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# Generate stepper-motor speed profiles in real time

**David Austin**

DECEMBER 30, 2004

**A new algorithm for stepper-motor acceleration allows speed profiles to be parameterized and calculated in real time. This algorithm can run on a low-end microcontroller using only simple fixed-point arithmetic operations and no data tables. It develops an accurate approximation for the timing of a linear ramp with constant acceleration and deceleration.**

It's commonly thought that the timing of a linear speed ramp for a stepper motor is too complex to be calculated in real time. The exact formula for the step delay is in Equation 8. The solution has been to store the ramp data in precompiled arrays, but this method is inflexible and wastes memory. The alternative has been to use a more powerful and expensive processor than otherwise needed or a high-level stepper-control IC. This article develops an accurate approximation that has been implemented in C using 24.8 fixed-point arithmetic on a mid-range PIC microcontroller.

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Motor step signals can be generated by a 16-bit timer-comparator module as commonly integrated in microcontrollers. On the PIC, the CCP (capture/compare/pwm) performs this function. It allows steps to be timed to the resolution of one timer period. Each step advances the motor by a constant increment, typically 1.8 degrees on a hybrid stepper motor.

## MOST READ

The timer frequency should be as high as possible while still allowing long delays as the motor is accelerated from stop. A timer frequency of 1MHz has been used. A maximum motor speed of 300rpm is then equivalent to a delay count of 1,000. It's necessary to have high timer resolution to give smooth acceleration at high speed.

## Notation and basic formulas

Delay (sec) programmed by timer count $c$:

$$\delta t = \frac{c}{f}$$

<div align="center">Equation 1</div>

$f$ = timer frequency (Hz).
Motor speed $\omega$ (rad/sec) at fixed timer count $c$:

$$\omega = \frac{\alpha.f}{c}$$

<div align="center">Equation 2</div>

$\alpha$ = motor step angle (radian).
1rad = $180/\pi$ = 57.3deg. 1rad/sec = $30/\pi$ = 9.55rpm.

Acceleration $\omega'$ (rad/sec$^2$) from adjacent timer counts $c1$ and $c2$:

$$\omega' = \frac{2.\alpha.f^2.(c1-c2)}{c1.c2.(c1+c2)}$$

<div align="center">Equation 3</div>

Equation 3 assumes fixed-count speed (Equation 2) at the midpoint of each step interval (Equation 1), as on a linear ramp, Figure 1. Note that $\omega'$ resolution is inversely proportional to the cube of the speed.
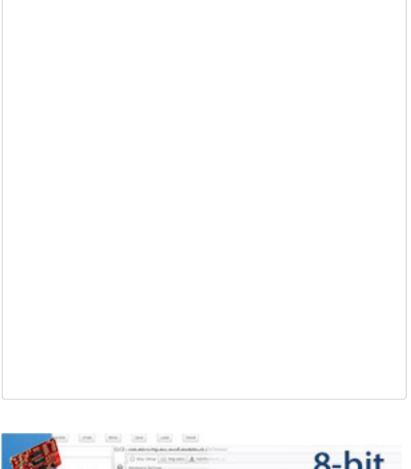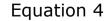


**Figure 1: Ramp geometry: move of $m$=12 steps**
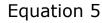
## Linear speed ramp—exact

On a linear ramp, acceleration $\omega'$ is constant, and speed $\omega(t) = \omega'.t$. Integration gives the motor shaft angle $\theta(t)$:

$$\theta(t) = \int_0^t \omega(\tau).d\tau = \frac{\omega'.t^2}{2} = n.\alpha$$

<div align="center">Equation 4</div>

$n \geq 0$ step number (real). When the shaft is at $\theta = n.\alpha$, (integer $n$) it's time for the $n$th step pulse:

$$t_n = \sqrt{\frac{2.n.\alpha}{\omega'}}$$

<div align="center">Equation 5</div>

The exact timer count to program the delay between the $n$th and $(n+1)$th pulses ($n \geq 0$) is:

$$c_n = f \cdot (t_{n+1} - t_n)$$

<div align="center">Equation 6</div>

The initial count $c_0$ factorizes out to give Equations 7 and 8:

$$c_0 = f \sqrt{\frac{2.\alpha}{\omega'}}$$

<div align="center">Equation 7</div>

$$c_n = c_0 \cdot \left( \sqrt{n+1} - \sqrt{n} \right)$$

<div align="center">Equation 8</div>

Note that $c_0$ sets the acceleration, proportional to $(1/c_0)^2$ .

In real-time, Equation 8 would require calculation of a square-root for each step, with the added problem of loss of precision by subtraction.

