ValveInsight

Data Acquisition – Application Manual

For further information please check our landing page: burkert.com/ValveInsight
The software package to integrate the switching detection and switching time measurement is freely available on GitHub.
github.com/buerkert/valveinsight

Contents

1 About this document 3

2 Inrush current basics 4

2.1 Introduction 4
2.2 Example data Bürkert type 6724 4
2.3 Example data Bürkert type 6757 5

3 Functions of ValveInsight 6

3.1 Switching Detection 6
3.2 Switching Time Monitoring (Switching Duration) 6
3.3 Advanced Functions 7

4 Limitations 8

5 Requirements 9

5.1 Preface 9
5.2 Power supply 9
5.3 Current measurement 10
5.4 Voltage measurement 11

6 Algorithm integration 12

7 Test electronics 13

7.1 ValveInsight Evaluation Board 13
7.2 ValveInsight Test Box 13

8 Example Schematics 14

8.1 Current Measurement 14
8.2 Voltage Measurement 16
8.3 Valve Control 17

9 Summary 18

1 About this document

The purpose of this manual is to help you to understand the functionality of ValveInsight and to give you a hands-on instruction of how to implement it into your application. Please note that this manual focuses on the functionalities of switching detection and switching time monitoring.
If you need further assistance with the implementation of ValveInsight, please contact us.

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2 Inrush current basics

2.1 Introduction

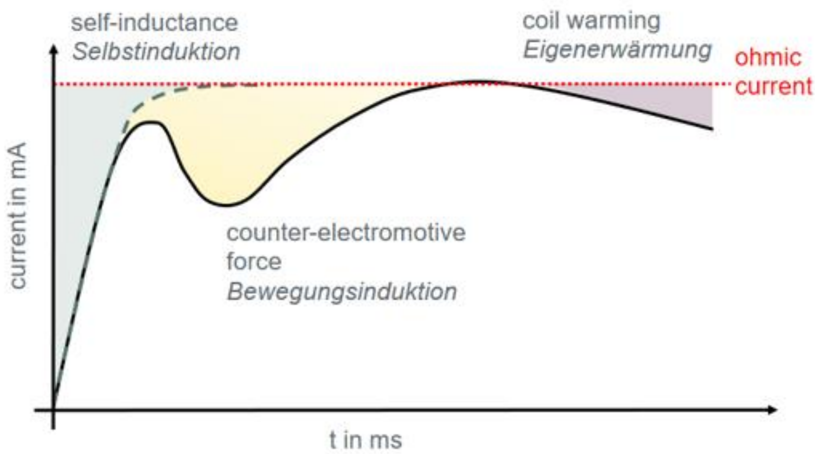

Figure 1: Schematic overview of the inrush current for a Bürkert electrodynamic valve.

A valve with an electrodynamic actuator will generate a mutual induction current during the movement of its coil. This induction current is superposed on the ohmic current and of a similar order of magnitude. Therefore, a measurement of the total current and a separation into induction current and ohmic current is relatively easy.
Figure 1 shows a schematic overview of the different parts of the inrush current for a Bürkert Whisper Valves using the example type 6724.
The first part – the steep increase – is dominated by the self-induction. The magnetic field builds up, but the actuator does not move. The build-up of the magnetic field is very fast because the actuator of Bürkert Whisper Valves has a big air coil.
The second part – the local minimum – is a superposition of self-inductance and counter-electromotive force due to the actuator movement. The counter-electromotive force dominates in this regime.
The third part of the current curve is a slow decrease of the current due to the warming of the system because of the ohmic resistance of the coil.

