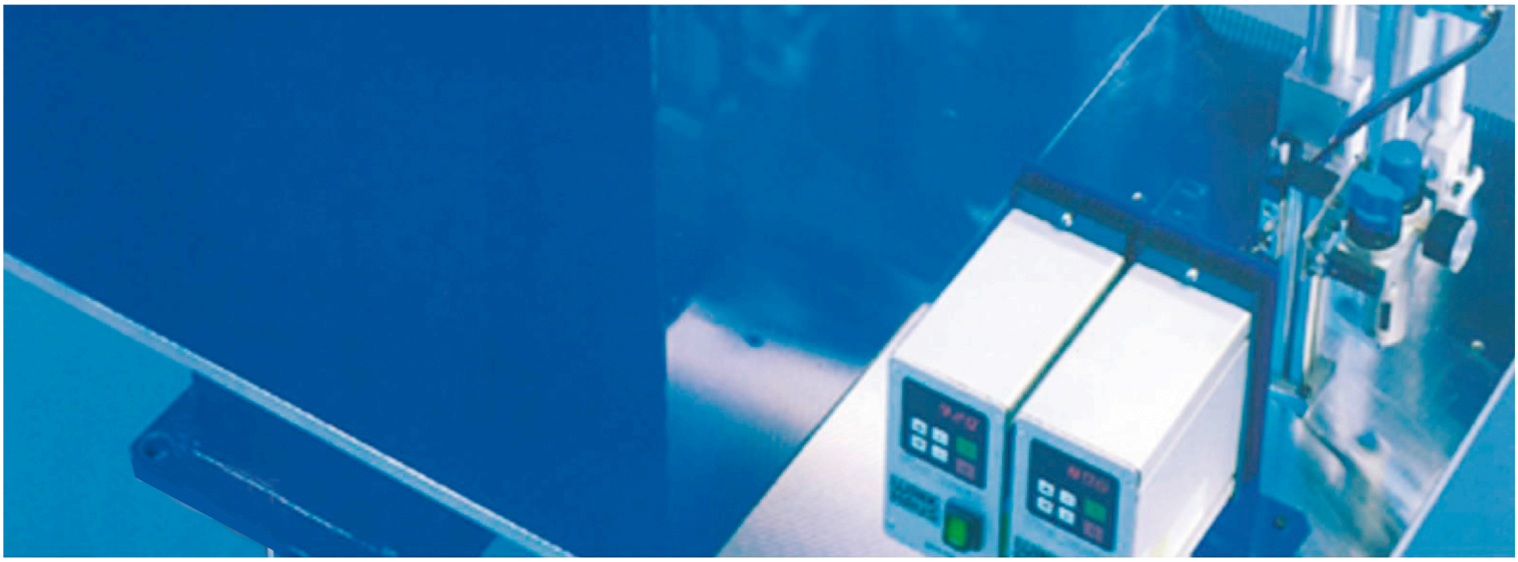


REOVIB

Control units for flexible automation

Hand book for installing and setting up
REOVIB controllers
Concepts, questions and background information

Pure|Power|Perfection

Contents

1.0 General information about the REOVIB product range

The REOVIB range from REO ELEKTRONIK AG comprises all equipment produced for vibratory feeder engineering. This includes controllers for vibratory feeders, measuring and monitoring equipment, with corresponding transducers.

All types of feeder control units are available, using thyristors or triacs with phase-angle control or the newer technique employing a frequency inverter. There are free-standing or panel-mounting versions, with many variations to choose from and integrated functions for controlling product flow, depending on the unit type.
In most instances the product throughput is set by using a front-panel potentiometer or the user display but the panel mounted units have inputs provided for an external, throughput set-point source from a 0…10V signal voltage, 0(4)…20mA signal current or a potentiometer.
Control signals inputs, e.g. Start/Stop (Enable), or for sensors, e.g. track control, are usually brought out to connectors in the case of enclosed units, or to terminals where panel-mounted versions are concerned.

REOVIB thyristor or triac controllers provide step-less adjustment or regulation of the feeder throughput setting by varying the output voltage. The vibrating frequency is always dependent on mains frequency because thyristors and triacs can only influence the available supply half-wave (phase-angle control). When only one half of the mains sine wave is selected the feeder vibrates at the same frequency as mains frequency and when both halves are used the feeder vibrates at twice that of mains frequency. Using one half of the mains sine wave is referred to as half-wave operation or 3000 vibrations/min (for a mains frequency of 50Hz). The use of both halves of the mains sine wave is called full-wave operation or 6000 vibrations/min (for a mains frequency of 50Hz). A 60Hz supply correspondingly gives 3600 and 7200 vibrations/min. REOVIB control units are equally suitable for operating with either frequency and can be set, by using a link switch, to match the feeder frequency.

REOVIB Frequency inverter specially developed for use with vibratory feeders provides a highly stable, drive frequency, independent of the supply frequency, tuned to that of the feeder and adjustable in 0.1Hz steps. It is said by feeder manufacturers that the mechanical performance compares with that of mains frequency. After assembly, using standard spring packs and components, the feed system can be electronically fine-tuned to give optimum performance. The controller seeks for the resonant frequency of the feed system, at a comfortable feed level, using a patented method, and then saves this in memory for future use. Throughput setting of the feeder is achieved by using the variable output voltage of the controller. The amplitude is held constant whilst the controller is working in regulation mode thus compensating for widely varying loads, caused by high and low product levels. The amplitude feedback signal is generated from an accelerometer, fitted onto the feeder. A further advantage is gained through energy saving because the incoming mains power is reduced to 1/3 of that used by previous controllers. The feeders also run much quieter and component orientation is more efficient because of the sinusoidal output current. In addition to easy control of the feeder, other functions such as track and sensor control are integrated into the control unit. Input and output ports are available for interlocking with other units or a supervisory system. The touch-panel and display are user-friendly and allow settings to be made accurately and repeatable. User settings can be saved and recalled.

REOVIB measurement and monitoring units comprise simple instruments for controlling the vibration waveform (converts signal to 0…100% display), or units used for maximum and minimum limit monitoring. An accelerometer is fitted onto the feeder to provide a feedback signal.

2.0 Background to feed engineering

The use of mechanical vibrators for feeding material, dosing, screening or mixing of goods is long established. Drives, with so called out-of-balance motors and vibrating equipment with electromagnetic drives are certainly the most widely applied. Electromagnetic drives are more frequently used in automation engineering and hence some fundamental differences require further explanation. In general one is referring here to vibratory feeders.
Vibratory feeders comprise the actual drive unit, including one or more coils, a reaction base, a spring system and tooling, which can be in the form of a tray, tube, track or a bowl with a spiral track inside. Tray shaped vibratory feeders that deflect in one direction, are used to convey material and are generally referred to as "Linear Feeders". Vibratory feeders with a spiral track and a spring/coil combination that gives a composite motion that are used for sorting, orientating and feeding parts, are known as "Bowl Feeders".

2.1 The vibration wave form

The vibratory motion in the case of a vibratory feeder moves backwards and forwards in a straight line. The direction of movement is at a specific angle relative to horizontal, referred to as the "vibrating angle". The movement plotted against a time axis gives a curve approaching the shape of a sine wave.

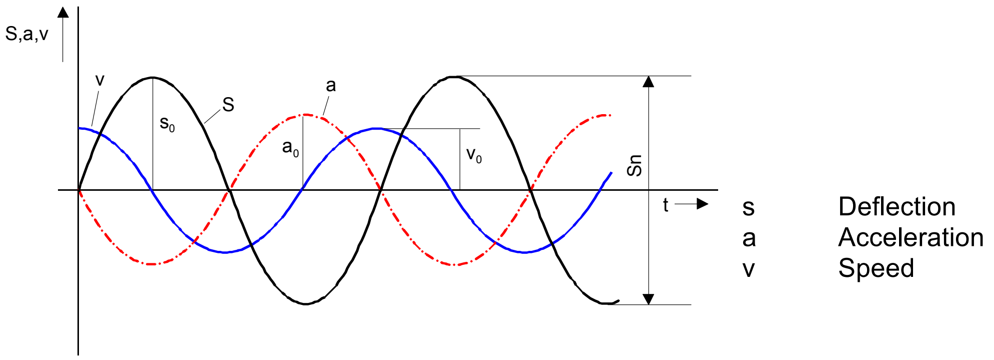


Diagram 1 The vibration curve

The sinusoidal waveform is derived from the formula

$s = s_0 \sin \omega t$ [mm]

where "s" is the time based vibration movement, s_0 the amplitude (half of the total deflection) and ω the cycle frequency ($2 \pi f$).

