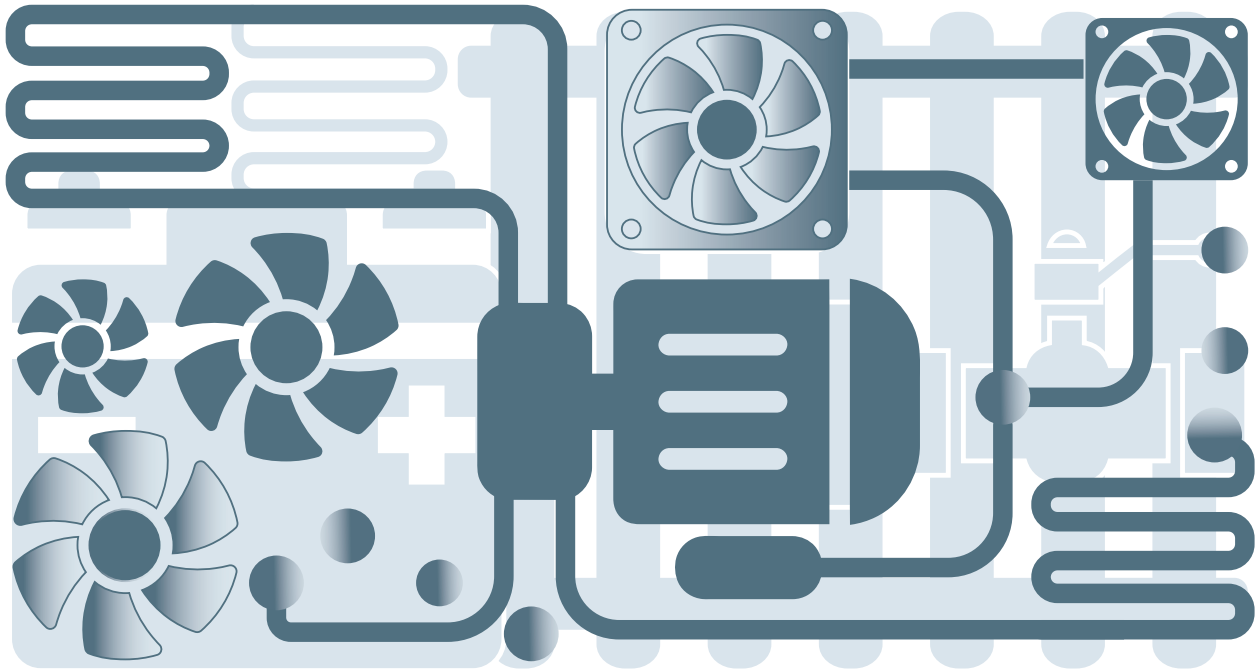
CARLO GAVAZZI
Automation Components

CARLO GAVAZZI

White paper



Pumps and fans ON/OFF monitoring

When knowing the motor is running makes the difference

Francesco Vedana
International Product Manager

May 2021

CARLO GAVAZZI

Pumps and fans ON/OFF monitoring. When knowing the motor is running makes the difference

INTRODUCTION

Turning a motor ON doesn't automatically mean that it is running. There may be failures around and the control system (a PLC or a Building Management System - BMS) must be informed that the action is not being delivered. The usual point is "how valuable is to know this early?", to trigger the actions to deploy as countermeasures. We'll address the most important aspects and propose some solutions to increase the value of the performance in applications like water circulation pumps and fans.

ABSTRACT

We'll illustrate a way to reduce down time in pumps and fans applications using early motor fault detection. This method uses the motor itself to detect if the respective service is operating correctly, to trigger some actions in case of failure. The result is a tangible reduction in down time (in some cases down to zero). Money is therefore saved and the value can be considerable, according to the specific application.

