# VIRTEC Foundation Library User Guide

Version 2.3.1

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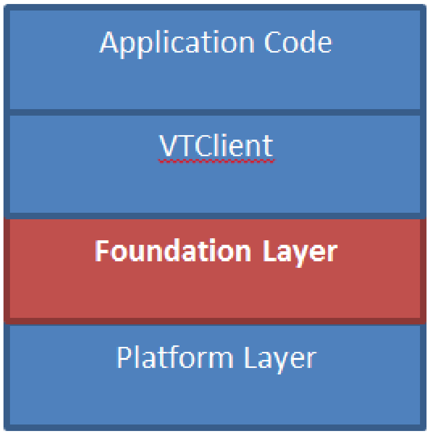
# Introduction

ISO 11783 (ISOBUS) consists of the following parts, under the general title *Tractors and machinery for agriculture and forestry - Serial control and communications data network*:

- *Part 1: General standard for mobile data communication*
- *Part 2: Physical layer*
- **Part 3: Data link layer**
- *Part 4: Network layer*
- **Part 5: Network management**
- *Part 6: Virtual Terminal*
- *Part 7: Implement messages application layer*
- *Part 8: Power train messages*
- *Part 9: Tractor ECU*
- *Part 10: Task controller and management information system data interchange*
- *Part 11: Mobile data element dictionary*
- **Part 12: Diagnostics services**
- *Part 13: File server*

The parts shown above in **bold** are included in the VIRTEC Foundation Library.

## Overview



*VIRTEC Layers block diagram*

The foundation layer provides core ISOBUS functionality, including:

- Network NAME Table Management
- Address Claiming
- TP and ETP message transport management
- Packet routing
- Request and acknowledgement handling
- ECU, Software, and Product ID management
- Diagnostic protocols

## Definitions

**Message**
A multi-packet message. Within the VIRTEC libraries, messages are of type ISOBUS_Message_T.

**Packet**
A single packet message. Within the VIRTEC libraries, packet are of type ISOBUS_Packet_T.

## Setting up Foundation

### Foundation Data Structures and Required Declarations

In order to develop an ISOBUS application, several foundation data structures must be declared.

#### Pipes

Pipes allow for data to be transported between different parts of an application. Pipes are declared as type `Pipe_T` while a collection of pipes are declared as type `Pipes_T`

Pipes have a name, a priority and a size.

**name** is self explanatory
**priority** is the scheduler priority upper limit for all tasks that can access this pipe
**size** is the maximum number of bytes the pipe can hold

## Declaring pipes and a pipe collection

The easiest method of creating a collection of pipes for use in your application is by storing pipe information in a separate header file and using the Foundation's built-in macros, along with some custom ones for reading the appropriate information from the header file.

### *Example Pipes.h*

**Example**

```
#ifndef PIPE
#define PIPE(name, priority, size)
#endif //PIPE

//PIPE(name,priority,size)
PIPE(Pipe0, MY_MUTEX_PRIORITY,    8)
PIPE(Pipe1, MY_MUTEX_PRIORITY,    8)
PIPE(Pipe2, MY_MUTEX_PRIORITY,    8)
PIPE(Pipe3, MY_MUTEX_PRIORITY,    8)
PIPE(Pipe4, MY_MUTEX_PRIORITY,  256)
PIPE(Pipe5, MY_MUTEX_PRIORITY,  256)
PIPE(Pipe6, MY_MUTEX_PRIORITY,  512)
PIPE(Pipe7, MY_MUTEX_PRIORITY,  512)
PIPE(Pipe8, MY_MUTEX_PRIORITY, 1785)
PIPE(Pipe9, MY_MUTEX_PRIORITY, 1785)

#undef PIPE
```

### *Pipe Initialization Code*

**Example**

```
// Create individual Pipe arrays (for pipe collection)
#define PIPE(name, priority, size)  static MAKE_PIPE_ARRAY(name,
MinAddressable_T, size);
#include "Pipes.h"

// Pipe Array
static Pipe_T MyApp_PipeArray[] =
{
  #define PIPE(name, priority, size)  MAKE_Pipe_T(name, priority),
  #include "Pipes.h"
};

// Final Pipe Collection
```

```
static Pipes_T MyApp_PipeCollection = MAKE_Pipes_T(MyApp_PipeArray,
MY_MUTEX_PRIORITY);
```

## Transport Sessions

Transport sessions hold all the necessary information to keep track of TP and ETP transport sessions in progress.

### Declaring Transport Sessions

Transport sessions are declared as type `ISOBUS_TransportSession_T`

You'll want to ensure that your foundation includes enough transport sessions to support the requirements of your application.

**Example**

```
// TP session array for Application
static ISOBUS_TransportSession_T MyApp_TP_Sessions[4];
```

## Functionalities

Functionalities are used for conformance testing and designate the capabilities of your application. If your application will not be conformance tested, you do not need to include them. At a minimum, an application must include the Minimum Control Function functionality.

For VTClient applications, you will also need to include the Universal Terminal Working Set functionality.

The Foundation library and the VTClient library include `MAKE_XXXX` macros you can use to declare your applications functionalities. See the example code below for usage.