2.2 Example data Bürkert type 6724

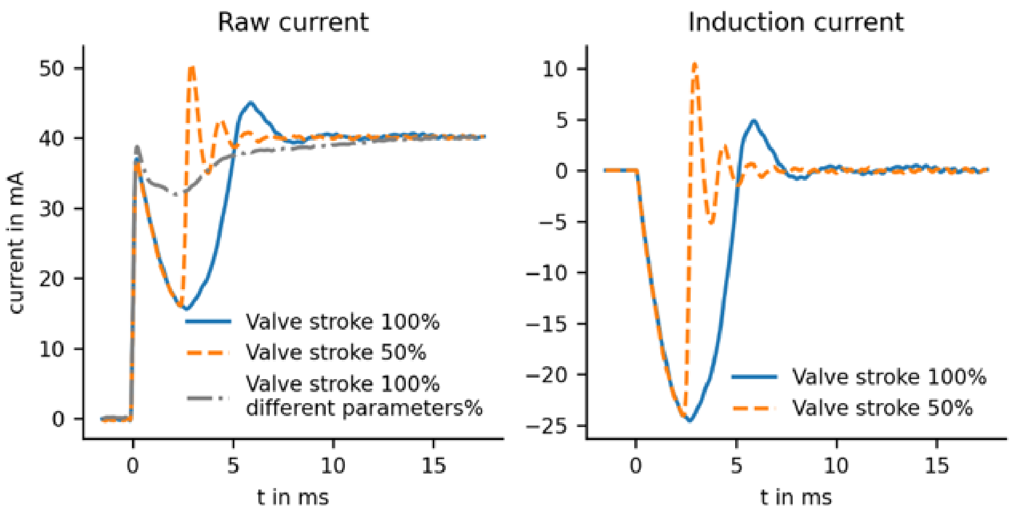

Figure 2: Raw current measurement of the Bürkert type 6724 electrodynamic valve (left). Estimate of the induction current for the same time span (right).

Figure 2 shows current measurements for Bürkert type 6724 valves. The other types of the Bürkert Whisper Valve series show similar behaviour (see chapter 2.3). The blue solid line shows the switching current for a fully functioning valve. The grey dash-dotted line in the left part of the figure shows the switching current for a fully functioning valve with different parameters. This highlights that the curve shapes of the inrush current among working valves can be quite different. The curve shape depends on parameters such as environmental temperature, coil temperature, diaphragm material, supply pressure, backpressure, supply voltage and so on. The difference between both curves is clear and pronounced and shows that valve and environmental parameters can be inferred from the curve shape.
If the environmental parameters are known, the curve shape is related to the movement of the actuator. The orange dashed line shows the inrush current for a damaged or blocked valve performing only a partial stroke. The partial actuator movement has a clear and pronounced effect on the current curve.

2.3 Example data Bürkert type 6757

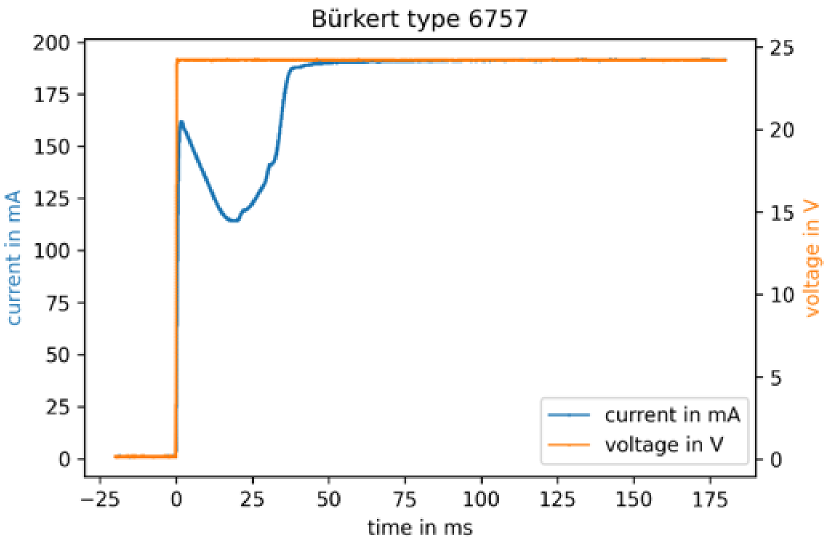

Figure 3: Raw current and voltage of a prototype Bürkert type 6757 electrodynamic valve.

