Series 430
Pneumatic Controller Modules Type 3433
Additional Modules Type 3437

Application

Controller modules for installation in Type 3430 Pneumatic Controllers · Additional modules for supplementing controller modules used in special industrial processes

The Type 3433 Controller Modules are designed for input and output signals ranging from 0.2 to 1.0 bar (3 to 15 psi) and for supply air pressure of 1.4 bar (20 psi).

The plugs of the controller module are inserted in the self-sealing plug connectors of the control station and secured by a mounting screw. The controller modules may be combined with a Type 3437 Additional Module for bumpless manual/automatic transfer, control mode changeover or signal limitation.

Versions

The controller modules contain a comparator working according to the motion-balance method. This comparator includes four metal bellows stabilized by springs and arranged in square form. The proportional-action coefficient K_p can be adjusted mechanically. Standard versions have K_p = 0.2 to 20 and special versions K_p = 0.4 to 40.

Type 3433-1 (Fig. 1) · Controller module for P control action with integrated operating point adjuster

Type 3433-2 (Fig. 2) · Controller module for PI control action Optionally with feedback limitation

Type 3433-3 (Fig. 3) · Controller module for PID control action Optionally with feedback limitation

Type 3433-4 · Controller module for PD control action

Type 3433-5 · Controller module for P and PI control actions Application as PI controller and P controller with integrated operating point adjuster

Type 3433-6 · Controller module for PD and PID control actions

Type 3433-9 · P controller module with set point dependent operating point

The additional modules are connected between the controller module and its respective plug connector strip (see Fig. 7).

Type 3437-1 (Fig. 4) · Additional module for limitation of the control signal y_A, the feedback signal (connection R) or the reference variable w · Combination with all Type 3433 Controller Modules

Type 3437-2 [1] (Fig. 5) · Additional module for control mode changeover of the respective controller · Combination with the Type 3433-2 or Type 3433-3 Controller Modules · Optionally with set point dependent operating point adjuster

Type 3437-3 [1] (Fig. 6) · Additional module for bumpless manual/automatic transfer · Combination with the Type 3433-2 or Type 3433-3 Controller Modules

[1] Optionally available with output pressure

Fig. 1 · Type 3433-1 P Controller Module

Fig. 2 · Type 3433-2 PI Controller Module

Fig. 3 · Type 3433-3 PID Controller Module

Fig. 4 · Type 3437-1 Signal Limiter

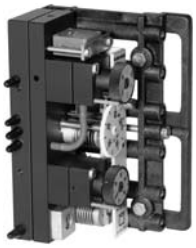


Fig. 5 · Type 3437-2 Control Mode Changeover

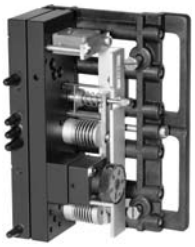


Fig. 6 · Type 3437-3 Manual/auto Transfer

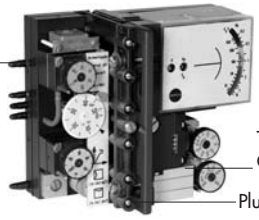


Fig. 7 · Type 3433-3 Controller Module with Type 3437 Additional Module

Principle of operation of controller modules

Type 3433-2 · PI Controller Module (Figs. 8 and 9)

The controlled variable x and the reference variable w act as pneumatic overpressures between 0.2 and 1 bar (3 to 15 psi) on the metal bellows (5) and (7) over the turnboard A. When x exceeds w, the actual value bellows (7) causes the cross spring pivoted swash plate (1) to move around the pivot (2) towards the set point bellows (5). As a result, the nozzle (9) comes closer to the flapper plate (10). The pressure in the nozzle increases, causing the signal pressure Y_A produced by the booster (16) to increase, which is fed back without delay to the bellows R2 (8) over the turnboard B and with delay to the bellows R1 (6) over the external connection R and the T_n restrictor (18). The position of the swash plate and the signal pressure y_A continues to change until the distance between nozzle and flapper plate reaches its initial value and the signal pressure y_A assumes a value which is assigned to the controlled variable x and the adjusted proportional-action coefficient K_p, i.e. until the system deviation no longer exists.

