Technical Note

Analog Input and Potentiometer Scaling Variable Frequency Drives

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History

Rev.	Comments	Date
V1.0	First published	22nd November 2021

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1 Introduction

Sometimes it is necessary to scale or limit the range of analog inputs or keypad potentiometers to suit an application.

Delta drives provide three methods to do this, the two-point, the three-point and the bias & gain method. Keypad potentiometers aka variable resistors VR can only use the bias & gain method. For analog inputs, refer to table 1.0.1

Table 1.0.1 Analog Input Setting Modes by Drive Model

	Two-Point Method	Three-Point Method	Bias & Gain Method
C2000 Series		✔	✔
ME300		✔	✔
MH300		✔	✔
MS300		✔	✔
VFD-E	✔		
VFD-EL	✔		
VFD-EL-W	✔		

Be aware that this document addresses qualified persons, and it cannot replace profound technical education and training.

2 Multi-Point Methods

These methods require defining several points from pairs of numbers. One number in each pair determines a specific voltage or current of the analog input. The other number determines the corresponding frequency in percent of the maximum frequency according to parameter 01-00. The drive will then connect those points by straight lines to provide a characteristic curve of frequency and analog input value.

2.1 Two-Point Method

The two-point method is available for analog inputs of VFD-E, VFD-EL and VFD-EL-W drives.

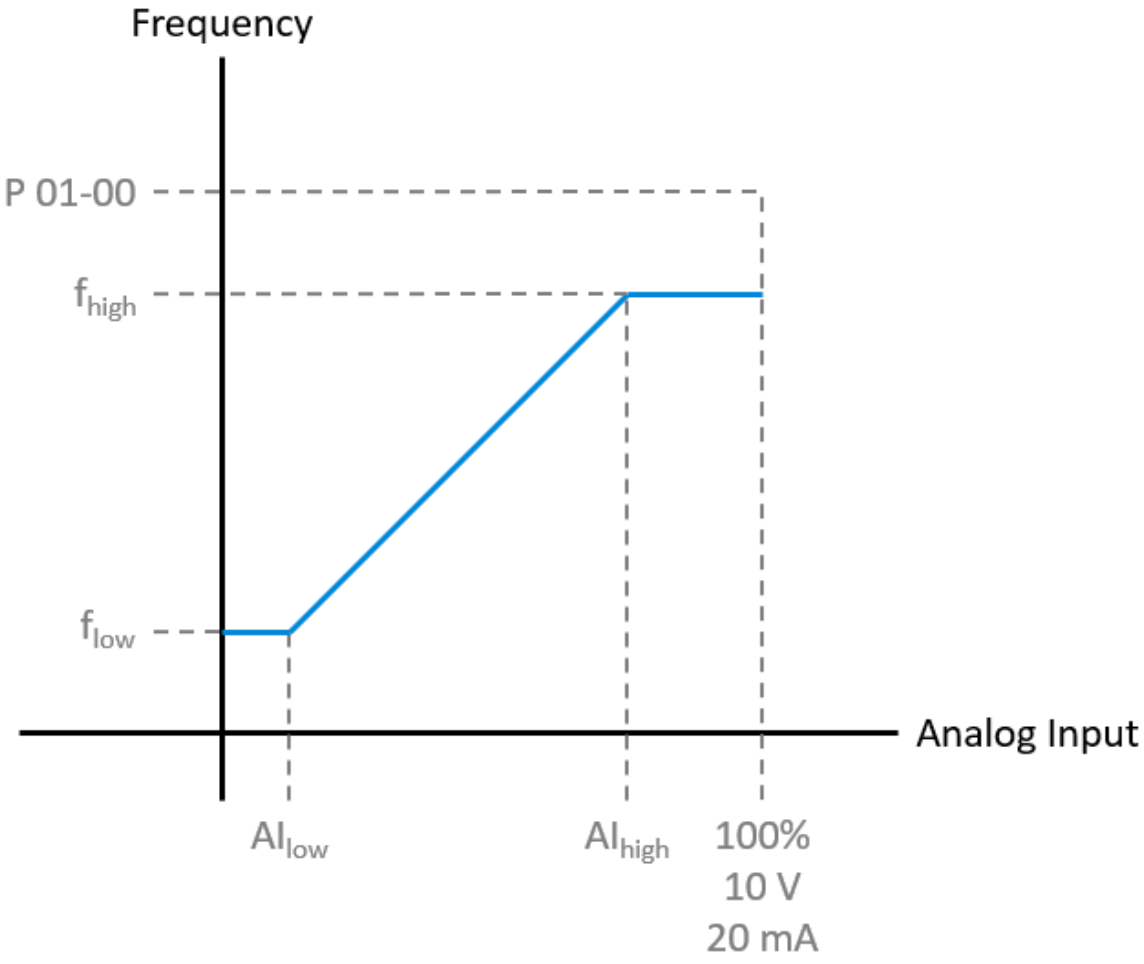

Figure 2.1.1 Two-Point Curve

Table 2.1.1 shows which parameters to use for which analog input.