### Declaring functionalities

**Example**

```
// Functionalities supported by this application
static const Functionalities_T  MyApp_Functionalities[] =
{
  // Supports Minimum Control Functionality
  MAKE_Functionalities_T__MinimumControlFunction(),
  // Supports Universal Terminal
  MAKE_Functionalities_T__UniversalTerminal_WorkingSet()
};
```

## Diagnostic Trouble Codes

If you application needs to implement Diagnostics, a DTC structure will need to be declared.

### Declaring the DTC Structure

Diagnostics can be declared easily using the MAKE_DTC_T macro. The first parameter is the SPN (Suspect Parameter Number) and the second is the FMI (Failure Mode Indicator).

**Example**

```
// DTCs used by MyApp
static const DTC_T  MyApp_DTCArray[] =
{
  MAKE_DTC_T(0, 0)
};

static DTC_Status_T
MyApp_DTCStatusArray[sizeof(MyApp_DTCArray)/sizeof(DTC_T)];
```

## RX Message Queue

Received packets can be queued to lower processing priority. This is an optional feature depending on the requirements of your application.

### Declaring an RX Message Queue

The foundation library comes with several macros to simplify the code necessary to declare an RX queue. Please see the below example code for usage.

**Example**

```
// Queue used for receive packets to lower processing priority
static MAKE_QUEUE_ARRAY(MyApp_RxQueueArray, ISOBUS_Packet_T, 50);
static Queue_T MyApp_RxQueue = MAKE_Queue_T(MyApp_RxQueueArray,
MY_MUTEX_PRIORITY);
```

## Software ID

The software will require a software version to be associated with the Foundation.

### Declaring a Software ID

The are several macros to simplify the code necessary to declare and register a software ID. Please see the below example code for usage.

**Example**

```
// Version of App Software    (Product,Major,minor,build)
#define APP_SOFTWARE_VERSION    SoftwareVersion("MyApp",0,0,1)

// Initialize Software ID structure for the App software
SoftwareId_T MyApp_SoftwareIdEntry = MAKE_SoftwareId_T(APP_SOFTWARE_VERSION);

// Register Software ID to the list
SoftwareId_Register(&Solution_SoftwareId_List, &MyApp_SoftwareIdEntry);
```

# Foundation

## Declaring a Foundation

### Example

```
// Create Foundation Functionality structure
Foundation_T MyApp_Foundation =
  MAKE_Foundation_T(
    &Solution_SwTimerList,
    &Networks[0],
    // **************************************************************
    // sa_primary              = 128 (0x80) Primary source address
    // choose_sa_fn            = NULL (use built-in 128-247 range)
    // priority                = PL_8
    // **************************************************************
    MAKE_ISOBUS_AddressClaim_S(128, NULL, PL_8),
    // **************************************************************
    // self_configurable       = 1, this is a Self-configurable address
    // industry_group          = 2, Agricultural and forestry equipment
    // device_class_instance = 0,
    // device_class            = 2,
    // function                = 129, On-board Diagnostic Unit
    // function_instance       = 0,
    // ecu_instance            = 3,
    // manufacturer_code       = 514, DISTek Integration, Inc
    // identity_number         = 1
    // **************************************************************
    MAKE_ISOBUS_Name_T(1,2,0,2,129,0,3,514,1),
    MAKE_ISOBUS_Transport_T(MY_MUTEX_PRIORITY, 2, 16, MyApp_TP_Sessions,
MyApp_PipeCollection),
    MAKE_LanguageCallbackList_T(MY_MUTEX_PRIORITY),
    MAKE_ISOBUS_EcuId_T(MY_MUTEX_PRIORITY, Solution_EcuId_Fields),
    MAKE_ISOBUS_SoftwareId_T(PL_6, Solution_SoftwareId_List),
    MAKE_ISOBUS_ProductId_T(MY_MUTEX_PRIORITY, Solution_ProductId_Fields),
    MAKE_ISOBUS_DiagnosticProtocol_T(ECU_DIAGNOSTICS_ISO_11783_LEVEL_1,
MY_MUTEX_PRIORITY),
    MAKE_DTC_List_T(MyApp_DTCArray, MyApp_DTCStatusArray, MY_MUTEX_PRIORITY),
    MAKE_ISOBUS_Functionalities_T(MY_MUTEX_PRIORITY, MyApp_Functionalities),
    MAKE_ISOBUS_Certification_T(14, 0, 514, 7, 0,  1, 0, 0, 0, 0, 0, 1, 1, 0,
0, 0, 0, 0),
    MAKE_Memory_T(Memory_Read, Memory_Write),
    MAKE_Foundation_PacketHandler_List_S(&MyApp_RxQueue, NULL,
MY_MUTEX_PRIORITY),
    MAKE_Request_S(MY_MUTEX_PRIORITY),
    MAKE_Acknowledge_S(MY_MUTEX_PRIORITY)
  );
```

## Foundation Initialization

Once the Pipes and Foundation_T structure have been set up, using the corresponding macros, they will need to be initialized. Within the initialization function for the application, the Pipes_Init(&<pipe collection name>) function and Foundation_Init(&<Foundation_T structure name>) function will need to be called. Neither of these functions will return any value.

See example code below for a function definition of a foundation initialization routine.

**Example**

```
void MyApp_ISOBUS_Init(void)
{
   Pipes_Init(&MyApp_PipeCollection);
   Foundation_Init(&MyApp_Foundation);
}
```

## Scheduling a Foundation Task

There are three functions that must be referenced within the task scheduler pertaining to the Foundation.