The proportional-action coefficient is set by the adjuster (14) and the reset time T_n on the restrictor (18). Zero adjustment is used to calibrate the controller module.

Fig. 9 shows the schematics of the Type 3433-2 PI Controller Module. The operating direction - increasing or decreasing signal pressure for increasing controlled variable - can be selected on the turnboard A.

Whenever a switching pressure is applied to the connection S in the manual mode, the T_n start-up relay (19) changes over. It opens the bypass to the T_n restrictor (18), and hence causes uniform pressure distribution to the bellows R1 and R2.

When delivered, the turnboard A is adjusted to y_A, i.e. the signal pressure y_A is fed back directly to the bellows R2, and to the bellows R2 via connection R. In this arrangement, the controller provides standard air delivery and output pressure damping. Therefore, the additional air volume usually needed under extraordinary service conditions – such as especially short signal transmission and small connected air volume – is now no longer needed. Switching the turnboard B to position R is useful for a large connected air volume, for fast control loops, and if the control signal must cover a long transmission distance. In this arrangement, the signal pressure y_A is fed back to the bellows R1 and R2 via connection R. The controller shows a good air delivery characteristic for these applications.

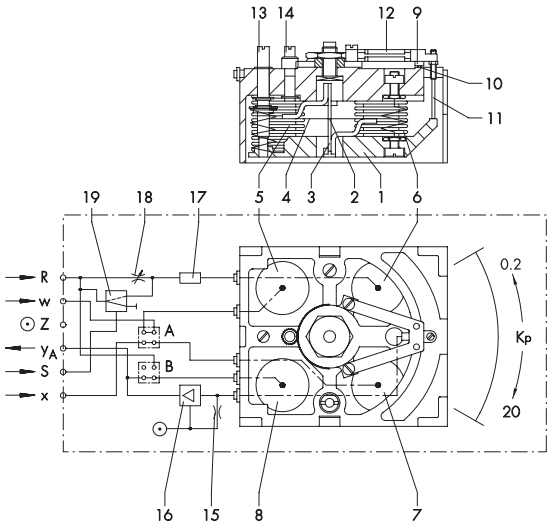


Fig. 8 · Schematics of Type 3433-2 PI Controller Module

Version with feedback limitation on next page

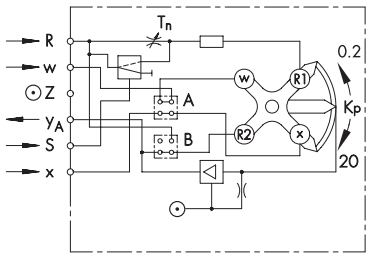


Fig. 9 · Type 3433-2 PI Controller Module

Legend for Figs. 8 to 15

w Reference variable (set point)
x Controlled variable

A Turnboard for operating direction
B Turnboard for feedback function
R Feedback for bellows R1
S Switching pressure

1 Swash plate
2 Pivot
3 Pivot pin
4 Cross spring pivot
5 Set point bellows w
6 Feedback bellows R1
7 Actual value bellows x
8 Feedback bellows R2
9 Nozzle

10 Flapper plate
11 Pin
12 Springs
13 Zero adjustment
14 Adjuster for K_p
15 Restriction
16 Booster
17 Volume
18 T_n restrictor
19 T_n start-up relay

Symbols for the schematic diagrams:

Supply air
Fixed restrictor
Turnboard
Adjustable restrictor
Pneumatic adjuster
Booster
Start-up relay

Type 3433-1· P Controller Module (Fig. 10)
Design and principle of operation essentially are the same as for Type 3433-2. However, the T_n restrictor (18) and the start-up relay (19) are replaced by an operating point adjuster. Its constant pressure adjustable between 0.2 and 1 bar is transmitted to the feedback bellows R1 and the signal pressure y_A produced by the booster is transmitted to the feedback bellows R2 via the fixed turnboard B.