Table 2.1.1 Parameter List for Two-Point Curve

Functional Description	Parameter Number		
	AVI	Depending on DIP Switch (VFD-E only)	
		ACI	AVI2 (VFD-E only)
Analog value for minimum frequency (AI_{low})	04.11	04.15	04.20
Minimum frequency (f_{low})	04.12	04.16	04.21
Analog value for maximum frequency (AI_{high})	04.13	04.17	04.22
Maximum frequency (f_{high})	04.14	04.18	04.23

2.2 Three-Point Method

The three-point method is available for analog inputs of C2000 series and M300 series.

Parameter 03-50 allows to select if this method is used, and for which of the available analog inputs.

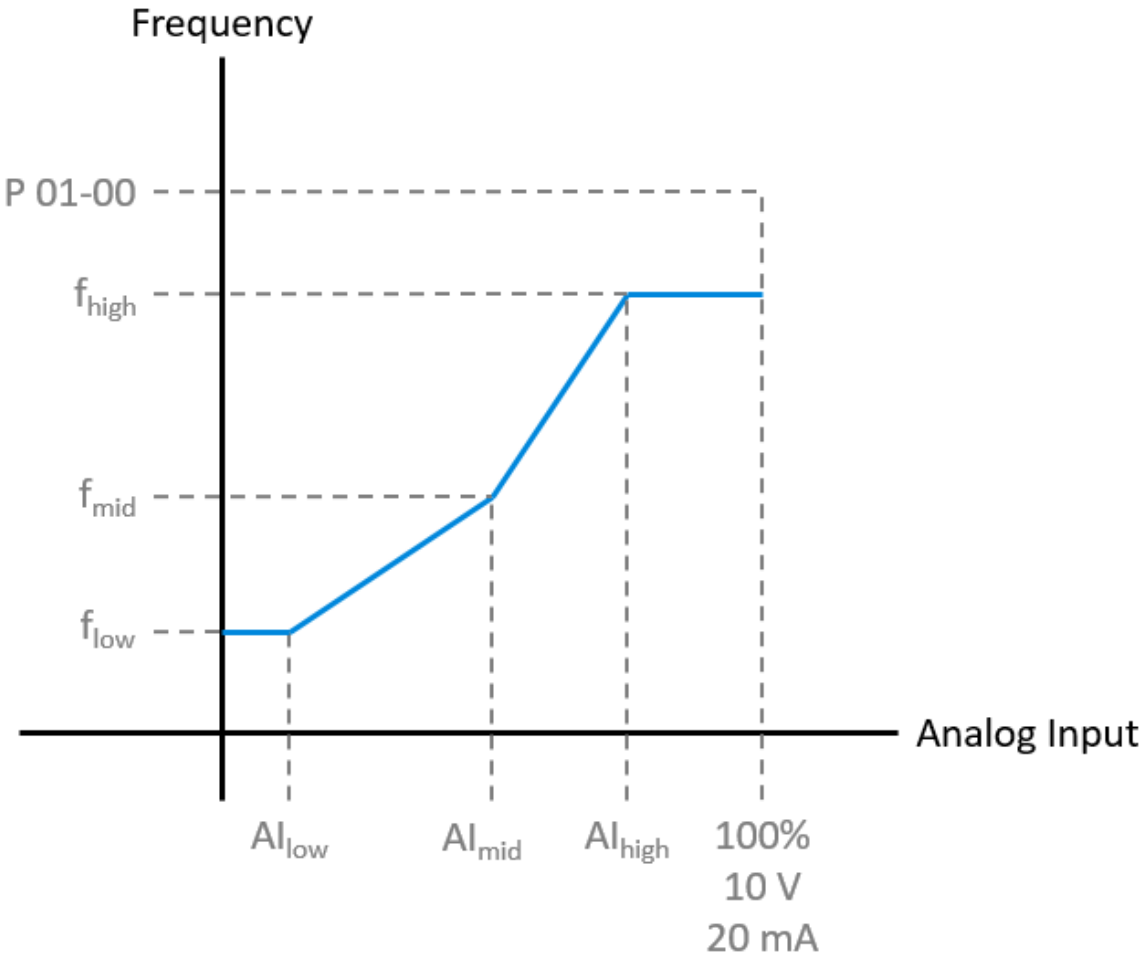

Figure 2.2.2 Three-Point Curve

Table 2.2.2 shows which parameters to use for which analog input.

