, (Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile, Zone Sud - Bâtiment 153, 200 rue de Paris, Aéroport du Bourget, F – 93352 Le Bourget Cedex) with the use of the official Warning-Unit manufacturer L'Hotellier-program

We already requested support and decoding from the BEA but have not the results yet.

Also due to holidays of Airbus we have not their input about the decoding yet.

The Warning Unit and the unsoldered memory chip will be in the storage of the BFU under the BFU file-number 17-0587-DX / Aservate 00715 until further notice.

Additional information about the Warning-Unit (abstract of a manufacturer explanation):

The warning unit is located in the upper centre of the instrument panel. It has a non volatile memory which can store 31 events in a chronological order but without time stamp. The data is written to the memory in a continuous loop. Therefore the number of flights which are stored in the memory depends on the number of events generated during each flight.

All status changes of the Warning Unit (Audio/Visio) represent an event and fill one of the 31 available memory spaces.

Example: Warning light goes ON → event
Warning light goes OFF → event
Audio Warning (e.g. Gong) goes ON →event
Audio Warning goes OFF →event

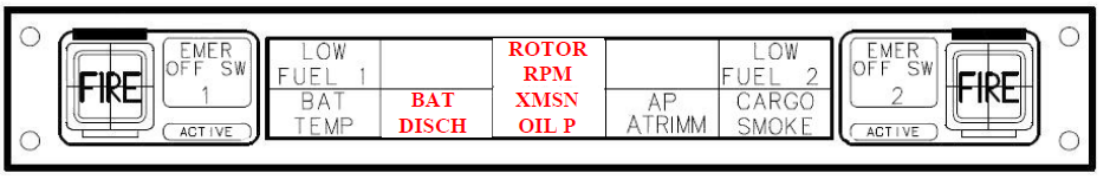
The change of the backlight illumination is not recorded
But: If the indication "FIRE", "EMER OFF SW 1/2" or "ACTIVE" are switched on, they will be recorded.

During the normal engine start procedure following warnings will always appear:
ROTOR RPM (<95%)
XMSN Oil P
BAT DISCH

At the beginning of the start procedure all three warnings illuminate:

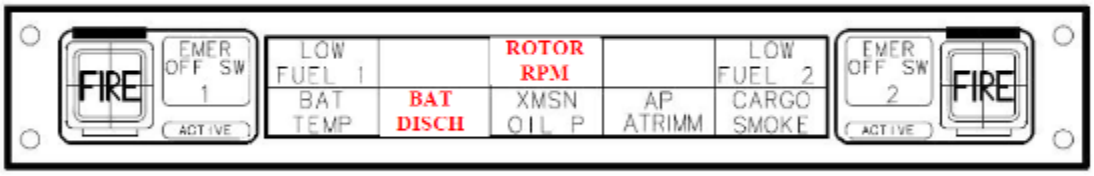
- ROTOR RPM (<95%) because the Main Rotor starts to turn slowly.
  Nominal Main Rotor RPM speed (100%) is 395 revolutions per minute
- XMSN Oil P: The Oil Pressure of the Main Transmission is below the threshold of 0,5 bar as the Main Transmission and therefore also the Oil Pumps which are driven by the Main Transmission start to turn.
- Battery DISCH: The battery is discharged because it feeds the starter which accelerates the first engine until it has reached its self-sustaining speed. This is also the case if the aircraft is started with an external power unit.

To start the engine the engine main switch is put to the IDLE position. In this position the engine will accelerate to Ground Idle Speed which is ≈ 74% Rotor RPM.



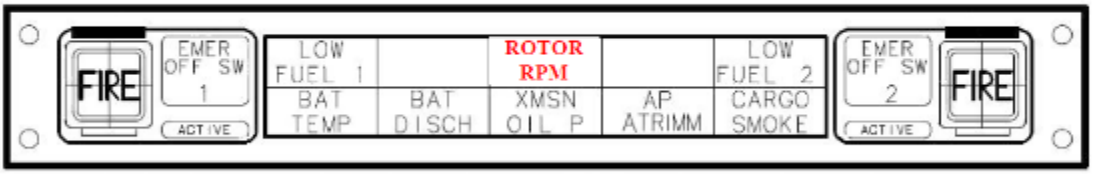
Beginning of engine start sequence

At first the Main Transmission Oil Pressure warning is turned off when the oil pressure rises above the threshold of 0,5 bar.



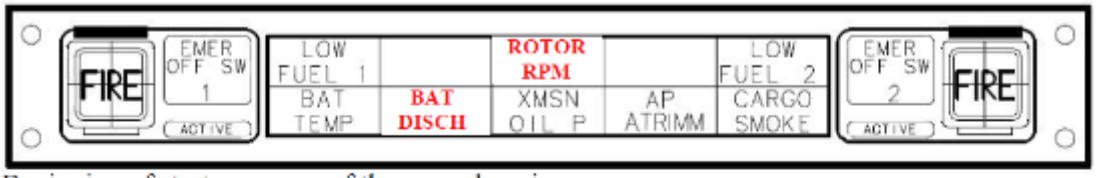
Main Transmission Oil Pressure Warning is turned off

Once the first engine has reached its self-sustaining speed the Starter/Generator switches from Starter to Generator mode. The threshold for this is set to 50% N1.



