Interfacing with iMOTION™ products

How to connect to products and boards

About this document

Scope and purpose

iMOTION™ products integrate the Motion Control Engine (MCE) to perform the control of a variable speed drive. The field-proven MCE implements field-oriented control (FOC) using single or leg shunt current feedback and uses space vector PWM with sinusoidal signals to achieve highest energy efficiency. The MCE supports sensorless operation as well as the use of digital hall switches or analog hall elements. It also integrates multiple protection features like over- and under voltage, over current, rotor lock, etc. The latest implementation also provides algorithms to perform power factor correction (PFC), and integrates a flexible scripting engine.

Targeting diverse applications, the MCE provides several configurable interfaces that can be used to configure and command the variable speed drive.

This application note describes the interfaces offered by iMOTION products, the debug and tuning tool iMOTION link and the evaluation boards, and gives examples of typical use cases.

The application note assumes that the MCE is already programmed and running; programming of the device at the end of the manufacturing line is described in the iMOTION™ device programming manual [1].

Intended audience

This application note is targeting developers implementing a variable speed drive using an iMOTION™ product with integrated Motion Control Engine (MCE).

Note: This Application Note refers to generation 2.0 of the MCE.

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1 MCE interfaces

The Motion Control Engine (MCE) provides several interfaces to communicate with users, external controllers or other devices. This chapter briefly describes them and gives typical application use cases.

It should be noted that not all iMOTION products implement all interfaces. For product specific availability, please refer to the product data sheet [2] and the MCE software reference manual for technical details [3].

The selection and configuration of the interfaces depends on the settings defined in the respective configuration file (*.mc2) created via MCEWizard and the resulting parameter file for use with MCEDesigner. As an example, most of the configuration files provided by Infineon for evaluation boards like the MADK control cards select the MCEDesigner protocol on UART0 and User UART on UART1 (see 1.4 Serial interfaces - UART).

1.1 Analog voltage input

Applying an analog voltage to the VSP input is probably the simplest way to provide a start-stop-speed command to the motor controller.

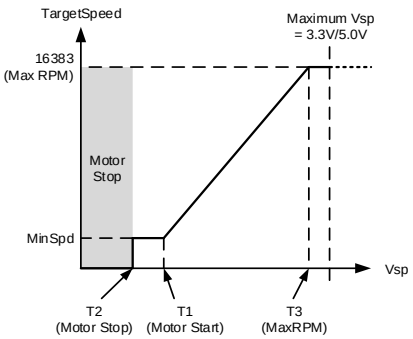


Figure 1 VSP Analog Input

The motor will start if the voltage rises above a certain limit, and the target motor speed will change linearly with the input voltage. The respective thresholds are configurable, and the direction input (DIR) is used to switch between forward and reverse. [3]

If a nonlinear/custom dependency is required, an analog input to the scripting engine can be used with the speed scaling being implemented in the respective script. This would also allow for a single voltage input controlling the motor system from reverse to stop to forward.

Together with a simple potentiometer, the analog input can be used e.g. in fan applications.

1.2 Frequency or duty cycle input

A digital pulse signal can be used in a similar manner as the analog input to control the speed. In this case, the signal is applied to the DUTYFREQ input while again the DIR input sets the rotation direction.

The speed of the drive is commanded either via the frequency or the duty cycle (pulse width) of the input signal.

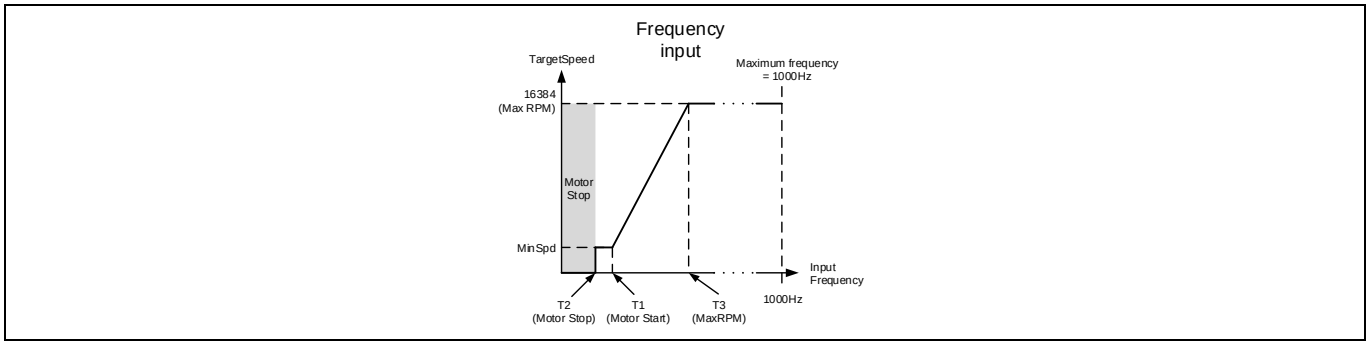


Figure 2 Frequency Input

As with the analog control input, the respective limits can be configured. [3]

This way of controlling the speed is commonly found in systems where the drive is connected to a host controller. In such cases the pulse output (PGOUT) as described in chapter 1.3 is used as feedback signal.

