

CURRENT LOOP TUNING



FreeMASTER layout settings

- Show the control page as a bar
 - Sets the layout to see the control page as well as the algorithm block description/oscilloscope/recorder
 - Ctrl+5 or menu/View/Show Control Page as a Bar

The screenshot displays the FreeMASTER software interface. On the left, the Project Tree shows a hierarchy for 'PMSM FOC sensorless control', including 'Control', 'Speed', 'IDQ', 'Position', 'Faults & Trips', 'GDU Faults', 'PMF Faults', 'Sensors/Actuators', 'OpenLoop - Scalar Control', 'Position/Speed', 'iABC', 'Position', 'Voltage', 'Udc', 'uDRReq', 'uAIBReq', 'PWM', 'Id current', and 'Iq current'. The main window is titled 'Motor Control Application Tuning Tool' and features a 'Welcome to MCAT' section with a block diagram of the motor control system. The diagram includes components like Ramp, PI w/ AW, LPF, PI w/ AW, dq, U^{REG}, SVM, VSI, Sensor SW Switch, MAF / IIR, Angle Tracking Observer, and Back EMF Observer. A 'Variable Watch' table is visible at the bottom right, listing parameters such as Speed Required, Position Mode, Clear Faults, State, Event, and alignment parameters.

Name	Value	Unit
On/Off	?	BOOL
Speed Required	?	[rpm]
Mode	?	ENUM
Position Mode	?	ENUM
Clear Faults	?	BOOL
State	?	ENUM
Event	?	ENUM
drvFOC.alignCntr	?	DEC
drvFOC.alignCntrInit	?	DEC
drvFOC.alignvoltage	?	unit



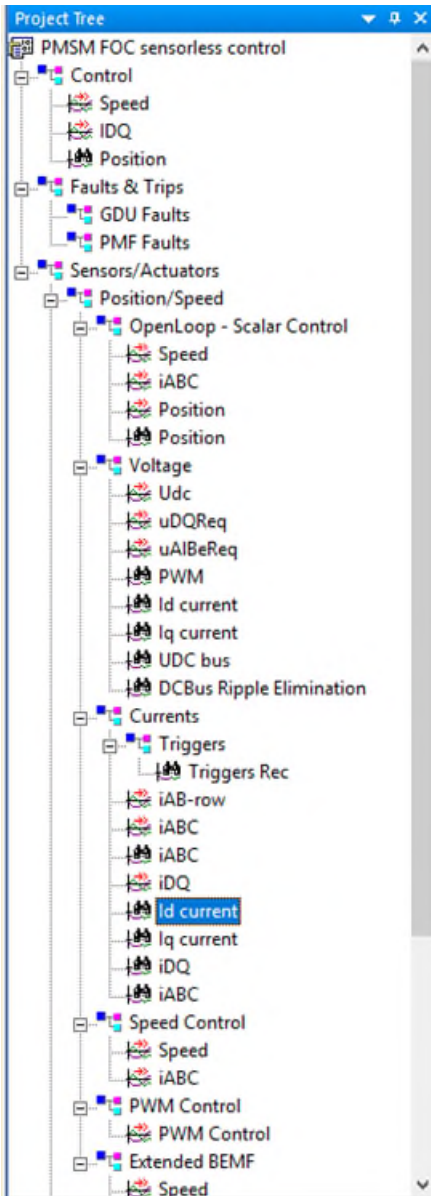
Select Control Struct. Page, Enable the Current FOC

- Control Struc. Page
- Current FOC

The screenshot displays the NXP Motor Control Application Tuning Tool interface. The top navigation bar includes the NXP logo and the title "Motor Control Application Tuning Tool". Below this, a menu bar shows various tabs: "Introduction", "Parameters", "Current Loop", "Speed Loop", "Sensors", "Control Struc.", "Output File", and "App Control". The "Control Struc." tab is selected and highlighted with an orange box. The main content area is titled "Application Control Structure" and features a "State Control" section with a red "ON" button and a grey "OFF" button. Below this is the "Application State" section, which shows "READY". The "Cascade Control Structure Composition" section lists several control modes: "Scalar Control" (DISABLED), "Voltage FOC" (DISABLED), "Current FOC" (ENABLED), "Speed FOC" (DISABLED), and "Position & Speed Feedback" (ENABLED). The "Current FOC" button is highlighted with a red box. To the right of these buttons are input fields for various parameters: "V/rpm_factor" (input field with up/down arrows), "Uq_req" (input field with value 0), "Speed_req" (input field), "Ud_req" (input field), "Uq_req" (input field), "Id_req" (input field with value 0), "Iq_req" (input field with value 0), and "Speed_req" (input field). A "view" button is present next to each control mode. The bottom of the interface shows "MCAT 1.1.0" on the left and "NXP Semiconductors, Motor Control Solution" on the right.