- An initialization function
- The periodic Foundation_Task function
- The Foundation_Uninit function

The initialization function you must write yourself, an example is included above. The other two functions are part of the library and must therefore be passed a pointer to your foundation structure. See the example code below for guidance.

**Example**

```
//   Init function
INIT(MyApp_ISOBUS_Init)

//   Task function,                       period (ms),   priority
LIBRARY_TASK(Foundation_Task, &MyApp_Foundation,   80,   PL_10)

//   Exit function
LIBRARY_EXIT(Foundation_Uninit, &MyApp_Foundation)
```

# Using the Foundation

## Sending and Receiving Single-Packet Messages

The Network_SendPacket() function sends a packet over the ISOBUS, while respecting the ISOBUS Polite Address Claim rules. Use this function when the message you want to send has a fixed data length of 8 bytes or less. For larger (or *potentially larger*) messages, please see Sending and Receiving Multi-Packet Messages.

You can also register (and unregister) a function in your app, to be called whenever a packet is received on a given network.

### Available API Functions

- Network_SendPacket()
- Foundation_PacketHandler_Register()
- Foundation_PacketHandler_Unregister()

## Sending and Receiving Multi-Packet Messages

Transport sessions handle the transfer of multi-packet data on the bus using TP (9-1785 bytes data) or ETP (1786B-117MB data) protocol. The decision of which (TP or ETP) is handled by the Foundation automatically and determined by the size of the data you want to transfer.

Use the `Transport_` functions when you either know you want to send more than 8 data bytes, or when you're not sure if more bytes will be needed (for example, for variable-size messages).

### Available API Functions

- Transport_SendMessage()
- Transport_MessageHandler_Register()
- Transport_MessageHandler_Unregister()
- Transport_Abort()

## Filtering

A number of basic `Filter_...()` functions are provided by VIRTEC. These can be used whenever a Foundation API requests a "filter" or "filter function", to determine whether or not to accept a packet. They return `TRUE` if the given packet passes the filter acceptance criteria, and `FALSE` otherwise. See the specific filter function definitions in the API Reference for details.

### Available API Functions

- Filter_DestinationSpecificToMe()
- Filter_SentToMyWorkingSet()
- Filter_GlobalOrWorkingSetOrDestinationSpecificToMe()
- Filter_SentToWorkingSetMember()
- Filter_SentFromMyWorkingSet()

### Writing your own Filter

The Filter function receives a pointer to the incoming packet, and to the application's Foundation_T structure. This should grant the function access to all the information necessary to determine whether or not to filter a packet. This includes access to the Network_T structure via the Foundation_T structure.

To accept the packet, return TRUE. To reject the packet, return FALSE.

Filter_<name>() functions must conform to the following Function Prototype (where the actual name of the function is user-defined):

**Example**

```
bool_t Filter_Name(const ISOBUS_Packet_T *packet, const struct Foundation_S
*foundation);
```

### Developer Notes

Filter functions limit the processing of packets to those of concern. A number of Filter_<name>() functions are provided by the VIRTEC Foundation library. A user may also write their own.

*Note: Because the application is typically interested in packets destined globally, to the working set, or to the application's claimed address, the default filter used in most cases is* Filter_GlobalOrWorkingSetOrDestinationSpecificToMe().

## Address Claiming

### Available API Functions

- AddressClaim_IsClaimed()

### Developer Notes

Address claiming is handled automatically by the Foundation library. After initialization the Foundation will attempt to claim the address specified in your Foundation data structure. If the desired address cannot be claimed, the foundation will attempt to claim the next available address within the range 128 - 247. If you opted to provide a source address function to the MAKE_ISOBUS_AddressClaim_S macro, then that user-defined function will be called to determine the next source address to try.

In your application code, the only address claim function that may be of use to you is the AddressClaim_IsClaimed() function, which will return a boolean indicating whether or not the foundation has claimed an address. The other address claim functions are used internally in the foundation and should not be used.

# Network Management

## Available API Functions

- NameTable_NameToNameTableIndex()
- NameTable_NameMaskToNameTableIndex()

## Developer Notes

The `NameTable_NameToNameTableIndex()` and `NameTable_NameMaskToNameTableIndex()` functions will take a CAN NAME and return the index into the CAN NAME Table, if the given NAME is found. The "NameMask" function allows the user to pass in a mask, which will match a portion of the NAME (e.g., if the user wanted to get the indexes for all the entries from a particular manufacturer).

# Identification

## Available API Functions

- SoftwareIdList_Init()
- SoftwareId_Register()
- SoftwareId_Unregister()

## Developer Notes

These API functions should be used within your application to register your software with the linked list of Software IDs.

# Utilities

## Available API Functions

- Utility_MemoryCopy()
- Utility_ToLowerCase()
- Utility_ToUpperCase()
- String_Length()
- String_LimitedLength()

## Developer Notes

The Utility API Functions allow you to perform a few basic operations without having to write your own function to achieve the same interaction with the Foundation.

One of the most useful of these utility API functions is the `Utility_MemoryCopy()` which allows you to input a pointer to a source, and another pointer to a destination, and the Utility API function will copy the data in the memory location of the source pointer into the memory location of the destination pointer.

The Utility_ToLowerCase() and Utility_ToUpperCase() API functions are fairly straight-forward. They take the input character(s) and convert them, as described in the function name, either from uppercase to lower case, or from lower case to upper case.