The vibrating speed is derived from the differential of deflection over time

$v = \frac{ds}{dt} = s_0 \, \omega \cos \omega t$ with

$v_0 = s_0 \, \omega$

the acceleration

$a = \frac{ds^2}{dt^2} = -s_0 \, \omega^2 \sin \omega t$ with

$a_0 = s_0 \, \omega^2$

2.2 The feed wave form

Diagram 2 shows a vibratory drive unit with a unidirectional deflection (linear feeder). The direction of movement is determined by the vibrating angle. The material on the track is accelerated along the deflection path.

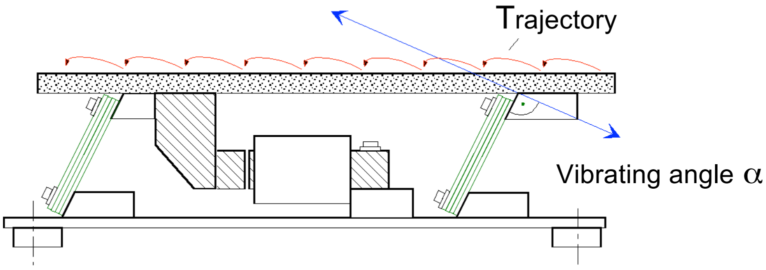
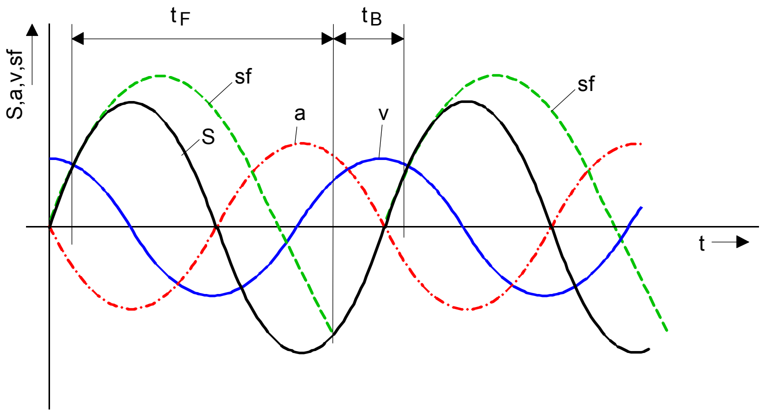


Diagram 2

The product describes a trajectory on the track (micro throw principle) which is determined by the vertical component of the vibration acceleration exceeding that of the basic acceleration. The product lifts off the feed track during forward movement, follows the trajectory over the time period t_F (see diagram 3), meets the feed track again, where it remains for a time period t_B, in contact with the feed track until the cycle starts again. The trajectory is so small and fast that it cannot be discerned with the naked eye.



t_F	Trajectory time
t_B	Contact time
sf	Product movement
s	Deflection
a	Acceleration
v	Speed

Diagram 3 Trajectory path of the product

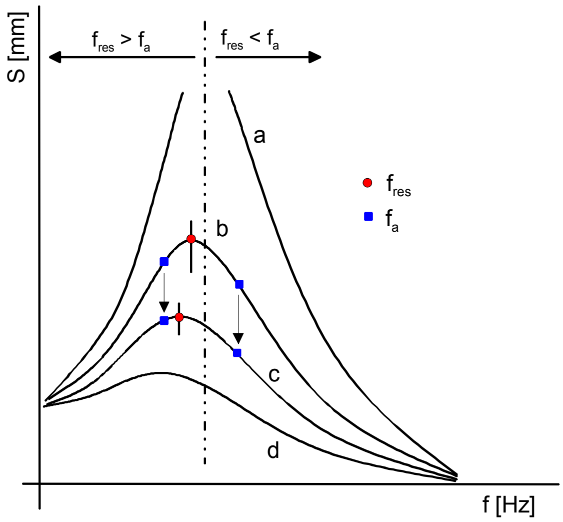
In practice, the feeder throughput is of particular interest. This is dependent on the horizontal component of the vibrating speed of the feeder during the contact time t_B and because the take-off point does not coincide with the highest horizontal speed, the product speed never reaches that of the vibrating speed. The achievable feeder throughput is different for each product and depends on the vibrating frequency and amplitude. An increase of the feeder throughput cannot be achieved by adjustment amplitude alone; the correct vibrating frequency must also be selected for the product.

2.3 Vibrating frequency and resonance

Every vibratory system has a resonant frequency, which relates to its mass, spring constant and product weight. If a feeder could be driven at resonance, in theory the amplitude is infinite and the system would be uncontrollable. In practice such a condition cannot be achieved without something extra. Mechanical resonance, however, displays a very specific characteristic and so the vibrating frequency of a feeder cannot be too far away from resonance, otherwise the achieved deflection would be negligible. Furthermore, a damped system, working at resonance, is not viable because every change of the damping caused by the product would result in a change of the amplitude and hence the feeders throughput.
Conversely, operating at resonance also offers some advantages. The energy usage is greatly reduced and the vibration movement becomes much more harmonic (sinusoidal), which results in a much quieter operation. Modern drive controllers such as the **REOVIB MFS** range constantly monitor the vibration movement and provide a regulated operation, whereby the vibrating frequency is maintained at resonance and amplitude is held constant.

2.3.1 Resonant condition

Diagram 4 shows various resonance curves for a feeder with different damping levels. This demonstrates the relationship between damping and the shift in resonant frequency.



a	=	without damping (theoretical).
b – d	=	increasing damping levels.
f_a	=	drive frequency.
f_{res}	=	resonant frequency
$f_{res} > f_a$	=	under critical operation
$f_{res} < f_a$	=	over critical operation

Diagram 4

One can see from the curves that the resonant frequency of the vibrating system reduces with increased damping. Different feeder drive characteristics can be achieved by tuning the vibratory system to a value above or below the drive frequency. In practice both possibilities can be applied.

2.3.2 Under-critical operation

For under-critical operation the drive frequency f_a is lower than the resonant frequency f_{res}. When the damping increases, by loading the feeder, the resonant frequency gets closer to the drive frequency. In this way the system compensates itself and is unaffected by load changes. The power and the deflection run in phase in this drive method, i.e. the air gap at maximum current is smaller than at rest. This method of tuning is chosen mainly for large feed conveyors or products that are inclined to interlock. At very low frequencies the coil yoke can lock-up when the current comes into phase with the vibratory movement., defined by the under frequency limit.

2.3.3 Over-critical operation

For over-critical operation the drive frequency f_a is greater than the resonant frequency $f_{res.}$ When the damping increases the amplitude increases. Likewise, interlocking products tend to cause a reduction of the feeders resonant frequency. In this operating method the power and vibratory movement are phase opposed, which dictate the use of a large reaction base and a higher current draw. In practice this method of tuning is used in automation engineering where a large reaction base can be used, in most instances for good engineering reasons, and the resonance curve is very flat because of high damping. The forced stability achieved by high damping must, however, be traded against a high power usage.

3.0 Operating methods for vibratory feeders

3.1 Unregulated drive control

For unregulated control (output voltage control) the feeder **must** be tuned to operate away from resonant frequency, by a specific amount. This difference determines the stability of a feeder, when it is subjected to load changes, caused by the product. Depending on the feed system, the difference between the tuned frequency and the resonant frequency is approximately ± 3Hz. When controllers with a fixed frequency are used (e.g. thyristor or triac), the correct frequency is set by changing the spring pack and/or fitting compensation weights. By using controllers that have a variable frequency output (frequency inverters), the electrical drive frequency can be easily set to match the mechanical frequency, thus removing the need for time consuming mechanical tuning.

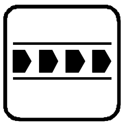
3.2 Regulated drive control

It is possible to operate a vibratory feeder at resonance if a frequency inverter is used for holding the feeder at resonant frequency and the amplitude at a level determined by a selected set-point. To achieve this, the vibratory movement has to be measured and fed back to the frequency controller. Normally a sensor is fitted to the vibrating part of the feeder to obtain this measurement. The signal generated is used not only to hold the feeder at resonant frequency but also to maintain constant vibration amplitude by varying the output voltage. The feeder is always running with the greatest effectiveness when operating in this manner.