Table 2.2.2 Parameter List for Three-Point Curve

Functional Description	Parameter Number		
	AVI	ACI	AUI (C2000 Series only)
Analog input curve selection	03-50		
Analog value for minimum frequency (AI_{low})	03-51 (C2000 Series) 03-63 (M300 Series)	03-57	03-63
Minimum frequency (f_{low})	03-52 (C2000 Series) 03-64 (M300 Series)	03-58	03-64
Analog value for centre frequency (AI_{mid})	03-53 (C2000 Series) 03-65 (M300 Series)	03-59	03-65
Centre frequency (f_{mid})	03-54 (C2000 Series) 03-66 (M300 Series)	03-60	03-66
Analog value for maximum frequency (AI_{high})	03-55 (C2000 Series) 03-67 (M300 Series)	03-61	03-67
Maximum frequency (f_{high})	03-56 (C2000 Series) 03-68 (M300 Series)	03-62	03-68

3 Bias & Gain Method

This method is available for analog inputs of C2000 series and M300 series drive as well as for keypad potentiometers on ME300, MS300, VFD-E, VFD-EL and VFD-EL-W. The bias refers to the X-axis.

For convenience, we suggest to choose f_{high} = P01-00 (f_{max}). If $f_{max} > f_{high}$, the drive does not exploit the entire input range.

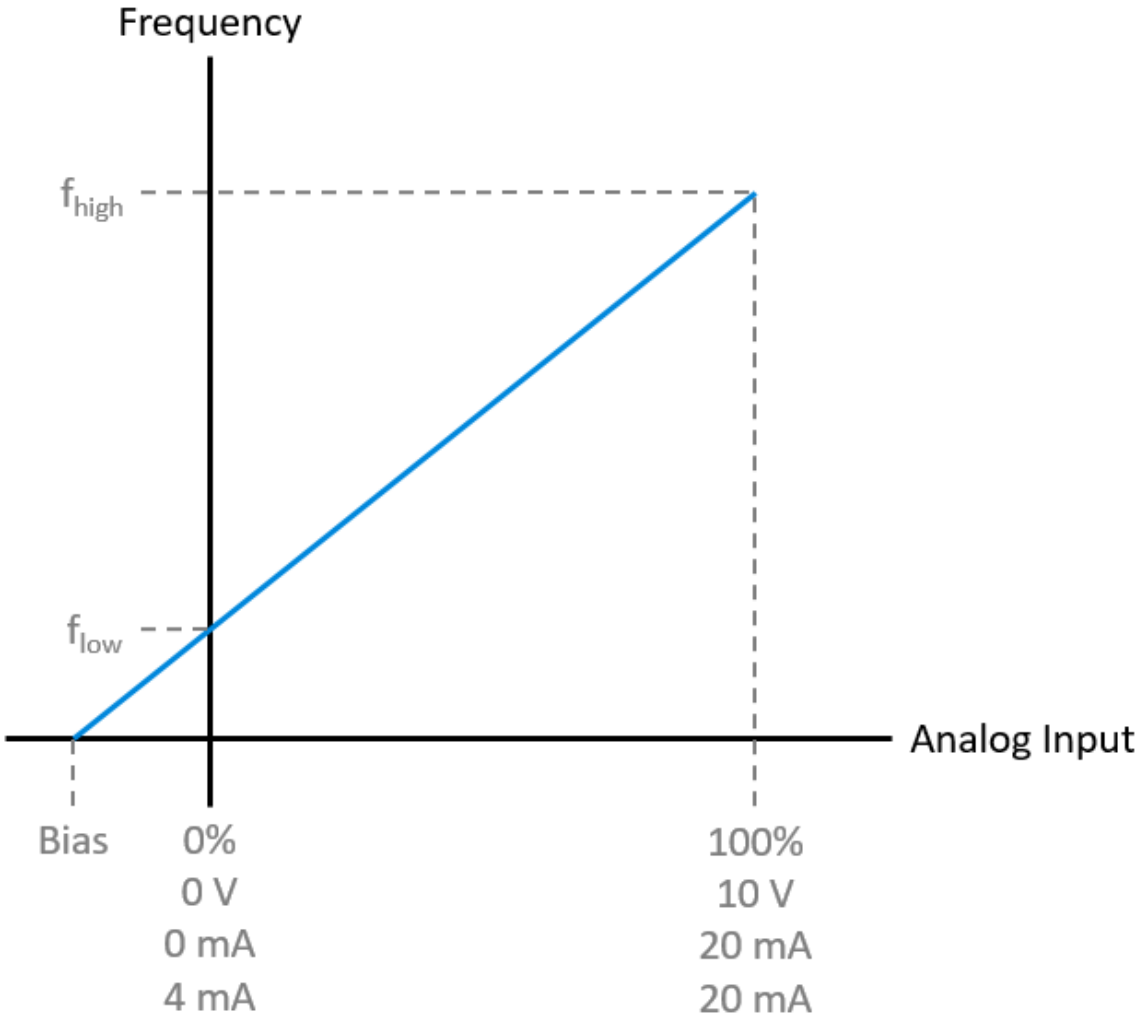

Figure 3.0.1 Bias & Gain Curve

It is necessary to define the gain, i.e. the slope of the curve.

