PLC_MOTION_LAYER
TwinCAT project

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PLC_MOTION_LAYER

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Introduction to motion layer approach

- motivation for a motion layer
- use cases
- specific construction

Motivation:

- **Centralized control:**
  - Sync communication
  - Async communication
  - Agnostic to communication technology

- **Decentralized execution of motion tasks**
  - Data consistency in cyclic multi task environments
  - Local machine with modular design specifications
  - Unified procedure for modular software architecture
  - Use of top layer consistent through different architectures

Motivation:

- **Use of TwinCAT supported/updated libraries**
  - Tc2_MC2
  - Tc2_MC2_Drive
  - Tc2_NC
  - Tc2_NCI
  - Tc2_PlcInterpolation
- **Open code base**
  - Migration to Tc3 MC in preparation
  - Customer/user specific changes possible
  - Access to code
  - Conversion to library possible by customer/user
- **Compiled PLC**
  - Source code is not on shipped machine

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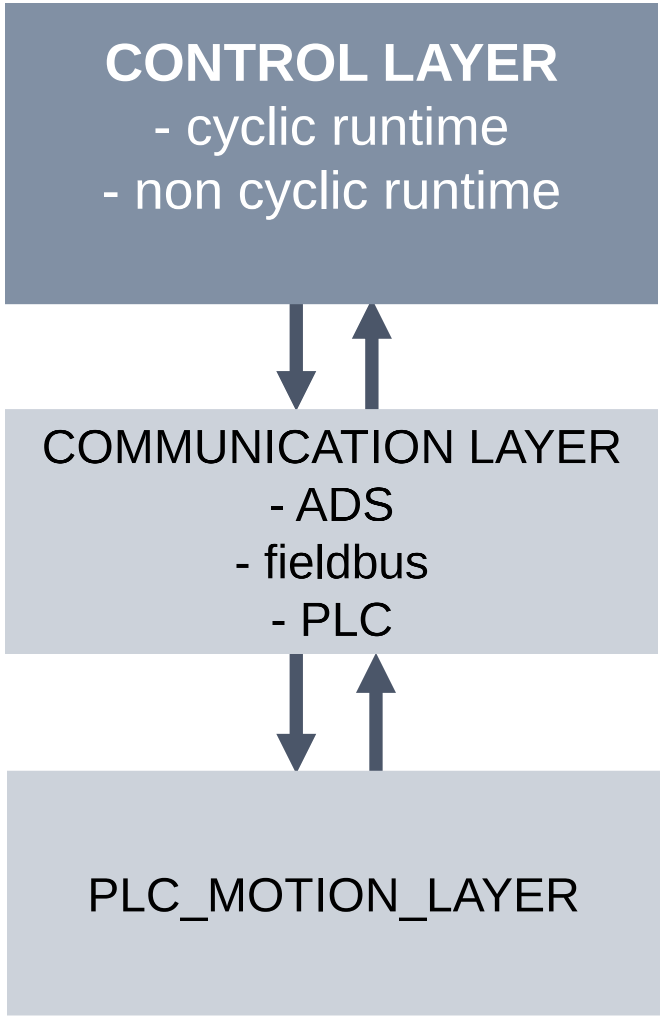
Motivation:

- Use of TwinCAT motion without detailed coding knowledge
- Transparency of communication layer
- Code base shall remain independent of control layer
- Configurable Options for specific libraries / TC functions
- Balanced load for configurable options in machine layout
- Stable cpu use for XFC applications



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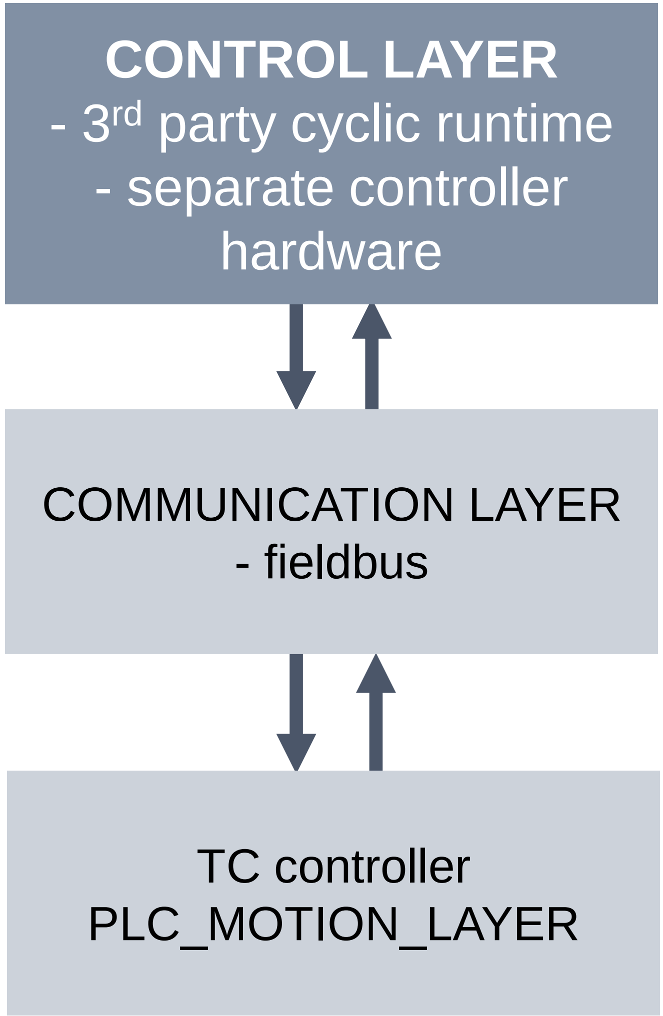
Use cases:

- Separate controller for machine logic
- Any fieldbus (EtherCAT, Profi…)
- Connected through TwinCAT mappings
- Execution of motion tasks in PLC_MOTION_LAYER TwinCAT controller