Select Oscilloscope to Track the Step Response

- Select **Id current** from the left Project Tree panel
 - This recorder is set to make a snapshot of the step response in the “D-axis” current loop
 - The embedded code is set to not spin the motor if the “D-axis” current is demanded and the Current FOC is enabled



```
static tBool focSlowLoop()
{
    tFrac16 current = 0;
    tFrac16 weight = 0;
    SWLIBS_2Syst_F16 tempIDQReq;

    if(cntrState.usrControl.FOCcontrolMode != speedControl)
    {
        // required speed for open loop start-up in sensorless mode = MERG_SPEED_1_TRH*1.5
        //wRotElReq = MERG_SPEED_1_TRH * 9.55 * 1.5 / pp = MERG_SPEED_1_TRH * 4.775 = ((MERG_SPEED_1_TRH*Frac16(0.596875)) << 3;
        if (cntrState.usrControl.FOCcontrolMode == voltageControl && drvFOC.uDQReq.f16Arg2==0)
            drvFOC.pospeControl.wRotElReq = 0;
        else if (cntrState.usrControl.FOCcontrolMode == currentControl && drvFOC.currentLoop.pIDQReq->f16Arg2==0)
            drvFOC.pospeControl.wRotElReq = 0;
        else if (cntrState.usrControl.FOCcontrolMode != scalarControl)
            drvFOC.pospeControl.wRotElReq = MLib_ShL_F16(MLIB_Mul_F16(FRAC16(0.75),MERG_SPEED_1_TRH),1);
    }
}
```


Select Oscilloscope to Track the Step Response

- Select **Id current** from the left Project Tree panel
 - This recorder is set to make a snapshot of the step response in the “D-axis” current loop

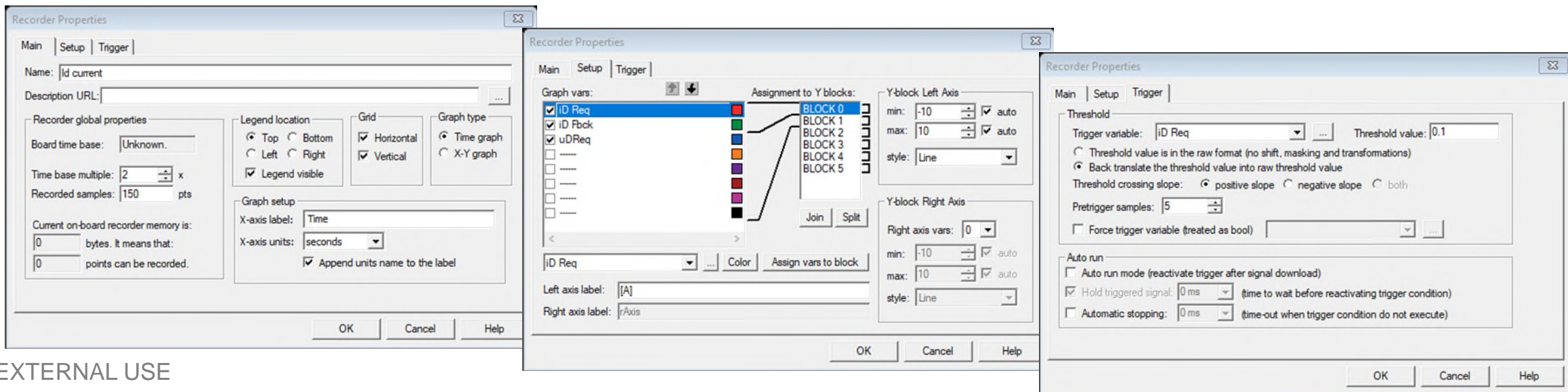
The screenshot displays the NXP Motor Control Application Tuning Tool interface. On the left, the Project Tree panel shows a hierarchical structure of control components. The 'Id current' component is highlighted in blue. In the center, the Recorder configuration window shows a list of variables to be recorded, with 'Id current' selected. The main window displays a plot of the Id current response over time. On the right, the Application Control Structure panel shows the state of various control loops, with 'Current FOC' set to 'ENABLED'.