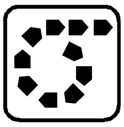
For more information refer to section 9.0 Guidance on using regulation control with frequency inverters.

4.0 REOVIB – Symbols

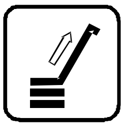
The following icons are used to denote unit functions



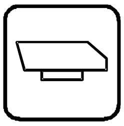
Linear feeder — Straight line vibratory feeder



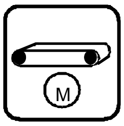
Bowl feeder — Vibratory feeder with a spiral track



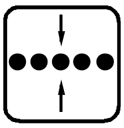
Elevator — Motor driven pre-feeder



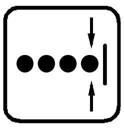
Hopper feeder — Vibratory pre-feeder



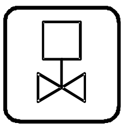
Band feeder — Belt pre-feeder



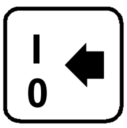
Track Sensor — Track control (product line)



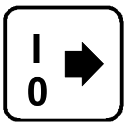
Position Sensor — Sensor for level control



Solenoid — Solenoid valve, e.g. for air blast



Enable input On / Off — Control input START / STOP



Status output On / Off — Control output ON / OFF

5.0 REOVIB – Terms

Through the course of time, various terms that sometimes seems different but is really the same, relating to equipment, functions and characteristics, have evolved. These have been compiled, below, together with explanations. In instances where there are several terms relating to a theme, the most widely used expression is underlined.

Bowl feeder	Feed equipment fitted with a round bowl that has a spiral track inside; components move upwards and outwards along the track and tooling is fitted sort the components so that they leave the feeder correctly orientated.
Linear feeder *Track feeder/ In-Line feeder*	Feed equipment for conveying orientated components in a straight line
Pre-feeder *Bunker / Feeder hopper*	Large vibratory feeders (bulk storage), feed conveyors or slatted belt elevators; used for topping-up bowl feeders, over a long period, without the need for manual intervention.
Component *Product, Material*	The material or work-piece that is fed by the vibratory feeder
Vibrating frequency	The **mechanical** frequency at which the feeder vibrates. In the case of thyristor or triac controllers this is completely dependent on the mains supply frequency. When both half waves of the mains cycle are used this gives a frequency that is twice that of the mains supply. When a half-wave only is used this provides a frequency the same as that of the mains supply. A frequency inverter can provide a frequency that is independent of the mains supply frequency.
Vibrating speed	Refers to the derivative of deflection against time
Amplitude *Deflection*	Deflection of the feeder [mm] relative to the static air-gap between the coil and armature; normally expressed as the entire backward/forward (±) movement.
Resonant frequency	A particular frequency at which a feeder vibrates with the minimum power requirement. In theory resonance is defined as the frequency that gives infinite amplitude.
Off-resonance condition	A difference between the operating frequency and the resonant frequency of a vibratory feeder
Over-critical operation	Running a feeder at a frequency that is higher than resonant frequency; the amplitude becomes smaller as loading or damping increases.
Under-critical damping	Running a feeder at a frequency that is lower than resonant frequency; the amplitude is not affected by product loading.
Air-gap *Static air gap*	The space between the coil and armature when a feeder is at rest
Feeder power *Feeder speed / Feeder throughput*	A measurement of the amount of components fed over a time period
Full-wave control *6000 vibs / min* *100 Hz operation*	Both mains, sine wave, half-cycles are controlled. The vibrating frequency is twice the mains frequency. 6000 vibrations / min at 50Hz mains frequency 7200 vibrations / min at 60 Hz mains frequency

Half-wave control 3000 vibs / min <u>50 Hz operation</u>	Only one half of the mains sine wave is controlled. The vibrating frequency is the same as the mains frequency. 3000 vibrations/ min at 50 Hz mains frequency 3600 vibrations/ min at 60 Hz mains frequency
Soft start	To prevent a sudden switch-on to full feeder throughput; a ramp-up time is used instead. Purpose: To reduce the likelihood of coil hammering and components being thrown off the feed track
Soft stop	The feeder is ramped down when the feeder is switched off by using the enable input or track control. Purpose: To reduce product storage changes
U_{max} / U_{min}	A facility to adjust the maximum and minimum output voltage levels of the control equipment; the set-point range can then be varied between these limits. Purpose: For adapting different feeders to work with a controller
Track control	A component sensor is used, in conjunction with the controller, to maintain a semi-constant level (queue) of product around a fixed point (sensor position Purpose: To reduce the unnecessary running time of feed equipment and deterioration of product finish
Component high/low level control	Control of component storage, between two track sensors Purpose: To reduce the unnecessary running time of feed equipment and deterioration of product
t_{on} / t_{off}	On/off switching time-delays Purpose: To adjust a feeders response to track sensor signals
Pre-feeder control	Replenishment of product i response to a level control sensor,e.g. fitted in a bowl feeder. When the depth of components drops below set a certain level, the pre-feeder switches on and “tops-up” the feed system.
Coarse/fine control	Operation with two feeder speeds:fast and slow
Pulsed operation	Feeder runs with a pulsing, on/off action,e.g. to separate components
Accelerometer or amplitude sensor	A sensor to control the actual amplitude of a vibratory feeder Can be used either for monitoring or as a feedback transducer for amplitude regulation.
Mill controller	Used with small capacity grinding mills, to ensure that a mill is fed with the optimum throughput of material. The feeder is regulated in response to the loading of the mill. The motor current is used to monitor to mill loading. Motor current increases as a greater amount of material is fed and so the feeder throughput is reduced. When the motor current drops the feeder throughput is increased.
Material sensor Component sensor	A sensor that determines if components are present or not at a particular point This sensor can be a light barrier, initiator or a switch.
PNP / NPN output	Depending on its construction, a sensor can give out a positive signal e.g. +24V, or in the case of an open collector provides a ground return path. When a positive signal is provided this is referred to as a PNP output. When the output is switched to earth this is referred to as an NPN output.
Active/passive photo-electric sensor	Active photoelectric sensors have an integrated switch amplifier and give a definite output signal that is either PNP or NPN. For passive photoelectric sensors there must be provision in the control unit for a photo-receiver to be used.
Namur sensor	A sensor that reacts to the proximity of metallic materials with a resistance change 2 wire system

6.0 Functions of control units

6.1 Enable input or Stop/Start input

An input for interlocking with a supervisory systemm e.g. PLC or several controllers together, with a specific relationship, e.g. paddle-switch regulation of a pre-feeder from a bowl feeder (see status output).
Inputs are usually configured for use with contacts or a 24 VDC signal. The controller runs when the contacts are closed or 24 VDC is applied.

6.2 Status output

A contact or 24 VDC output signal to indicate if a feeder is on or off. The signal can be used to regulate preceding or subsequent controllers, e.g. pre-feeder.

6.3 Soft start

When a feeder is turned on, the sudden thrust can cause components to be displaced or in extreme cases it can cause the coil to hammer. To prevent this happenings the output voltage can be gradually ramped up. The ramp up time is normally adjustable. This protects the feeder by providing a “soft start“.

6.4 Soft stop

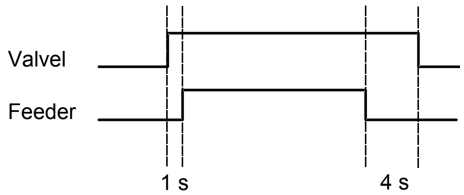
To reduce the disturbance of components or material (in precision applications) a feeder can be slowly ramped down to a stop. The ramp time is normally adjustable.

6.5 Coarse/fine control

To reduce overfilling when feeding material to a weighing machine, e.g. packing machines, a feeder can be fun slower, shortly before reaching the target weight. Additional contacts are provided in a weigher for this purpose. These contacts switch the controller to a second set-point level, which reduces the feeder through-put. Upon reaching the target weight, the feeder switches off completely. This operating mode can be selected in REOVIB digital controllers, as an alternative to using track control. The second set-point for “fine feed“ is adjusted through the control panel. The sensor socket is used for the input signal.