1.3 Feedback signals – LED and pulse output

The MCE provides two dedicated output signals, a status LED and a pulse output.

The LED is used to signal the status of the control loop. For example, the status LED blinks at 0.5Hz for a PFC-related fault and at 50Hz for a motor-related fault. For further details please refer to the MCE manual. [3]

The pulse generator output can generate a square wave pulse output in sync with the motor rotation which can be used by a host controller to monitor the actual motor speed. The number of pulses to be generated for a full rotation can be configured. For details please refer to the respective data sheet. [2]

1.4 Serial interfaces - UART

The serial interfaces of the MCE provide the most flexible way of controlling the drive. They can be used for configuration or to issue a command to the MCE, and they provide a feedback channel that can be used to read back the status of the drive.

For the serial interfaces, one has to differentiate between the physical interface and the functional protocol. The assignment of the protocol to the physical interface can be changed via configuration options.

The MCE supports two physical interfaces: **UART0** and **UART1**.

Functionally, three different communication modes are offered as shown in the following table.

Table 1 MCE communication protocols

Protocol	Description
MCEDesigner	used for communication with MCEDesigner, i.e. programming, configuration, tuning and real time monitoring
User UART	used in the customer system to communicate with a (central) host controller
JCOM	used in the IMC300 dual core series to communicate between MCE and MCU

MCEDesigner protocol is only used to communicate with the Infineon tools and not meant to be used in any customer application.

The user UART and JCOM protocols are both described in detail in the Motion Control Engine Software Reference Manual [3].

The user UART protocol supports a special networking mode, where multiple slaves, i.e. MCE controlled motors, communicate with a common master. A typical use case would be the rotor controllers in a drone. If this mode is to be used, the TX output of the respective UART should be configured as open drain output. [3]

The following tables list the configuration options for the individual iMOTION product families.

Table 2 Physical UART to protocol assignment for IMC100, IMD110, IMM100 series

	MCEDesigner	User UART
UART0	**default**	*configurable*
UART1	*configurable*	**default**

As described previously, the assignment depends on the settings in the respective parameter set and configuration file (*.mc2). The term ‘default’ refers to the fact that most of the configuration files provided by Infineon, e.g. most evaluation boards like the MADK control cards, select the MCEDesigner protocol on UART0 and User UART on UART1.

Table 3 Physical UART to protocol assignment for IMC300

	MCEDesigner	JCOM	User UART
UART0	**default**	*configurable*	*configurable*
UART1	*n.a.*	**default**	*n.a.*

Attention: ***Special care should be taken when reconfiguring the assignments. A UART configured for user mode or even when being disabled will no longer be accessible via MCEDesigner, e.g. for reconfiguring/ reprogramming the IC.***

1.5 Interchip communication – JCOM (IMC300 only)

The JCOM protocol is based on a high-speed serial link. Its main use is in the IMC300 motor control IC series implementing the communication between the MCE and the additional embedded microcontroller.

As given in *Table 3, Physical UART to protocol assignment for IMC300*, the MCE in the IMC300 series provides direct access for MCEDesigner via UART0 in order to allow configuration, tuning and monitoring of the drive.

In the final application, the recommended use case is commanding the MCE from the embedded MCU via JCOM. Accordingly, it is recommended, that all other control interfaces are disabled.

Infineon provides a driver for the JCOM interface for the embedded MCU in source code, making it easy to get started. The development of the system code on the MCU including the communication is significantly simplified by the fact that the MCE runs autonomously from the microcontroller. That means developers can keep the motor spinning (optionally monitored via MCEDesigner) while coding and debugging the application code on the MCU core.

1.6 Serial wire debug

iMOTION products that integrate a programmable microcontroller are based on the common ARM® Cortex®-Mx core type, typically an ARM® Cortex®-M0.

These controllers provide programming and debug access via the standard ARM® interfaces, namely serial wire debug (SWD). SWD uses a three-wire connection (data-clock-ground) and details can be found on the ARM® web site. [4]

2 iMOTION™ Link

iMOTION™ Link is the standard PC interface for all new iMOTION products. It is based on SEGGER J-Link technology and provides the following interfaces to the target (iMOTION driven board) and the PC (USB).