## Approximating linear ramp

Ratio of successive exact timer counts from Equation 8:

$$\frac{c_n}{c_{n+1}} = \frac{c_0 \cdot \left( \sqrt{n+1} - \sqrt{n} \right)}{c_0 \cdot \left( \sqrt{n} - \sqrt{n-1} \right)} = \frac{\sqrt{1+1/n} - 1}{1 - \sqrt{1-1/n}}$$

<div align="center">Equation 9</div>

Taylor series:

$$\sqrt{1 \pm \frac{1}{n}} = 1 \pm \frac{1}{2.n} - \frac{1}{8.n^2} + O\left( \frac{1}{n^3} \right)$$

<div align="center">Equation 10</div>

Equation 11 is the second-order approximation to Equation 9 using Equation 10:

$$\frac{c_n}{c_{n-1}} = \frac{4.n - 1}{4.n + 1}$$

<div align="center">Equation 11</div>

Equation 11 can be rearranged for faster calculation:

$$c_n = c_{n-1} - \frac{2.c_{n-1}}{4.n + 1}$$

<div align="center">Equation 12</div>

Finally, we can disconnect the physical step number, $i$, from the step number $n$ on a ramp from zero, to give the general-purpose ramp algorithm shown in Equation 13. Here $n$ determines the acceleration and increments with $i$ for constant acceleration. To ramp up from stop, $n_i = i$, $i = 1, 2, \ldots$ :

$$c_i = c_{i-1} - \frac{2.c_{i-1}}{4.n_i + 1}$$

<div align="center">Equation 13</div>

Negative $n$-values give deceleration. In particular, Equation 14, with $n_i = i - m$, can be used to ramp any speed down to stop in the final steps of a move of $m$ steps:

$$c_i = c_{i-1} - \frac{2.c_{i-1}}{4.(i-m)+1}, i < m$$

<div align="center">Equation 14</div>

**Table 1: Accuracy of the step-delay approximation**

| Step $n$ | Exact (9) | Approx (11) | Relative error |
|---|---|---|---|
| 1 | 0.4142 | 0.6000 | 0.4485 |
| 2 | 0.7673 | 0.7778 | 0.0136 |
| 3 | 0.8430 | 0.8462 | 0.00370 |
| 4 | 0.8810 | 0.8824 | 0.00152 |
| 5 | 0.9041 | 0.9048 | 7.66E-4 |
| 6 | 0.9196 | 0.9200 | 4.41E-4 |
| 10 | 0.9511 | 0.9512 | 9.42E-5 |
| 100 | 0.9950 | 0.9950 | 9.38E-8 |
| 1,000 | 0.9995 | 0.9995 | 9.37E-11 |

## Accuracy of approximation

Table 1 shows that the approximation is accurate even at low step number $n$ and relative error decreases with $n^3$. However, $n=1$ has a significant inaccuracy. The inaccuracy at $n=1$ can be handled in two ways:

- Treat $n=1$ as a special case. Using $c1$ 0.4056 $c0$ compensates for the inaccuracies at the start of the ramp and allows Equation 7 to be used to calculate $c0$.
- Ignore the inaccuracy. In place of Equation 7 use Equation 15:

$$c_0 = 0.676.f\sqrt{\frac{2.\alpha}{\varpi'}}$$

<div align="center">Equation 15</div>

The first alternative gives an almost perfect linear ramp. The second alternative starts with a fast step. This is to the good, as it helps keep the motor moving between step pulses 0 and 1-and establishes the angle error needed to generate torque. It also allows a wider range of accelerations to be generated with a 16-bit timer and has the advantage of simplicity. It's therefore recommended to ignore the inaccuracy at $n=1$.
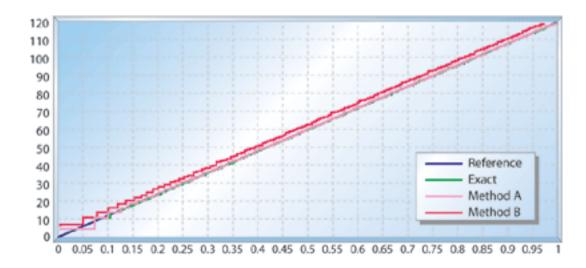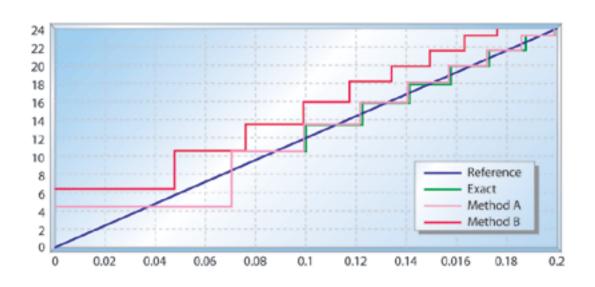