Type 3433-3 · PID Controller Module (Fig. 11)
This module essentially corresponds to the Type 3433-2 PI Controller Module. However, it contains an additional derivative element providing the rate in the input branch of the controlled variable x. In steady state, the output signal of the derivative element D1 equals the input signal x. When the input signal x changes, the derivative-action element D1 amplifies the signal change by about ten times corresponding to the derivative-action gain. This amplification is reduced to the ratio 1:1 as a function of the derivative-action time adjusted on the T_v restrictor. The T_v start-up relay D2 bypasses the Tv restrictor when a switching pressure is applied to the input S.

Type 3433-4 · PD Controller Module (Fig. 12)
This module is a P controller with an additional derivative-action element providing the rate in the input branch of the controlled variable x. When the input signal x changes, the derivative-action element D1 amplifies the signal change by about ten times corresponding to the derivative-action gain. The derivative signal decreases according to an e-function and corresponds to x after having passed the derivative-action time adjusted on the T_v restrictor. In contrast to the P controller, the PD controller acts, in case of disturbances, much stronger on the controlled system for a certain period of time, thus providing advantages in controlled systems with time constant or dead time. When a switching pressure is applied to input S, the T_v start-up relay (D2) changes over and bypasses the T_v restrictor.

Type 3433-5 · P/PI Controller Module (Fig. 13)
The P/PI controller module can alternatively be used as P controller with operating point adjustment or as PI controller. This module simplifies inventory and scheduling since P and PI controllers are suitable for more than 80 % of applications. Employing this module is also useful whenever the dynamic properties of the controlled system are not known. Its design corresponds to that of the PI and P controller module. The P/PI selector switch can be used to transmit either the feedback pressure (PI controller) or the output pressure of the operating point adjuster (P controller) back to the feedback bellows R1.

Type 3433-9 · P Controller Module with set point dependent operating point (Fig. 14)
This P controller module corresponds to the Type 3433-1, however, with set point dependent operating point. The operating point shifts in proportion to the set point w. Since the operating point need not be readjusted, this module is ideally suited to systems in which the set point is frequently changed.

Feedback limitation for Type 3433-2/-3
The Type 3433-2/-3 PI/PID Controller Modules can optionally be equipped with maximum feedback limitation (Fig. 15). When exceeding the adjusted limit value, feedback is limited and constant pressure which corresponds to the maximum value is supplied. Thus, the dynamic behavior of the controller module is influenced since the T_n element becomes ineffective. In this state, the module functions as P or PD controller with an operating point that corresponds to the adjusted limit value. This feedback limitation is suitable, e.g. for non-linear control processes and system-oriented solutions.

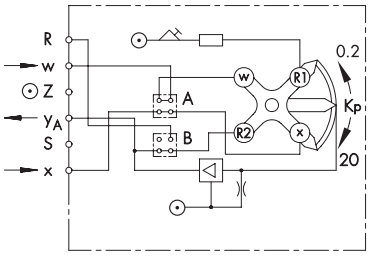


Fig. 10
Type 3433-1
P Controller
Module
(fixed
turnboard B)

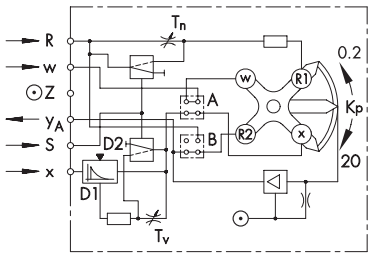


Fig. 11
Type 3433-3
PID Controller
Module

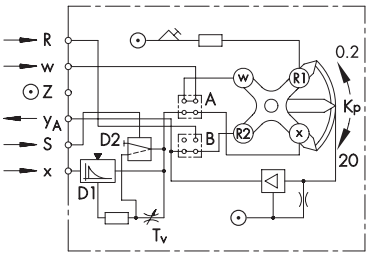


Fig. 12
Type 3433-4
PD Controller
Module
(fixed
turnboard B)