Figure 3 iMOTION link

Target side:

- Galvanically isolated UART
- Galvanically isolated SWD
- Galvanically isolated 3.3 VDC output to the target board with 100 mA current capability

PC side:

- USB interface to PC
- USB enumerated virtual COM port
- Debug interface based on SEGGER J-Link
- Power for the 3.3 V output is drawn from the USB port

In terms of functionality, iMOTION Link supports the following:

- Programming of MCE firmware, parameters and scripts
- Tuning of motor parameters with MCEDesigner
- Programming and debugging application code via SWD

Most of the evaluation boards from Infineon, namely the MADK control boards, have the isolated PC interface integrated on the board connected to UART0 of the MCE and configured to MCEDesigner protocol. When beginning to use the MADK control boards, the MCE can be programmed and configured with MCEDesigner via the isolated PC interface. Thus, iMOTION Link is normally not required for MADK control boards.

In working with iMOTION Link, it is important to keep in mind that the whole system consists of two isolated building blocks – the PC/USB side and the part connected to the target board. Each part requires its own power supply. While the PC side is powered directly via the USB port, the target side can either be powered from the target board or via the integrated isolated power supply (switch 3.3V OUT).

In case of the MADK system, the respective power board generates the control board supply voltage required and the DC voltage is fed to the control board via the M1 or M3 connector. If using iMOTION Link with the MADK system (i.e. to provide the user UART connection to UART1 interface) the iMOTION Link 3.3V internally generated output supply should therefore be switched off.

If the target board does not provide the DC supply voltage for the iMOTION controller on board (e.g. inverter part of the system is not powered on or is not connected in the case of MADK system), the iMOTION Link output power supply needs to be switched on in order to be able to connect and communicate to the iMOTION IC.

Attention: ***It must be assured that only one supply is applied at any time. Using internal and external supply in parallel could lead to permanent damage of the iMOTION Link.***

iMOTION Link as well as the on-board debugger (built in iMOTION MADK boards) are based on Segger technology. The required interface driver will be automatically installed with the installation of MCEDesigner. Alternatively, it can be installed or updated using the download ‘J-Link Software’ from the Segger website. [5]

Examples of typical use cases for iMOTION Link will be given in the following chapters.

3 Evaluation boards

The following chapter describes the interfaces provided on the evaluation boards, focusing on the MADK control boards. Not all boards are described in detail here, but most boards follow the same strategy. Connection to the PC is done via an on-board isolated interface providing isolated access for MCEDesigner or (for products containing a programmable ARM® Cortex® microcontroller core) Segger J-Link debugger protocol.

All MCE control interfaces as described above (VSP, DUTYFREQ, User UART) are made available as pin headers.

Care must be taken since these headers reside on the 'hot'/AC side of the MADK system.