**Figure 2: Stepper-motor speed ramp**

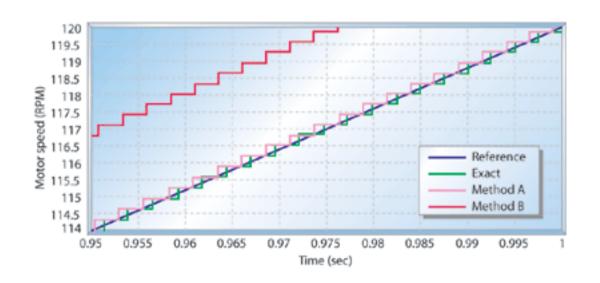**Figure 3: Start of ramp detail**
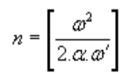


**Figure 4: End of ramp detail**

Figures 2 through 4 compare the options for a target ramp from 0 to 120rpm in 1sec. For clarity, step changes in speed are shown, calculated from Equation 2. The true profile should be close to a straight line.

$2.c/(4.n+1)$ in Equation 12 could be approximated by $c/2.n$. Some effects would be:

- The algorithm would still produce a linear ramp.
- $c_0$ would be closer to the "exact" value shown in Equation 7: 88.6% instead of 67.6% for the same ramp acceleration.
- A single equation like Equation 13 could no longer be used for both acceleration and deceleration.

## Changes of acceleration

From Equations 4 and 5 we can obtain an expression for the step number $n$ as a function of speed and acceleration:

$$n = \left[ \frac{\omega^2}{2.\alpha.\omega'} \right]$$

<p style="text-align:center">Equation 16</p>

Thus the number of steps needed to reach a given speed is inversely proportional to the acceleration:

$$n1.\alpha_1' = n2.\alpha_2'$$

<p style="text-align:center">Equation 17</p>

This makes it possible to change the acceleration at a point on the ramp by changing the step number $n$ in the ramp algorithm Equation 13. Moreover, using signed $\omega'$ values results in signed $n$-values that behave correctly in the algorithm. Only $\omega' = 0$ needs special handling.

The $n$-value given by Equation 17 is correct for $t_n$. However $c_n$ represents an average for the interval $t_n .. t_{n+1}$. Equation 17 is usually adequate, but it's more accurate to add a half-step to $n$-values for use in the ramp algorithm:

$$(n1+0.5).\alpha_1' = (n2+0.5).\alpha_2'$$

<p style="text-align:center">Equation 18</p>

The numerical example shown in Table 2 changes acceleration from 10 to 5 and to -20rad/sec² from step 200. Complex speed profiles can be built up piecewise in this way.

**Table 2: Acceleration changes**

| Step i | $n_i$ | ci (13) | ω' (3) | notes |
|---|---|---|---|---|
| 198 | 198 | 2,813.067 | | $c_{199} = c_{198} - \dfrac{2.c_{198}}{4.199+1}$ |
| 199 | 199 398.5 -100.25 | 2,806.008 | 10 | 10.(199+.5) = 5.(398.5+.5) = -20.(-100.25+.5) |
| 200 | 399.5 | 2,803.498 | 5 | $c_{200} = c_{199} - \dfrac{2.c_{199}}{4.399.5+1}$ |
| 201 | 400.5 | 2,799.001 | 5 | etc. |
| 200 | -99.25 | 2,820.180 | -20 | $c_{200} = c_{199} - \dfrac{2.c_{199}}{4.-99.25+1}$ |
| 201 | -98.25 | 2,834.568 | -20 | etc. |

## Deceleration ramp

For a short move of $m$ steps, where the up-ramp at $\omega'_1$ meets the down-ramp at $\omega'_2$ before max speed is reached, the step number $m$ at which to start decelerating is, from Equation 17:

$$n = \frac{m.\omega'_2}{\omega'_1 + \omega'_2}$$

<div align="center">Equation 19</div>

$\omega'_1$ = acceleration, $\omega'_2$ = deceleration (positive). Round $n$ to integer and calculate $c_n$ .. $c_{m-1}$ using Equation 14.

In other cases, Equations 17 or 18 can be used to calculate the number of steps $n2$ needed to stop at deceleration $\omega'_2$, given that the present speed was reached at step $n1$ with acceleration $\omega'_1$. Round $n2$ to integer and calculate $c_{m-n_2}$ .. $c_{m-1}$ using Equation 14.

## Smooth shift to max speed

The ideal speed profile would make a smooth transition from ramp acceleration $\omega'$ to max speed $\omega_{max}$. Higher speed is possible by reducing the acceleration near the top of the ramp, and you can avoid possible undesirable effects of a discontinuity in acceleration.