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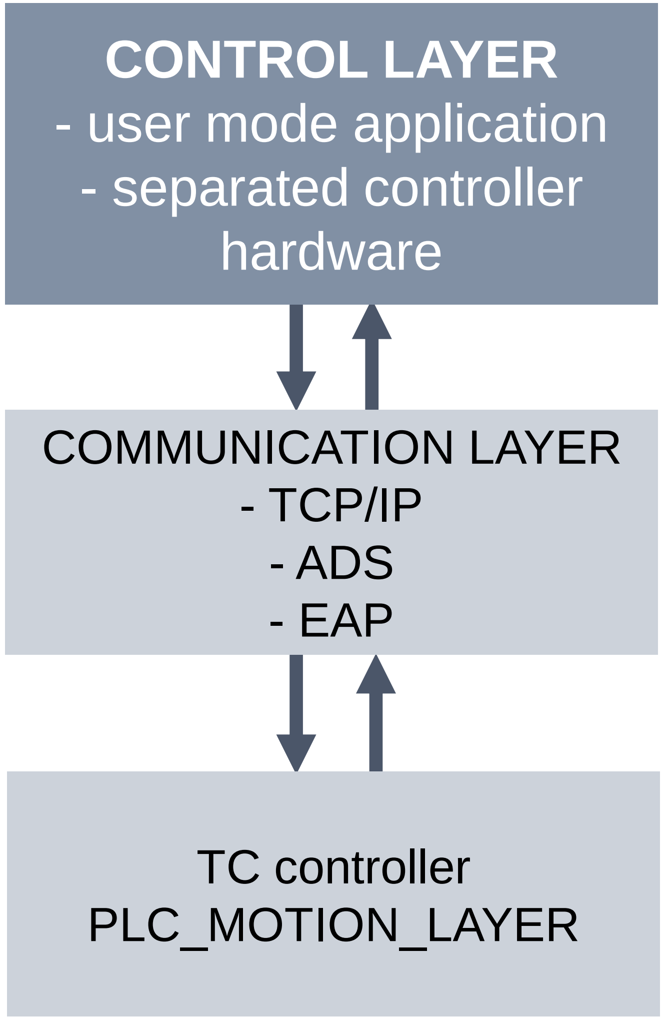
Use cases:

- Separate controller for machine logic
- Any network
- Connected through TwinCAT mappings
- Execution of motion tasks in PLC_MOTION_LAYER TwinCAT controller



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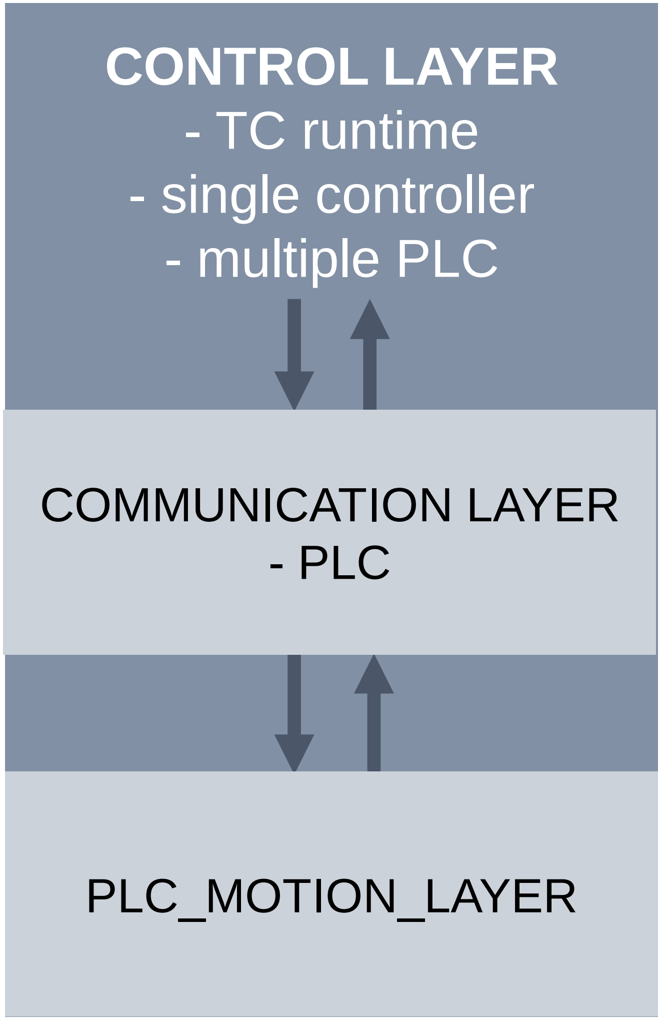
Use cases:

- One controller for machine logic
- Multiple PLC for machine logic
- Connected through TwinCAT mappings
- Execution of motion tasks