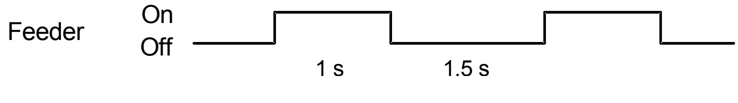
6.6 Air valve output

Sometimes it is necessary, with troublesome components, to provide an air blast that will transfer product from one feeder to another (e.g. from a bowl to a linear feeder). In such instances the air is only required whilst a feeder is running. This output is configured so that the valve switches on one second before the feeder starts and switches off four seconds after it stops.



6.7 Pulsed operation

A pulsed component flow is required for some applications, e.g. components that tangle or nest.
In digital controllers there is a function available and this has independently adjustable On/Off time settings. See example below:-

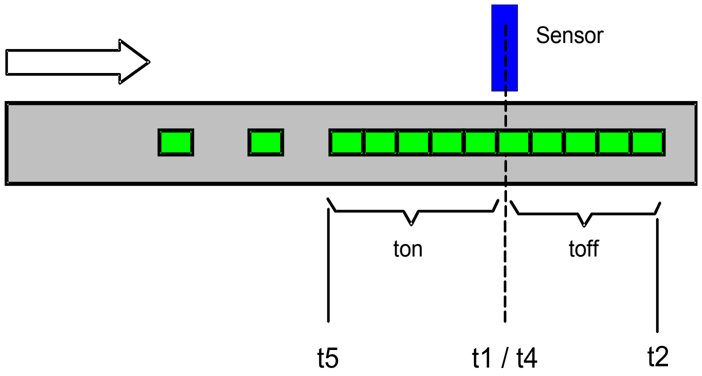


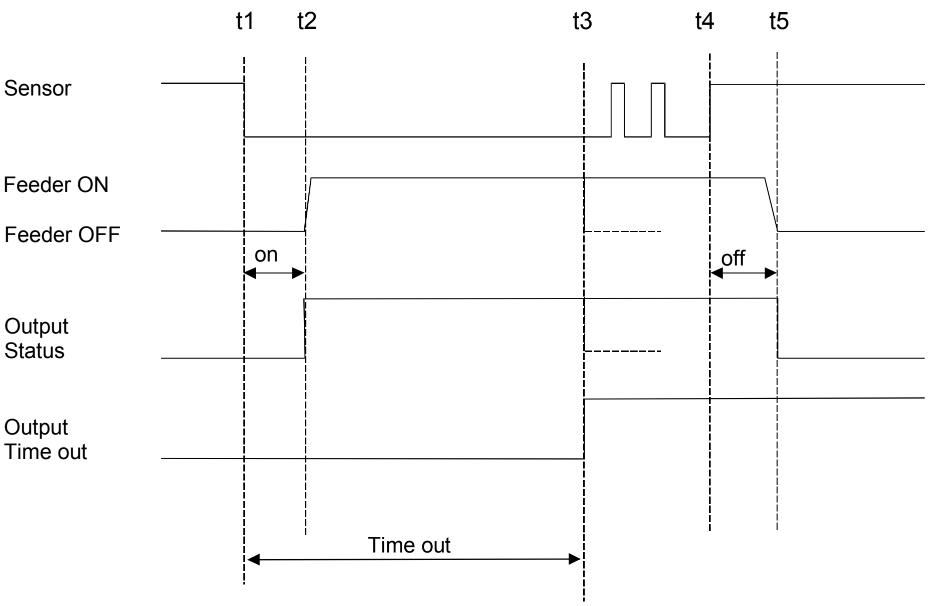
6.8 Track control

Material flow can be regulated by employing track control, whereby unnecessary feeder running time (decreasing noise and energy consumption) and degradation of the component can be reduced.

6.8.1 Single point control

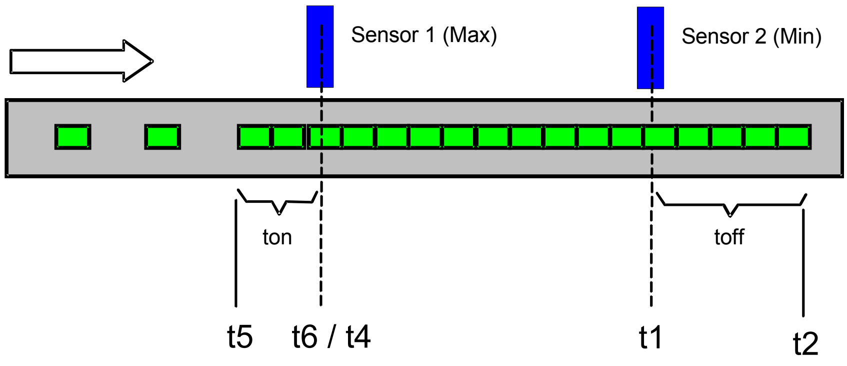
A bowl feeder is controlled from a material sensor located along the component track.
The feeder is switched on and off in response to a sensor, which monitors the material level. Internal, adjustable timers "t_{on} and t_{off}" are used to delay the switching, and so the material level rises and falls around the position of the sensor on the feed track.
The power output from the controller is switched on after product falls below the sensor position and the switch on time delay has expired (t2). When product builds up behind the sensor position (t4), and the switch off time delay has expired (t5), the power output from the control unit switches off. The time delays are reset if gaps in the product flow are detected. The delay is always timed, precisely, from detection of the first or last component. The on/off time delays are set by using trimmers or a programming menu in display panel.

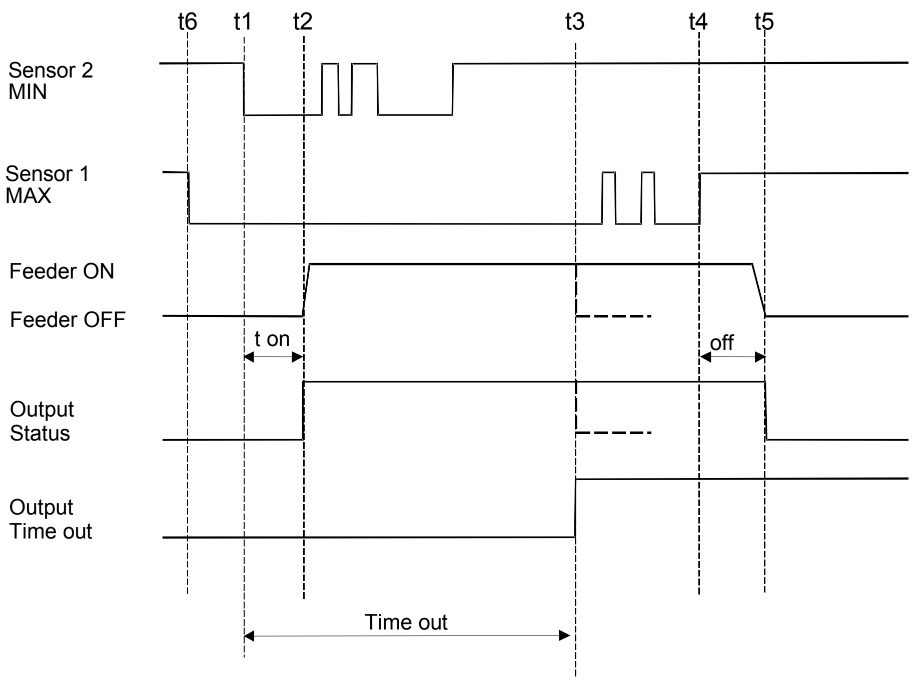




6.8.2 Min/Max Control

When two sensors are used for track control, the feeder is switched off when material builds up beyond the "max" sensor and the time delay has elapsed (t5). The feeder switches on again when the product level drops below the "min" sensor and the corresponding time delay has elapsed (t2). The adjustable time delays determine, precisely, the quantity of components that can go beyond the sensor positions. The time delays are reset if gaps in the product flow are detected. The delay is always timed, precisely, from detection of the first or last component. The on/off time delays are set by using trimmers or a programming menu in display panel.