The String_Length() API function is also fairly strait-forward. It returns the size of the string to which the input pointer is pointing to. The String_LimitedLength() API function performs the same operation, but it also allows you to set a limit on the size that will be returned. If the string in question is longer than the specified limit, the function will return the value of the specified limit.

# Timing

## Available API Functions

- SoftwareTimerList_Init()
- SoftwareTimer_PeriodicTask()
- SoftwareTimer_Register()
- SoftwareTimer_Unregister()
- SoftwareTimer_Get()
- SoftwareTimer_Set()

## Developer Notes

Software timers allow you to track the passage of time within your application. The foundation maintains a list of software timers.

To create a timer for use in your application, you can use the Foundation's [MAKE_SoftwareTimer_T] macro.

**Example**

```
SoftwareTimer_T my_timer = MAKE_SoftwareTimer_T();
```

To create a *list* of timers for use in your application, you can use the Foundation library's [MAKE_SoftwareTimerList_T] macro. See example below. In this example, we are creating a list of software timers, specifying that the the periodic timers maintenance task SoftwareTimer_PeriodicTask() will be called by the task scheduler every 10 milliseconds, and that the ceiling priority of tasks that can access the software timer is "PRIORITY_MAX". Note that period specified here (10 milliseconds in this example) must match the actual task scheduling period in your task scheduler, for calls to the SoftwareTimer_PeriodicTask() function.

**Example**

```
SoftwareTimerList_T  Solution_SwTimerList =
MAKE_SoftwareTimerList_T(milliseconds(10), PRIORITY_MAX);
```

Once a timer list has been declared, the list must be initialized with the `SoftwareTimerList_Init()` function. Simply pass it a pointer to the timer list you have declared.

Once your timers list has been declared, initialized, and scheduled in your task scheduler, you can then register new timers to your timer list as well as unregister previously registered timers. To do this you can use the register and unregister functions listed above.

Once registered, a timer's value can be set using the `SoftwareTimer_Set()` function. There are a series of macros that will help you set a timer using the proper units you wish to use. The macros will generate the proper value, of the proper data type ([`Time_T`]). These macros are:

- microseconds(x)
- milliseconds(x)
- seconds(x)

**Example**

```
// Set time to 100ms
SoftwareTimer_Set(&my_timer, milliseconds(100));
```

Once a timer's value is set, its value will be decremented in real time by the scheduled periodic task until it reaches 0. For code readability the value 0, of type `Time_T` can be returned by the macro `TIMER_EXPIRED`. See the example below for usage, which also demonstrates usage of the `SoftwareTimer_Get` function:

**Example**

```
if(SoftwareTimer_Get(&my_timer) == TIMER_EXPIRED)
{
  // Do something we were waiting to do
}
```

# API Reference

## Data Types

**`AddressClaim_PendingEchoCount_T`**: `uint8_t`
**`CAN_Identifier_T`**: `uint32_t`
**`DTC_Index_T`**: `uint16_t`
**`DTC_OccurrenceCount_T`**: `uint8_t`
**`DTC_T`**: `uint8_t`
**`EcuDiagnosticProtocolId_T`**: `uint8_t`
**`Frequency_T`**: `uint32_t`
**`FunctionalityGeneration_T`**: `uint8_t`
**`ISOBUS_DLC_T`**: `uint32_t`
**`ISOBUS_GroupFunction_T`**: `uint8_t`

**ISOBUS_ManufacturerCode_T**: `uint16_t`
**ISOBUS_PacketData_T**: `unsigned char`
**ISOBUS_PacketPriority_T**: `uint8_t`
**ISOBUS_PGN_T**: `uint32_t`
**ISOBUS_PacketSequence_T**: `uint32_t`
**ISOBUS_TransportRetry_T**: `uint8_t`
**NameTableIndex_Bitfield_T**: `uint32_t`
**NameTableIndex_T**: `uint8_t`
**SourceAddress_T**: `uint8_t`
**Time_T**: `uint32_t`

## Enumerations

### ISOBUS_Direction_T

This enum is used to identify whether an ISOBUS packet/message is being sent or received by the CAN hardware

#### Signature

```
typedef enum ISOBUS_Direction_E ISOBUS_Direction_T
```

#### Members

**ISOBUS_RX**
ISOBUS packet is received by the CAN hardware

**ISOBUS_TX**
ISOBUS packet is sent by the CAN hardware

### ISOBUS_MessageEvent_T

This enumeration defines the events for ISOBUS messages

#### Signature

```
typedef enum ISOBUS_MessageEvent_E ISOBUS_MessageEvent_T
```

#### Members

**MESSAGE_INITIATED**
The message transfer has begun and a pipe is allocated

**MESSAGE_PIPE_FULL**
The message transfer is stalled waiting for pipe space

**MESSAGE_PIPE_EMPTY**
The message transfer is stalled waiting for data to send

**MESSAGE_COMPLETE**
The message transfer has been completed

**MESSAGE_ABORTED**
The message transfer has been aborted

## Functions

### AddressClaim_IsClaimed()

API indicating whether the application has an address. Indicates that the application has claimed an address and is permitted to actively participate (send messages) on the bus.

#### Signature

```
bool_t AddressClaim_IsClaimed(const Foundation_T *foundation)
```

#### Parameters

**foundation**
Pointer to App Foundation_T structure

#### Returns

**bool_t**
`TRUE` The application may send messages
`FALSE` The application may not send messages

### Filter_DestinationSpecificToMe()

Filter packets sent only to my claimed source address. Accepts only messages sent destination specific to the source address claimed by the supplied `foundation` structure. All other packets are rejected.