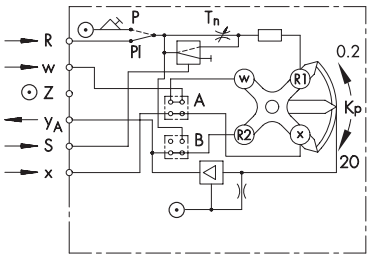


Fig. 13
Type 3433-5
P/PI Controller
Module

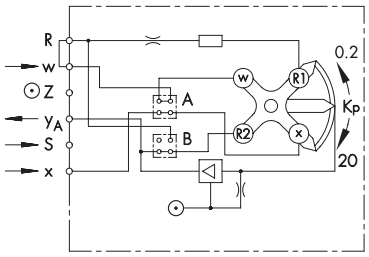


Fig. 14
Type 3433-9
P Controller
Module with set
point dependent
operating point
(fixed
turnboard B)

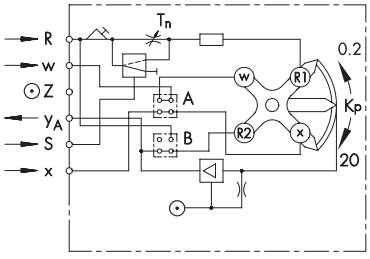


Fig. 15
Type 3433-2
PI Controller
Module with
feedback
limitation (L)

Principle of operation of additional modules

Type 3437-2 · Control Mode Changeover (Fig. 16)
When starting up a plant, the set point should be reached as fast as possible and without oscillations. This is especially true for fixed set point control of discontinuous processes, such as batch operation of autoclaves, vulcanizers, etc. Graph 1 in the diagram (Fig. 16.2) schematically represents the start-up and break-in performance of a temperature controller with PI or PID controller module. A corresponding controller having a control mode selector switch, however, provides better start-up performance as shown by graph 2.
Fig. 16 illustrates the functional diagram of the additional module for control mode changeover of the assigned PI or PID controller module. In this case, the output switching pressure S_{St} of the comparator S1, depending on error $x_d = w - x$ and the adjusted value x_{ds}, determines the control mode. S_{St} can assume values that correspond to the binary signal "0" or "1".
The following conditions apply:

PI/PID control mode for $x_d \leq x_{ds}$ and S_{St} = "0"

P control mode for $x_d > x_{ds}$ and S_{St} = "1"

Assuming that $x_d > x_{ds}$ at the beginning of the start-up procedure (see Fig. 16.2). Then, the controller module functions as P controller with an operating point set via adjuster S3. This control mode allows to reach the set point immediately. When x exceeds the adjusted switching point, the result is $x_d \leq x_{ds}$ and S_{St} = "0". This configuration causes the control system to act as PI or PID controller. This control mode, in return, ensures that the set point is reached without oscillation and prevents offset, provided that x_{ds} has been adjusted according to the system requirements.
The identically adjustable turnboards A and S4 are used to select the operating direction, this is increasing or decreasing signal pressure for increasing controlled variable.

Note: Control mode changeover by means of signal limitation, see Type 3437-1. On request, this controller module is available with set point dependent operating point adjuster. The operating point shifts in proportion to the set point w and can be set on the adjuster S6: w ±0 ... 20% (see Fig. 16.1).
The module can optionally be equipped with a pressure limiter S5 [1] limiting the signal pressure y_A of the controller to the adjusted maximum value.