$$Gain = \left(1 - \left(\frac{f_{low}}{f_{high}}\right)\right) * 100\%$$

The bias needs to be determined, i.e. evaluate where the resulting curve crosses the X-axis. Observe the negative sign of the numerator.

$$Bias = \left(\frac{-f_{low}}{f_{high} - f_{low}}\right) * 100\%$$

Example 3.0.1

A user wants to control the output frequency between 20 Hz and 40 Hz from the keypad of ME300 or MS300. The gain setting is.

$$Gain = \left(1 - \left(\frac{20}{40}\right)\right) * 100\% = 50\%$$

The bias setting is.

$$Bias = \left(\frac{-20}{40 - 20}\right) * 100\% = \ -100\%$$

Table 3.0.1 Parameter Settings for Example 3.0.1

Parameter	Value	Description
P00-20	7	Master frequency command source from keypad
P01-00	40.00 Hz	Maximum operation frequency
P03-39	1	VR input as frequency command
P03-40	-100.0%	VR input bias
P03-41	1	Lower than or equal to bias
P03-42	50.0%	VR input gain

3.1 Positive and Negative Bias

This parameter has five settings to define the curve shape. In combination with the reverse setting parameter, it is possible to create five different basic curves.

Table 3.1.1 Positive and Negative Bias Parameter

AVI	ACI	AUI	VR / Keypad Potentiometer
03-07 (C2000 Series, M300 Series)	03-08 (C2000 Series, M300 Series)	03-09 (C2000 Series)	03-41 (ME300, MS300) 04.01 (VFD-E, VFD-EL, VFD-EL-W)

- 0 means, the curve will pass through the intersection of X- and Y-axis. Bias settings have no effect