There are several ways to achieve a smooth transition while still allowing real-time computation on a low-end processor:

- Reduce $\omega'$ in stages, giving a piecewise linear transition.
- Add a power term to the denominator of the ramp algorithm.
- Scale the change from $c_{i-1}$ to $c_i$ by a linear factor.

Now let's compare these methods.

### Piecewise linear

This method, shown in Figure 5, is very flexible. Any number of breaks can be used. A set of $\omega$-values is chosen at which $\omega'$ is successively reduced. The ramp algorithm in Equation 13 is used. At each step, $n$ is incremented, and if $\omega$ (or $c$) crosses a break value, $n$ is recalculated.

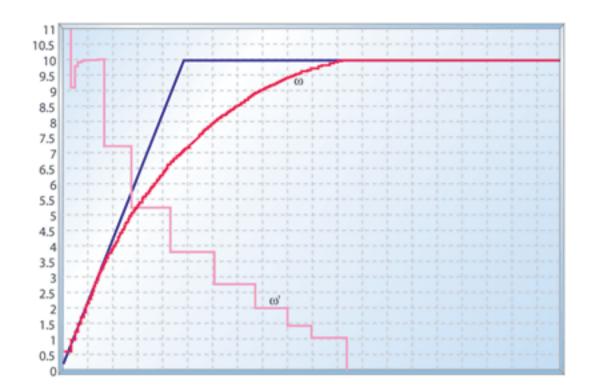**Figure 5: Piecewise**

Figure 5 results from the $j$th break given by $(c)_{j=0} = 3.c_{min}$, $(c)_j = ((c)_{j-1}+c_{min})/2$, $(n_i)_j = 1.375.(n_{i-1}+1)$, $j = 1,2,..,7$. $(c)_j$ = delay count at $j$th break, $c_{min}$, = delay count at $\omega_{max}$.

**Power term**

Equation 20 adds a power term to the denominator of the ramp algorithm (Equation 12):

$$c_n = c_{n-1} - \frac{2.c_{n-1}}{4.n+1+k.n^p}$$

<div align="center">Equation 20</div>

At low speed (low step-number $n$), the power term $k \cdot n^p$ is negligible, so acceleration is constant. As speed rises, $k \cdot n^p$ starts to dominate, eventually reducing the acceleration to zero. A higher power $p$ produces a sharper "knee." The approach to $\omega_{max}$ is asymptotic.

The transition occurs around $k \cdot n^p = 4.n$. This can be used to calculate an approximate value for the constant $k$ from initial acceleration $\omega'$ and required max speed $\omega_{max}$:

$$k = \frac{4}{n_{transition}^{p-1}} = 4.\left(\frac{2.\alpha.\omega'}{\omega_{max}^2}\right)^{p-1}$$

<div align="center">Equation 21</div>

The graphs in Figure 6 use Equation 21 to calculate $k$ for $p=2,3,4,5$. The curve falls short of $\omega_{max}$ for $p=2$ but $k$ is good for higher powers.



**Figure 6: Power term, $p=2,3,4,5$**

## Linear factor

In this method we run the ramp algorithm (Equation 12) up to step $n1$ and then scale the changes in $c$ by a factor that reduces from 1 at step $n1$ to 0 at step $n2$:

$$c_n = c_{n-1} - \frac{2.c_{n-1}}{4.n+1} . \frac{n2-n}{n2-n1}, n1 \le n \le n2$$
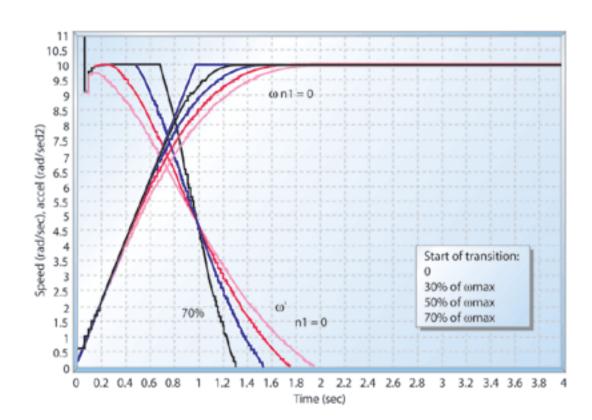
Equation 22



**Figure 7: Linear factor**

The acceleration curve is fairly linear and symmetrical over the transition. $\omega_{max}$ is reached in about twice the time taken with no transition, as shown in Figure 7. $\omega_{max}$ can be estimated by integrating a continuous version of Equation 22,

$$\frac{dc}{c} = \frac{-2}{4.n+1} . \frac{n2-n}{n2-n1} .dn$$

. We obtain:

$$\omega_{max}^2 = \frac{2}{e} . \alpha . \omega' . (n1+.5) . \left(\frac{n2+.5}{n1+.5}\right)^{\frac{n2}{n2-n1}}$$

Equation 23

Equation 23 is accurate for a wide range of parameters, including $n1=0$. It then simplifies to Equation 24 (compare with Equation 16):

$$n1 = 0, n2 = \left[\frac{\omega_{max}^2}{0.736.\alpha.\omega'}\right]$$

Equation 24

In Figure 7, the linear factor method is applied with transition ranges starting at 0 and 30%, 50%, and 70% of $\omega_{max}$.