Figure 3 shows the measured current and voltage for a Bürkert type 6757 valve. The type 6757 follows similar construction principles as the 6724, therefore the behaviour of the inrush current is comparable. Due to a different power range, the absolute value of the current is different

3 Functions of ValveInsight

3.1 Switching Detection

One of the standard algorithms offered by ValveInsight is switching detection. Utilizing a straightforward algorithm, the inrush current curve depicted in chapter 1 is employed to deduce actuator motion or stroke. The share of induction current derived from the curve provides this valuable information. The algorithm approximates the integral of the drop in the current curve resulting from the induction current, compared to a current curve without actuator movement. If the algorithm determines the integral to be significantly large, the valve is classified as switched. In cases where actuator movement is reduced due to a fault, this will be identified by a diminished integral, and the valve will be considered as not switched.

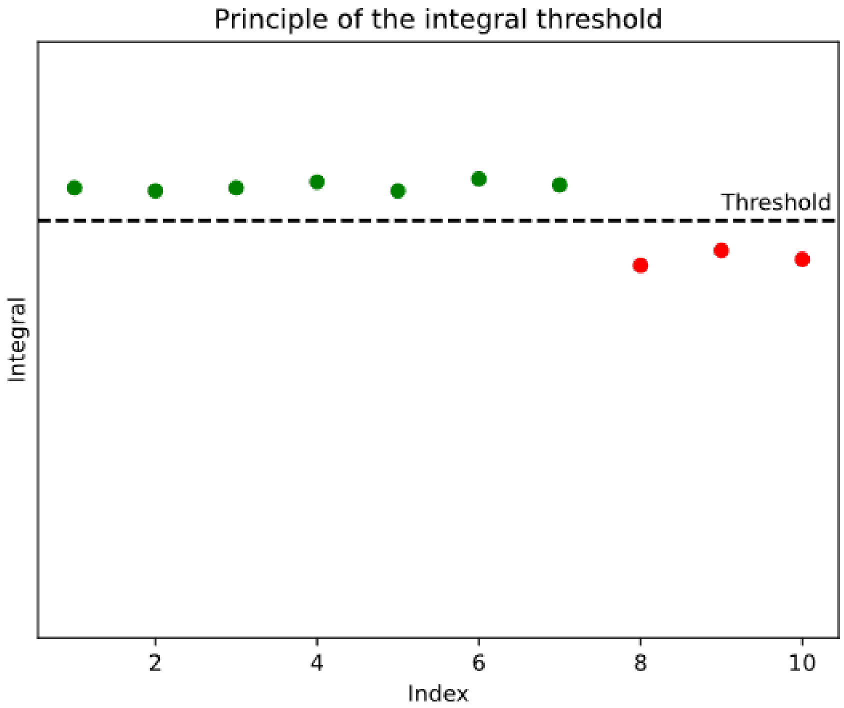

Figure 4: Principle of integral threshold to recognise poor switching

3.2 Switching Time Monitoring (Switching Duration)

In addition to detecting switching, ValveInsight also calculates switching duration. The switching time calculated by ValveInsight differs from the specifications in valve data sheets. According to DIN ISO 12238:2001, the data sheets determine the time based on pressure build-up on the outlet side from 0% to 10%. ValveInsight calculates switching time based on actuator movement alone.
The "Integral Threshold" method is recommended for calculating switching duration. This approach employs the same integral calculation as utilized in the switching detection algorithm. It identifies the switching duration by pinpointing the moment when the integral value initially surpasses the predefined threshold for successful switching.
Additional methods for determining the switching duration are available on the ValveInsight Github page.

3.3 Advanced Functions

In addition to the standard algorithms displayed, ValveInsight technology enables several advanced functions. These functions depend on parameters such as temperature, diaphragm material, supply pressure, backpressure, media viscosity, and others, which affect the switching behaviour of the valve. In most cases, these functions demand stricter requirements on valve control, measurement and analysis and require specific algorithm training.