Variable	Name	Value	UNIT
ON/OFF	?	?	ENLM
Speed Required	?	?	[rpm]
Mode	?	?	ENLM
Position Mode	?	?	ENLM
State	?	?	ENLM
Event	?	?	ENLM
Clear Faults	?	?	ENLM
uReq	?	?	[A]
uReq	?	?	[A]
dFOC_posspOpenLoop_QLowerLimit	?	?	unit
dFOC_posspOpenLoop_QUpperLimit	?	?	unit
dFOC_currentLoop_pP9_AWQ_F15C23c	?	?	unit
dFOC_currentLoop_pP9_AWQ_F15C23c	?	?	unit
dFOC_currentLoop_pP9_AWQ_u19G2Hr	?	?	unit
dFOC_currentLoop_pP9_AWQ_F15C23c	?	?	unit
dFOC_currentLoop_pP9_AWQ_u19G2Hr	?	?	unit
dFOC_uReq_Limit	?	?	unit
dFOC_uReq_Limit	?	?	unit
dFOC_uReq_Limit	?	?	unit
dFOC_uReq_Limit	?	?	unit
dFOC_uReq_Limit	?	?	unit
dFOC_uReq_Limit	?	?	unit
dFOC_uReq_Limit	?	?	unit
dFOC_uReq_Limit	?	?	unit



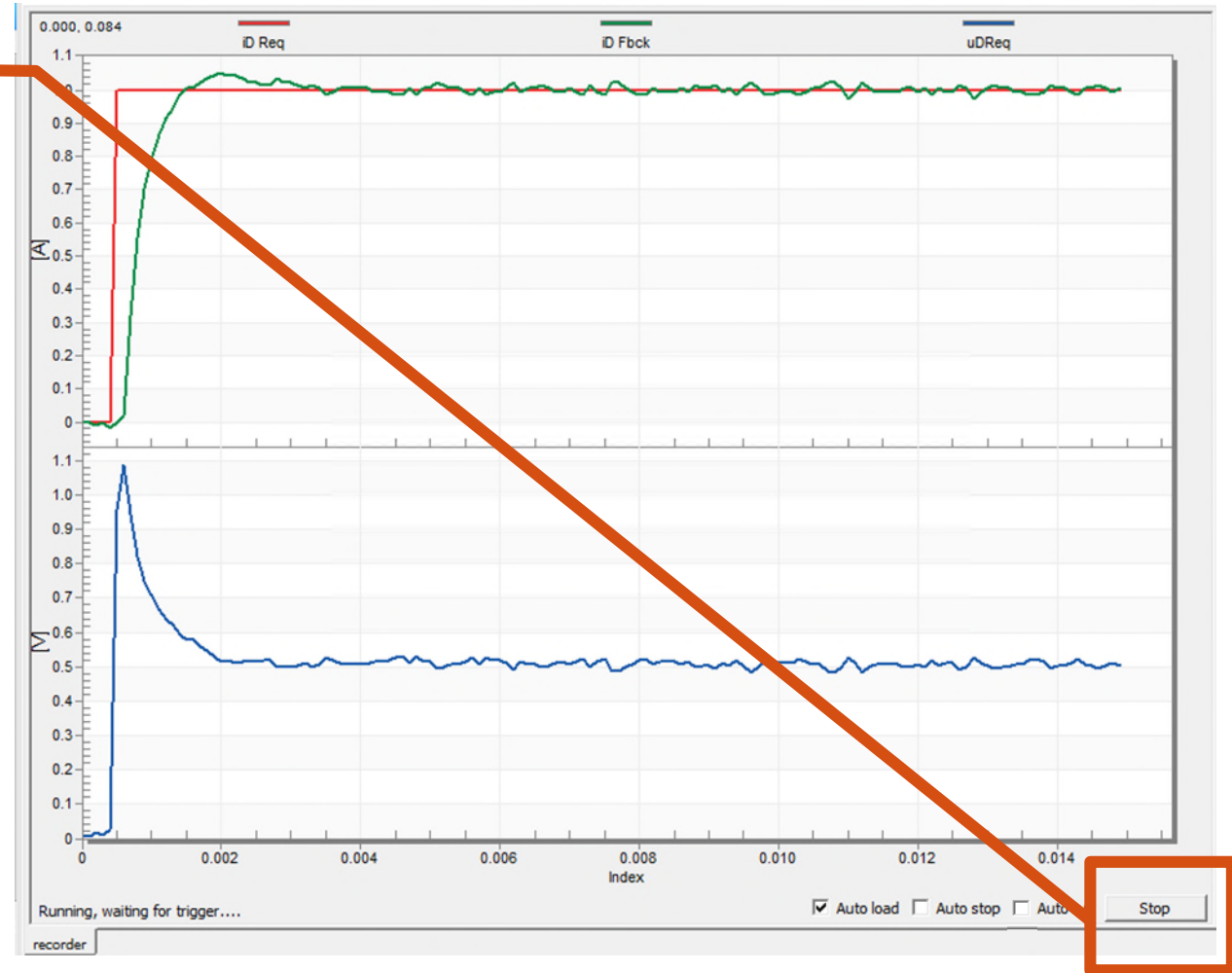
Select Oscilloscope to Track the Step Response

