Application Note: Setting Up User Units, Speed References, and Ramp Rates in the AMC

By default, the AMC assumes that the user units to be worked with are normalized encoder counts in the application that is being designed. This typically is not the case, as most applications would like to work in more practical linear or rotary units, such as degrees or millimeters. The following example will discuss how to change the user units of the AMC to more accurately reflect the application specifics, where in this case study it is desirable to work in millimeters.

1. **Determine the number of User Units that occur for 1 revolution of the motor, or if a transmission is present (e.g. gearbox) for 1 revolution on the output of that transmission and the number of motor revolutions to achieve that output.**

   For example, if there is a pulley and belt system, with a motor and gearbox attached to the pulley, where *d* is the diameter of the pulley, and *n* is the ratio of the gearbox, the circumference *c* will be the linear distance traveled per output revolution of the gearbox:

   $$c = \pi d$$

   For the circumference *c* the pulley traveled *n* revolutions.

   If the diameter of the pulley is 100 mm, and the gear ratio is 10:1:

   $$c = \pi * 100mm = 314.159\, mm$$

   Therefore, it takes 10 revolutions of the motor to travel 314.159 mm.

2. **Based upon this information, enter the AMC Slave User Units Ratio and AMC User Units Output Ratio into Menu 31.**

   The AMC Slave User Units Ratio (Pr 31.006 and Pr 31.007) will convert the normalized encoder position (any encoder resolution scaled to the resolution defined by 32 bits - Pr 3.057, which equals 16 bits (65536 “normalized counts”) in this case) that is provided to the AMC from Pr 3.058 (*P1 Normalized Position*) into “user units” that are desired by the user for the specific application. The AMC Slave User Units Ratio is defined as the *number of user units (uu) per normalized encoder resolution multiplied by the number of revolutions to travel that number of user units*. In an equation it looks as follows:

   $$AMC\ Slave\ UU\ Ratio = \frac{Number\ of\ User\ Units}{n * Normalized\ Encoder\ Resolution} = \frac{Pr\ 31.006}{Pr\ 31.007}$$

   It is important to provide the AMC sufficient resolution for the User Units to be used in the speed and ramp rates, which are defined as uu/ms and uu/ms^2. It is recommended that the primary user units to be used (mm, in this case) be multiplied by a factor of 1000. This creates user units of 1/1000 of a millimeter, or µm (0.001 mm). Therefore the AMC Slave UU Ratio becomes:

$$\frac{1000 * 314.159}{10 * 65536} = \frac{Pr\ 31.006}{Pr\ 31.007} = \frac{314159}{655360}$$

From this equation, the *AMC Slave User Units Numerator* (Pr 31.006) is 314159, and the *AMC Slave User Units Denominator* (Pr 31.007) is 655360, where user units are millimeters with 3 implied decimal places (0.001 mm).

The AMC User Units Output Ratio will convert user units in the AMC back to normalized encoder counts in the drive. This ratio is simply the inverse of the AMC Slave User Units Ratio:

$$AMC\ Output\ UU\ Ratio = \left[\frac{Pr\ 31.006}{Pr\ 31.007}\right]^{-1} = \frac{Pr\ 31.008}{Pr\ 31.009}$$

Therefore, the *AMC Output User Units Ratio Numerator* (Pr 31.008) is 655360 and the *AMC Output User Units Ratio Denominator* (Pr 31.009) is 314159. These values will now scale the output speed reference from the AMC to the drive to suitable units for the drive.