6.8.3 Sensor Time-out

Additional function available in digital controllers when the sensor switches (t1) an additional timer **"Sensor-Time-out"** is started. After a preset time (e.g. 30...240 sec.) the feeder is switched off (t3), providing that in the meantime no further product has been detected by the sensor. The status signal is initiated, simultaneously, and a flashing error message, "Error" "SE", is displayed. This function is optional and must be selected in the track control menu, where "E.E." = I is to activate.

See the track control time diagram

7.0 Controls

7.1 Analogue Units

Potentiometers and link switches are used for adjusting throughput configuring analogue units to operate with specific feeders. The functions and locations of the potentiometers and link switches are fully explained in the operating instruction manual for the controller.

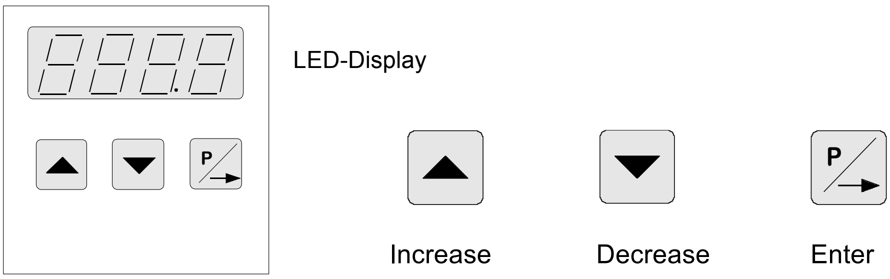
7.2 Digital units

Digital units are provided with a display and programming keys that are used for adjusting all parameters and the feeder throughput. Because the same keys and display are used for all different settings, a strict setting up procedure must be followed. Pass code protection of the parameter settings prevents tampering by un-authorized personnel.
Factory settings can be recalled for setting up as from new or when a control unit is used with another feeder, for instance. The factory settings are reinstated by selecting menu “C 210“(Parameter “FAC“). Under the same menu it is possible to recall user settings that have been previously stored using Code “C143“(Parameter “US.PA“).

Below is an explanation of the main setting components that are provided on controllers.

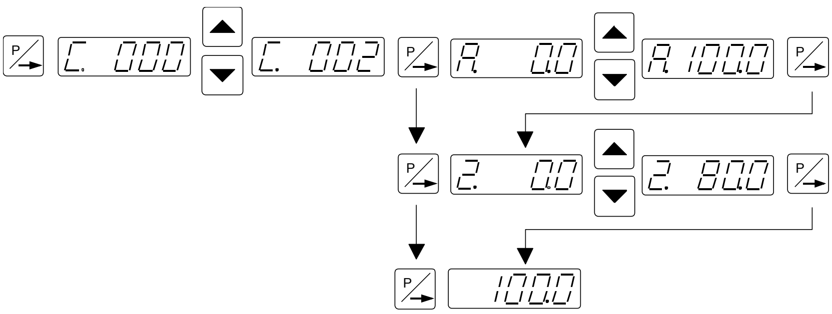
7.2.1 Three key control panel

The operation and setting up of the unit is achieved by using three keys in conjunction with an LED display that can be found on the front panel. These controls are all that is needed for selecting all operating modes and setting all parameters.
To prevent accidental or unauthorized adjustment the parameter settings are stored under user menus. A pass code must be entered to open the menus. Different menu codes are provided for the various function groups (refer to controller operating instructions).



Pushing down the key for a short time causes the display to increase, or decrease, by one step (unit or tenth). Depressing the key for a longer time causes the displayed value to step in ten units at a time.
Changed values are saved upon leaving the programming mode or if no keys are pressed for a period of 60 seconds.

All setting routines are commenced by pressing the programming button “P“. The following diagram should clarify the sequence in which keys are pressed:

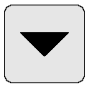


1. Press the “P“ key
2. Select the code number with the cursor keys
3. Press the “P“ key. This displays the first menu point. The required menu point can be found by repeatedly pressing the “P“ key (scrolling).
4. The value in the menu point can be changed with the cursor keys.
5. Scroll to the next menu point or to the end of the menu, which returns the display to the set point value, by pressing the “P“ key.

To exit the menu and return back to the normal display, quickly, depress the “P“ key for 5 seconds.

7.2.2 Reset set-point to zero
for units that do not have I/O keys on the front panel

When a setting has been left in an undesirable state, e.g. hammering of the coil could occur or too high a current inrush, causing nuisance tripping, the set-point can be instantly reset to zero in the following manner:

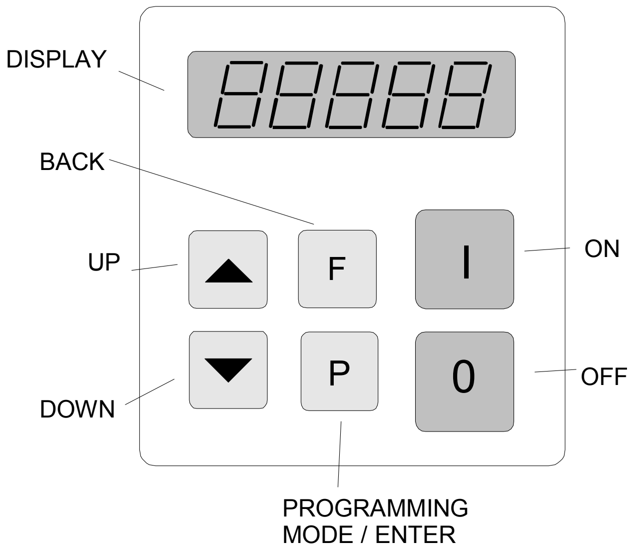
Press the down cursor key whilst  switching on the supply using the mains switch.

Using this procedure, after resetting to zero, the set-point can be increased again gradually or the frequency setting can be changed, for instance.

7.2.3 Six key control panel

The six buttons and a LED display found in the front panel are used for operating and setting up the unit. All operating methods and adjustable parameters can be set up through this panel.
The “I“ and “O“ buttons are used for switching the unit ON and OFF, however, **these do not provide mains isolation,** they simply inhibit the power semiconductors
The “P“, “F“ and “Cursor Buttons“ are used for parameter adjustment. Parameters are set by using menu controls which are called up by entering operator codes. These are explained in more detail in the section “setting up instructions“.

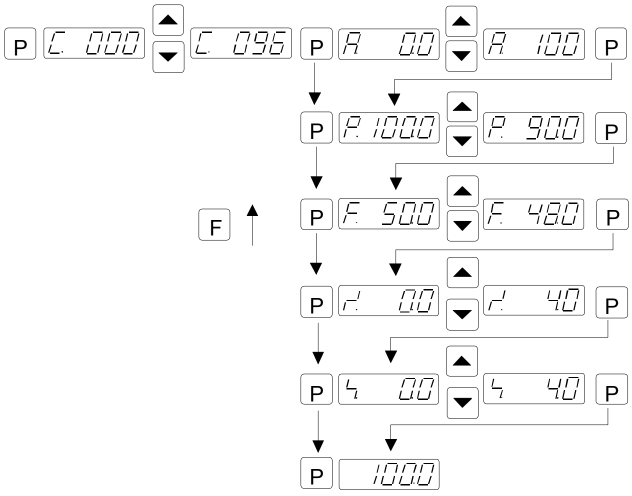
The display value can be increased or decreased by units, or tenths of units, by a short press of the cursor buttons. Holding the buttons down will cause the display to change in units often.



To prevent accidental or unauthorized adjustment the parameter settings are stored under user menus. A pass code must be entered to open the menus. Different menu codes are provided for the various function groups (refer to controller operating instructions).
Changed values are saved upon leaving the programming mode or if no keys are pressed for a period of 100 seconds.

All setting routines are commenced by pressing the programming button “P“. The following diagram should clarify the sequence in which keys are pressed:

Example: To set feeder parameters



Feeder Speed 0...100 %

Maximum limit 100...5 %

Frequency [Hz]

Soft start time 0...5 sec.

Soft stop time 0...5 sec.

Running mode

1. Press the “P“ key
2. Select the code number with the cursor keys
3. Press the “P“ key. This displays the first menu point. The required menu point can be found by repeatedly pressing the “P“ key (scrolling).
4. The value in the menu point can be changed with the cursor keys.
5. Scroll to the next menu point or to the end of the menu, which returns the display to the set-point value, by pressing the “P“ key. To exit the menu and return back to the normal display, quickly, depress the “P“ key for 5 seconds.
6. The “F” key may be used to step back to the previous point within a menu.