HOW TO KNOW IF THE SERVICE IS RUNNING

USING THE MOTOR AS A SENSOR

The two main questions the engineer has to address are:

1. **How can I know that the pump is actually pumping, or that the fan is really moving the air in the right way?**
2. **How can this be made in an effective and inexpensive way?**

The solution described uses the motor itself as a sensor, to state that the service is delivered. The assumption is that, if the current is flowing, the motor is running, and the service is provided. Is it always true? Not 100% of the times, even if the approximation can be very reliable. Some potential failure modes may not be detected and the engineer must find out how to detect them if they are likely for the specific application.

Locked rotor	If, for instance, the pump is seized, the current raises above the setpoint, so the motor is detected as running, although it is in a very dangerous state. It quickly starts overheating and, eventually, flaming. There is always a magnetic and thermal protection for this condition and it quickly trips. This ends up to no current, signalling that the service is not being performed anymore.
Blocked outlet (i.e. the water circuit is closed, or there is a closed damper after the fan)	The motor current increases, even if the thermal protection may not trip. A pump usually fails if water isn't circulating, bringing the situation back to the previous case. To be safe, in case this failure is perceived as likely, the engineer shall provide some further information on the status of the valves and the dampers to be communicated to the PLC (using limit switches, for instance).

Dry run in a pump	It is the enemy of the state for pumps. If this happens the pumps fails and locks very quickly, so we are back to the locked rotor case.
Loss of load (open pipe and water loss, or broken belt for a fan)	These are very major failures in the system because the damages may go far beyond the simple lack of service. Tools like water leakage sensors should be installed. Measuring the motor current won't help. Usually fans for this type of applications don't use a belt (used for quite bigger fans). If there is a belt, this failure won't be detected. At the same time, pipe failure isn't very likely to happen, unless very poor maintenance is in place.

A lot of failure modes, which are usually the most frequent, are detected:
- blown fuses;
- broken wires;
- motor coils insulation failures and;
- many more.

This makes detecting the motor current a very effective way to be sure that the service is taking place.
Finally, a failure of the current sensor itself (usually output stuck always ON or always OFF) is immediately detected by the PLC as soon as, for instance, the command is OFF and the feedback is ON.

OTHER WAYS TO KNOW IF THE SERVICE IS RUNNING

Monitoring motor current isn't the only way to know the service is provided. There are some other. Here below some examples with advantages and disadvantages.

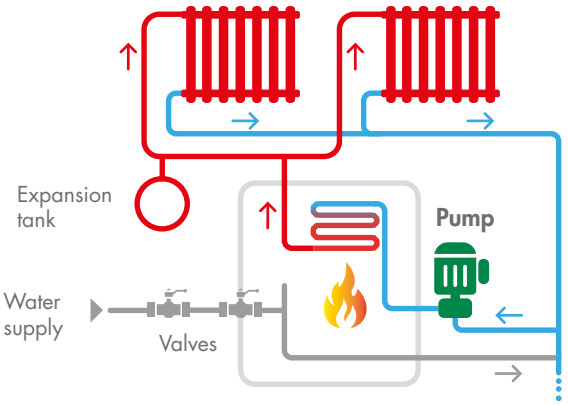
Use an auxiliary contact on the contactor/relay or on the circuit breaker		Very simple to install and inexpensive.
		What it detects is just the contactor/breaker status. A blown fuse, a wire cut, or any failure after the contactor aren't detected. This solution closes the loop a bit too early in the control chain.
Use the alarm relay of the Variable Frequency Drive		If the Drive is in the control loop and the relay output is available, it is absolutely a good idea.
		A lot of applications don't need variable speed, so it doesn't make sense to use a Variable Frequency Drive. Furthermore, an out-of-the-loop monitoring device is usually more reliable.
Install a pressure transducer (in case of fan) or a flow meter (in case of pump)		This solution closes the feedback loop at the very end, monitoring the real service. It is the ultimate way to know what is happening.
		There are mechanical parts (more subject to wear and tear) and the installation cost is higher. An air pressure transducer may not work properly, for instance if a door is left open.