#### Signature

```
bool_t Filter_DestinationSpecificToMe(const ISOBUS_Packet_T *packet, const
struct Foundation_S *foundation)
```

#### Parameters

**packet**
Incoming packet to test

**foundation**
Pointer to the application's Foundation structure

#### Returns

**bool_t**
`TRUE` Packet passes the filter (process)
`FALSE` Packet failed the filter (drop)

### Filter_GlobalOrWorkingSetOrDestinationSpecificToMe()

Filter packets sent to my claimed source address, globally, or to my working set master. Accepts only messages sent destination specific to the source address claimed by the supplied `foundation` structure, to the working set master address, or sent globally. All other packets are rejected.

#### Signature

```
bool_t Filter_GlobalOrWorkingSetOrDestinationSpecificToMe(const
ISOBUS_Packet_T *packet, const struct Foundation_S *foundation)
```

#### Parameters

**`packet`**
Incoming packet to test

**`foundation`**
Pointer to the application's Foundation structure

#### Returns

**`bool_t`**
`TRUE` Packet passes the filter (process)
`FALSE` Packet failed the filter (drop)

### Filter_SentFromMyWorkingSet()

Filter packets sent from members of my working set. Accepts only messages sent from a member of my working set. All other packets are rejected.

*Note: This filter will cause all of this application's transmitted packets to also be received!*

#### Signature

```
bool_t Filter_SentFromMyWorkingSet(const ISOBUS_Packet_T *packet, const
struct Foundation_S *foundation)
```

#### Parameters

**`packet`**
Incoming packet to test

**`foundation`**
Pointer to the application's Foundation structure

#### Returns

**`bool_t`**
`TRUE` Packet passes the filter (process)
`FALSE` Packet failed the filter (drop)

### `Filter_SentToMyWorkingSet()`

Filter packets sent only to my working set master. Accepts only messages sent destination specific to the source address claimed by the supplied `foundation` structure. All other packets are rejected.

#### Signature

```
bool_t Filter_SentToMyWorkingSet(const ISOBUS_Packet_T *packet, const struct
Foundation_S *foundation)
```

#### Parameters

**`packet`**
Incoming packet to test

**`foundation`**
Pointer to the application's Foundation structure

#### Returns

**`bool_t`**
`TRUE` Packet passes the filter (process)
`FALSE` Packet failed the filter (drop)

### `Filter_SentToWorkingSetMember()`

Filter packets to a member of my working set. Accepts only messages sent to a member of my working set. All other packets are rejected.

#### Signature

```
bool_t Filter_SentToWorkingSetMember(const ISOBUS_Packet_T *packet, const
struct Foundation_S *foundation)
```

#### Parameters

**`packet`**
Incoming packet to test

**`foundation`**
Pointer to the application's Foundation structure

#### Returns

**`bool_t`**
`TRUE` Packet passes the filter (process)
`FALSE` Packet failed the filter (drop)

### `Foundation_Init()`

Meta-task for initializing VIRTEC Foundation structure for one app

### Signature

```
void Foundation_Init(Foundation_T *foundation)
```

### Parameters

**`foundation`**
Pointer to the application's Foundation structure

### Returns

(void)

## `Foundation_PacketHandler_Register()`

Register a PacketHandler with a application's Foundation structure. Note: The Foundation library must be initialized prior to the application being initialized. This sets up an application callback that is called whenever a packet with a particular PGN is received on the network. The packets must also pass a given filter function (defined when creating the Foundation_PacketHandler_Node_S) before the callback will be called. See the Filtering section for more details on filters.

For example:

```
void myMessageCallback(const ISOBUS_Packet_T *incoming_packet, struct
Foundation_PacketHandler_Node_S *info)
{
   // If needed, we could parse info->Pointer_1 or info->Pointer_2 if we
populated those at an earlier time.

   NameTableIndex_T source_name_tbl_i;

   uint32_t utc_time;
   uint32_t date;
   uint8_t local_minute_offset;
   uint8_t local_hour_offset;

   source_name_tbl_i = incoming_packet.Header.Source;

   utc_time  = incoming_packet.Data[0];
   utc_time |= incoming_packet.Data[1] << 8;
   utc_time |= incoming_packet.Data[2] << 16;

   date  = incoming_packet.Data[3];
   date |= incoming_packet.Data[4] << 8;
   date |= incoming_packet.Data[5] << 16;

   local_minute_offset = incoming_packet.Data[6];
   local_hour_offset   = incoming_packet.Data[7];

   // do something with this data...
}

#define TIME_AND_DATE_PGN 0x0FEE6

struct Foundation_PacketHandler_Node_S my_handler =
MAKE_Foundation_PacketHandler_Node_S(TIME_AND_DATE_PGN, myMessageCallback,
NULL, NULL, NULL);

...

void myInitTask(void)
{
   ...

   // if `registered` is TRUE then myMessageCallback() will be called
whenever TIME_AND_DATE_PGN is sent to us!
   uint8_t registered = Foundation_PacketHandler_Register(&MyApp_Foundation,
&my_handler);

   ...
}
```

### Signature

```
bool_t Foundation_PacketHandler_Register(Foundation_T *foundation, struct
Foundation_PacketHandler_Node_S *handler)
```

### Parameters

**`foundation`**
Pointer to the application's Foundation structure

**`handler`**
Packet handler struct to unregister

### Returns

**`bool_t`**
`TRUE` Packet handler was successfully registered
`FALSE` Packet handler was not registered (perhaps already registered?)