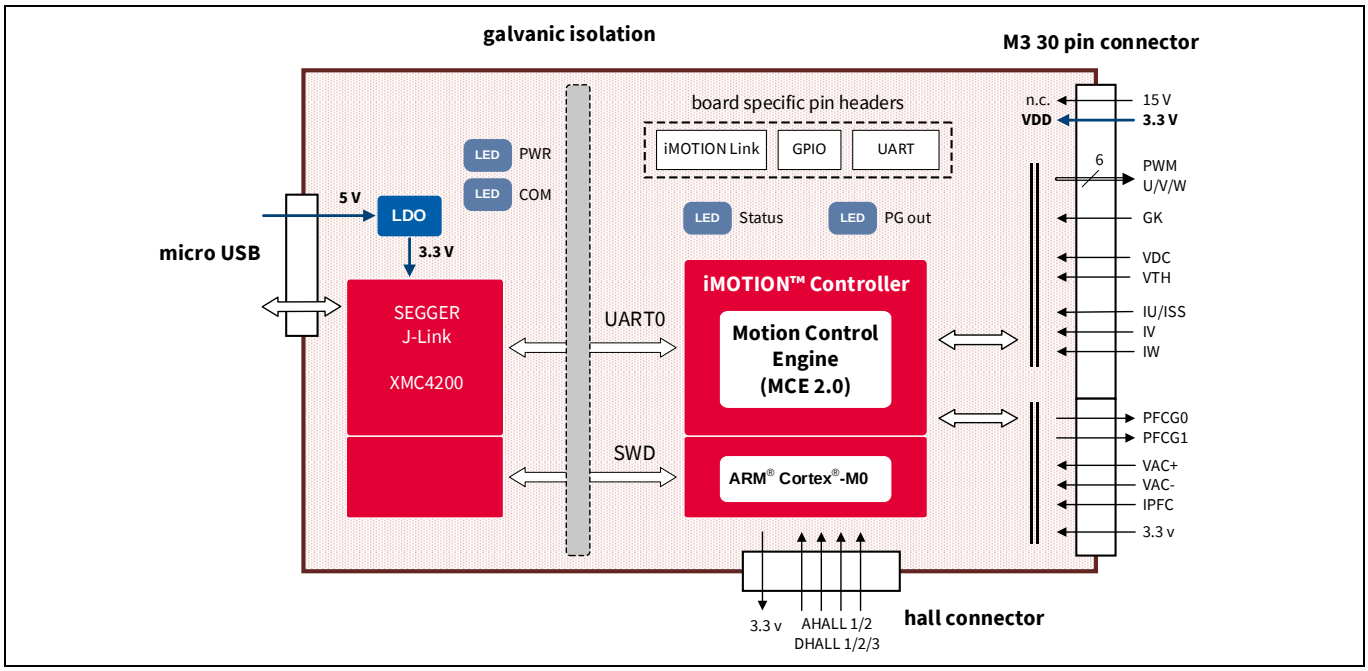


Figure 4 Block diagram of MADK control board EVAL-M3-302F

Shown in Figure 4 is the block diagram of the EVAL-M3-302F as an example of an MADK control board with the respective interfaces. The M3 connector is the interface to the resp. power board, in this example including motor as well as PFC control functionality. And the iMOTION™ motor controller is powered via the M3 connector from the connected power board.

For technical details including the schematic, please refer to the board documentation. [7]

3.1 IMC100 MADK board EVAL-M1-101T

This board is based on the IMC101T-T038. As a member of the IMC100 family, this controller provides two physical UARTs.

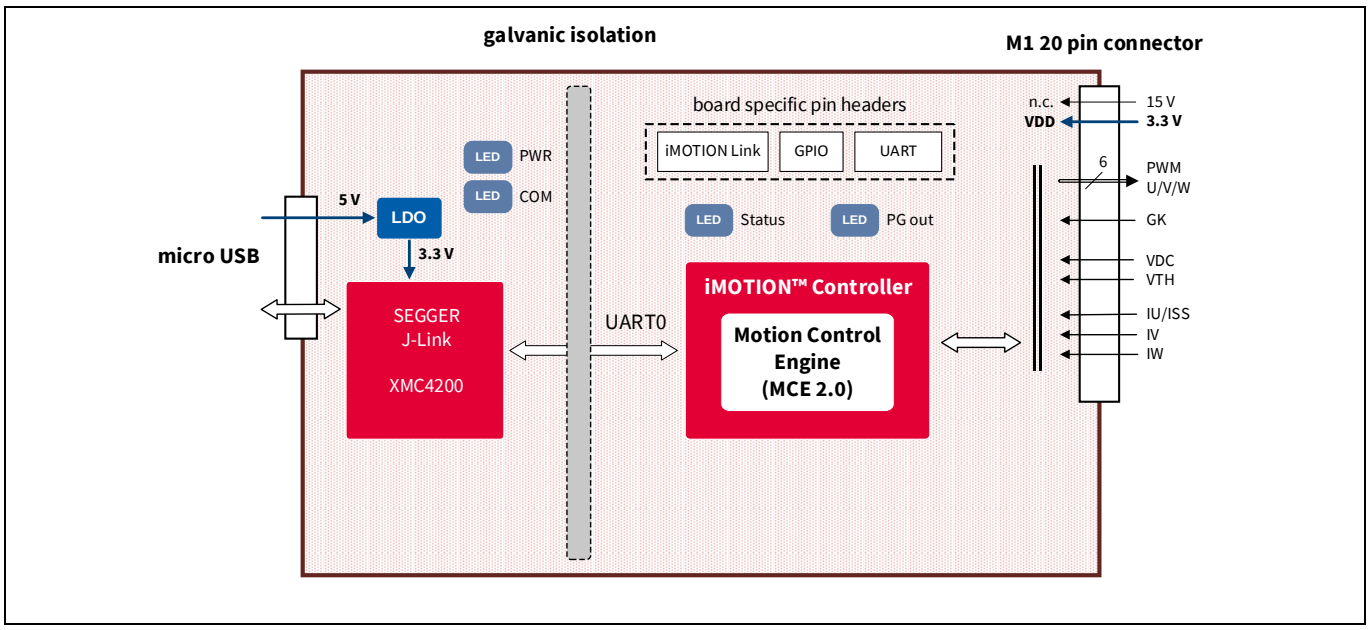


Figure 5 MADK control board EVAL-M1-101T

Like all control boards for the Modular Application Design Kit (MADK) the board has an on-board PC interface that is galvanically isolated from the motor control section. This on-board debugger is based on Segger J-Link technology and works in a very similar way to the iMOTION Link described earlier. [8]

One notable difference is that it does not provide an (isolated) power supply for the control section. In the MADK system, this part is powered from the respective power board.

In the default setting, the UART0 is routed to the on-board PC interface and configured for MCEDesigner protocol.

Setting up the MADK system for a motor drive is done as follows:

- connect the control and power board
- connect to the PC (micro USB)
- apply (AC) power to the power board

Now MCEDesigner can be started and used to download the necessary files to the iMOTION IC, such as the actual MCE firmware, the parameter set for the power stage and motor as well as possibly a script file, if the scripting function is to be used.