For more information about the options available with intelligent valves featuring ValveInsight for your application, please contact us. Additionally, you can gain insights into the technical and physical principles of ValveInsight by reading our white paper titled “Whisper Valves with Diagnostic Features for the Smallest Liquid Volumes: Highly Precise and Reliable”.

4 Limitations

The following outlines the restrictions associated with the aforementioned standard algorithms:

- The integral calculation in the switching detection algorithm and the recommended method for determining the switching duration require the actuator movement to be completed. The algorithm detects the end of movement, but the valve must remain switched on long enough. For this purpose, the information from the table in chapter 5.3 (“Acquisition duration”) must be considered.
- Currently, the standard algorithms cannot be offered for device type 6724 with FFKM-HCR diaphragm.
- The standard algorithms for device types 6724 and 6757 as circuit function B are only available on request.
- The standard algorithms for device type 6712 are only available on request.
- Some variants of the 6757 contain an additional internal electronics circuit to optimize the switching behaviour. Using ValveInsight, we recommend using 6757 without internal electronics. Instead, integrate the circuit of internal electronics onto your own control unit to achieve an optimal ratio between switching behaviour and diagnostic capability. For more details, please contact us.
- Standard algorithms for 6757 with circuit function A and static back pressure cannot be offered. Please use circuit function I for such applications.
- Max. duty cycle for 6757 with orifice 4mm is 50%

5 Requirements

The control and measurement electronics must meet the following requirements to measure the current and voltage needed for ValveInsight.

5.1 Preface

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119.
The following requirements detail the data logging component, as the ValveInsight algorithms are intended to be integrated into central controls. A comprehensive explanation of the algorithm integration is provided in the according chapter.

5.2 Power supply

The power supply to the valve must work with an electronic switch (e.g. a MOSFET) to have no mechanical switch bouncing. The electronic switch should be designed as a Highside-Switch, especially for the advanced functions. The use of a Highside-Switch is generally recommended for ValveInsight.
The power supply should have a ripple and noise of less than 100 mV peak-peak.
The slope of the flank of the power supply to the valve should be more than 0.25 V / µs.

5.3 Current measurement

		Bürkert type 6712 (12V) / 6724 (12V)	Bürkert type 6712 (24V) / 6724 (24V)	Bürkert type 6757 (12V)	Bürkert type 6757 (24V)
Sampling rate	Must	100µs			
	Recommended	50µs			
Resolution		< 50µA		< 200µA	< 150µA
Accuracy (Signal noise)		< 100µA		< 400µA	< 250µA
Min. current		0mA			
Max. current		140mA	70mA	500mA[1]	250mA[1]
Acquisition duration[2]	Must[3]	25ms		100ms	
	Recommended[4]	>150ms		>200ms	

Table 1: Requirements for current measurements

- For advanced functions, the maximum current may be higher than the specified values, depending on the conditions
- For the standard algorithms, the device must be powered during the acquisition duration
- Minimum time required by most variants; Lower minimum time only on request
- Recommended time to include all limiting cases of external influences

The measurement setup must measure the current during the switching of the valve. The current measurement must start as soon as possible (< 100 µs delay) after the voltage is set or slightly rising (e.g. 1 ms before the voltage is set).
The requirements for the current measurement are listed in **Error! Reference source not found.**. With this s et of requirements, it is possible to handle each current curve that can occur within the specifications of the value. The requirements can be lowered,

- If the parameter space the valve is used in (only a certain temperature range, only a certain pressure range, etc.) does not include all limit cases,
- If the diagnostic quantity derived from the current curve is not required to be of high resolution (e.g. switching ok at > 90% flow, switching not ok < 50 % flow, in between no reliable statement possible).