- Key recorder properties (already set):
 - Main/Time base multiple – the embedded recorder routine is called within the PWM reload interrupt. The “Time base multiple” set to 2 means that the recorder collects data every 2nd reload opportunity
 - Trigger/Threshold value sets the trigger-point threshold of the iD Req to start data acquisition right after the user changes the required D-current.
 - Trigger/Autorun is set to wait for the trigger and to make one snapshot of the transient



Start the Recorder

- Click “Run” to get the Recorder ready



Switch ON the Application and Set the Demanded Current

- Switch ON the Application
- Set the Demanded Current

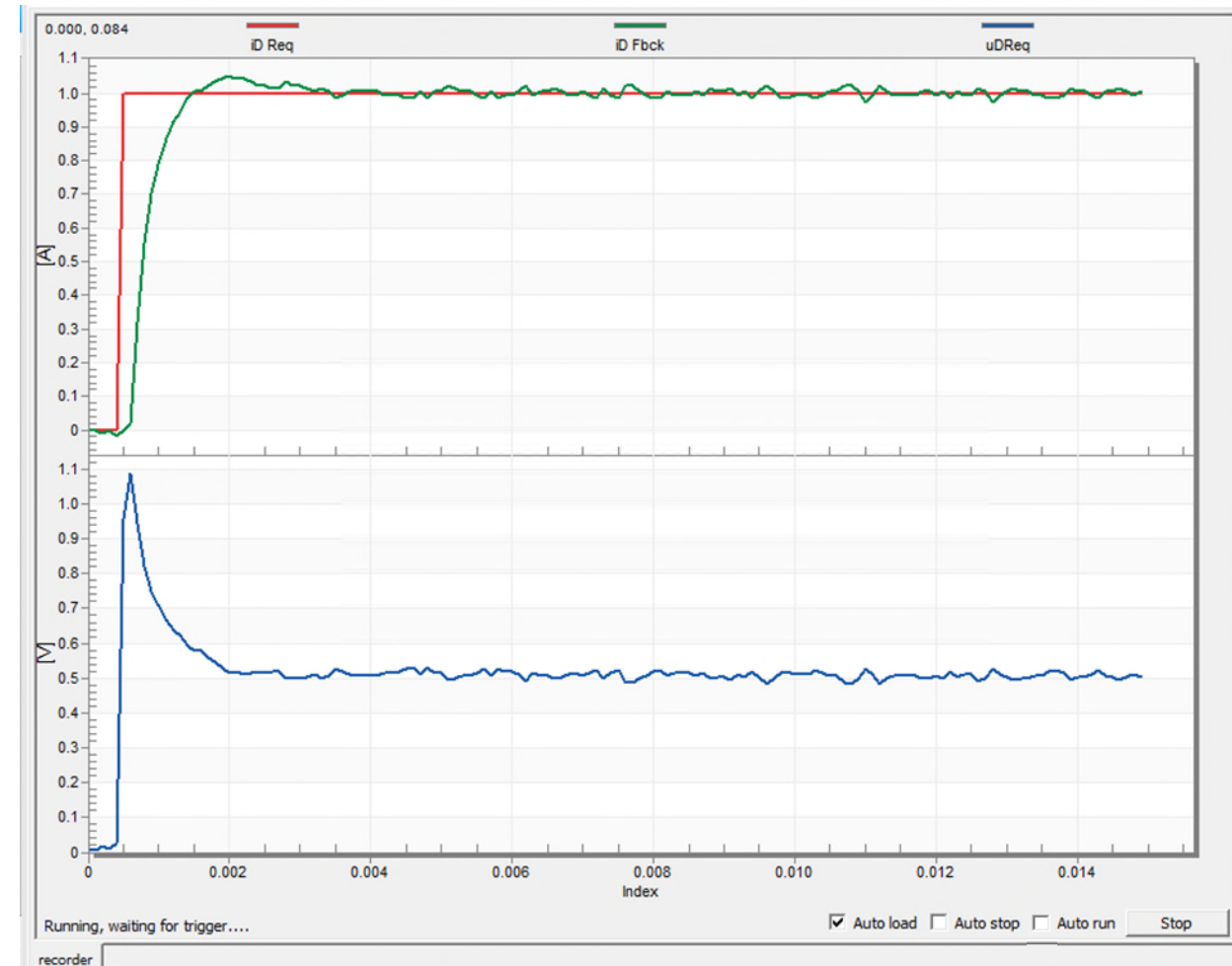
The screenshot displays the NXP Motor Control Application Tuning Tool interface. The top navigation bar includes the NXP logo and the title "Motor Control Application Tuning Tool". Below the navigation bar, the "Motor 1: PMSM" is selected, and the "Tuning Mode" is set to "Expert". The main content area is divided into several sections:

- State Control:** A red switch is shown in the "ON" position, highlighted with a blue box. Below it, the "Application State" is "READY".
- Cascade Control Structure Composition:** This section lists various control blocks and their states:
 - Scalar Control: DISABLED
 - Voltage FOC: DISABLED
 - Current FOC: ENABLED
 - Speed FOC: DISABLED
 - Position & Speed Feedback: ENABLED
- Parameters:** On the right side, several parameters are listed with input fields and units:
 - V/rpm_factor: [%]
 - Uq_req: [V]
 - Speed_req: [rpm]
 - Ud_req: [V]
 - Uq_req: [V]
 - Id_req: [A] (highlighted with an orange box, value is 5)
 - Iq_req: [A]
 - Speed_req: [rpm]
 - Position & Speed: encoder

The bottom of the interface shows the version "MCAT 1.1.0" and the text "NXP Semiconductors, Motor Control Solution".

See the Transient, Repeat if Necessary

- Rotor should not move between the end of the alignment (already aligned with the D-axis) and the D-axis current loop being activated.
- This test should be repeated for various demanded currents, such as 25%, 50%, 75% and 100% of the nominal current. However, the app should be deactivated every time after the transient has been displayed (to not overheat the motor). For these tests, the transients can be different due to the L_d (inductance) changes.
- Exponential response is a first step only. The system may require to “slow down” the control loop due to various reasons.



Change the PI Controller Settings

- Switch OFF the application
- Open the “Current Loop” tab
- Change the settings of the PI Controller as shown
- Repeat steps above to see different behavior

The screenshot displays the NXP Motor Control Application Tuning Tool interface. The title bar shows the NXP logo and the text "Motor Control Application Tuning Tool". Below the title bar, there is a navigation menu with tabs for "Introduction", "Parameters", "Current Loop", "Speed Loop", "Sensorless", "Control Struc", "Output File", and "App Control". The "Current Loop" tab is selected. The interface is divided into several sections: "Loop Parameters", "D axis Recurrent PI Controller", and "Q axis PI Controller - Recurrent". The "Loop Parameters" section includes fields for "Sample Time" (0.0001 [sec]), "F0" (300 [Hz]), and " ξ " (0.8 [-]). The "D axis Recurrent PI Controller" section includes fields for "D_CC1sc" (0.12145446), "D_CC2sc" (-0.09125347), and "D_Nshift" (0). The "Q axis PI Controller - Recurrent" section includes fields for "Q_CC1sc" (0.25079452), "Q_CC2sc" (-0.20620365), and "Q_Nshift" (0). A red box highlights the "F0" and " ξ " fields. A callout box with an orange border and text points to these fields, stating: "Manually control the loop behavior. The impact can be seen on the FreeMASTER recorder =>". At the bottom of the interface, there are three buttons: "Update Target", "Reload Data", and "Store Data". The footer of the interface shows "MCAT 1.1.0" and "NXP Semiconductors, Motor Control Solution".

Loop Parameters		D axis Recurrent PI Controller		Q axis PI Controller - Recurrent	
Sample Time	0.0001 [sec]	D_CC1sc	0.12145446	Q_CC1sc	0.25079452
F0	300 [Hz]	D_CC2sc	-0.09125347	Q_CC2sc	-0.20620365
ξ	0.8 [-]	D_Nshift	0	Q_Nshift	0

Manually control the loop behavior. The impact can be seen on the FreeMASTER recorder =>

Getting Ready for the Test - Checklist

- ✓ Communication is running
- ✓ MCAT visible
- ✓ Id current recorder visible
- ✓ Recorder started
- ✓ Control Structure set to Current FOC
- ✓ Demanded Id_req set to non zero value

- ✓ The resulting step response is shown