As stated above, the IMC101T offers a second physical UART1 which is by default configured for the User UART protocol. UART1 is routed to the pin header J1 residing in the control section. ([8], Table 4)

Depending on the system architecture, this UART1 can be directly connected to a host controller via Rx/Tx lines. Care must be taken in terms of the voltage levels, since this is the ‘hot’/AC side.

If the User UART protocol is desired to be made available on the PC, there are two options.

The recommended method is to use iMOTION Link. After soldering the respective pin header on J1 connector, the iMOTION Link can be connected (correct notch position of connector is marked on the board).
iMOTION Link will provide the galvanic isolation and present a second virtual COM port (VCOM) on the PC that is using the User UART protocol. (see Figure 6 below)

1. *UART0 (MCEDesigner) – on-board PC interface – VCOM1 – MCEDesigner*
2. *UART1 (User UART) – iMOTION Link – VCOM2 – terminal or else*

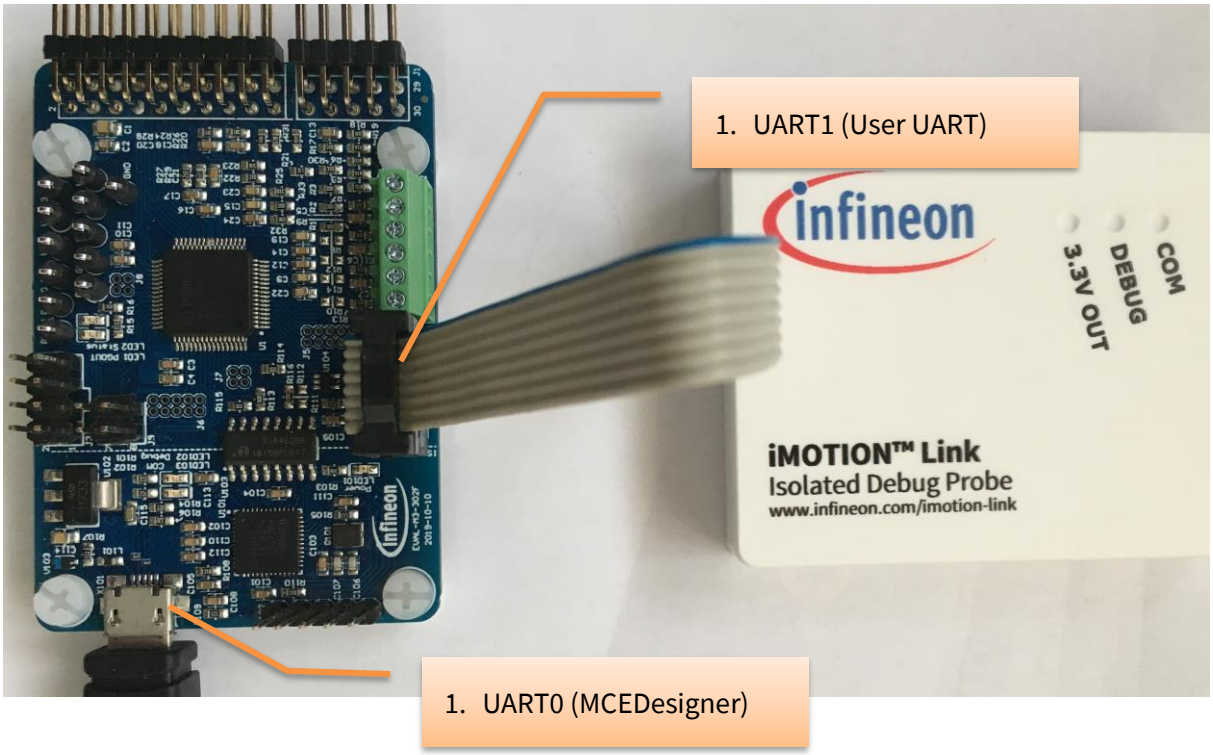


Figure 6 Using iMOTION Link on UART1 of the MADK control board

The enumeration of the COM ports on the PC is done automatically. The easiest way to differentiate between them is to plug in one after the other and monitor the enumeration in the device manager.

Both the on-board debugger and iMOTION link only use the virtual COM port channels; the actual debug channels (SWD) are not used.

The alternative to using iMOTION Link is to reconfigure the UART0 (which is routed via the on-board debugger) to User UART protocol. Since doing so makes the further use of MCEDesigner on this interface impossible, this is only recommended for experienced users.

Please refer to *5.1, Regaining access with MCEDesigner* for the procedure to configure UART0 back for MCEDesigner.

3.2 IMC300 MADK board EVAL-M3-302F

This board is based on the IMC302A-F064. As a member of the IMC300 family, this is a dual core controller integrating the MCE with an additional microcontroller (MCU). A block diagram of this board is given in Figure 4.