A linear-factor transition can also be applied to the downramp:

$$c_i = c_{i-1} - \frac{2.c_{i-1}}{4.(i-m)+1} . \frac{i-n3}{m-n3-1}, n3 \le i < m$$

Equation 25

Step-number $n3$, the start of the transition from max speed to the down-ramp, is calculated as in the previous example. For a short move, $n3=n2$, calculated by Equation 19.
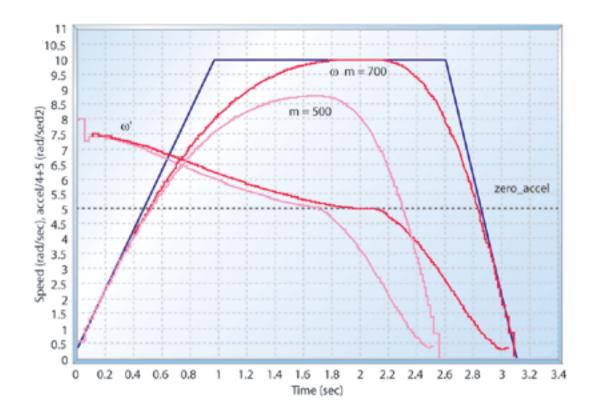
**Figure 8: Linear factor: dual transitions**

Figure 8 shows examples with and without a section at $\omega_{max}$: $m=700$, $\omega'_1 =10$, $\omega'_2 = -20$, $n1=0$, $n2=432$, $n3=484$; and $m=500$, $n2=n3=333$, other parameters unchanged.

## Transition methods in sum

The form of the transition curve is assumed to be less important than ease of calculation and control of parameters, particularly $\omega_{max}$ and the size of the transition region.

The piecewise-linear method is flexible and can be arranged to require no more calculation than a simple ramp, and give a visually smooth speed profile. It may not work with some sets of parameters, though.

In the power-term method, the $k$-parameter is easily calculated from $\omega_{max}$. Calculating the power term creates problems in fixed-point arithmetic, as values vary over a wide range.

The linear-factor method is recommended as reliable and easy to calculate in fixed-point arithmetic. Because $\omega_{max}$ is reached at a known step number, the method is good for short moves and can transition from acceleration to deceleration with no discontinuity, as Figure 8 demonstrates. Starting the transition at $n1=0$ gives a narrow transition region, and it's straightforward to calculate $n2$ from $\omega_{max}$.

The methods are compared in Figures 5 through 7.

## Implementation

You can implement this stepper-control algorithm using a PIC18F252 and a L6219. The L6219 stepper driver IC performs the following functions:

- Provides diode-protected H-bridge drives capable of 46V/750mA to the two motor windings
- Translates digital signals from the PIC to current direction in the motor windings (PHASE1, 2 inputs)
- Limits each winding current to 0, 33%, 67%, or 100% of a preset value by chopping the drive to the H-bridge transistors (inputs I01, I11, I02, I12)

The maximum current is set by a current-sense resistor for each winding.

The L6219 doesn't have "step" and "direction" control lines like some stepper control ICs. The winding phase sequence must be provided by the PIC. This makes control slightly more complicated but gives extra flexibility and reduces cost. It also means that the phase can be restored easily on power-up.

By using the I-inputs, the L6219 can be used for half- and quarter-step operation. For full-step, they can be tied together and driven by one GPIO from the PIC.