## `Foundation_PacketHandler_Unregister()`

Unregister a PacketHandler with a application's Foundation structure

### Signature

```
bool_t Foundation_PacketHandler_Unregister(Foundation_T *foundation, struct
Foundation_PacketHandler_Node_S *handler)
```

### Parameters

**foundation**
Pointer to the application's Foundation structure

**handler**
Packet handler struct to unregister

### Returns

**bool_t**
TRUE Packet handler was successfully unregistered
FALSE Packet handler was not unregistered (was not registered in this list)

## Foundation_Task()

Meta-task for processing all VIRTEC Foundation tasks for one app

### Signature

```
void Foundation_Task(Foundation_T *foundation)
```

### Parameters

**foundation**
Pointer to the application's Foundation structure

### Returns

(void)

## NameTable_NameToNameTableIndex()

This function finds the NAME table index for the supplied NAME.

### Signature

```
bool_t NameTable_NameToNameTableIndex(Network_T *network, const ISOBUS_Name_T
name, NameTableIndex_T *name_table_index)
```

### Parameters

**network**
The CAN network containing the NAME table to search

**name**
The 8-byte NAME to search for

**name_table_index**
A pointer to a NameTableIndex_T, which the function will fill with the found index (if a match is found)

### Returns

**`bool_t`**
`TRUE` A matching NAME is in the table and `name_table_index` has been updated with the index `FALSE` No matching NAME was found

### `NameTable_NameMaskToNameTableIndex()`

This function finds the next entity in the NAME Table whose NAME matches the given mask. Multiple matches can be found by calling the function again with `name_table_index` still set to the previous one found.

#### Signature

```
bool_t NameTable_NameMaskToNameTableIndex(Network_T *network, const
ISOBUS_Name_T name, const ISOBUS_Name_T mask, NameTableIndex_T
*name_table_index)
```

#### Parameters

**`network`**
The CAN network containing the NAME table to search

**`name`**
The 8-byte NAME to search for

**`mask`**
An 8-byte mask indicating the significant bits of the NAME to search on (1=significant, 0=ignore)

**`name_table_index`**
A pointer to a `NameTableIndex_T`, which the function will fill with the found index (if a match is found)

#### Returns

**`bool_t`**
`TRUE` The NAME is in the table (a claim was received) and `name_table_index` has been updated with the index (or next matching index) `FALSE` The NAME is not in the table (not claimed)

### `Network_SendPacket()`

Send packet on CAN interface and enforce Address Claim rules. Acts as a gateway to enforce the ISOBUS Polite Address Claim rules. Don't send any massages until the NAME Table is populated. Then send all AddressClaim messages, and application messages if the application has claimed an address, and the message is not destination spicific or the destination is global or the destination address has also been claimed.

1. Return value
    1. `TRUE` indicates that the CAN driver accepted responsibility to ensure the `packet` goes out on the bus. This may mean that the CAN packet has been placed on the

        hardware to send, or that it is placed in a Queue and will be sent when there is opportunity.

    2. `FALSE` indicates that the CAN driver is unable to accept responsibility to send the packet, so the calling task should try again later.

2. Callback
    1. The callback function pointer is called when the packet is actually sent on the bus. This typically corresponds to the transmit interrupt after the packet is sent. In some cases, the CAN driver may call the callback when the packet is placed on the hardware.
    2. Passing `NULL` as the `callback` parameter is valid, and indicates that no callback is provided.

Here's an example of how to use the callbacks:

```
void MyCallbackFunction(const struct ISOBUS_Callback_S *callback_struct)
{
   // Here, you can reference callback_struct->Pointer_1 or ...->Pointer_2
   // if you want to pass data into this callback.
   // In this example, callback_struct->Pointer_1 will equal
SOME_VALUE_I_CARE_ABOUT

   ...
}

bool_t SendMyPacket(void)
{
   ISOBUS_Packet_T my_packet;
   my_packet.Header.PGN         = 0x01234;
   my_packet.Header.Destination = desination_name_table_index;
   my_packet.Header.Source      = my_name_table_index;
   my_packet.Header.Direction   = ISOBUS_TX;
   my_packet.Header.Priority    = DEFAULT_TRANSPORT_PRIORITY;
   my_packet.DLC   = 8;
   my_packet.Data = { 0, 1, 2, 3, 4, 5, 6, 7 };

   ISOBUS_Callback_T my_callback_struct;
   my_callback_struct.Function = MyCallbackFunction;
   my_callback_struct.Pointer_1 = &something_i_care_about;
   my_callback_struct.Pointer_2 = NULL;

   // Here "MyApp_Foundation" is just a pointer to your application's
Foundation structure.
   // queued will tell us whether the packet was queued to be sent
   // MyCallbackFunction() will be called when the packet is actually
transmitted on the bus
   bool_t queued = Network_SendPacket(&my_packet, my_callback_struct,
MyApp_Foundation);
```

```
    // return whether the packed is queued and will be sent shortly (or not)
    return queued;
}
```

#### Signature

```
bool_t Network_SendPacket(ISOBUS_Packet_T *iso_packet, const
ISOBUS_Callback_T *callback, const Foundation_T *foundation)
```

#### Parameters

**`iso_packet`**
ISOBUS packet to be sent on the bus

**`callback`**
Callback to be called once packet is successfully sent on the bus. These callbacks have the signature from the `Function` member of ISOBUS_Callback_T). The `Pointer_1` and `Pointer_2` members can be set to any data that the callback function will need when it is called.