Type 3437-3 · Bumpless Manual/automatic Transfer (Fig. 17)
Bumpless transfer from manual to automatic mode can only be carried out when the signal pressure y_A of the controller and the manual signal pressure y_H are the same. In common instrumentation, y_A and y_H are equalized manually. The Type 3437-3 Additional Module connected between controller and control station carries out this equalization. This module comprises a comparator U1 operating according to the force-balance principle and a selector switch U2 connected to the feedback loop. In manual mode, the manual signal pressure y_H is applied to the connection R, the switching pressure S to the switch U2 and the output pressure of the comparator U1 to the feedback bellows R1. However, the position of the turnboard B must correspond to Fig. 17. When y_H differs from y_A, the comparator is changing the pressure on R1 until y_H and y_A are equal again. This guarantees bumpless transfer without manual equalization at any time.
The module can optionally be equipped with a pressure limiter U3 [1] limiting the signal pressure y_A of the controller to the adjusted maximum value.

[1] Cannot be combined with controller modules

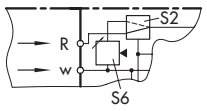
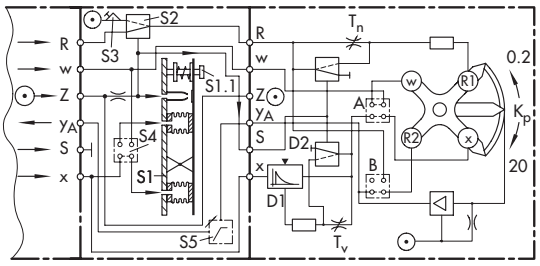


Fig. 16.1 · Arrangement with set point dependent operating point adjuster S6



Control station | Type 3437-2 Control Mode Changeover | Type 3433-3 PID Controller Module

Fig. 16 · Type 3437-2 Control Mode Changeover
Typical application with Type 3433-3 PID Controller Module
Turnboard A and S4 equal
Turnboard B fixed

S	Comparator	S4	Turnboard
S1.1	x_{ds} adjuster	S5	Pressure limiter
S2	Selector switch	S6	Adjuster (optional)
S3	Adjuster		

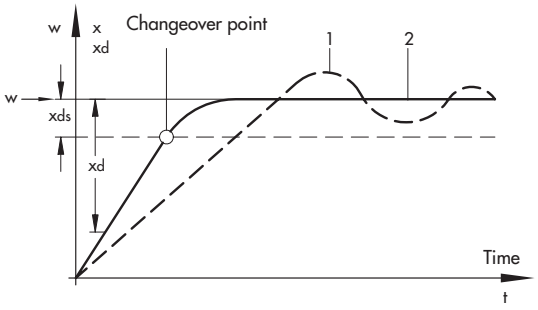
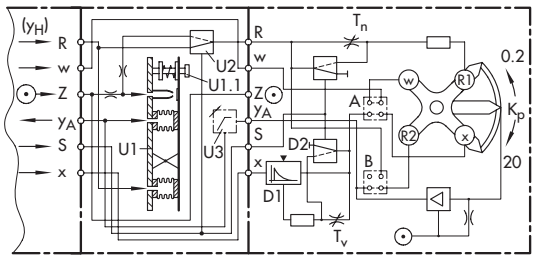


Fig. 16.2 · Start-up diagram of temperature control systems
Graph 1: PI or PID controller w/o control mode changeover
Graph 2: PI or PID controller with control mode changeover



Control station | Type 3437-3 Manual/automatic Transfer | Type 3433-3 PID Controller Module

Fig. 17 · Type 3437-3 Bumpless Manual/auto Transfer
Typical application with Type 3433-3 PID Controller Module, fixed turnboard