3. **Based upon the user units selected, calculate appropriate speed references for the application to be written to the AMC Profile Generator in Menu 39.**

In the AMC, the units for speed references are in user units per millisecond (uu/ms), so some calculation should be done to convert engineering speed references to AMC speed references. Typically, speed is defined in linear or rotary speed units, both of which will be illustrated here. First, consider this application where the commanded speed on the machine is a linear speed of millimeters per second (e.g. 400 mm/s). With dimensional analysis, units can be converted from mm/s to uu/ms, where uu are 1/1000 of a mm (0.001 mm).

$$AMC\ Speed\ Reference\ = \frac{mm}{s} * \frac{1\ s}{1000\ ms} * \frac{1000\ uu}{mm}$$

Inserting the desired engineering speed reference into this equation and canceling units' yields:

$$AMC\ Speed\ Reference\ = \frac{400\ \cancel{mm}}{\cancel{s}} * \frac{1\ \cancel{s}}{1000\ ms} * \frac{1000\ uu}{\cancel{mm}} = \ 400.00\ \frac{uu}{ms}$$

Therefore, for an index to reach a speed of 400 mm/s, the *AMC Maximum Profile Speed* (Pr 38.003) should be set to 400 uu/ms.

Next, consider the situation where attaining a certain motor *rotational* speed is more important that a linear speed. For example, if it is desired for the motor to reach 1250 RPM during an index, the unit conversion with dimensional analysis to get to uu/ms (0.001 mm/ms) would be as follows:

$$AMC\ Speed\ Reference = \frac{revolutions}{minute} * \frac{1\ minute}{60{,}000\ ms} * \frac{314159\ uu}{n * revolutions}$$

Inserting the desired engineering speed reference into this equation and canceling units yields:

$$AMC\ Speed\ Reference = \frac{1250\ \cancel{revolutions}}{\cancel{minute}} * \frac{1\ \cancel{minute}}{60{,}000\ ms} * \frac{314159\ uu}{10\ \cancel{revolutions}} = 654.49\ \frac{uu}{ms}$$

Note, that since the speed of the motor is being considered instead of the speed of the output of the gearbox, it is necessary to define the number of user units per *n* revolutions of the motor, where *n* = 10 in this case. For the motor to reach 1250 RPM during an index, the *AMC Maximum Profile Speed* (Pr 38.003) should be set to 654.49 uu/ms.

If the user units that were selected do not seem to providing the resolution that is desired, causing "jittery" or granular motion, or the slave user unit ratio must be greater than one, *AMC Auto Resolution Enable* (Pr 31.015) can be enabled, allowing the AMC to internally increase the resolution of the user units to give better speed resolution.

4. **Based upon target speed derived from the user unit ratio, calculate appropriate ramp rates to be written to the AMC Profile Generator in Menu 39.**

In the AMC, the units for ramp rates (acceleration and deceleration) are in user units per millisecond^2 (uu/ms^2), so some calculation should be done to convert engineering ramp references to AMC speed references. Considering the linear speed calculation from Step #3, we will work out an acceleration rate of 1.5 seconds from zero speed to max speed, and a deceleration rate of 3 seconds from max speed to zero speed. For the ramp rates, simply divide the maximum profile speed (Pr 38.003) by the time in milliseconds that is desired for the ramp. For acceleration:

$$AMC\ Profile\ Acceleration = \frac{Pr\ 38.003}{Ramp\ Time} = \frac{400.00\frac{uu}{ms}}{1500\ ms} = 0.266\ \frac{uu}{ms^2}$$

For deceleration:

$$AMC\ Profile\ Deceleration = \frac{Pr\ 38.003}{Ramp\ Time} = \frac{400.00\frac{uu}{ms}}{3000\ ms} = 0.133\ \frac{uu}{ms^2}$$

Therefore, to attain the ramp rates for acceleration and deceleration as defined above, *AMC Profile Acceleration* (Pr 38.001) should be set to 0.266 uu/ms^2, and *AMC Profile Deceleration* (Pr 38.002) should be set to 0.133 uu/ms^2.

5. **Now that all necessary motion related parameters have been scaled to the appropriate user units of 0.001 mm, review the destinations of these values:**

Relative AMC Index Position (mm)	=	Pr 34.003
AMC Profile Maximum Speed	=	Pr 38.003
AMC Profile Acceleration	=	Pr 38.001
AMC Profile Deceleration	=	Pr 38.002

For further discussion and information on AMC User Units, see Menus 31 & 38 in the Unidrive M700 Parameter Reference Guide.