WHEN KNOWING IN ADVANCE MAKES THE DIFFERENCE

As for any feature of the system, the engineer shall state the benefit of using an ON/OFF relay against the cost of the device, of the space in the cabinet, of cabling and of the inputs of the PLC. Here below some examples of applications where the benefits are widely larger than the costs.

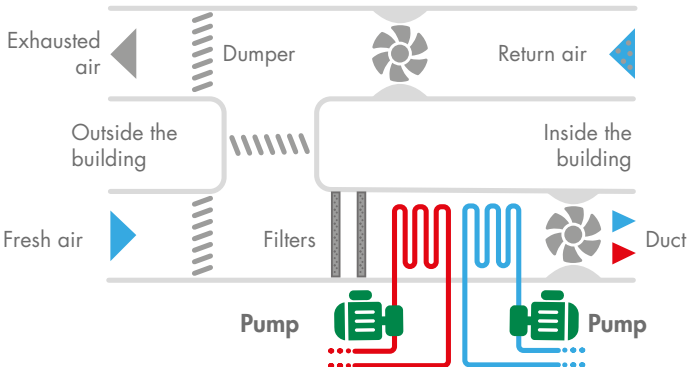
WATER CIRCULATION PUMPS IN HEATING OR COOLING SYSTEMS IN A BUILDING

These pumps are usually small, so the current to be detected may be below 1A. If used for hot water, when they fail the temperature of the building decreases quickly and some of the pipes run the risk to freeze. If with chilled water, the temperature of the building grows quickly and the quality of the ambient drops. At the end of the day, in both cases, the building may need to be evacuated as non-compliant to be used as a working environment. The money loss is large.
Knowing immediately that there is a fault, that is as soon as the pump stops working, rather than when the air temperature change is perceived, gives time to the service team to fix the issue even before it's time to evacuate the building, avoiding the corresponding loss.

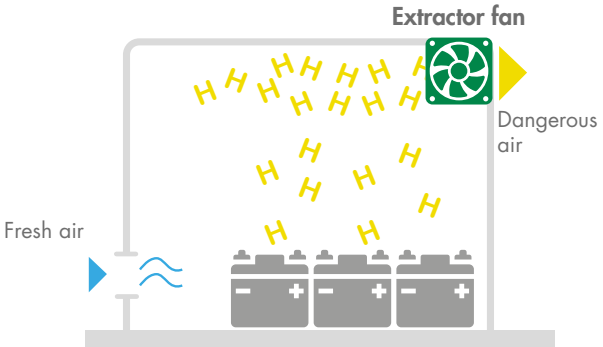


CHILLER WATER CIRCULATION IN AIR HANDLING UNITS

Air Handling Units may have an internal chiller or use cold water coming from an external one. In this case there is a pipe loop to feed a heat exchanger installed in one of the stages of the Air Handling Unit. Chilled water is provided using a pump. If it fails, the easiest and quickest way to detect the failure is to check if the pump is running. With this information the service team can be alerted to fix the issue before the quality of the air in the building isn't acceptable.



BATTERY ROOM FANS



A lot of companies have a small or medium battery room to feed the UPS. During heavy discharges (so are the ones generated by the UPS systems) and the recharges, the batteries may release hydrogen and oxygen through their valves. If the gas concentration arises above the ignition point, the ambient becomes explosive. That's why battery rooms are equipped with a small extractor fan to ensure air exchange in the room. The fan is small because the gas production is very limited, and its purpose is just to avoid gas accumulation.
Failure of the fan means potential danger, and has to be addressed immediately, so knowing if it is working is crucial.

INFORMATION COUNTS: LET'S USE IT!

Usually the command (start motor) and the feedback (motor running) go together. Otherwise, the PLC or BMS has some options, depending on the application. They don't exclude each other.