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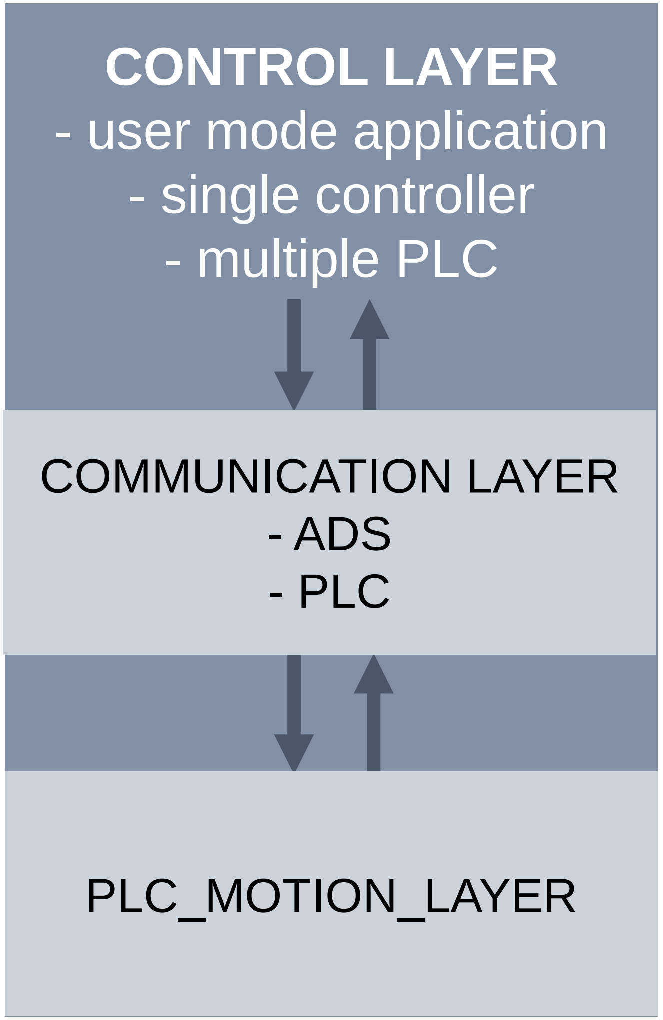
Use cases:

- One controller for machine logic
- User mode application AND/OR multiple PLC
- ADS for symbol access by user mode application
- TwinCAT mapping for connecting multiple PLCs for specific application purposes
- Execution of motion tasks



Specific construction:

- TwinCAT PLC project
- Use of specific syntactic code behaviour
- Software design
- Compiler defines / pragmas
- Logging system

TwinCAT project:

- Default TwinCAT project
  - Adjust core settings to target hardware
  - Add NC/PtP
    - Optional add NCI channel

- TwinCAT PLC
  - Add existing Item: PLC_MOTION_LAYER
  - Add task reference
  - Option: add compiler defines (NCI, CAM, BSD)

- Adjust constants in:
  - PLC_MOTION_LAYER/PLC_CONSTANT

- Compile
  - PLC_MOTION_LAYER Instance mapping is built

specific syntactic code behaviour:

- C like state machines
  - State changes need not consume one PLC cycle
  - Same cycle response to command on cyclic interface

- OnChange detection for new commands
  - Cyclic check whether the command has changed

- State always carries offset about progress of command (busy, error, done)

- Instance FBs are called within states

Software Design:

- Every TwinCAT function has dedicated wrapper
  - Separate namespaces
  - Optional library binding

- Cross communication via interfaces
  - NCI, CAM, XFC use interfaces in order to enable optional binding
  - If compiler define is not set, empty interfaces are used instead of instances

- Ctrl/State structures for commanding required function
  - PtP – ctrl/state
  - NCI – ctrl/state
  - CAMMING – ctrl/state

- Parameter structures carry required data for commanded function
  - PtP – (SetPos, SetVelo, SetAcc, MasterAxisIndex…)
  - NCI – (AxisGroupId, AxisIndex, MFunc, RParameter…)
  - CAMMING – (MasterAxisIndex, TableId…)

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Software Design:

PLC_MOTION_LAYER / GVL_AXIS

```
//---------------------------------------
// command and state structure
//----------------------------------------
Ctrl  : ARRAY[1..MAX_AXIS] OF
        ST_AXIS_CTRL;

State : ARRAY[1..MAX_AXIS] OF
        ST_AXIS_STATE;

//---------------------------------------
// cyclic interface function block
//----------------------------------------
Control  : ARRAY[1..MAX_AXIS] OF
           FB_McAxisCtrl;
```

PLC_MOTION_LAYER / GVL_NCI

```
//---------------------------------------
// command and state structure
//----------------------------------------
stChannelCtrl  : ARRAY[1..MAX_NCI_CH] OF
                 ST_CTRL_NCI;

stChannelState : ARRAY[1..MAX_NCI_CH] OF
                 ST_STATE_NCI;

//---------------------------------------
// cyclic interface function block
//----------------------------------------
fbNciCtrl : ARRAY[1..MAX_NCI_CH] OF
            FB_NciChannelCtrl;
```

PLC_MOTION_LAYER / GVL_CAM

```
//---------------------------------------
// command and state structure
//----------------------------------------
Ctrl  : ARRAY[1..MAX_AXIS] OF
        ST_CAM_CTRL;

State : ARRAY[1..MAX_AXIS] OF
        ST_CAM_STATE;

//---------------------------------------
// cyclic interface function block
//----------------------------------------
Control  : ARRAY[1..MAX_AXIS] OF
           FB_CamCtrl;
```