U1	Comparator
U1.1	Zero adjuster
U2	Selector switch
U3	Pressure limiter

Type 3437-1 · Signal Limiter (Fig. 18)
Depending on the version of this versatile additional module, either the signal pressure y_A, feedback (connection R) or the reference variable w can be limited to a high or low limit value. The limiter issues a corresponding constant signal whenever the maximum value is exceeded or the minimum value is not reached. Each of the additional modules comprises two adjusters B1 and B2 and a springless selector switch B3. They are connected to the transmission line which corresponds to the respective version. In the unlimited operating range, the signal pressure is transmitted without being changed. When reaching the high limit value, the adjuster B1 limits the signal pressure and generates a constant pressure p_{max} that corresponds to the maximum value. The adjuster B2 provided with supply air is used to set the low limit value p_{min}. The selector switch B3 compares this value with the signal pressure. When the signal pressure does not reach the limit value, the switch B3 changes over and the adjuster B2 is connected to the output. Hence, the generated pressure always remains within the adjusted range between p_{min} and p_{max}.

When providing signal limitation for feedback R (see Fig. 18.2), PI or PID controller modules function as P or PD controller whenever y_A is beyond the limit range (p_{max}, p_{min}). Therefore, it is possible to use this combination also for control systems which have their control mode changeover released by the controller signal pressure (y or y_A). In contrast to instrumentation with Type 3437-2 Control Mode Changeover (see Fig. 16), this type of control system works on the operating point p_{min} or p_{max} whenever the limit value is exceeded or not reached. The device arrangement and the connection correspond with Fig. 16. However, Type 3437-2 is replaced by Type 3437-1.

When providing signal limitation for the signal branch y_A (Fig. 18.1), the controller module generates the signal pressure p_{max} or p_{min} whenever y_A is beyond the limit range. As far as PI or PID controllers are concerned, the T_n influence becomes ineffective since y_A is fed back to the connection R. This output signal limitation is suitable for the following applications:

- Non-linear control processes
- Safety limitations or connection of large pneumatic actuators in order to avoid unnecessary supply or venting of the actuator, and hence lag times
- Controllers connected in series in order to ensure signal coupling to the downstream controller and/or to limit the reference variable w_2
- Ratio control systems in order to maintain minimum flow rate and/or to limit maximum flow rate.

When signal limitation shall be provided for the signal transmission line w, further specialized solutions are available.

Signal limiters are not suitable for combination with controller modules with feedback limitation.