Inform the facility manager	This is always a good idea. The person in charge of the building immediately realises what is going wrong and decides what to do, probably among the following options.
Call the service team for immediate repair	In a heating or cooling system of an office building, the quality of the environment quickly deteriorates to chilling or too hot, the people working there may have to leave, so work is interrupted. A quick response of the service team may fix the issue before the effect is even perceived by the occupants.
Plan a service call	This solution is usually less expensive than the one before, because quick response normally costs more, and other service actions can be planned together with this one. For instance, there may be two pumps in the heating system and it's not very cold outside, so service can be delivered by a single pump until the service call is completed.
Deploy some counteractions to the effects of the failure	Sometimes this solution is feasible. In the battery room example, when the failure of the extractor fan increases the risk of having potentially explosive environment, the room window can be opened until the fan is fixed, if there is a window.

CHOOSING AN ON/OFF SENSOR FOR YOUR MOTOR

WHAT ARE THE MAIN FEATURES OF AN ON/OFF SENSOR?

SMALL SIZE
Space in the electrical panel is always limited and the engineer doesn't want to reorganise it or, worse, get a bigger cabinet. Ideally a small space below the relay or the contactor is the best option.

EASY TO INSTALL AND TO CABLE
Less cabling means less material and installation cost and less opportunities for mistakes.

EASY TO INTERFACE WITH A PLC
The output of the sensor should naturally connect to the PLC input. The best solution is a transistor, possibly both for NPN and PNP connection.

MOTOR INRUSH CURRENT MUST NOT BE AN ISSUE
It is much bigger than the nominal motor current and may damage the measuring input of the sensor, which must be very insensitive to it.

THE CARLO GAVAZZI SOLUTIONS

ON/OFF monitoring for small pumps and fans (open-collector output)

SOLUTION	With a built-in current transformer, it works for nominal currents from 200 mA to 60 A. Setpoint is fixed for trouble-free installation, and motor inrush current is easily managed thanks to a very high maximum transient current. No auxiliary power supply for less wirings, and the output is either NPN/PNP or AC/DC, to match the most used types of load. Finally, the size is further reduced and includes the panel mounting feature to adapt the device to every situation.
ADVANTAGES	• Space saving • Easy to install • Motor current down to 200 mA • No settings • Quick and easy to cable • High immunity to motor inrush current

Suggested device	EIS H 200MA 024: fixed setpoint 200 mA, NPN/PNP output EIS H 400MA 230: fixed setpoint 400mA, 0.5 A, 250 V ac/dc output
Standard function	ON/OFF load detection
Power supply	Not required
Main purpose	Inform the controller that the pump or the fan is working
Addressee of the notification	PLC, BMS

ON/OFF monitoring for large pumps and fans (open-collector output)

SOLUTION	DIA53 includes a built-in current transformer for nominal currents up to 100A, so for quite large loads. Combined NPN/PNP output makes the connection to the PLC immediate. Furthermore, there is no need of auxiliary power supply voltage, so installing it just means inserting the load cable through the hole, connecting two wires for the output, and adjusting the desired setpoint.
ADVANTAGES	• Space saving • Easy to install • Nominal current up to 100A • Quick and easy to cable • High immunity to motor inrush current

Suggested device	DIA53
Standard function	Overcurrent sensor
Power supply	Not required
Main purpose	Inform the controller that the pump is working
Addressee of the notification	PLC, BMS

ON/OFF monitoring for small pumps and fans (voltage-free contact output)

SOLUTION	Manages the current setpoint from 20 mA to 5 A nominal. It has a relay output, so a great variety of loads can be driven (even a lamp in a synoptic panel). It works brilliantly for small currents. It needs auxiliary power supply to work.
ADVANTAGES	• Potential free contact change-over output • Nominal current down to 20 mA

Suggested device	DIA02
Standard function	Overcurrent relay
Power supply	24-48 V ac/dc or 115/230 V ac
Main purpose	Activate a light, a relay, …
Addressee of the notification	PLC, notification lamp, bell, …