8.0 General manufacturers’ instructions for the installation of REOVIB control units.

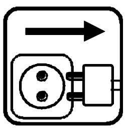
Electrical equipment must be installed by technically qualified personnel. Qualified personnel are persons who, because of their training, experience and position as well as their knowledge of appropriate standards, regulations, health and safety requirements and working conditions, are authorized to be responsible for the safety of the equipment, at all times, whilst carrying out their normal duties and are therefore aware of, and can report, possible hazards (Definition of qualified employees according to IEC 364).

The control unit and feed equipment should be checked, before installation, to ensure that they have been selected for use under local conditions:

- Supply voltage
- Mains frequency
- Mechanical frequency of the feed system
- Power rating of the feed system

Safety warning

!! Beware: Remove mains plug before opening and when working inside the controller.



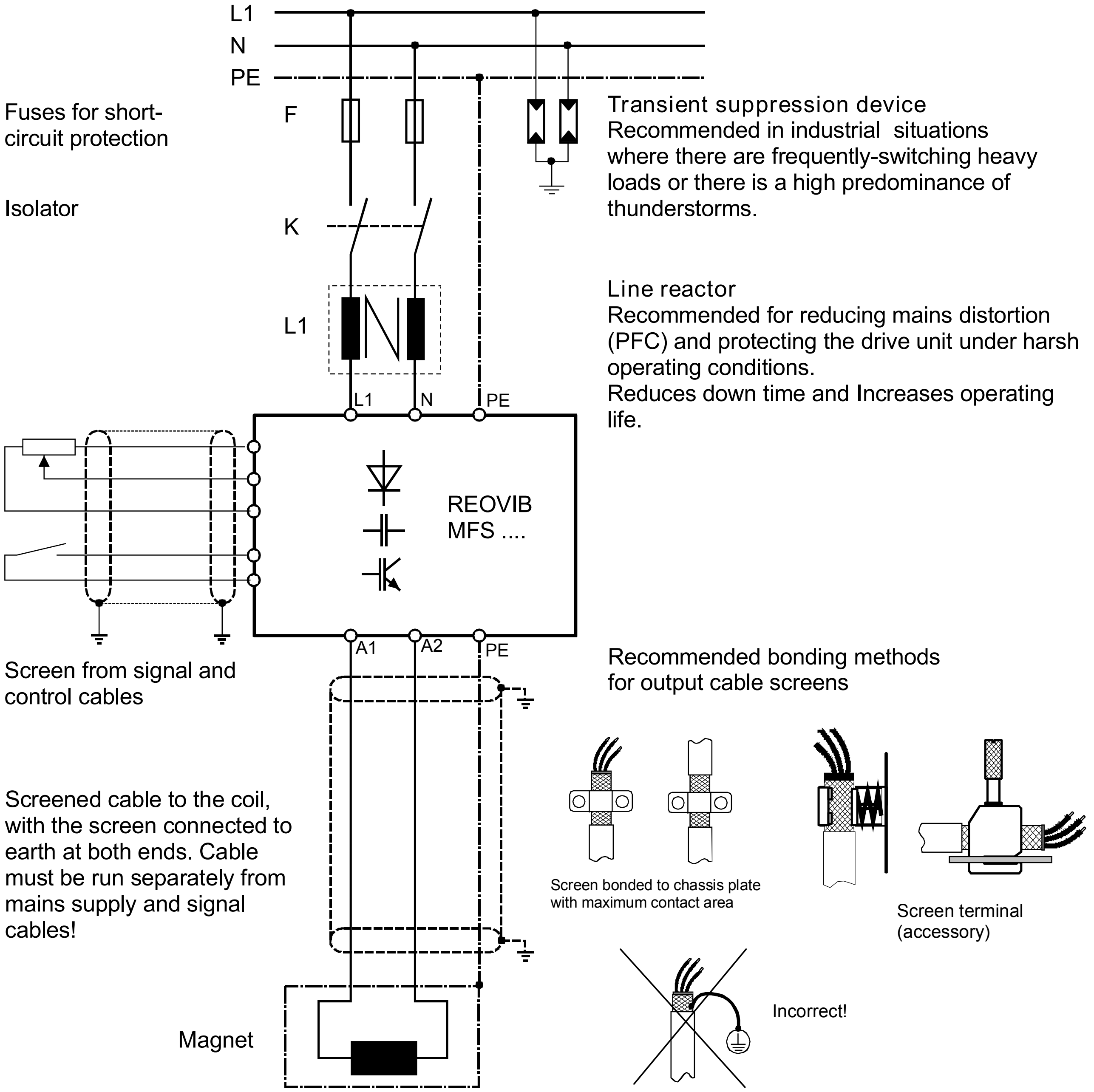
Graphic symbol

- Emergency stop devices must be provided for all applications. Operation of the emergency stop must inhibit any further uncontrolled operation.
- **Electrical connections must be covered**
- **The earth connection must be checked, for correct function, after installation.**

8.1 Before installation

- Read the instruction manual carefully, in certain circumstances there are additional instructions relevant to the installation of a particular controller (special attention should be given to warnings).
- Isolate from the mains supply, i.e. do not plug into mains socket.
- Connect the control according to the connection diagram.
- Adjust set-point to zero and put the unit mains switch in the off position.
- Insert the plug into the mains supply socket.
- Switch the unit on.
- Enable the unit, if necessary, perhaps from a supervisory system.
- The feeder throughput can now be adjusted using the set-point potentiometer (display).

8.1.0 Connection diagram for frequency drives



8.1.1 Setting the mechanical vibrating frequency

It is essential to set the frequency of the coil current, correctly, otherwise there will be a loss of feeder throughput or the coils will overheat. The vibrating frequency for **thyristor** or **triac controllers,** is selected by using a switch (normally a link switch), depending on the type of controller. The programming menu is used in digital controllers.

For 100Hz (120Hz) vibrating frequency, this switch must be closed or a link fitted and for 50Hz (60Hz) vibrating frequency the switch must be open, or a link is removed.
In the case of **frequency inverters** the vibrating frequency has a step less setting through the operator front panel.

Coils can be damaged if the vibrating frequency is set incorrectly (too low).

The rating label on a coil is often not very explicit, e.g. 50Hz is stated but no reference is made to whether this is mains frequency or the vibrating frequency of the feeder (generally it refers to the electrical frequency). It is important (in the case of thyristor and triac controllers) to know if the coil operates with one or both of the mains half-waves (6000 or 3000vibs/min).

Coils for 50Hz (3000 vibs/min) are often designated with the additional wording "for rectifier operation".

A coil for 6000 vibs/min installed to operate on half-wave (3000 vibs/min) will draw too high a current and will inevitably overheat, leading to breakdown. The frequency adjustment range, on frequency controllers, is very wide and so it is particularly important to monitor the coil current.
When in doubt the current must be checked.

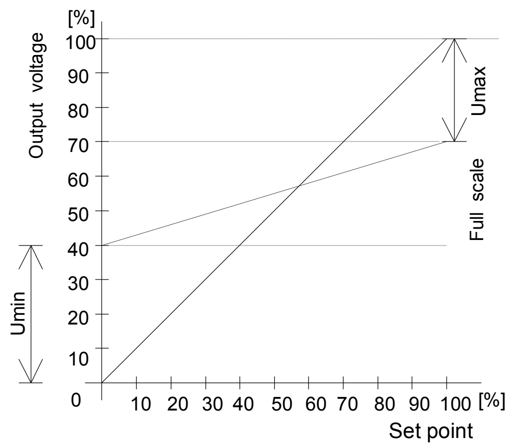
8.2 Setting the feeder throughput

Different feeder constructions (size, weight, damping etc.) means that the set-point control range, i.e. they has to be trimmed for each individual feeder. In other words, the output voltage value at which material just moves and also which gives maximum deflection, differs from feeder to feeder. The trimmers Umin and Umax are used for setting the control range, so that it can be fully used, whether this be for control from a set point potentiometer, 0...10V control voltage or 0(4)...20mA current signal.

Controllers with digital control panels, because of their improved setting abilities, do not require this facility. It is only necessary to limit the maximum feeder throughput, to either protect the coil against hammering or to limit a feeder that is too quick (jamming or interlocking parts).