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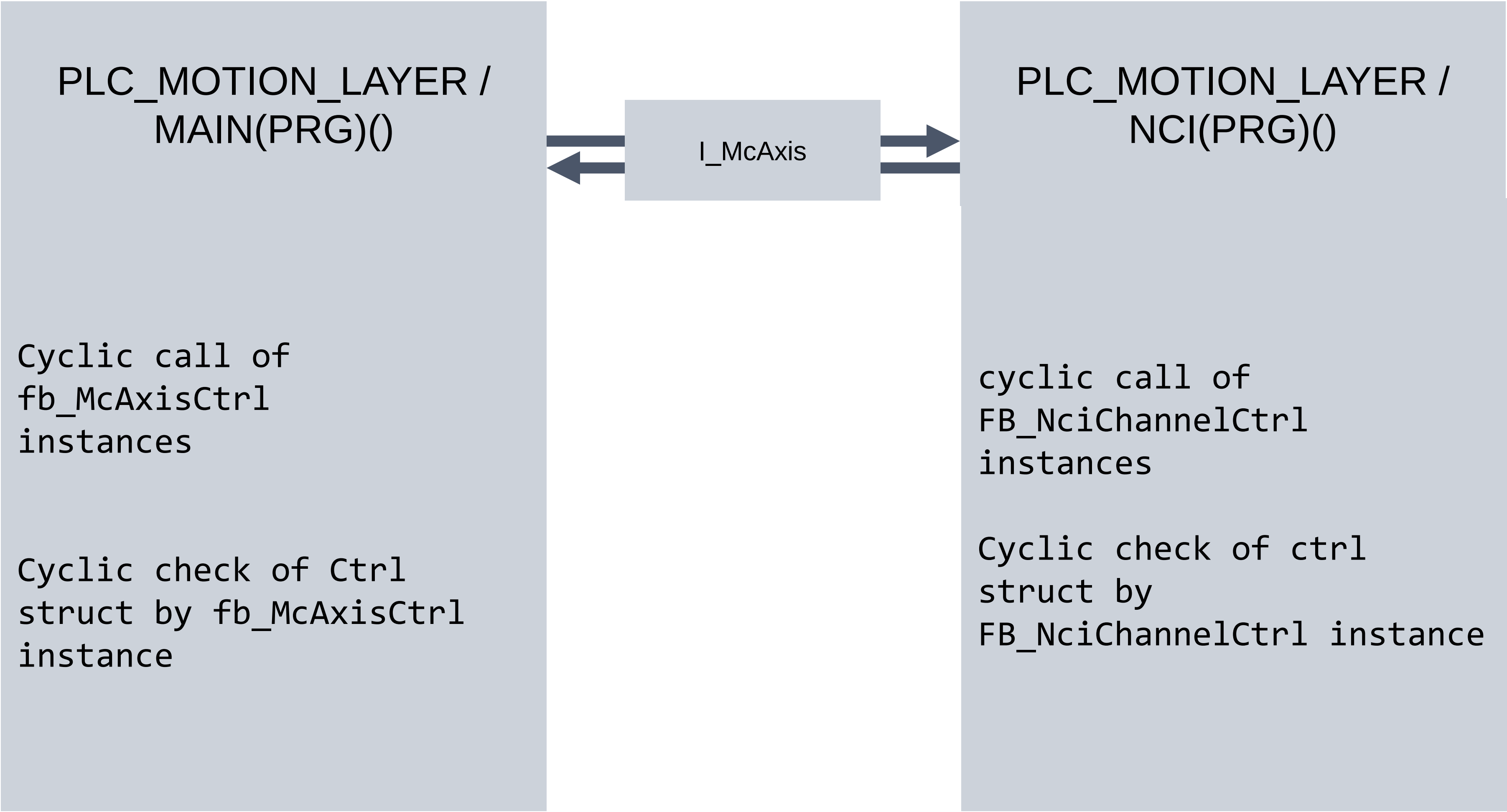
Software Design:



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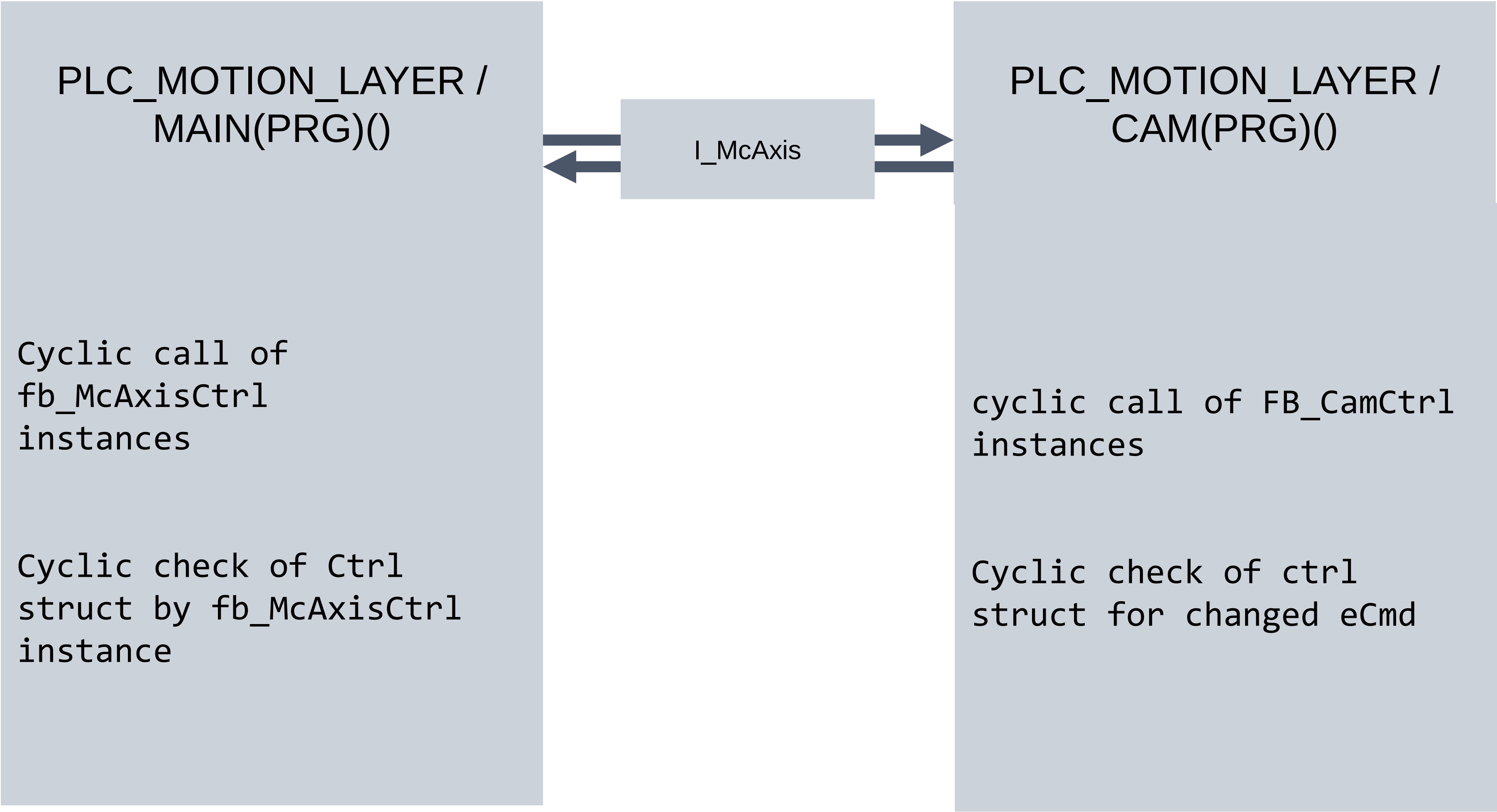
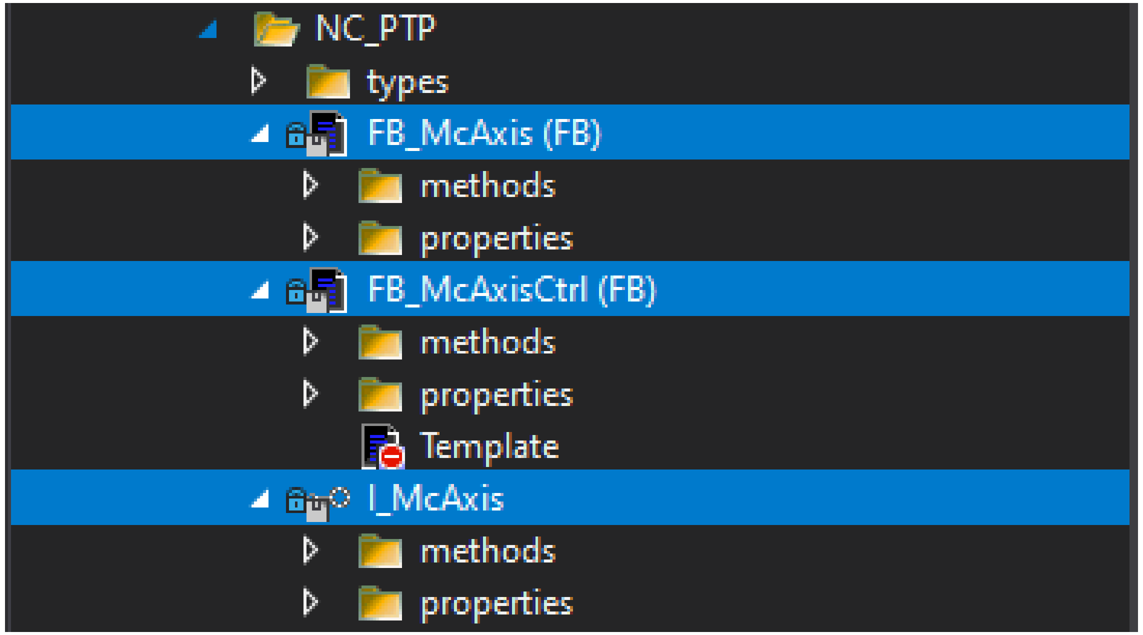
Software Design:



GVL_AXIS:

- McAxis: Point To Point axis
  - Base class **FB_McAxis** wraps Tc2_MC2 function blocks and implements interface
  - **FB_McAxisCtrl** extends base class with cyclic execution wrapper
  - **I_McAxis** is used in advanced motion features (NCI, CAM, XFC)



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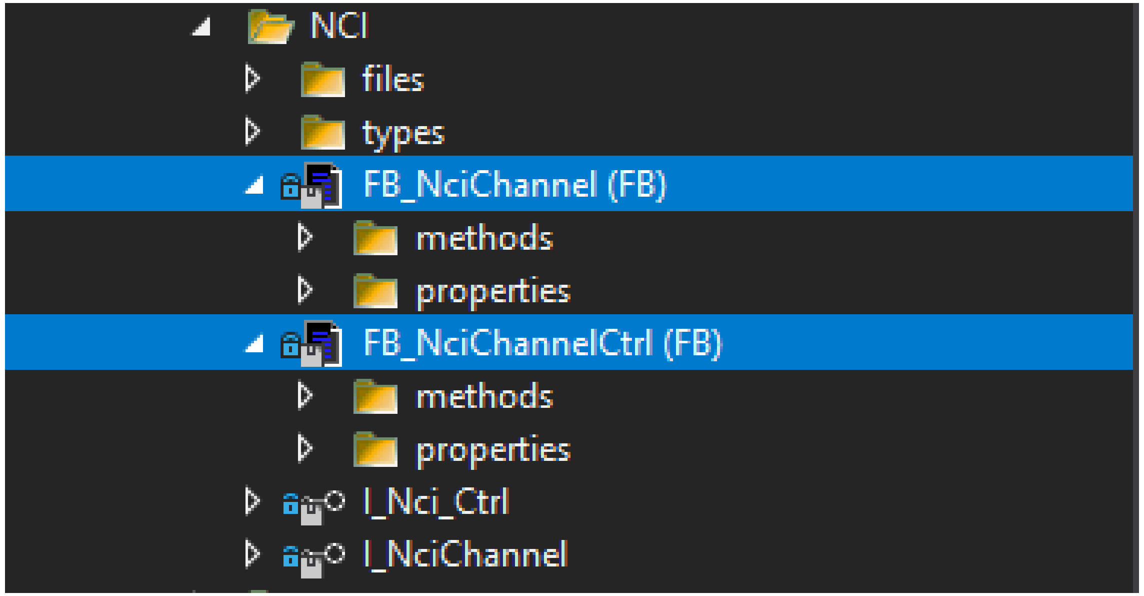
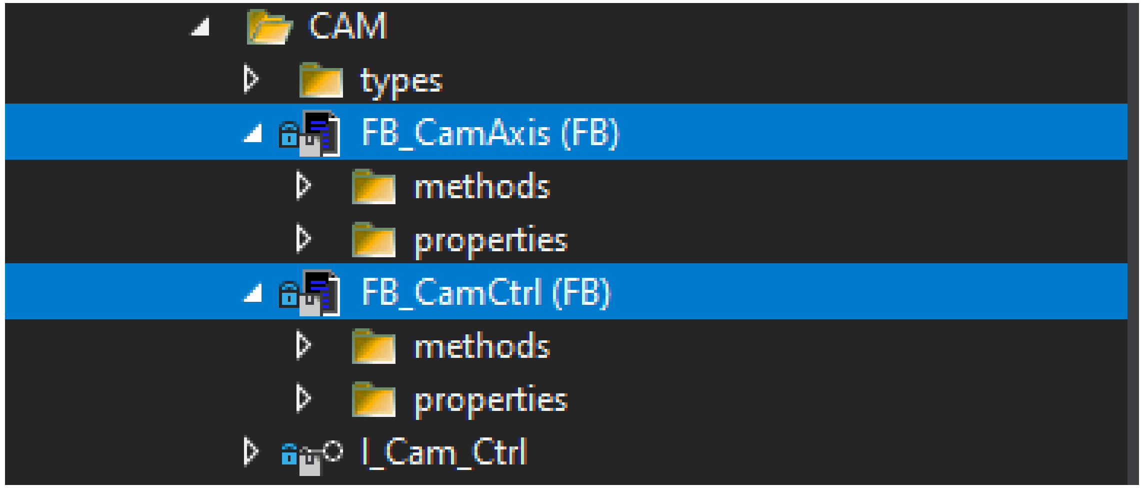
GVL_NCI:

- NCI Channel: XYZ interpolated
  - Base class **FB_NciChannel** wraps Tc2_NCI function blocks and implements interface
  - **FB_NciChannelCtrl** extends base class with cyclic execution wrapper and implements interface
  - **I_NciChannel** and **I_Nci_Ctrl** are only valid if compiler define is set before compiling project



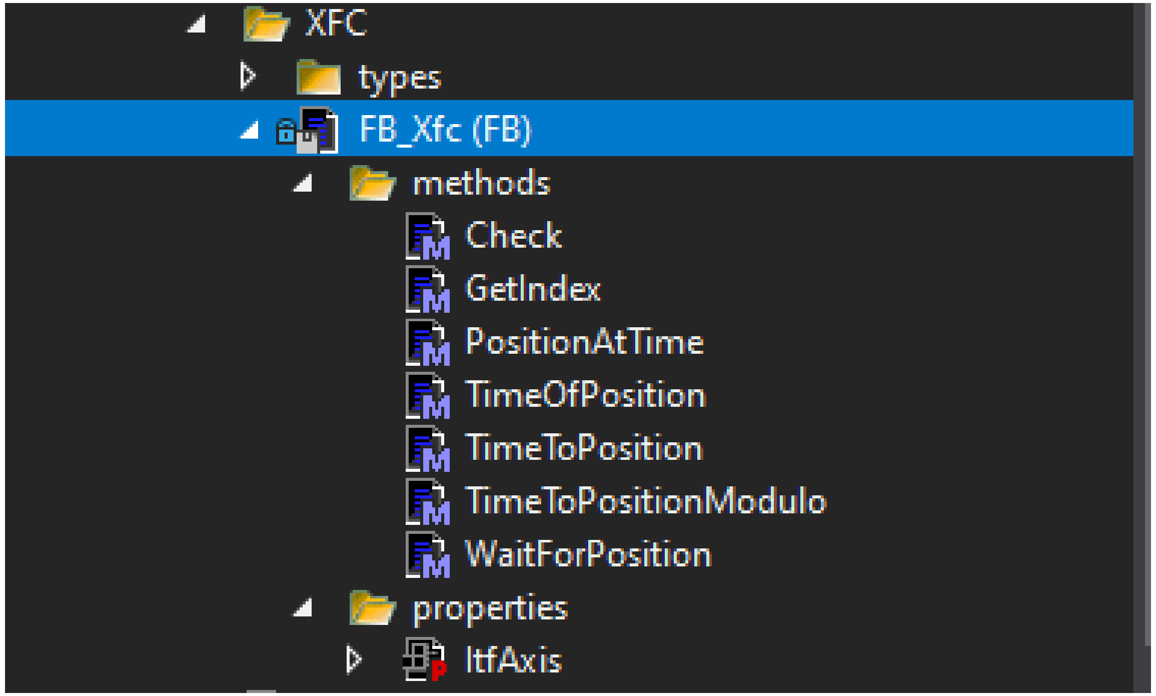
GVL_CAM:

- Camming:
  - Base class **FB_CamAxis** wraps Tc2_MC2_Camming function blocks and implements interface
  - **FB_CamCtrl** extends base class with cyclic execution wrapper and implements interface
  - **I_Cam_Ctrl** is only valid if compiler define is set before compiling project