Microchip's PIC18F252 is a 28-pin device with the same footprint as the PIC16F876. The more powerful core of the '252 makes it easier to program in C. Figure 9 shows how the internal timing resources were configured for controlling the L6219.
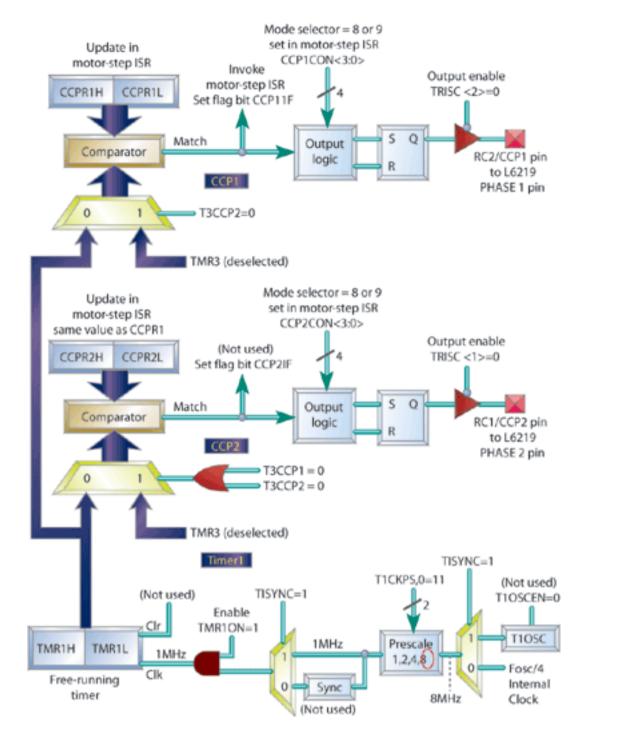
**Figure 9: PIC18F252 timer configuration for L6219 interface**

An 8MHz crystal and the PIC's ×4 PLL frequency multiplier are used to generate a 32MHz processor clock. This is divided by four to clock the timers at 8MHz. Driving the motor involves the following sequence:

1. Get parameters: step count, direction, delay count $c_0$, max speed and so forth.
2. Set up hardware: initialise CCP1 and CCP2, enable motor current, enable CCP1 interrupts.
3. Service CCP1 interrupts: count the steps and execute a state machine to reconfigure the CCPs and calculate the next timer value.
4. Clean up: after the last step, disable CCP1 interrupts, current off, flag the move done.

The listing (online at http://www.eetimes.com/design/embedded/source-code/4210291/Motor-c (http://www.eetimes.com/design/embedded/source-code/4210291/Motor-c)) is a minimal demo of these steps, with linear ramps, fixed maximum speed and accelerations. The author used the CCS compiler. Minor changes will be required for other compilers.

## Stepping out

The real-time algorithms I've explained here significantly reduce the processing power needed for smooth speed control of stepper motors. The linear ramp algorithm can be adapted to piecewise linear speed profiles and smooth transitions from ramp to max speed.

**David Austin** is a freelance software engineer from Durham, U.K. You can reach him at dave@slotech.fsnet.co.uk (mailto:dave@slotech.fsnet.co.uk).

## Resources

Acarnley, Paul. *Stepping Motors— A Guide to Theory and Practice, 4th edition*. London: Institution of Electrical Engineers, 2002.

Kenjo, Takashi and Akira Sugawara. *Stepping Motors and their Microprocessor Controls, 2nd edition*. Oxford University Press, March, 1995.

Control of Stepping Motors— A Tutorial www.cs.uiowa.edu/~jones/step/ (http://www.cs.uiowa.edu/%7Ejones/step/)

**Suppliers' Web sites:**

PIC18F252 www.microchip.com (http://www.microchip.com)

L6219 www.st.com (http://www.st.com)

PIC C compiler www.ccsinfo.com (http://www.ccsinfo.com)

Stepper motors www.rotalink.com (http://www.rotalink.com)

Mathcad (graphs) www.mathsoft.com (http://www.mathsoft.com)

(mailto:?subject=Generate stepper-motor speed profiles in real time&body=http://www.embedded.com/design/mcus-processors-and-socs/4006438/Generate-stepper-motor-speed-profiles-in-real-time)

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## 14 COMMENTS                                           WRITE A COMMENT

**Deepak_K (/User/Deepak_K)**    POSTED: JUN 12, 2015 6:52 AM EDT

Hi,

After equation 12, I could not understand the approach. I think I veered away from the point..I failed to understand this part:

"Finally, we can disconnect the physical step number, i, from the step number n on a ramp from zero, to give the general-purpose ramp algorithm shown in Equation 13. Here n determines the acceleration and increments with i for constant acceleration. To ramp up from stop, ni = i, i=1,2, . . . :"

Can anyone please try to explain what is "i" and why did it come in?
Also what is the difference between n and i?

**REPLY (/LOGIN?ASSETID=203&SUCCESSFULLOGINREDIRECT=HTTP%3A%2F%2FWWW.EMBEDDED.COM%2FDESIGN%2FMCUS-PROCESSORS-AND-SOCS%2F4006438%2FGENERATE-STEPPER-MOTOR-SPEED-PROFILES-IN-REAL-TIME)**

**Deepak_K (/User/Deepak_K)**    POSTED: SEPT 4, 2014 5:09 AM EDT

Hi,

What if we just modulate the frequency of the pulse train to the motor with a sine function (0 to 90 degrees)? Wouldn't that give a smooth s shaped curve?