5.4 Voltage measurement

		type 6712 (12V) / 6724 (12V)	type 6712 (24V) / 6724 (24V)	type 6757 (12V)	type 6757 (24V)
Sampling rate[1)]		<1ms	<1ms	<1ms	<1ms
Resolution		< 25mV	< 50mV	< 25mV	< 50mV
Accuracy (Signal noise)		< 25mV	< 25mV	< 25mV	< 25mV
Min. voltage[1)]		0V	0V	0V	0V
Max. voltage		14V	28V	14V	28V
Acquisition duration[2)]	Must[3)]	25ms		100ms	
	Recommended[4)]	>150ms		>200ms	

Table 2: Requirements for voltage measurement

- Significantly stricter requirements apply to advanced functions; shown requirements for standard algorithms only
- Shown requirements for standard algorithms only; an individual duration applies for advanced functions
- Minimum time required by most variants; Lower minimum time only on request
- Recommended time to include all limiting cases of external influences

Your electronics must measure the voltage during the switching of the valve. The requirements for the voltage measurement are given in Table 2.
Standard algorithms: The voltage can be measured as time series. It is also possible to only measure the final steady-state voltage at the end of the acquisition duration.
Most of the advanced functions need a high sampled negative voltage measurement.

6 Algorithm integration

Bürkert offers predefined standard algorithms on GitHub to easily integrate ValveInsight functionalities into your application. These include switching detection and switching time monitoring, available in Python or C for flexible integration. For details, see the repository's README file.
For a first impression, Jupyter Notebooks are provided to demonstrate and visualize the core algorithms.
To integrate the Python algorithms into your application, you need to include the following folder in your project. This will make the Python algorithms available for use.

https://github.com/Buerkert/ValveInsight/tree/main/algorithms_python/src/valveinsight

When utilizing Platform IO, you have the option to open the entire PlatformIO project. However, if you prefer to only integrate the C-algorithms into your project, you will need to copy the files from the following link:

https://github.com/Buerkert/ValveInsight/tree/main/algorithms_c/Valve%20Insight%20PlatformIO/lib

For those unfamiliar with ValveInsight, you can explore our example PlatformIO projects to understand the algorithms and integrate them on your device.

Scan the QR code below to go directly to the ValveInsight GitHub-respository

https://github.com/Buerkert/ValveInsight
It is advisable to offer a service interface for updating the algorithm, as it is consistently enhanced to ensure optimal utilization of ValveInsight's capabilities in the future.

7 Test electronics

7.1 ValveInsight Evaluation Board

The ValveInsight Evaluation Board offers a robust platform for testing its standard algorithms in a streamlined manner. The compact plug-on solution can be integrated in different environments. The board can be connected to a customer's environment through the communication interface. In addition, the board offers the possibility of using only individual circuit parts to carry out step-by-step commissioning on the customer's existing control system.

Figure 5: Bürkert ValveInsight Evaluation Board

Further information can be found in the manual of the Evaluation Board. The board can be purchased through Bürkert.
For optimal integration in series applications, it is advisable to incorporate ValveInsight into the customer's control system as outlined in this document. This approach ensures straightforward and cost-efficient implementation.

7.2 ValveInsight Test Box

The Test Box can perform different functions. In addition to demonstrating the integrated standard algorithms, this box provides the possibility of being used as a data logger and measurement electronics. This allows you to work together with Bürkert to develop special advanced functions to further extend the benefits of ValveInsight.

Figure 6: Bürkert ValveInsight Test Box

The test box is only available upon request via your Bürkert contact person and can be made available for initial tests or demonstrations for a limited period. It is not available for sales. The box is not suitable for serial usage, and we recommend implementing all ValveInsight functionality directly into existing electronics, as explained in this application manual.

8 Example Schematics

For series applications, we recommend integrating the measurement and control circuits directly into device electronics. This chapter outlines several recommendations from our perspective; however, these are not exhaustive, and alternative approaches may also be appropriate. Please note that Bürkert does not provide any guarantees nor accepts responsibility for the information provided in the following recommendations.