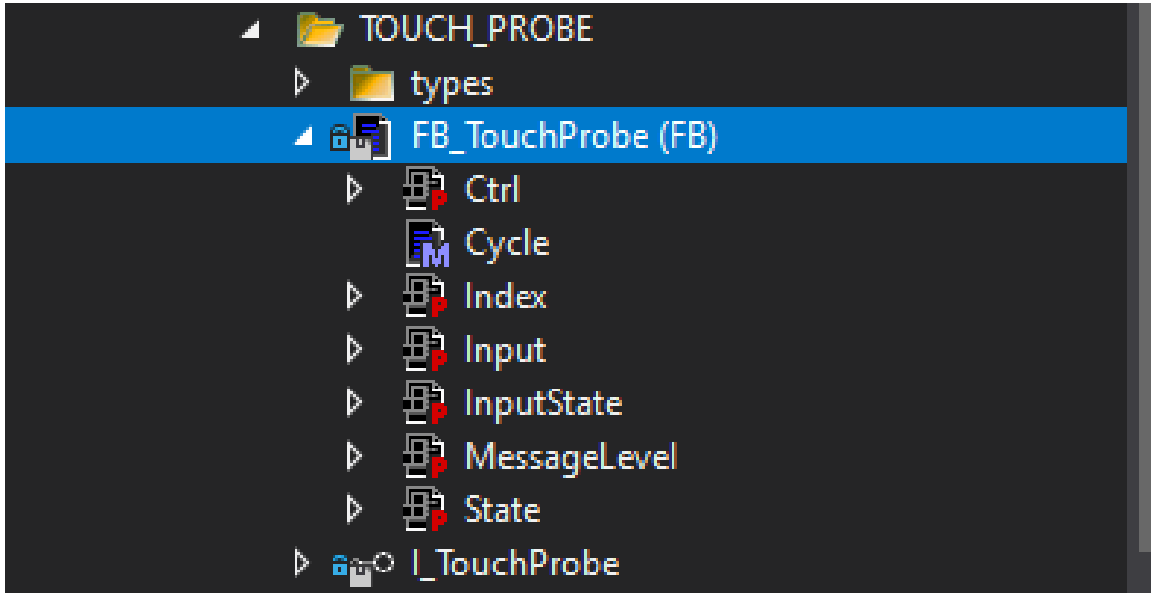
GVL_FUNCTIONS:

- XFC classes:
  - Base class **FB_Xfc** wraps Tc2_MC2_XFC function blocks for Distributed Clock position/time applications



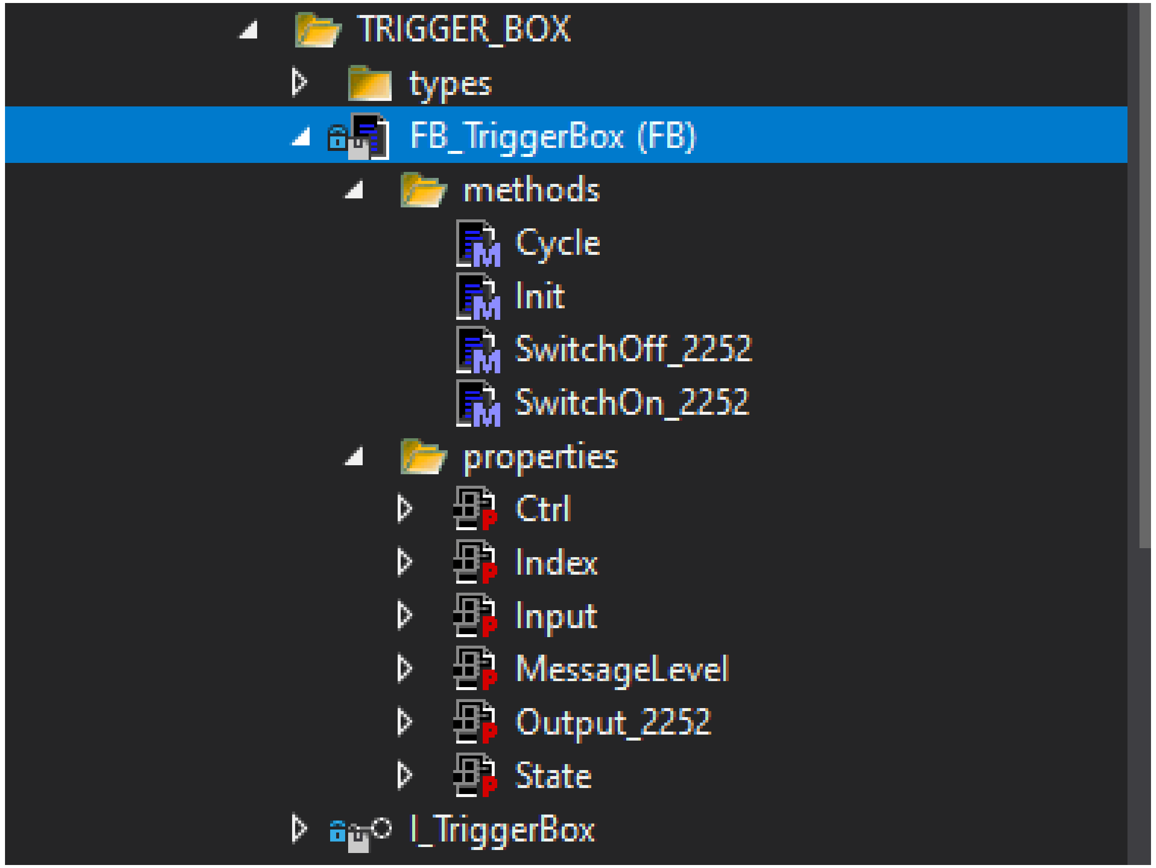
GVL_FUNCTIONS:

- Touch Probe:
  - **FB_TouchProbe** extends **FB_Xfc**
    - Cyclic execution with Ctrl/State pair
    - Must be connected to input device
  - **I_TouchProbe** is only valid if compiler define is set before compiling project