**REPLY (/LOGIN?ASSETID=203&SUCCESSFULLOGINREDIRECT=HTTP%3A%2F%2FWWW.EMBEDDED.COM%2FDESIGN%2FMCUS-PROCESSORS-AND-SOCS%2F4006438%2FGENERATE-STEPPER-MOTOR-SPEED-PROFILES-IN-REAL-TIME)**

**Jorick23 (/User/Jorick23)**    POSTED: AUG 14, 2014 3:56 PM EDT

My application has a very simple way of ramping quickly up to speed. Every step interrupt, I take the timer count (based on a 120 MHz clock) and shift it right (divide by power of 2) by a set amount and subtract the result from the timer count to get a new timer count for the next step. This results in a somewhat linear increase in speed. This also works for speed decreases where the shifted value is added to the timer count.

For slower ramps of over a second, I have the starting and ending rates in a 64-bit integer, something like billionths of a revolution per second. Prior to the ramp, I figure out how much of a rate increase or decrease needs to be done every millisecond (the tick count rate). Then I convert the rate to a timer count inside the tick interrupt with one divide by a precomputed constant.

**REPLY (/LOGIN?ASSETID=203&SUCCESSFULLOGINREDIRECT=HTTP%3A%2F%2FWWW.EMBEDDED.COM%2FDESIGN%2FMCUS-PROCESSORS-AND-SOCS%2F4006438%2FGENERATE-STEPPER-MOTOR-SPEED-PROFILES-IN-REAL-TIME)**

**Jupiik (/User/Jupiik)**    POSTED: MAY 4, 2011 10:21 PM EDT

I tried it the way altronics suggested and I got nonlinear speed profile (blue line in graph) thats because (speed = distance / time) and time is below "/" so it has nonlinear function in speed but if you keep whole time in memory reversed value (1/time) and every step add constat value and

THEN reverse it and set to counter you will get nice linear speed profile (red one in graph) and i didnt have to use any hard Equations. But to be honest this article was base for whole my work/study about stepper motor speed profiles generating. (btw sorry for slovak in graph but anyway its obvious and I was lazy to translate it..)
http://dl.dropbox.com/u/545374/rychlostny%20profil.jpg (http://dl.dropbox.com/u/545374/rychlostny%20profil.jpg)

**Sunil.Singh #3 (/User/Sunil.Singh %233)** POSTED: JUL 24, 2011 12:43 PM EDT

Hi Jupiik,

I tried to understand your comment but probably don't understand it fully. I would appreciate if you may elaborate "whole time in memory reversed value (1/time) and every step add constat value and THEN reverse it and set to counter you will get nice linear speed ".

Thanks
sunil

**Cch1955 (/User/Cch1955)** POSTED: MAR 12, 2012 7:41 PM EDT

Hi Jupiik,
i have project where you simplified computation for trapazoidal ramp calulation would be helpful. Is it possible to see you paper or the equation or code involved? Thanks so much.
CCH

**Altronics (/User/Altronics)** POSTED: MAR 13, 2011 5:37 AM EDT

Couldn't that same linear ramp be more easily implemented by simply using a small set delay time (say 1ms) multiplied by a start delay factor and a decreasing loop between each step?

Example:

Start delay time =100 //100ms
decrement factor = 2

for (x=100; x=0; x=x-2)
{
move_motor_1_step();
delay(x);
}

get the idea?

**Triffid Hunter (/User/Triffid%20Hunter)** POSTED: APR 10, 2011 10:59 PM EDT

I wish it were that easy!

acceleration is dv/dt. your algorithm increases dv while decreasing dt, giving an exponential change in velocity rather than linear.

Thus, you either cannot attain high speeds because the motor can't supply enough torque, or your acceleration from slow speeds or stop is infuriatingly low. There will be a sweet spot around the knee of this exponential curve, where you won't notice the difference much, but if you're ramping significant mass from zero to some high speed you'll be significantly affected.

EMC2 simply has a constant velocity, and updates that velocity from a separate timer every 10mS or so. It's a simple approach, albeit far less elegant than the one described in this article.

**Susan.rambo (/User/Susan.rambo)**     **POSTED: NOV 1, 2010 1:40 PM EST**

I reposted the Motor.c code in our new source code library. You can find it here
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(The link in this article is also now up to date.) I'll be updating all the ESD/ESP
magazine source code archive links in the next month to make sure all source
code from Embedded Systems Programming/ESD magazine is connected to an article and vice
versa.

--Susan Rambo
Managing editor, ESD magazine

**Jamesyn (/User/Jamesyn)**     **POSTED: JAN 10, 2014 4:13 PM EST**

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**Greatfog (/User/Greatfog)**     **POSTED: NOV 1, 2010 12:39 PM EST**

Ms. Rambo, Managing Editor of Embedded Systems Design, has fixed the link to
the code. Thank you, ma'm!