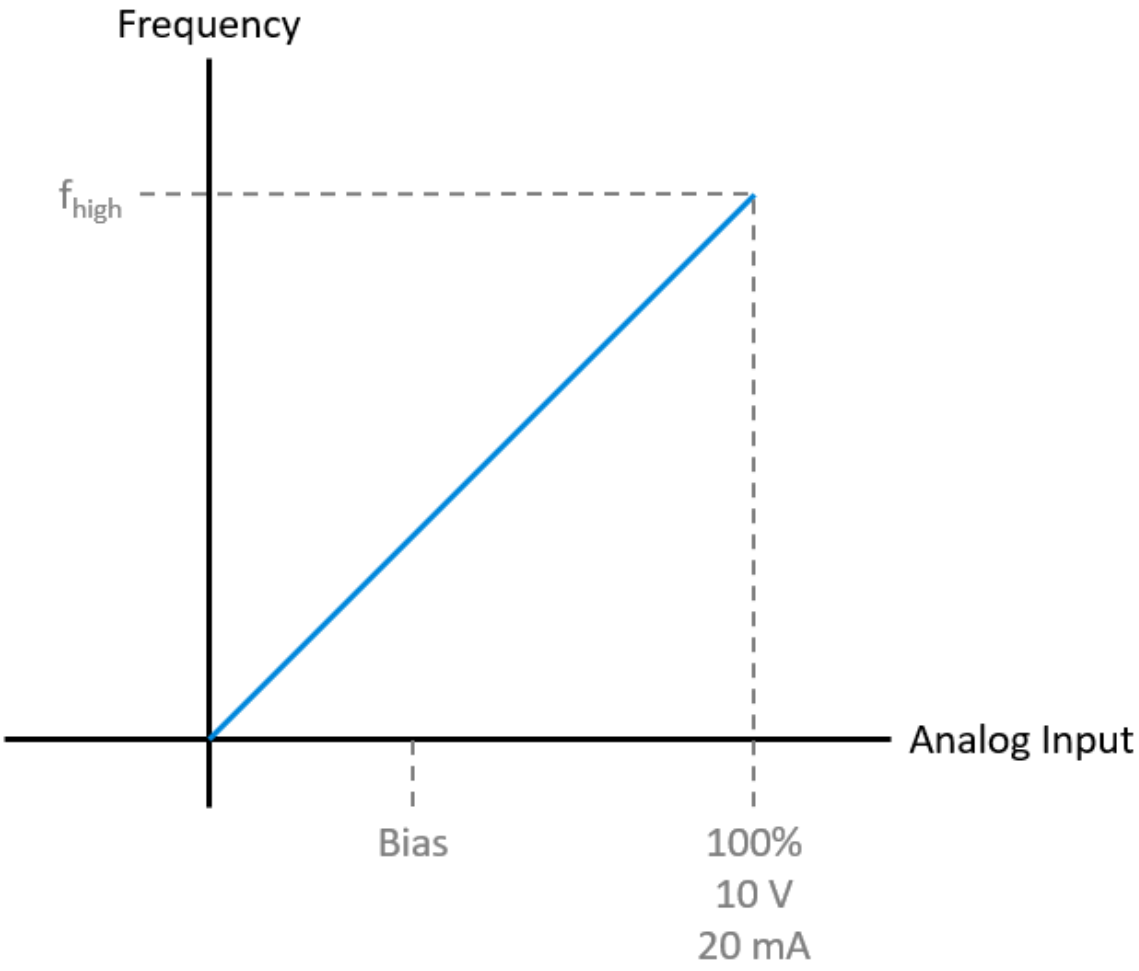

Figure 3.1.1 “No Bias” Curve

- 1 means, the frequency will be 0, if the analog input value is below bias

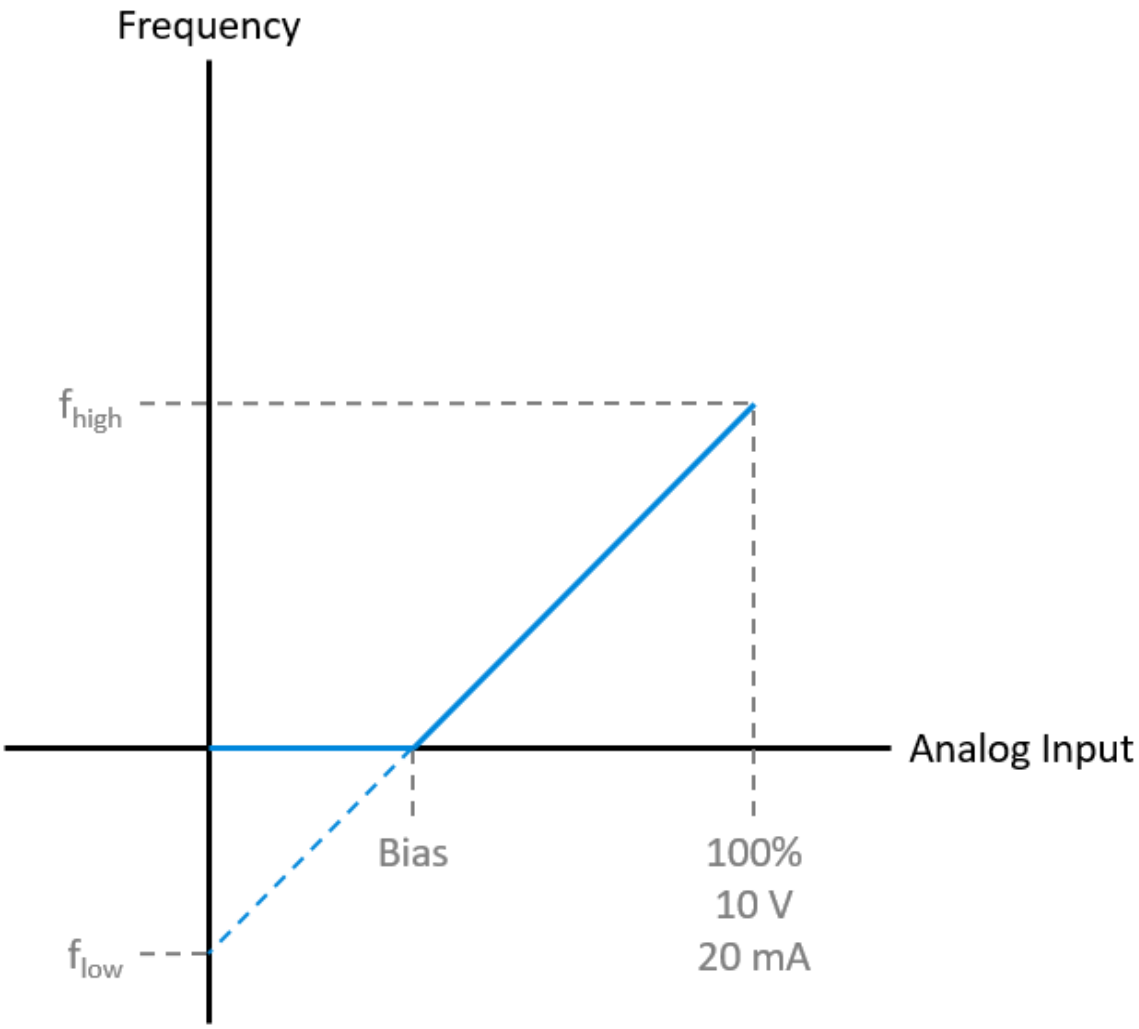

Figure 3.1.2 “Lower than or Equal to Bias” Curve

- 2 means, the frequency will be 0, if the analog input value is above bias

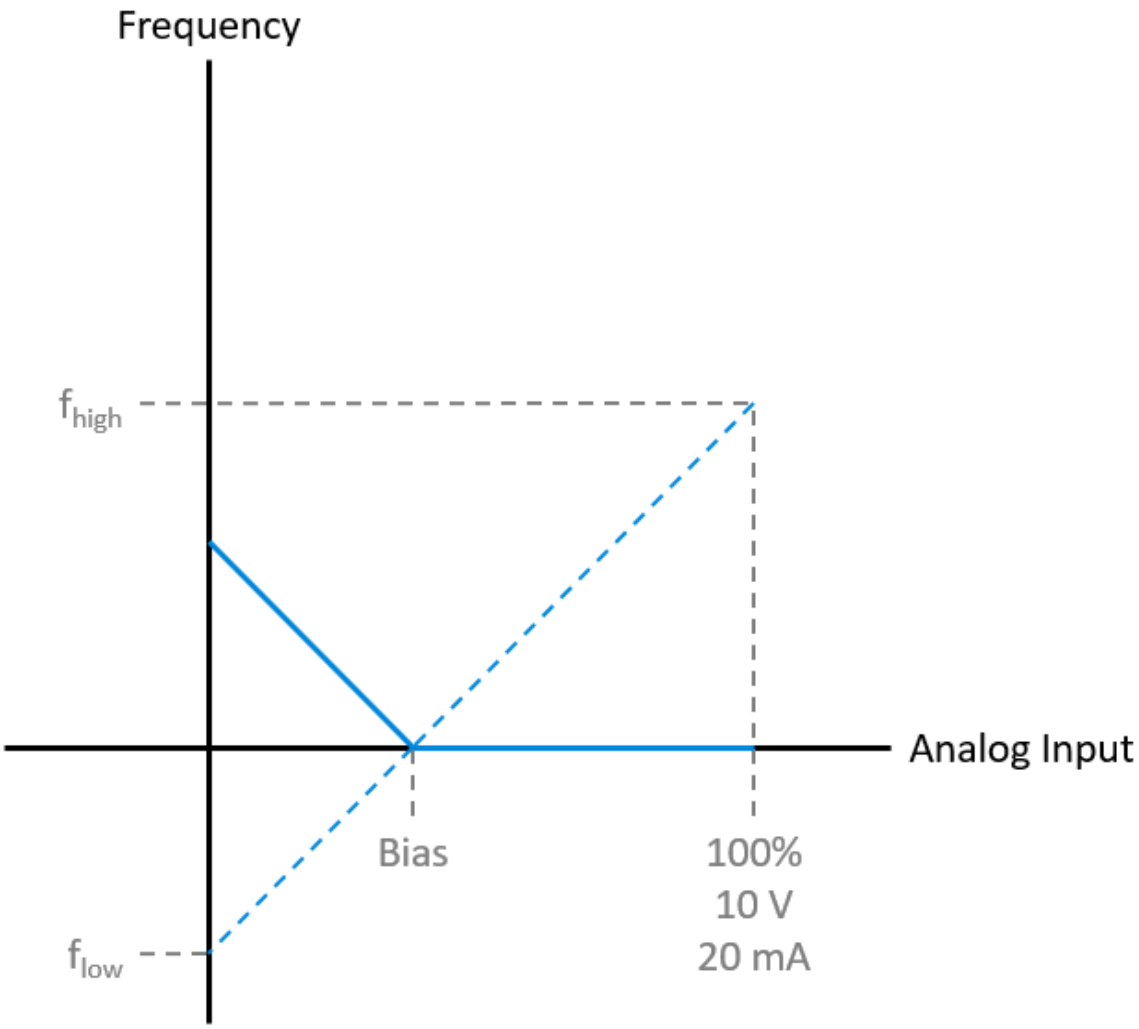

Figure 3.1.3 “Greater than or Equal to Bias” Curve

Example 3.1.1

A user wants to control the speed of a fan from AVI in fail-safe mode, i.e. when a wire breaks at the analog input, the drive shall run at full speed to provide cooling. 0 V at AVI correspond to 50 Hz, and 10 V correspond to 0 Hz. For the gain setting, f_{low} = 0 Hz and f_{high} = 50 Hz is 100%, because division by zero is not possible, but the slope is considered symmetrical.

$$Gain = \left(1 - \left(\frac{0}{50}\right)\right) * 100\% = 100\%$$

For the bias setting, f_{low} and f_{high} stay as they are, i.e. f_{low} = 50 Hz and f_{high} = 0 Hz.

$$Bias = \left(\frac{-50}{0 - 50}\right) * 100\% = 100\%$$

Table 3.1.2 Parameter Settings for Example 3.1.1

Parameter	Value	Description
P00-20	2	Master frequency command source from external analog input
P01-00	50.00 Hz	Maximum operation frequency
P03-00	1	AVI input selection as frequency command
P03-03	100.0%	AVI input bias
P03-07	2	Greater than or equal to bias
P03-11	100.0%	AVI input gain