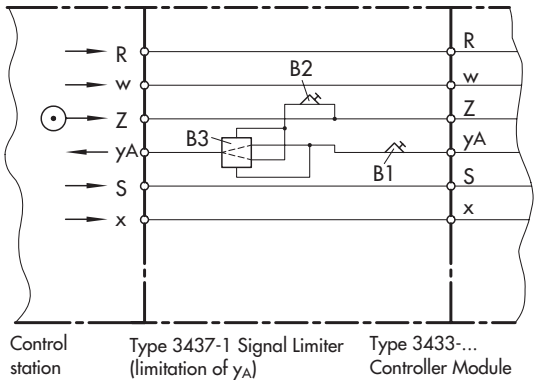


Fig. 18.1 · Limitation of y_A

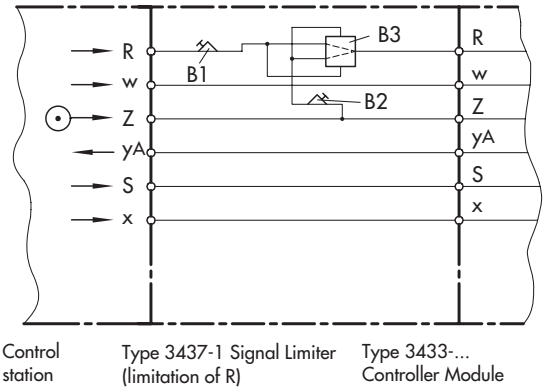


Fig. 18.2 · Limitation of R

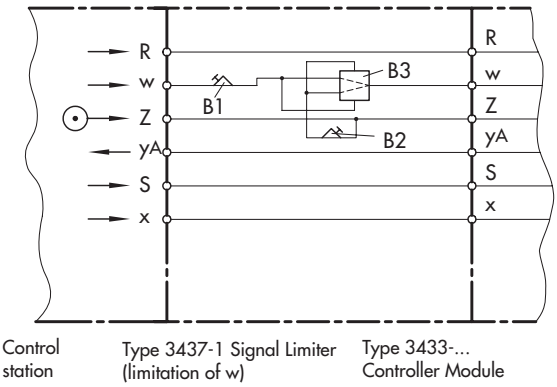


Fig. 18.3 · Limitation of w

Fig. 18 · Type 3437-1 Signal Limiter

B1 Adjuster for p_{max}
B2 Adjuster for p_{min}
B3 Springless selector switch

Table 1 · Technical data · All pressures in bar (gauge)

Controller Module Type	**3433-1**	**3432-2**	**3433-3**	**3433-4**	**3433-5**	**3433-6**	**3433-9**
Control mode	P	PI	PID	PD	P/PI	PD/PID	P [1]
Control parameters	Proportional-action coefficient K_p = 0.2 to 20 or 0.4 to 40 Reset time T_n = 0.03 to 50 min. Derivative-action time T_V = 0.01 to 10 min. Derivative-action gain of x ≈ 10 Type 3433-1/-4/-5/-6: Operating point adjustment: 0.2 to 10 bar (2 to 15 psi)						
Input	0.2 to 1.0 bar (3 to 15 psi) · Max. 0.02 to 1.35 bar (0.3 to 19 psi) Max. air delivery > 1.5 m_n^3/h Air delivery for adjustment "y_A": approx. 1 m_n^3/h per % of system deviation Air delivery for adjustment "R": approx. 3 m_n^3/h per % of system deviation						
Air supply	Supply pressure 1.4 bar (20 psi)						
Air consumption in steady state	< 0.1	< 0.05	< 0.13	< 0.1	< 0.05	< 0.13	< 0.1
Actuating offset	< 0.5 %						
Tracking error	< 0.5 %						
Threshold	< 0.01 %						
D element	Deviation of controlled variable x: < 1 %						
Supply air influence of 1.4 ± 0.1 bar	< ± 0.1 % (D element additionally: < ± 0.2 %)						
Temperature influence/°C	< ± 0.01 % (D element additionally: < ± 0.01 %)						
Permissible ambient temperature range	–20 °C to +60 °C						
Weight	0.7 kg						
Additional modules							
Input	0.2 to 1.0 bar (3 to 15 psi)						
Output	0.2 to 1.0 bar (3 to 15 psi) · Max. 0.02 to 1.35 bar (0.3 to 19 psi) Air delivery and load characteristic same as for associated controller module, version with output pressure limiter: max. air delivery: > 0.5 m_n^3/h						
Air supply	Supply pressure 1.4 bar (20 psi)						
Type 3437-1 · Signal Limiter	Version for: y_A limitation · R limitation · w limitation						
Type 3437-2 · Control Mode Changeover	Changeover point: Error xds adjustable from 0 to 50 % Operating point: For P control action adjustable from 0.2 to 1 bar (3 to 15 psi)						
Type 3437-3 · Bumpless Manual/automatic Transfer							
Permissible ambient temperature range	–20 °C to +60 °C						
Weight, approx.	0.4 kg						

[1] With set point dependent operating point

Ordering text

Type 3433- ... Controller Module
Output 0.2 to 1 bar / 3 to 15 psi
Optionally, special version with feedback limiter /
K_p = 0.4 to 40

Type 3437-1 Additional Module for limitation of high and low limit of control signal y_A / feedback signal R / reference variable w

Type 3437-2 Additional Module for control mode changeover with / without output pressure limiter

Type 3437-3 Additional Module for bumpless manual/automatic transfer with / without output pressure limiter

Specifications subject to change without notice.

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