**`foundation`**
Pointer to the application's Foundation structure

#### Returns

**`bool_t`**
`TRUE` Packet queued to be sent `FALSE` For some reason, packet will not be sent (at this time)

### `Network_RegisterHandler()`

Adds a packet handler function to the list of handlers for a given network. This sets up an application callback that is called whenever any packet is received on the network. This function is for advanced use cases where a user might need to inspect every packet; e.g., when createing a CAN bridge. For most packet handling needs, Foundation_PacketHandler_Register() or Transport_MessageHandler_Register() should be used instead.

For example:

```
void ShouldICareAboutThisMessage(const ISOBUS_Packet_T *incoming_packet,
struct Network_PacketHandler_S *info)
{
    // If needed, we could parse info->Pointer_1 or info->Pointer_2 if we
populated those at an earlier time.

    // or we could switch on any other member of incoming_packet, or set up a
complex if/else, etc.
    switch (incoming_packet->Header.PGN)
    {
    case 0x0FEE6:
        // stuff to do when message 0x0FEE6 comes in...
```

```
      break;
   default:
      // for any other message, we don't care
      break;
   }
}

Network_PacketHandler_T my_handler =
MAKE_Network_PacketHandler_T(ShouldICareAboutThisMessage);

...

void myInitTask(void)
{
   ...
   Network_RegisterHandler(&MyApp_Foundation.Network, &my_handler);
}
```

### Signature

```
bool_t Network_RegisterHandler(Network_T *network, Network_PacketHandler_T
*handler)
```

### Parameters

**`network`**
The ISOBUS network to watch

**`handler`**
The packet handler structure, containing callback function to call when a message is received

### Returns

**`bool_t`**
`TRUE` The handler was successfully set up. `FALSE` The handler wasn't successfully set up, and your callback won't be called when the packet is received.

## `Network_UnregisterHandler()`

Unregisters a packet handler function from the list of handlers for a given network. The opposite of Network_RegisterHandler(). For most use cases, the `Foundation_PacketHandler_...()` or `Transport_MessageHandler_...()` APIs should be used instead of the `Network_...Handler()` ones.

### Signature

```
bool_t Network_UnregisterHandler(Network_T *network, Network_PacketHandler_T
*handler)
```

### Parameters

**`network`**
The ISOBUS network that we don't need to watch anymore

**`handler`**
The packet handler structure that we want to remove from the list of ones to look at, when a packet comes in on this network

### Returns

**`bool_t`**
`TRUE` The handler has been succesfully unregistered. `FALSE` For some reason, the handler was not unregistered.

## `SoftwareId_Register()`

Register a SoftwareId_T structure

### Signature

```
bool_t SoftwareId_Register(SoftwareIdList_T *list, SoftwareId_T *swid)
```

### Parameters

**`list`**
Software ID list with which to register

**`swid`**
Pointer to the Software_ID structure to be registered

### Returns

**`bool_t`**
`TRUE` Successfully registered
`FALSE` Registration failed

## `SoftwareId_Unregister()`

Register a SoftwareId_T structure

### Signature

```
bool_t SoftwareId_Unregister(SoftwareIdList_T *list, SoftwareId_T *swid)
```

### Parameters

**`list`**
Software ID list with which to unregister

**`swid`**
Pointer to the Software_ID structure to be unregistered

### Returns

**bool_t**
TRUE Successfully unregistered
FALSE Unregistered failed

### SoftwareIdList_Init()

Initialize the Software ID List

#### Signature

```
void SoftwareIdList_Init(SoftwareIdList_T *list)
```

#### Parameters

**list**
Software ID List to initialize

#### Returns

(void)

### SoftwareTimerList_Init()

Initialize the Software Timer List

#### Signature

```
void SoftwareTimerList_Init(SoftwareTimerList_T *list)
```

#### Parameters

**list**
Software Timer List to initialize

#### Returns

(void)

### SoftwareTimer_Get()

Get the value of a timer

#### Signature

```
Time_T SoftwareTimer_Get(const SoftwareTimer_T *timer)
```

#### Parameters

**timer**
timer to read

#### Returns

**Time_T**
Value of the timer

### `SoftwareTimer_PeriodicTask()`

Decrements each timer in the list by timer period until it reaches a value of 0

#### Signature

```
SoftwareTimer_PeriodicTask(SoftwareTimerList_T *list)
```

#### Parameters

**`list`**
List of Software Timers to decrement

#### Returns

(void)

### `SoftwareTimer_Register()`

Register a Software Timer

#### Signature

```
bool_t SoftwareTimer_Register(SoftwareTimerList_T *list, SoftwareTimer_T
*timer)
```

#### Parameters

**`list`**
List to register with

**`timer`**
timer to register

#### Returns

**`bool_t`**
`TRUE` Timer was successfully registered
`FALSE` Timer registration failed

### `SoftwareTimer_Set()`

Set the value of a timer

#### Signature

```
void SoftwareTimer_Set(SoftwareTimer_T *timer, Time_T timeout)
```

#### Parameters

**`timer`**
Timer to set

**`timeout`**
Time until timeout

### Returns

(void)