8.1 Current Measurement

For the current measurement, a basic combination of a shut and opamp can be used. On the evaluation board, the circuit below is used (R2 and C1-3 not strictly necessary but are recommended to avoid noise on the measured signal).

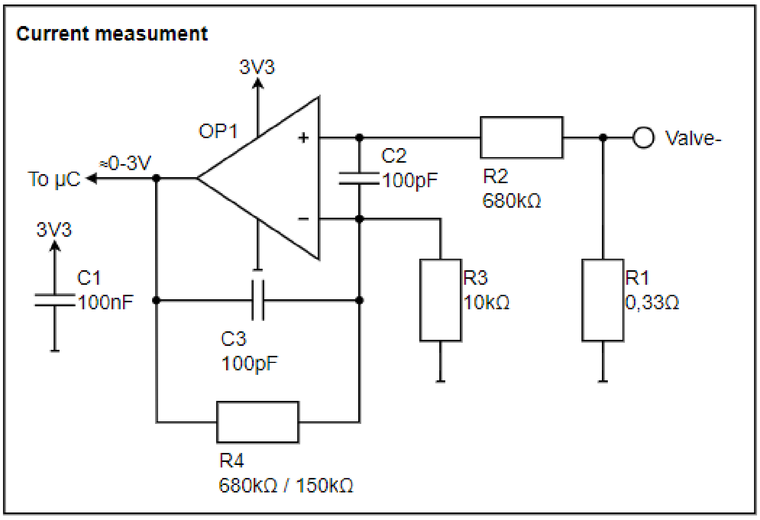

Figure 7: electronics circuit for current measurement

	Supplier	Ordercode	EOL [Years] [1]	Overall Risk [1]	Component price [2]	Price * Qty
OP1	Texas Instruments	TLV9001IDBVR	13.9	Low	0.089 €	0.089 €
	Microchip Technology	MCP6006T-E/OT	21.4	Low	0.140 €	
C1	Samsung EM	CL05B104KO5NNNC	4.9	Low	0.004 €	0.004 €
	KEMET	C0402C104K4RAC	10.2	Low	0.007 €	
C2&3	Samsung EM	CL05C101JB5NNNC	4.9	Low	0.003 €	0.006 €
	Kemet	C0402C101J5GAC	6.8	Low	0.005 €	
R1	Panasonic	PAN ERJ3RQFR33V	5.6	Low	0.032 €	0.028 €
	Bourns	CRL0603-FW-R330ELF	6.9	Low	0.028 €	
R2	Yageo	RC0402FR07680KL	6.7	Low	0.003 €	0.003 €
	Vishay	CRCW0402680KFKED	6.1	Low	0.008 €	
R3	Yageo	RC0402FR0710KL	12.7	Low	0.004 €	0.004 €
	Vishay	CRCW040210K0FKED	6.1	Low	0.007 €	
R4[3] 680kΩ	Yageo	RC0402FR07680KL	6.7	Low	0.003 €	0.003 €
	Vishay	CRCW0402680KFKED	6.1	Low	0.008 €	
R4[3] 150kΩ	Yageo	RC0402FR07150KL	6.7	Low	0.004 €	
	Vishay	CRCW0402150KFKED	6.1	Low	0.006 €	
TOTAL						**0.137€[4]**

[1] = Source: Siliconexpert / 2025.04.17

[2] = Source: Producer or Octoparts / 2025.04.17 / Median@Qty1000

[3] = Dependent on max measured current (150kΩ for 6757 otherwise 680kΩ)

[4] = component cost, assembly and handling costs are dependent on customers supply chain

8.2 Voltage Measurement

The voltage divider below is designed for 24V valves and to withstand relatively high positive and negative voltage spikes. Feel free to adjust as needed / convenient.