ON/OFF monitoring for large pumps and fans (voltage-free contact output)

SOLUTION	DIB01 combines the high nominal current of DIA53 (up to 100 A) and its insensitiveness to the inrush current with the flexibility of the relay output. The built-in current transformer makes installation easier and quicker, while multiple current ranges and adjustable time delay make the device extremely flexible, also to be used as a stand-alone solution. It requires an auxiliary power supply voltage.
ADVANTAGES	• Potential free contact change-over output • Nominal current from 2A • High immunity to motor inrush current

Suggested device	DIB01CM24100A
Standard function	Overcurrent relay
Power supply	24 V dc and 24 to 240 V ac
Main purpose	Activate a light, a relay, …
Addressee of the notification	PLC, notification lamp, bell, …

CONCLUSIONS

Having a feedback on the status of a lot of loads can be crucial to save money in case of failure thanks to immediate and appropriate reaction. The easiest, most cost effective and quickest way, is measuring the motor current as a proxy of the service delivery. Using a current sensor, and comparing its output to the required action, provides the control system with the information to deploy the most appropriate counteraction and fix the issue minimising down time cost.

OUR SALES NETWORK IN EUROPE

AUSTRIA
Carlo Gavazzi GmbH
Ketzergasse 374,
A-1230 Wien
Tel: +43 1 888 4112
Fax: +43 1 889 10 53
office@carlogavazzi.at

BELGIUM
Carlo Gavazzi NV/SA
Mechelsesteenweg 311,
B-1800 Vilvoorde
Tel: +32 2 257 4120
Fax: +32 2 257 41 25
sales@carlogavazzi.be

DENMARK
Carlo Gavazzi Handel A/S
Over Hadstenvej 40,
DK-8370 Hadsten
Tel: +45 89 60 6100
Fax: +45 86 98 15 30
handel@gavazzi.dk

FINLAND
Carlo Gavazzi OY AB
Ahventie, 4 B
FI-02170 Espoo
Tel: +358 9 756 2000
myynti@gavazzi.fi

FRANCE
Carlo Gavazzi Sarl
Zac de Paris Nord II, 69, rue de la Belle Etoile,
F-95956 Roissy CDG Cedex
Tel: +33 1 49 38 98 60
Fax: +33 1 48 63 27 43
french.team@carlogavazzi.fr

GERMANY
Carlo Gavazzi GmbH
Pfnorstr. 10-14
D-64293 Darmstadt
Tel: +49 6151 81000
Fax: +49 6151 81 00 40
info@gavazzi.de

GREAT BRITAIN
Carlo Gavazzi UK Ltd
4.4 Frimley Business Park,
Frimley, Camberley, Surrey GU16 7SG
Tel: +44 1 276 854 110
Fax: +44 1 276 682 140
sales@carlogavazzi.co.uk

ITALY
Carlo Gavazzi SpA
Via Milano 13,
I-20045 Lainate
Tel: +39 02 931 761
Fax: +39 02 931 763 01
info@gavazziacbu.it

NETHERLANDS
Carlo Gavazzi BV
Wijkermeerweg 23,
NL-1948 NT Beverwijk
Tel: +31 251 22 9345
Fax: +31 251 22 60 55
info@carlogavazzi.nl

NORWAY
Carlo Gavazzi AS
Melkeveien 13,
N-3919 Porsgrunn
Tel: +47 35 93 0800
Fax: +47 35 93 08 01
post@gavazzi.no

PORTUGAL
Carlo Gavazzi Lda
Rua dos Jerónimos 38-B,
P-1400-212 Lisboa
Tel: +351 21 361 7060
Fax: +351 21 362 13 73
carlogavazzi@carlogavazzi.pt

SPAIN
Carlo Gavazzi SA
Avda. Iparraguirre, 80-82,
E-48940 Leioa (Bizkaia)
Tel: +34 94 480 4037
Fax: +34 94 431 6081
gavazzi@gavazzi.es