The on-board interface is identical to the one used on the EVAL-M1-101T but here the debug channel (SWD) is used to connect to the additional MCU core.

- UART0 (MCE core) – on-board debugger – VCOM1 – MCEDesigner
- SWD (MCU core) – on-board debugger – J-Link debugger – Keil or other IDE

After setting up the system, the user can immediately start configuring and running the motor via MCEDesigner.

The typical use case for the IMC300 dual core family is that the MCE is commanded from the integrated MCU. Accordingly, the MCE core in the IMC300 is configured in default configuration for JCOM. Infineon provides a driver for the JCOM interface for the embedded MCU in source code.

In the IMC300 series, the MCE runs independently from the microcontroller. That means developers can keep the motor running (being monitored via MCEDesigner) while getting started with coding and debugging the application code including the JCOM interface.

While developing the system application code on the MCU core, there might be the need to gain access to the interfaces provided by the MCU, like IO, serial ports or even the CAN interface. Therefore multiple IO pins of this device are made available via pin headers.

Again, care must be taken in terms of the voltage levels, since this is the ‘hot’/AC side.

One UART of the MCU can be made available on the PC by using an iMOTION Link as the interface. UARTs are available on headers J3 and J9 but can also be routed to other pins by using the pin multiplexer in the MCU.

3.3 IMM100 starter kit EVAL-IMM101T-015

EVAL-IMM101T-015 is a starter kit for iMOTION™ IMM101T-015M smart IPMs. The IMM101T-015M device is part of the iMOTION™ IMM100 Smart IPM series, so the following description is applicable to all respective IMM100 starter kits.

The starter kit contains the same isolated debug interface as the MADK control cards described above. The debug part is galvanically isolated, powered via USB and exposes a virtual COM port (VCOM) to the PC connected. Contrary to the MADK control cards, the starter kit might also have an option to power the iMOTION IC through USB which can be turned on/off by a slider switch on the board. Please refer to the resp. board documentation.

In the default setting, the UART0 is routed to the on-board debugger and configured for MCEDesigner protocol.

VSP and DUTYFREQ input are made available on pin headers on the 'AC' side.

Setting up the starter kit for a motor drive is done as follows:

- connect the on-board debugger to the PC (micro USB)
- apply AC power to the board or turn on the 3.3V switch if no AC power needed (e.g. for initial testing/programming of basic iMOTION IC functions)

Now MCEDesigner can be started and used to download the necessary files to the iMOTION IC, such as the MCE firmware, the parameter set for the power stage and motor as well as a script file, if scripting function is used. For a more detailed step-by-step description, please refer to the board user manual. [9]

Attention: It must be assured that only one supply is applied at any time. Using internal and external supply in parallel could lead to permanent damage of the starter kit.

4 Typical use cases

This chapter describes some typical use cases for iMOTION products, boards and iMOTION Link during the customer's design process.

4.1 Getting started with MADK

The Modular Application Design Kit (MADK) evaluation platform facilitates the rapid prototyping of a motor drive.

The combination of control and power board provides all that is needed to set up and run the motor, and does not require additional hardware like iMOTION Link.

The on-board debugger interface is powered via USB. The power board is directly powered by an AC or DC input. The respective power board in turn provides the power supply for the iMOTION controller residing on the control board.

After connecting the USB port and applying power to the power board, the user can immediately start with configuring, running and tuning the motor via MCEDesigner.

All control interfaces like VSP, DUTYFREQ or the User UART are available on the motor control (AC) side. In applications where an external host controller should be used, it can be directly connected here.

4.2 Connect User UART to PC

If the User UART should be connected to the PC, e.g. for using a terminal program to send and receive control commands, iMOTION Link can be used.

The MADK control boards provide a connection to both physical UARTs on a pin header. (e.g. J1 in case of the EVAL-M1-101T [8]) After assembling the respective pin header, iMOTION Link can be connected (correct notch position of the connector is marked on the board). iMOTION Link will provide the galvanic isolation and present a second virtual COM port on the PC configured for the User UART protocol.

- UART0 (MCEDesigner) – on-board debugger – VCOM1 – MCEDesigner
- UART1 (User UART) – iMOTION Link – VCOM2 – terminal or other program

Now a terminal (or other) program can be used to send and receive commands via the virtual COM port.

In parallel, MCEDesigner can be used to monitor the behavior of the drive and the reaction to the commands.

In this case, the iMOTION Link only uses the virtual COM port channel, whereas the actual debug channel (SWD) is not used.

4.3 Use of iMOTION Link internal power supply

As described above, the PC interface on the MADK control boards is powered via USB, but does not power the isolated iMOTION controller IC on the AC/drive side. Since the iMOTION Link provides an internal isolated power supply, it can be used to power the iMOTION controller. This can be useful in an environment where the direct AC connection on the MADK power board could be dangerous, e.g. in an office environment.