- 3 means the frequency will be 0 at the bias value. The slope rises symmetrically around the bias value

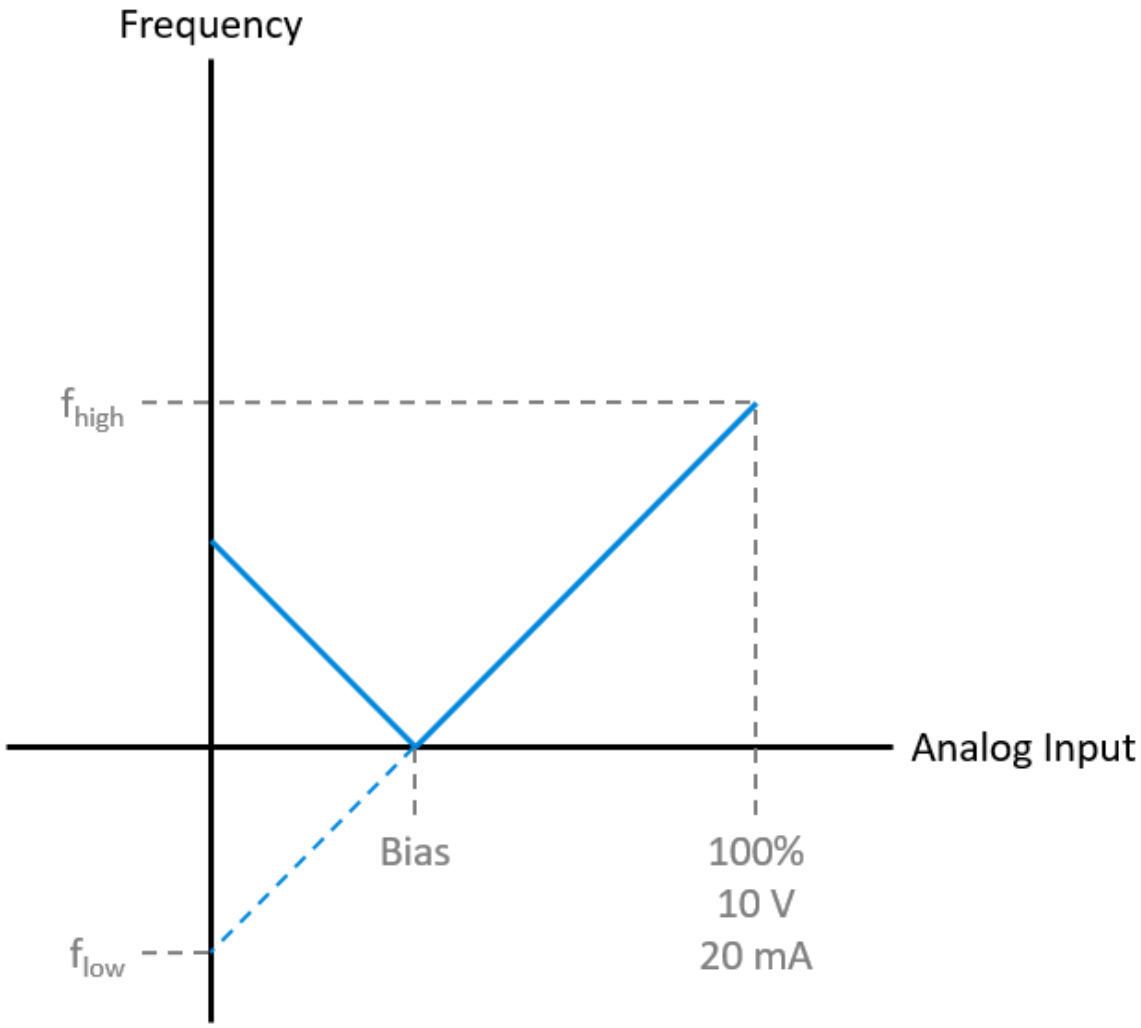

Figure 3.1.4 “The Absolute Value of the Bias Voltage while Serving as the Centre” Curve

- 4 means the frequency will be 0 at the bias value. It will rise above the bias. Its behaviour below the bias depends on the setting of 03-10 (C2000 series and M300 series) or 04.03 (VFD-E, VFD-EL, VFD-EL-W). If that parameter is 0, the curve looks like figure 3.1.4. If it is 1, the frequency will follow the curve through to the negative range like in figure 3.1.5. With this setting, above bias the motor runs forward and below bias it runs reverse.
  For ME300 and MS300 potentiometers, there is no equivalent to 03-10. Setting 03-41 = 4 always works like in figure 3.1.4.