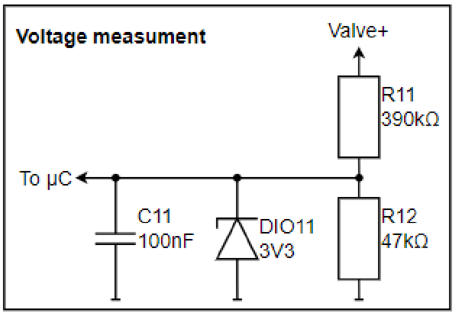

Figure 8: electronics circuit for voltage measurement

Product	Supplier	Ordercode	EOL [Years] [1]	Overall Risk [1]	Component price [2]	Price * Qty
R11	Yageo	RC0402FR-07390KL	12.9	Low	0.003 €	0.003 €
	Vishay	CRCW0402390KFKED	6.1	Low	0.008 €	
R12	Yageo	RC0402FR0747KL	6.7	Low	0.004 €	0.004 €
	Vishay	CRCW040247KFKED	6.1	Low	0.006 €	
DIO11	ON Semi	MM3Z3V3T1G	7.3	Low	0.022 €	0.022 €
	Diodes inc	BZT52C3V3S-7-F	6.2	Low	0.042 €	
C11	Samsung EM	CL05C101JB5NNNC	4.9	Low	0.003 €	0.003 €
	Kemet	C0402C101J5GAC	6.8	Low	0.005 €	
TOTAL						**0.032€[3]**

[1] = Source: Siliconexpert / 2025.04.17
[2] = Source: Producer or Octoparts / 2025.04.17 / Median@Qty1000
[3] = component cost, assembly and handling costs are dependent on customers supply chain

8.3 Valve Control

The use of a highside switch is recommended to not interfere with the measurements.

Product	Supplier	Ordercode	EOL [Years] [1]	Overall Risk [1]	Component price [2]	Price * Qty
C21	Samsung EM	CL05C101JB5NNNC	4.9	Low	0.003 €	0.003 €
	Kemet	C0402C101J5GAC	6.8	Low	0.005 €	
DIO21	Vishay	SMAJ28CA-E3/61	5.9	Low	0.068 €	0.068 €
	Yageo	SMAJ 28CA-TR	11.4	Low	0.075 €	
TR21	Vishay	SI2309CDS-T1-GE3	4.9	Low	0.190 €	0.169 €
	ON Semi	FDN5618P	6	Low	0.169 €	
TR22	Nexperia	PMV30ENEAR	12.7	Low	0.118 €	0.097 €
	Panjit	PJA3440_R1_00001	5.3	Low	0.097 €	
R21-23	Yageo	RC0402FR-0768KL	6.7	Low	0.003 €	0.009 €
	Vishay	CRCW040268K0FKED	6.1	Low	0.003 €	
TOTAL						**0.346€[4]**

Additional Information:

- R22 is used to avoid the maximum gate-source-voltage of TR21 to be exceeded
  ➔it can be removed if lower voltages e.g. 12V are used to switch the valve
- The free-wheeling diode and capacitor should be placed close to the switching transistor. This avoids fast current changes on long connections.
  ➔ lower emission of electromagnetic interference
- Allowing the current to flow through the Lorenz-force actuator through a free-wheeling diode reduces its speed while switching off. But if no path for the current to flow is provided. the voltage increases to damaging levels for the switching circuit.
  ➔ using a TVS-Diode as a free-wheeling diode can maximize switching speeds while protecting the semiconductor components.
  ➔ if the switching speed optimization is not needed. a cheaper option can be a normal diode.

9 Summary

ValveInsight enhances the intelligence of devices by monitoring the switching procedures for each individual valve. It offers two standard algorithms: providing data to ensure consistent and reliable switching behavior and to monitor the switching speed.

The application manual outlines the standard algorithms of ValveInsight and specifies the initial requirements for evaluation electronics. This approach allows for maximized cost efficiency in process monitoring without the need for sensor technology, thereby enhancing the safety and reliability of the analyses in your process. Please contact your Bürkert representative to explore additional application possibilities of ValveInsight or to personally test the standard algorithms using the evaluation board.