**Dandumit (/User/Dandumit)**     **POSTED: NOV 1, 2010 8:58 AM EST**

Great Info. I would like also to access the file motor.c but it seems to reject
anonymous login.

Maybe someone can help ?

**Tumnao (/User/Tumnao)**     **POSTED: OCT 11, 2010 9:52 AM EDT**

Great article!
What are the credentials to download the example file (motor.c)?

**SUNMY (/User/SUNMY)**     **POSTED: OCT 11, 2009 9:49 AM EDT**

good job!

**Deepak_K (/User/Deepak_K)**     **POSTED: JUN 12, 2015 6:52 AM EDT**

Hi,

After equation 12, I could not understand the approach. I think I veered away
from the point..I failed to understand this part:

"Finally, we can disconnect the physical step number, i, from the step number n on a ramp from zero, to give the general-purpose ramp algorithm shown in Equation 13. Here n determines the acceleration and increments with i for constant acceleration. To ramp up from stop, $n_i = i$, $i=1,2, \ldots$:"

Can anyone please try to explain what is "i" and why did it come in?
Also what is the difference between n and i?

**Deepak_K (/User/Deepak_K)**   **POSTED: SEPT 4, 2014 5:09 AM EDT**

Hi,

What if we just modulate the frequency of the pulse train to the motor with a sine function (0 to 90 degrees)? Wouldn't that give a smooth s shaped curve?

**Jorick23 (/User/Jorick23)**   **POSTED: AUG 14, 2014 3:56 PM EDT**

My application has a very simple way of ramping quickly up to speed. Every step interrupt, I take the timer count (based on a 120 MHz clock) and shift it right (divide by power of 2) by a set amount and subtract the result from the timer count to get a new timer count for the next step. This results in a somewhat linear increase in speed. This also works for speed decreases where the shifted value is added to the timer count.

For slower ramps of over a second, I have the starting and ending rates in a 64-bit integer, something like billionths of a revolution per second. Prior to the ramp, I figure out how much of a rate increase or decrease needs to be done every millisecond (the tick count rate). Then I convert the rate to a timer count inside the tick interrupt with one divide by a precomputed constant.

**Jupiik (/User/Jupiik)**   **POSTED: MAY 4, 2011 10:21 PM EDT**

I tried it the way altronics suggested and I got nonlinear speed profile (blue line in graph) thats because (speed = distance / time) and time is below "/" so it has nonlinear function in speed but if you keep whole time in memory reversed value (1/time) and every step add constat value and THEN reverse it and set to counter you will get nice linear speed profile (red one in graph) and i didnt have to use any hard Equations. But to be honest this article was base for whole my work/study about stepper motor speed profiles generating. (btw sorry for slovak in graph but anyway its obvious and I was lazy to translate it..)
http://dl.dropbox.com/u/545374/rychlostny%20profil.jpg
(http://dl.dropbox.com/u/545374/rychlostny%20profil.jpg)

**Sunil.Singh_#3 (/User/Sunil.Singh_%233)**   **POSTED: JUL 24, 2011 12:43 PM EDT**

Hi Jupiik,

I tried to understand your comment but probably don't understand it fully. I would appreciate if you may elaborate "whole time in memory reversed value (1/time) and every step add constat value and THEN reverse it and set to counter you will get nice linear speed ".

Thanks
sunil

**Cch1955 (/User/Cch1955)**   **POSTED: MAR 12, 2012 7:41 PM EDT**

Hi Jupiik,
i have project where you simplified computation for trapazoidal ramp
calulation would be helpful. Is it possible to see you paper or the equation
or code involved? Thanks so much.
CCH

**Altronics (/User/Altronics)**    POSTED: MAR 13, 2011 5:37 AM EDT

Couldn't that same linear ramp be more easily implemented by simply using a
small set delay time (say 1ms) multiplied by a start delay factor and a decreasing
loop between each step?

Example:

Start delay time =100 //100ms
decrement factor = 2

for (x=100; x=0; x=x-2)
{
move_motor_1_step();
delay(x);
}

get the idea?

**Triffid Hunter (/User/Triffid%20Hunter)**    POSTED: APR 10, 2011 10:59 PM
EDT

I wish it were that easy!

acceleration is dv/dt. your algorithm increases dv while decreasing dt,
giving an exponential change in velocity rather than linear.

Thus, you either cannot attain high speeds because the motor can't supply enough
torque, or your acceleration from slow speeds or stop is infuriatingly low. There will be a
sweet spot around the knee of this exponential curve, where you won't notice the
difference much, but if you're ramping significant mass from zero to some high speed
you'll be significantly affected.

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