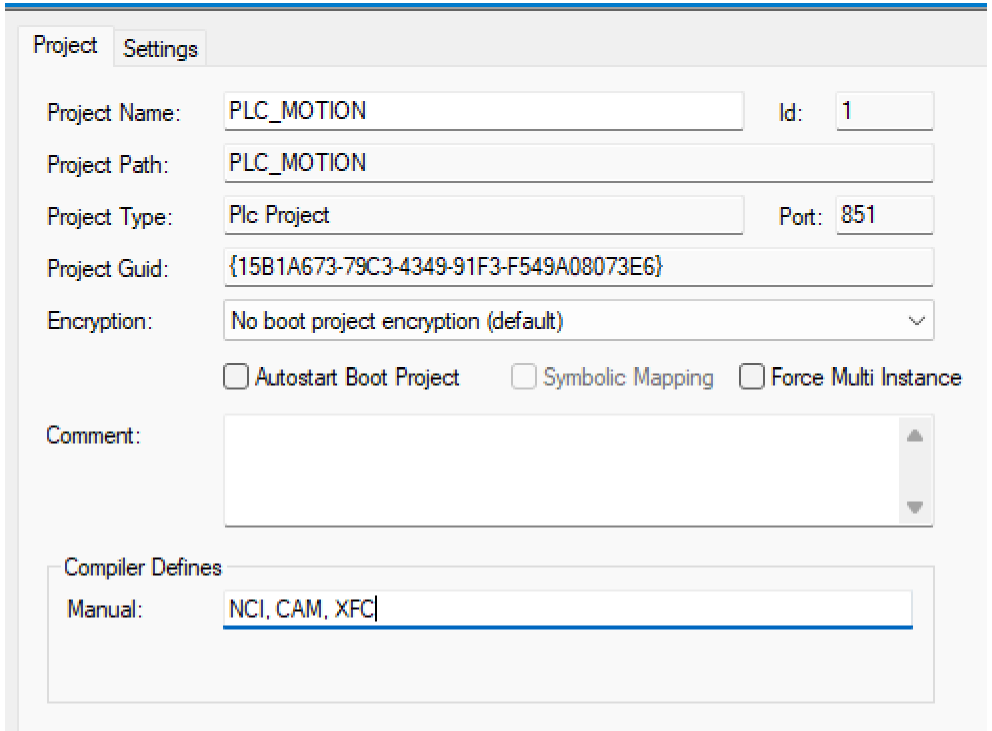
GVL_FUNCTIONS:

- Trigger Box:
  - **FB_TriggerBox** extends **FB_Xfc**
    - Cyclic execution with Ctrl/State pair
    - Must be connected to input/output device
  - **I_TriggerBox** is only valid if compiler define is set before compiling project



Compiler defines / pragmas:

- **BSD**
  - TC-BSD system specific variables are set
- **NCI**
  - NciChannel cyclic interfaces are used
- **CAM**
  - Camming cyclic interfaces are used
- **XFC**
  - TouchProbe and TriggerBox interfaces are used

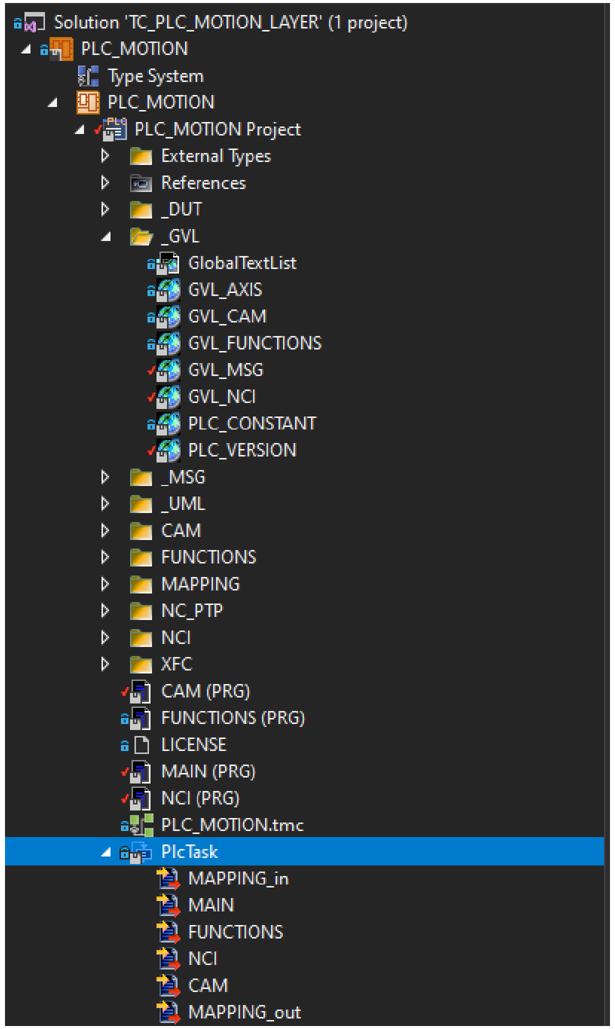


Compiler defines / pragmas:

- **AXIS_MAP**
  - MAPPING_in.AxisCtrl is copied onto GVL_AXIS.Ctrl and data structures
  - GVL_AXIS.State is copied onto MAPPING_out.AxisState and info structures
- **CAM_MAP**
  - MAPPING_in.CamControl is copied onto GVL_CAM.Ctrl
  - GVL_CAM.State is copied onto MAPPING_out.CamState and info structures
- **TRIGGER_MAP**
  - TouchProbe and TriggerBox interfaces are used

Cyclic call tree:

- **MAPPING_in(PRG)**
  - Copies mapping data onto input structures
- **MAIN(PRG)**
  - Cyclic call to FB_McAxisCtrl instances
- **FUNCTIONS(PRG)**
  - Cyclic call to TouchProbe and TriggerBox instances
- **NCI(PRG)**
  - Cyclic call to NCI channel instances
- **CAM(PRG)**
  - Cyclic call to FB_CamCtrl instances
- **MAPPING_out**
  - Copies state data onto mapping structures



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Logging System:

- Implementation from top down
  - → function based with global timestamp added automatically

- Enumeration based with 4 categories and timestamp
  - → ocurrance in strict timestamp order

- Error Id is mirrored directly from called instance
  - → Infosys error numbers can be searched in case of diagnosis

- Optional text for additional information

- Specific logging switch to get more detailed information aside error numbers

- Automated write procedure to ascii formatted file