When an external, analogue, set-point signal is used in conjunction with a digital controller, it is still necessary to adjust the minimum value.
In this case the setting is as follows:

1. Increase the throughput setting to the level where the feeder does not quite feed.
2. Now go into the user menu and select the external set point source. The value set previously will remain as the minimum level when the throughput signal is "0".



9.0 Setting up regulation control of frequency controllers

- To use regulation mode it is necessary to fit an accelerometer to the vibratory feeder.

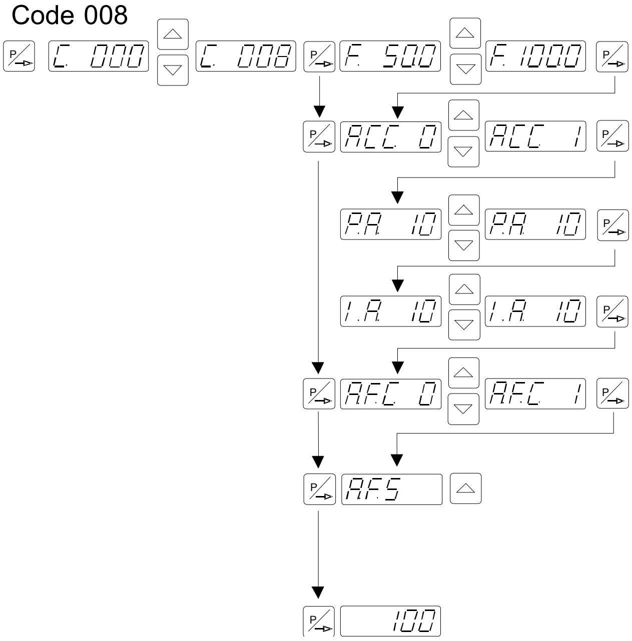
- When an accelerometer is used in regulation mode, it will sense and feed back **all** vibration signals. Stray signals can be generated by neighbouring equipment, inadequate supporting structures for the feed equipment or from inadequate mounting of the sensor itself. These can cause incorrect regulation. It is especially important to ensure that there are no external influences on the feeder, when an automatic frequency search is being carried out.

- **Resonant frequency:** Depending on the construction of the feeder and mass distribution, it is possible to have several frequencies that will exhibit resonance. The additional resonance points are multiples of the main resonant frequency. In certain, critical, circumstances the automatic frequency search may not locate resonance for this reason and in such cases the frequency must be set manually.

9.0.1 Set up menu for regulation control

E.g. REOVIB MFS 068

Code 008



Vib. frequency [Hz]

Select regulation mode
ACC. = 0 = Control without sensor
ACC. = I = Regulation with sensor

Regulation P characteristic
(Circuit gain)

Regulation I characteristic
(damps oscillations of the feeder)

Automatic frequency control
A.F.C. = 0 = Off
A.F.C. = I = On

Start freq. search

Return to normal running mode

Example menu only: for other control units the parameters may be different!

The controller, together with the sensor fitted on the feeder produce a feedback loop, whereby the signal generated from the sensor determines the control range of the set-point, i.e. the regulator controls the feeder so that the effective value (feeder power or intensity of vibration) relates to the provided set-point value. Because the effective value is dependent on the feeder (frequency, acceleration and amplitude) and in addition depends on the mounting position of the sensor, the regulator must be adapted to suit the output control range.
This is achieved by using the parameter "P" in menu "C 008". The measured sensor signal range is adjusted by changing this value. In most instances a value of less than 100 must be entered, so that the set-point can reach 100% or can go as high as possible.
When it is not possible to achieve an acceptable range the accelerometer should be mounted in the location which gives the greatest movement (see the bowl feeder example).
The importance of scaling this value is demonstrated when, for example, a feeder takes a very long time to ramp up, after it has been switched on.

9.1 Relationship between acceleration and amplitude

The sensor measures the momentary acceleration of the feeder. It generates a sinusoidal output voltage signal. The acceleration gets higher as the frequency increases. The sensor signal is greater for a higher frequency and lower amplitude than for a low frequency with higher amplitude.

Acceleration $a = \omega^2 s$ where $\omega = 2\pi f$ In practice the acceleration is influenced by gravitational force and the applied amplitude is measured in mm and so this gives the following formula: $a[g] = \frac{2^2 \pi^2 f^2 [Hz]^2 s_n [mm]}{9{,}81 \quad 2 \cdot 10^3} = \frac{f^2 [Hz]^2 s_n [mm]}{497}$ a[g] = Acceleration (with respect to gravitational acceleration of 9.81 m/s2) S_n[mm] = Applied amplitude	In practice where 497 is approximated to 500 this gives, for example: 1. Vibrating frequency 50Hz, amplitude 3mm $a = \frac{50^2 \cdot 3}{\approx 500} = 15g$ or 2. Vibrating frequency 33Hz,Amplitude 5mm $a = \frac{33^2 \cdot 5}{\approx 500} = 10{,}89g$

Using an accelerometer with an output signal of 0.3 V/g the sensor generates a peak voltage of 4.5V for a peak acceleration of 15g (example 1), corresponding to a 3.18Vrms value.

Example 1: => 15g => 4.5 V => 3.18 Vrms
Example 2: => 11g => 3.3 V => 2.33 Vrms

There is a wide variation in the g force generated by different feeders and hence great differences in the strength of feedback signal. The maximum setting [P] can be used to adjust the feedback signal to a realistic level.

9.2 Setting up instructions for using a controller in regulation mode

Connect the control equipment
Fit the sensor onto the feed equipment and connect to the controller

9.3 Determine resonant frequency

9.3.1 Manual setting of the vibrating frequency

A very low throughput setting must be used when adjusting the output frequency because it is possible to have very large deflection, with a very low voltage when passing through resonance. To determine resonance an analogue, moving-iron, RMS ammeter should be connected to the power output cable. **The resonant frequency has been reached when the maximum amplitude is achieved with the minimum current reading.**

9.3.2 Automatic frequency search

- Set throughput to zero
- Switch on regulation mode (menu C 008, set Parameter ACC = I)
- By activating the frequency search (menu C 008, select Parameter “A.F.S“ and press a cursor key to start search) this will determine the optimum feeder setting. When the resonant frequency has been found the controller will complete the search routine and return to the previous throughput setting (0).

9.4. Optimizing regulation

9.4.1 Control range adjustment

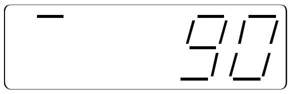
- Set Parameter “P“ in menu C 096 to 50% (maximum limit)
- Increase the through put ”A“ from zero. With a sufficient feedback signal from the sensor, the feeder amplitude can be gradually increased to 100%.
- If the maximum amplitude cannot be achieved with the 100% setting then further increase Parameter “P“ in menu C 008 and this will give more adjustment.
- Leave menu C 008. In normal running mode the throughput is displayed in %. If there is a horizontal bar in the upper first segment of the display, then the feedback signal is too low. Return to Parameter “P“ in menu C 008 and reduce this setting. If it is not possible to reduce this any further then the throughput setting must be reduced until the bar goes out.

9.4.2 Optimizing the regulation circuit when the feeder oscillates or has insufficient regulation response to load changes.

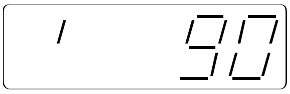
The response characteristics in the regulation circuit can be in menu C 008 using Parameter “P.A“ (Proportional Characteristic) and “I.A“ (Integral Characteristic).

Feeder throughput oscillates.
Reduce Parameter “P.A.“ in menu C 008 until the oscillating ceases.
If possible reduce Parameter “I.A.“ to zero or the lowest possible value.

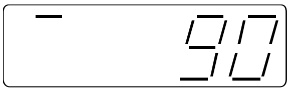
9.5 Diagnostic displays for non-optimized regulation settings



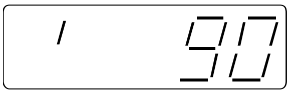
Controller has reached maximum output power.
The feedback signal from the sensor (accelerometer) is too weak relative to the selected throughput setting.
Reduce Parameter “P“ in menu C 096 or C 008.



The feedback signal from the sensor (accelerometer) is too strong.



