MOTION MAGIC WITH CTRE MOTOR CONTROLLERS

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CTRE Phoenix Motion Magic example

CTRE Phoenix motion profiling example

WHAT IS MOTION MAGIC?

- Drives the motor to a target position
- A form of geometric motion profiling with PID
  - Feedforward on velocity target, PID on position target
- Motion profile calculated as the motor runs

ADVANTAGES OF MOTION MAGIC

- Simple to use
  - Pass in PID-F, cruise velocity, target acceleration, and S-curve smoothing (to round the corners of the trapezoidal profile) as configs
  - Pass in target position when running Motion Magic
- Does not have to be calculated ahead of time
- Position PID gives precise control of the behavior of the robot
- Replaces position PID control
  - Has all the advantages of motion profiling with the simplicity of position PID control

CONFIGURING MOTION MAGIC

- Calculating kF:
  - Get motor velocity (with load) at a given percent output (Recommended: ~75% of max)
  - $kF = percOut * \frac{1023}{motorVel}$
- In the example below, the recorded velocity at 100% power was 5100 ticks/100ms

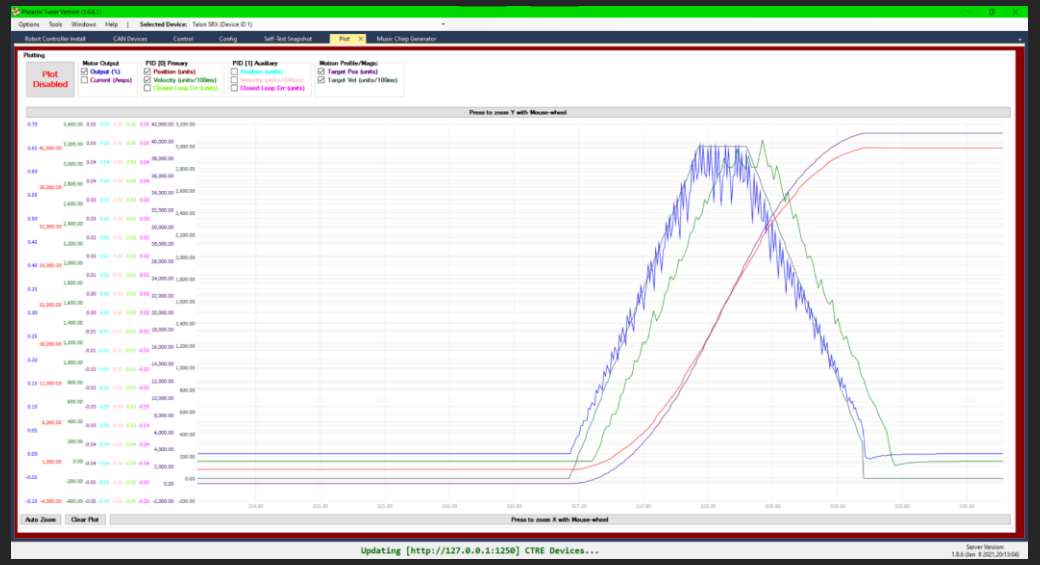
```
/* Set Motion Magic gains in slot0 - see documentation */
_talon.selectProfileSlot(0, 0);
_talon.config_kF(0, 1023 / 5100.0);
_talon.config_kP(0, 0.2);
_talon.config_kI(0, 0);
_talon.config_kD(0, 0);

/* Set acceleration and vcruise velocity - see documentation */
_talon.configMotionCruiseVelocity(3000);
_talon.configMotionAcceleration(3000);
_talon.configMotionSCurveStrength(4);
```

RUNNING MOTION MAGIC

- Given the target position `targetPos` and Talon SRX/FX `_talon`:
  - `_talon.set(ControlMode.MotionMagic, targetPos);`
- You can view percent output, current, target and recorded position and velocity, etc. in the Plot tab of Phoenix Tuner

```
_talon.set(ControlMode.MotionMagic, targetPos);
```



WHAT ABOUT MOTION PROFILING?

- CTRE offers the ability to run a motion profile in a special motion profile control mode
  - Feed Forward (kF) applies to the profile target velocity
  - PID applies to the profile target position
- Useful for passing in custom trajectories (such as from PathWeaver)
  - Requires a pre-calculated motion profile trajectory
- Configuring PID-F is identical to Motion Magic

USING MOTION PROFILING

- Configuring a motion profile
  1. Configure PID-F (see Motion Magic)
     - Do not configure cruise velocity, acceleration, or S-curve strength
  2. Add the points in the motion profile trajectory to a `BufferedTrajectoryPointStream`
- Running a motion profile
  1. Start the motion profile
     - Pass in the `BufferedTrajectoryPointStream` and the number of points to buffer
  2. Run until the motion profile is finished:

```
public boolean isFinished() {
    return _master.isMotionProfileFinished();
}
```

```
BufferedTrajectoryPointStream _bufferedStream = new BufferedTrajectoryPointStream();
boolean forward = true; // set to false to drive in opposite direction of profile (not really needed
                        // since you can use negative numbers in profile).

TrajectoryPoint point = new TrajectoryPoint(); // temp for for loop, since unused params are initialized
                                               // automatically, you can alloc just one

/* clear the buffer, in case it was used elsewhere */
_bufferedStream.Clear();

/* Insert every point into buffer, no limit on size */
for (int i = 0; i < totalCnt; ++i) {

    double direction = forward ? +1 : -1;
    double positionRot = profile[i][0];
    double velocityRPM = profile[i][1];
    int durationMilliseconds = (int) profile[i][2];

    /* for each point, fill our structure and pass it to API */
    point.timeDur = durationMilliseconds;
    point.position = direction * positionRot * Constants.kSensorUnitsPerRotation; // Convert Revolutions to
                                                                                   // Units
    point.velocity = direction * velocityRPM * Constants.kSensorUnitsPerRotation / 600.0; // Convert RPM to
                                                                                          // Units/100ms
    point.auxiliaryPos = 0;
    point.auxiliaryVel = 0;
    point.profileSlotSelect0 = Constants.kPrimaryPIDSlot; /* which set of gains would you like to use [0,3]? */
    point.profileSlotSelect1 = 0; /* auxiliary PID [0,1], leave zero */
    point.zeroPos = (i == 0); /* set this to true on the first point */
    point.isLastPoint = ((i + 1) == totalCnt); /* set this to true on the last point */
    point.arbFeedFwd = 0; /* you can add a constant offset to add to PID[0] output here */

    _bufferedStream.Write(point);
}
```

WHEN TO USE WHICH

- Motion Magic
  - Would normally use standard position PID control or a geometric motion profile
  - Want to have precise control of linear trajectories or of a single robot component (elevator, arm, etc.)
- Motion Profiling
  - Want to accurately move along curved trajectories (drivebase)