The control board should not be connected to any power board. iMOTION Link is connected to the pin header on the motor side that normally provides the interface to the UART1 (as described in chapter 4.2).

Enabling the 3.3 V output of iMOTION Link will power the iMOTION motor controller, allowing users to get familiar with the iMOTION tools like MCEDesigner or working with the integrated scripting capabilities.

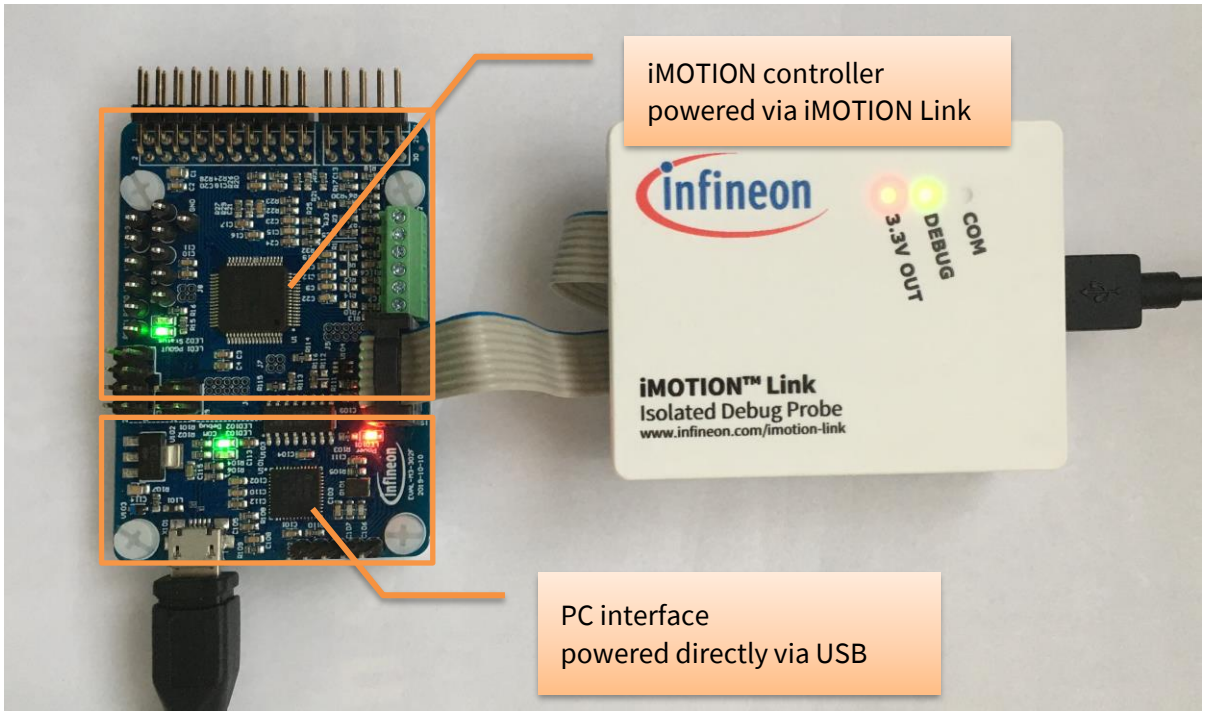


Figure 7 Applying the iMOTION Link internal supply

On most MADK control boards in the connection scheme as shown, iMOTION Link provides access to UART1, which is typically configured for User UART protocol as described in *1.4 Serial interfaces - UART.*

4.4 Customer designed board

For a customer board, iMOTION Link is the recommended interface during the board and system design process.

The board should provide a connection to UART0 of the respective iMOTION device. The iMOTION Link can then be used to program, configure and tune the device via this UART.

In the case of programmable devices, e.g. the MCU core in the IMC300 family, the SWD lines should also be routed to the iMOTION Link SWD interface.

It should be noted that iMOTION Link only provides one serial channel, so it is only possible to use either MCEDesigner (protocol) or User UART (protocol).

In using iMOTION Link with a custom designed board, the power supply of the isolated section has to be considered as described in the chapter 2. Therefore, either the target board must provide the supply via additional pins (as implemented on the MADK control boards) or the internal 3.3 V supply should be enabled.