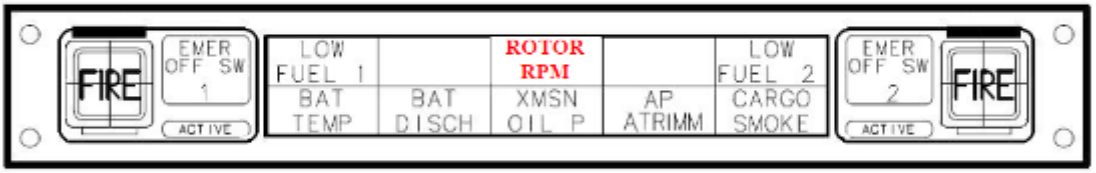
First engine has been started. As the engine is in IDLE mode it accelerates the main rotor to 74% RPM. Therefore the ROTOR RPM warning does not turn off.

The second engine is started and as the generator of the already running engine is not powerful enough to start the second engine on its own the battery discharge warning illuminates for a short time.



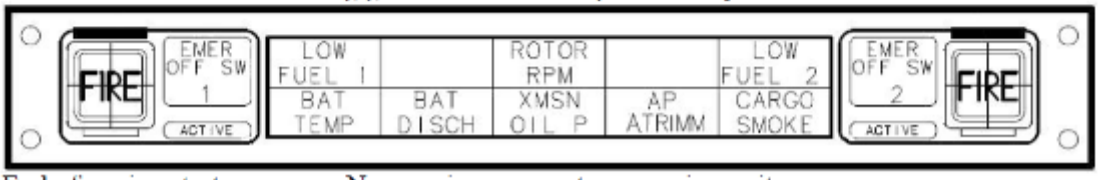
Beginning of start sequence of the second engine

Battery discharge warning goes off, because the generator only needs support from the battery for a very short time. The second engine accelerates to ground idle speed.



Engines running at ground idle speed

Finally the pilot puts both engine main switches to Flight they accelerate to 100% Rotor RPM and the ROTOR RPM warning goes off. The helicopter is ready for take off.



End of engine start sequence. No warnings present on warning unit

The following Warnings will be noticed and stored by the Warning-Unit:

3.1. Warnings

3.1.1. AP. A. TRIM

The warning AP. A. TRIM indicates a failure of the autopilot system. It is illuminated for 10 seconds. The signal is triggered by the autopilot computers.

3.1.2. Rotor RPM

The ROTOR RPM warning monitors a total of three limit values. It reacts in various ways depending on which limit value is exceeded or dropped below.

3.1.2.1. Rotor RPM < 95 % (<97 % T2/P2, T2+/P2+)

A steady red indication of ROTOR RPM and a pulsed tone is generated. (The pulsed tone can be switched off with AUDIO RES.)

3.1.2.2. Rotor RPM >106 %

The red indication ROTOR RPM flashes and a gong can be heard. (The gong can be switched off with AUDIO RES.)

3.1.2.3. Rotor RPM >112 %

The red indication ROTOR RPM flashes and a continuous tone is generated. (This tone cannot be switched off)

3.1.3. BAT TEMP

The red indication BAT TEMP comes on when a battery over temperature is detected (above 70 °C).

3.1.4. BAT DISCH

The red indication BAT DISCH comes on, when the battery is discharged more than 2 amperes.

3.1.5. XMSN OIL P

The red indication XMSN OIL P comes on when the oil pressure in the main gearbox is below 0.5 bar.

3.1.6. CARGO SMOKE

The red indication CARGO SMOKE appears, when there is a signal from the smoke detector in the rear cargo compartment.

3.1.7. FIRE-Warning with EMER OFF SW Switch

The warning unit consists of the fire warning logic circuit, FIRE indication with switch EMER OFF SW 1 and ACTIVE-indication respectively FIRE indication with switch EMER OFF SW2 and ACTIVE-indication.
The fire warning logic circuit displays individual fire warnings for engine 1 and engine 2 and if necessary activates the fire extinguisher system. Operation of the switch EMER OFF SW 1 cuts the fuel supply to engine 1 and the ACTIVE indication illuminates. Switch EMER OFF SW 2 cuts the fuel supply to engine 2.

3.1.8. LOW FUEL Warning

A low fuel warning is triggered by a sensor in the respective supply tank chambers of the fuel tank.

3.2. Audio Warnings

There are four kinds of audio warnings. They have different priority and some of them can be suppressed by the switch CDS AUDIO RES (located at the cyclic stick). But they recommence indicating with each new malfunction indication. The following exist in order of priority:

- Continuous tone: The continuous tone has a frequency of approx. 2400 Hz and cannot be suppressed. This tone is only activated by the signal ROTOR RPM > 112 %.
- Pulsed tone: The pulsed tone has a frequency of approx. 600 Hz and is generated with a 5 Hz rhythm. It can be suppressed. The pulsed tone is activated when ROTOR RPM is < 97 % (P2/T2) or 95 % (P1/T1).
- Gong: The gong is generated every three seconds and can be suppressed. The gong is activated as soon as any warning light illuminates, in case of ROTOR RPM only if the value of 106 % is exceeded. It may also be triggered by the Mast Moment Indicator and the LIMIT warning. Both are visualized on the FLI and not the warning unit.
- Warning bell: Can be suppressed and is activated by fire warning.

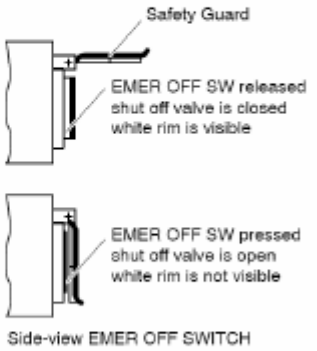
3.3. Other indications

3.3.1. ACTIVE

Illuminates white, if the EMER OFF SW has been released.

3.3.2. EMER OFF SW 1/2

Illuminates together with instrument lights.



Side-view EMER OFF SWITCH