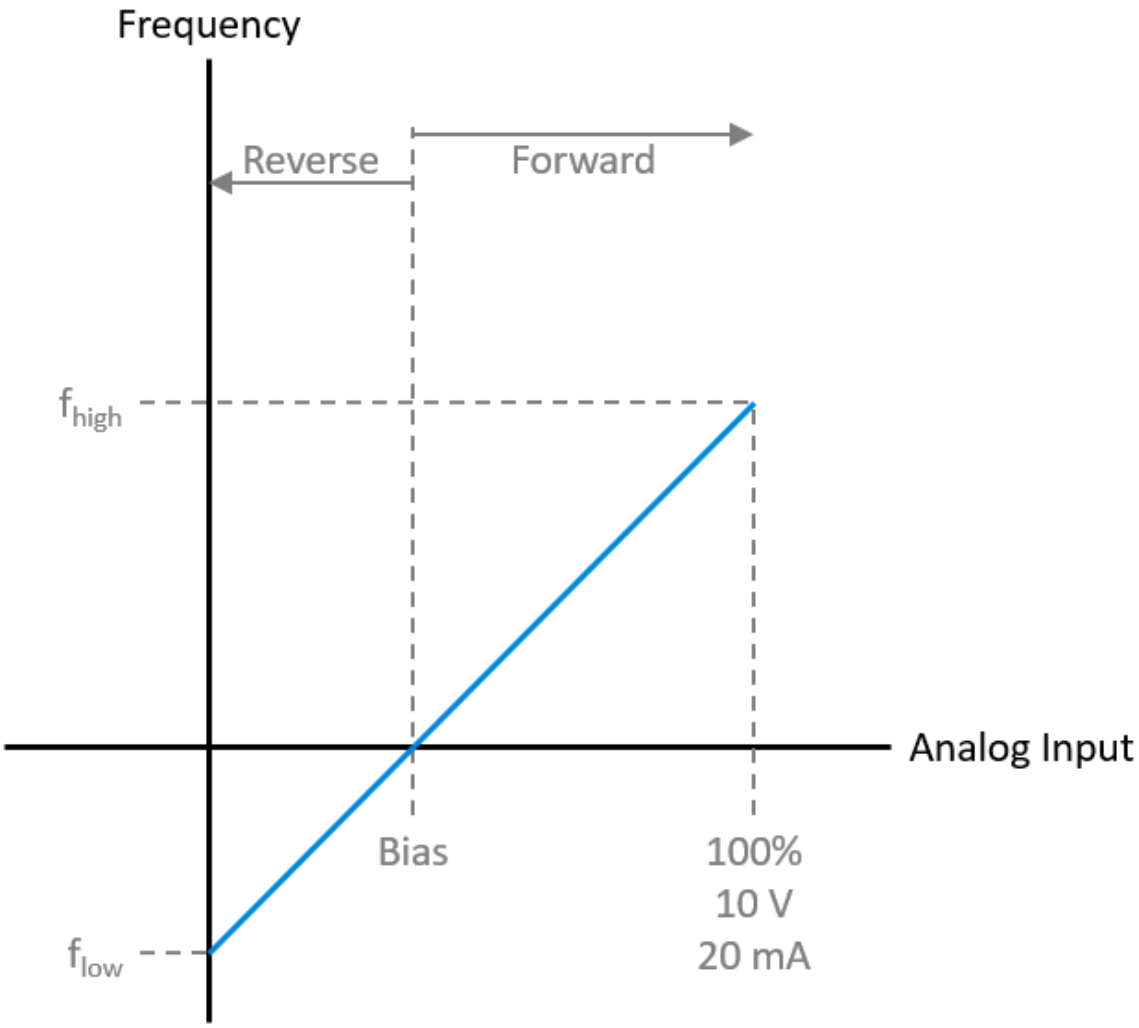

Figure 3.1.5 “Bias Serves as the Centre” & “Negative Frequency Allowed” Curve

Example 3.1.2

A user wants to control the speed from 50 Hz reverse to 50 Hz forward from AVI. When the voltage at AVI is 5 V, the output is 0 Hz. Increasing the voltage at AVI from 5 V upwards increases the frequency, and the motor turns in forward direction. Decreasing the voltage at AVI from 5 V downwards increases the frequency, and the motor runs in reverse direction. The gain setting is.

$$Gain = \left(1 - \left(\frac{-50}{50}\right)\right) * 100\% = 200\%$$

The bias setting is.

$$Bias = \left(\frac{-(-50)}{50 - (-50)}\right) * 100\% = 50\%$$

Table 3.1.3 Parameter Settings for Example 3.1.2

Parameter	Value	Description
P00-20	2	Master frequency command source from external analog input
P01-00	50.00 Hz	Maximum operation frequency
P03-00	1	AVI input selection as frequency command
P03-03	50.0%	AVI input bias
P03-07	4	Bias serves as the center
P03-10	1	Negative frequency input is allowd
P03-11	200.0%	AVI Gain