Alternating display:



The regulator oscillates rapidly.
Reduce Parameter “P.A“ in menu C 008.

10.0 Working frequency of the coil

With new applications the current should be monitored with a true RMS meter because it is possible to draw a current that is too high for the coil, by changing the frequency, even by only a small amount.
The coil should be selected for the correct frequency, to prevent too high a current draw, resulting in overloading of the coil.

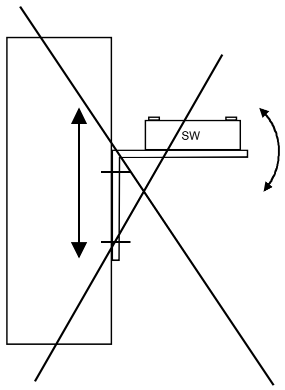
11.0 Measurement of output current and voltage

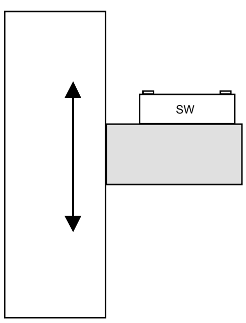
An effective measuring instrument that does not depend on a true sine wave for mains voltage or current, should be used (a sine wave is only generated at full output with full wave control).
The output from frequency controllers is generated by an electronic inverter with pulse-width, modulated switching. The voltage and current values cannot be measured with normal instruments. Preferably, a moving-iron measuring instrument (analogue meter) should be used. An analogue meter is recommended because electronic multi-meters, in this instance, will not measure reliably.

Recommended measuring equipment: REOVIB Measurement box 122

12.0 Accelerometer mounting

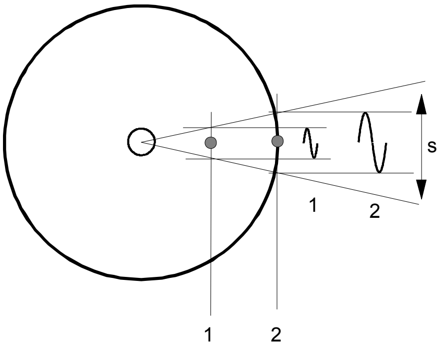
The accelerometer should generate signals for the movement and acceleration of the feeder, which are fed back to the regulator circuit of the control unit. Therefore it is very important that the sensor picks up no other extraneous vibration signals.





The sensor should be positioned so that it moves in the same direction as the feeder, ideally in the same plane as the springs, and it should be fitted on a solid block that will not generate vibration signals.

In regulation mode the magnitude of the output signal has a direct affect on the maximum amplitude of the feeder.



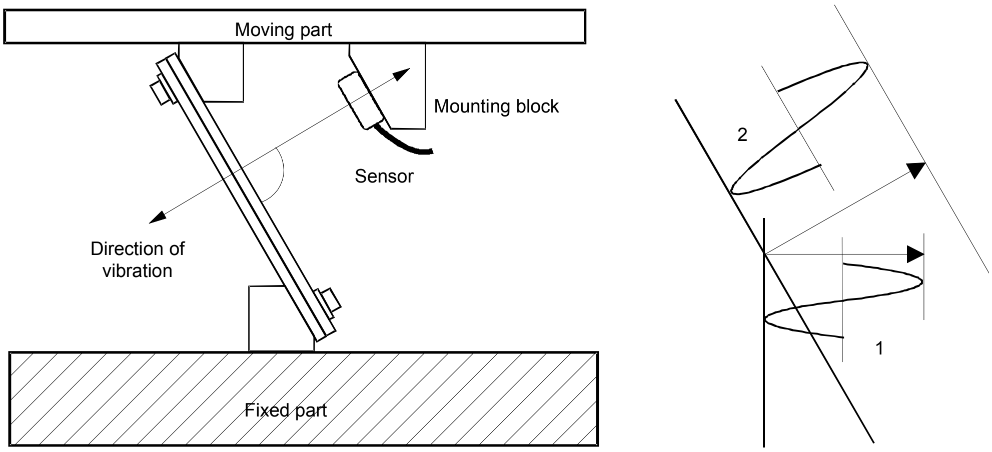
Bowl feeder example

On bowl feeders it is advisable to fit the sensor as near as possible to the outside diameter and in this position it will be subjected to the greatest movement.

The control range of the set-point will be considerably reduced when the sensor signal is weak.

s = deflection

Mounting position 1 = small movement
Mounting position 2 = large movement



Linear Feeder Example

1 = small amplitude because sensor is mounted vertically
2 = larger amplitude because sensor is mounted in the same plane as the springs

13.0 Trouble shooting – Analogue controllers

Unit doesn't work:
- Check supply voltage; check fuse and replace if necessary.
- Check short-circuit protection fuse in the controller and replace if necessary.
- Control input (Inhibit/Enable) correctly set?

Feed equipment has no power:
- Check that the correct vibrating frequency has been selected and change if necessary.
- Check supply frequency (50/60 Hz). Vibrating frequency and supply frequency must correspond.
- Setting of trimmer "Umax" is too low; adjust "Umax".

Feed equipment vibrates aggressively, coil hammers:
- Incorrect vibrating frequency setting. BEWARE: coil can be destroyed by overheating or damaged mechanically by hammering.
- Setting of trimmer "Umax" is too high; adjust "Umax".

Coil gets hot:
- Check that coil has incorrect supply rating.
- Incorrect vibrating frequency has been selected; adjust if necessary.
- Air-gap too big.

Track control doesn't operate:
- Sensor incorrectly wired; check connections.
- Check if time-out setting is too short (shorter than "t_{on}").
- Defective controller fuses (if fitted); check and replace if necessary.

14.0 Trouble shooting - Frequency controllers

Problem	Possible reason	Remedy
Feeder does not vibrate	• amplitude is set to zero • • incorrect frequency setting	• increase amplitude by pressing [P] key twice in menu C 000 and using arrow keys • carry out resonant frequency search
Feeder hammers when set point is set high	• feeder is operating too close to the resonant frequency • coil air-gap is too small	• adjust frequency • reduce maximum limit [P] • check air-gap (Caution – too wide an air-gap will increase current draw)
Magnet gets hot	• frequency setting is too low for the coil type • air-gap too wide	• increase the frequency or use a different coil • reduce the coil air-gap
“OFF“ is displayed and feeder does not work	• no enable signal	• provide enable signal using contacts or 24VDC signal • fit a link between enable terminals • invert parameter “-En”
After running for a short time the feeder stops and “Error SE” flashes in the display.	• sensor time out has been activated, no material available • no track sensor fitted • defective track sensor	• cancel sensor time out parameter “EE“ • check sensor • check sensor
After enabling the feeder or calling from a sensor, it only runs slowly, even though the soft start is set at “0” (applies to regulation mode only).	• maximum limit [P] has not been set correctly	• set the maximum limit to match the amplitude
Maximum amplitude is achieved with a very low set-point setting.	• The mounting position of the sensor has a small deflection. • Maximum limit [P] has not been set for the feeder.	• change mounting position • reduce maximum limit [P]

Error message	Type of fault	Possible reason	Remedy
ERROR – OL	Output power too high	• coil power is too high • frequency is set too low • coil air-gap is too large • short-circuit	• use a controller with a higher current rating • increase frequency • reduce air-gap • check wiring and coil
ERROR – OC	Current too high	• short-circuit on output • coil faulty	• check wiring and coil
ERROR – PEA	Peak current	• selected frequency too low • selected Amplitude too high	• increase frequency • decrease amplitude
ERROR – OU	Over voltage in DC link.	• supply voltage too high • back EMF from drive coil (possible at lower frequencies)	• check mains voltage • control unit may have to be changed for another type – contact manufacturer
ERROR – ACC	Sensor fault	• defective sensor • wrong sensor wiring	• test sensor • check wiring
ERROR – ETP	External temperature switch	• external temperature switch has reached his maximum • no temperature switch connected	• check magnet temperature • bypass the magnet temperature input
ERROR – SE	Track control sensor time-out exceeded	• sensor time-out is activated but not required • sensor has detected no product	• switch-off sensor time-out • check mechanical system
ERROR – EEP	Memory failure	• component problems	• contact manufacturer

If the above procedures do not solve the problem and it appears that the unit is faulty then please use the check sheet provided before returning the controller to your supplier.

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