Attention: ***It must be assured that only one supply is applied at any time. Using internal and external supply in parallel could lead to permanent damage of the iMOTION Link.***

5 Tips and tricks

5.1 Regaining access with MCEDesigner

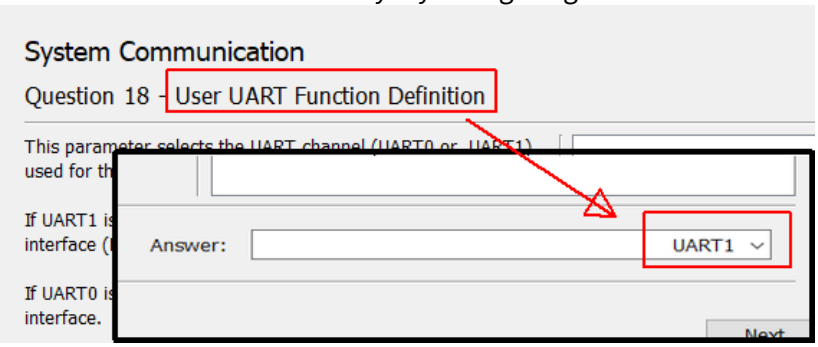
As described above, in case the UART0 on the MADK control boards is configured for User UART protocol it is no longer possible to connect with MCEDesigner.

Using the suitable User mode UART protocol it is possible to configure the UART0 back to MCEDesigner protocol. This can be done in two different ways, either by writing the respective configuration registers directly or by loading an alternative parameter set which has been stored earlier. (iMOTION products based on the MCE can store up to 15 different parameter sets.) [3]

In addition, there is another method to load a new parameter set with the help of MCEDesigner. This is based on the fact that upon device startup the MCE monitors the UART interface for an incoming connection request.

The procedure to program a new parameter set is as follows:

1. Prepare a parameter set with the UART0 configured to MCEDesigner protocol.
   In MCEWizard this is done ‘indirectly’ by configuring ‘User UART function’ to UART1 or Disabled

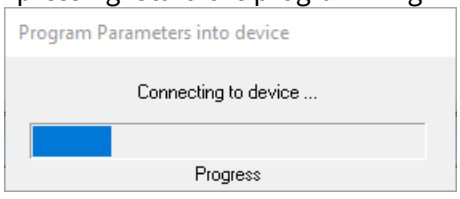


2. Switch off the iMOTION controller, but leave the debug/PC interface powered and connected to the PC.
   In case of an MADK control board this can be done by disconnecting the power board (M1/M3 connector).
   In case of the iMOTION Link leave this connected to the PC via USB cable.

3. Start MCEDesigner and select the correct COM port connected to the PC interface/iMOTION Link.
   Dismiss the error message about the MCEDesigner not being able to connect to the iMOTION IC.

4. Call the programmer window and select the parameter set as created above.

5. After pressing ‘Start’ the programming window will pop up.



6. Switch on the iMOTION controller, e.g. by plugging in the respective power board.
   As soon as the controller powers up he will connect to MCEDesigner and program the new parameter set.
   The timeout for powering up the iMOTION controller is approximately 20s.

It should now be possible to connect to the board with MCEDesigner again.

5.2 Connect with iMOTION Link to MADK boards

Due to the fact that the MADK control boards already provide an isolated interface, there is normally no need to use iMOTION link on them other than powering the motor control side as described above (4.3).

If for some reason iMOTION Link should be used to interface to the motor controller the existing connection to the on-board interface must be removed. This is necessary to avoid interference between the two debug/PC interface ICs.

On the MADK control boards the connection of the UART0 to the galvanic isolation is routed via zero-ohm resistors. These can be removed to open the connection to the on-board interface.

The concrete part numbers of these resistors might differ from board to board but typically they are close to the isolation IC. Please refer to the respective board documentation.

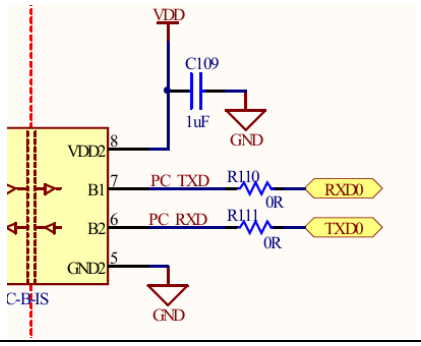


Figure 8 Connection to on-board debugger via digital isolator

References

[1] iMOTION™ Device Programming Manual, www.infineon.com/iMOTION

[2] Product documentation iMOTION, www.infineon.com/iMOTION

[3] iMOTION™ Motion Control Engine Software Reference Manual, www.infineon.com/iMOTION

[4] Arm Support Hub, https://developer.arm.com/

[5] SEGGER Microcontroller GmbH, www.segger.com

[6] iMOTION™ Link, https://www.infineon.com/cms/en/product/evaluation-boards/imotion-link/

[7] Modular Application Design Kit, https://www.infineon.com/MADK

[8] EVAL-M1-101T User Manual, https://www.infineon.com/cms/en/product/evaluation-boards/eval-m1-101t/

[9] EVAL-IMM101T-015 User Manual, https://www.infineon.com/cms/en/product/evaluation-boards/eval-imm101t-015/

Revision history

Document version	Date of release	Description of changes
1.0	2020-03-31	Initial version
1.1	2020-09-01	Added tips and tricks section, added some figures
1.2	2022-11-02	Corrected UART1 for IMC300

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