SWEDEN
Carlo Gavazzi AB
V:a Kyrkogatan 1,
S-652 24 Karlstad
Tel: +46 54 85 1125
Fax: +46 54 85 11 77
info@carlogavazzi.se

SWITZERLAND
Carlo Gavazzi AG
Verkauf Schweiz/Vente Suisse
Sumpfstrasse 3,
CH-6312 Steinhausen
Tel: +41 41 747 4535
Fax: +41 41 740 45 40
info@carlogavazzi.ch

OUR SALES NETWORK IN THE AMERICAS

USA
Carlo Gavazzi Inc.
750 Hastings Lane,
Buffalo Grove, IL 60089, USA
Tel: +1 847 465 6100
Fax: +1 847 465 7373
sales@carlogavazzi.com

CANADA
Carlo Gavazzi Inc.
2660 Meadowvale Boulevard,
Mississauga, ON L5N 6M6, Canada
Tel: +1 905 542 0979
Fax: +1 905 542 22 48
gavazzi@carlogavazzi.com

MEXICO
Carlo Gavazzi Mexico S.A. de C.V.
Circuito Puericultores 22, Ciudad Satelite
Naucalpan de Juarez, Edo Mex. CP 53100
Mexico
T +52 55 5373 7042
F +52 55 5373 7042
mexicosales@carlogavazzi.com

BRAZIL
Carlo Gavazzi Automação Ltda.Av.
Francisco Matarazzo, 1752
Conj 2108 - Barra Funda - São Paulo/SP
Tel: +55 11 3052 0832
Fax: +55 11 3057 1753
info@carlogavazzi.com.br

OUR SALES NETWORK IN ASIA AND PACIFIC

SINGAPORE
Carlo Gavazzi Automation Singapore Pte. Ltd.
61 Tai Seng Avenue #05-06
Print Media Hub @ Paya Lebar iPark
Singapore 534167
Tel: +65 67 466 990
Fax: +65 67 461 980
info@carlogavazzi.com.sg

MALAYSIA
Carlo Gavazzi Automation (M) SDN. BHD.
D12-06-G, Block D12,
Pusat Perdagangan Dana 1,
Jalan PJU 1A/46, 47301 Petaling Jaya,
Selangor, Malaysia.
Tel: +60 3 7842 7299
Fax: +60 3 7842 7399
info@gavazzi-asia.com

CHINA
Carlo Gavazzi Automation
(China) Co. Ltd.
Unit 2308, 23/F.,
News Building, Block 1,1002
Middle Shennan Zhong Road,
Shenzhen, China
Tel: +86 755 83699500
Fax: +86 755 83699300
sales@carlogavazzi.cn

HONG KONG
Carlo Gavazzi Automation
Hong Kong Ltd.
Unit No. 16 on 25th Floor, One Midtown,
No. 11 Hoi Shing Road, Tsuen Wan,
New Territories, Hong Kong
Tel: +852 26261332 / 26261333
Fax: +852 26261316

OUR COMPETENCE CENTRES AND PRODUCTION SITES

DENMARK
Carlo Gavazzi Industri A/S
Hadsten

CHINA
Carlo Gavazzi Automation (Kunshan) Co., Ltd.
Kunshan

MALTA
Carlo Gavazzi Ltd
Zejtun

ITALY
Carlo Gavazzi Controls SpA
Belluno

LITHUANIA
Uab Carlo Gavazzi Industri Kaunas
Kaunas

HEADQUARTERS

Carlo Gavazzi Automation SpA
Via Milano, 13
I-20045 - Lainate (MI) - ITALY
Tel: +39 02 931 761
info@gavazziautomation.com

Printed on 100% recycled paper
produced using
post consumer de-inked waste.

CARLO GAVAZZI
Automation Components

Energy to Components!

www.gavazziautomation.com

CARLO GAVAZZI

WP Pumps and fans ON/OFF monitoring ENG REV.00 04/21