## `SoftwareTimer_Unregister()`

Unregister a Software Timer

### Signature

```
bool_t SoftwareTimer_Unregister(SoftwareTimerList_T *list, SoftwareTimer_T *timer)
```

### Parameters

**`list`**
List to unregister with

**`timer`**
timer to unregister

### Returns

**`bool_t`**
`TRUE` Timer was successfully registered `FALSE` Timer registration failed

## `String_Length()`

Determines length of string (no limit to length)

### Signature

```
Size_T String_Length(const char *string)
```

### Parameters

**`string`**
C string to determine length of

### Returns

**`Size_T`**
Size of string

## `String_LimitedLength()`

Determines length of string (with a maximum length)

### Signature

```
Size_T String_LimitedLength(const char *string, Size_T limit)
```

### Parameters

**`string`**
C string to determine length of

**`limit`**
Maximum length of string

#### Returns

**`Size_T`**
Size of string

### `Transport_Abort()`

Abort a transport session (if it's still open)

#### Signature

```
bool_t Transport_Abort(const Foundation_T *foundation, const ISOBUS_Message_T
*message)
```

#### Parameters

**`foundation`**
Foundation Functionality structure for this application

**`message`**
Message/session to abort

#### Returns

**`bool_t`**
`TRUE` Session successfully closed
`FALSE` Session not closed

### `Transport_MessageHandler_Register()`

Register a Message/Event Handler

*Note: If the PGN is always a single packet message, you may improve performance by using* Foundation_PacketHandler_Register()_ instead._

#### Signature

```
bool_t Transport_MessageHandler_Register(Foundation_T *foundation, struct
Transport_MessageHandler_Node_S *message_handler_node)
```

#### Parameters

**`foundation`**
Foundation Functionality structure for this application

**`message_handler_node`**
Node containing DataPage/PGN and handler to register

### Returns

**`bool_t`**
`TRUE` `message_handler_node` was successfully registered
`FALSE` `message_handler_node` was not successfully registered

## `Transport_MessageHandler_Unregister()`

Unregister a Message/Event Handler

### Signature

```
bool_t Transport_MessageHandler_Unregister(Foundation_T *foundation, struct
Transport_MessageHandler_Node_S *message_handler_node)
```

### Parameters

**`foundation`**
Foundation Functionality structure for this application

**`message_handler_node`**
Node to unregister

### Returns

**`bool_t`**
`TRUE` `message_handler_node` was successfully unregistered
`FALSE` `message_handler_node` was not successfully unregistered

## `Transport_SendMessage()`

Initiate the transport of a message and sends packet using appropriate protocol

*Note: Please do not pass a valid structure with a* `NULL_` function pointer_

### Signature

```
bool_t Transport_SendMessage(const Foundation_T *foundation, ISOBUS_Message_T
*message, const ISOBUS_MessageCallback_T *callback)
```

### Parameters

**`foundation`**
Foundation Functionality structure for this application

**`message`**
Message to Send

**`callback`**
Contains callback information

### Returns

**`bool_t`**
`TRUE` Transport session opened
`FALSE` Transport session not opened

### `Utility_MemoryCopy()`

Copies from source to destination

#### Signature

```
void Utility_MemoryCopy(void destination, void source, Size_T size)
```

#### Parameters

**`destination`**
Destination for data to copy

**`source`**
Source of data to copy

**`size`**
size of data to copy (from sizeof())

#### Returns

(void)

### `Utility_ToLowerCase()`

Converts character to lower case

#### Signature

```
char Utility_ToLowerCase(char character)
```

#### Parameters

**`character`**
Character to convert

#### Returns

**`char`**
Character converted to uppercase

### `Utility_ToUpperCase()`

Converts character to lower case

#### Signature

```
char Utility_ToUpperCase(char character)
```

#### Parameters

**`character`**
Character to convert

### Returns

**`char`**
Character converted to uppercase

## Macros

### `MAKE_Acknowledge_S()`

This macro is used to initialize a struct Acknowledge_S

### Signature

```
MAKE_Acknowledge_S(priority)
```

### Parameters

**`priority`**
Highest priority of the tasks that access this structure

### `MAKE_DTC_List_T()`

This macro is used to create the DTC_List_T

### Signature

```
MAKE_DTC_List_T(dtc_array, dtc_status_array, priority)
```

### Parameters

**`dtc_array`**
Array name for SPN/FMI information

**`dtc_status_array`**
Array name for active/count information

**`priority`**
Maximum task priority accessing DTCs

### `MAKE_Foundation_PacketHandler_Node_S`

This macro is used to initialize a Foundation_PacketHandler_Node_S struct. These are needed to register a packet handler function with Foundation_PacketHandler_Register(). See that function's definition for an example of how this can be used.

### Signature

```
MAKE_Foundation_PacketHandler_Node_S(pgn, handler, filter, pointer1,
pointer2)
```

### Parameters

**`pgn`**
The PGN to register the packet handler for.

**`handler`**
The packet handler function to call, when the `pgn` is received (on this Foundation's network).

**`filter`**
A filter function to use, to filter out unwanted packets with the matching PGN. If the filter function returns `TRUE`, the `handler` function will be called. See the Filtering section of this guide for a list of filters that can be given here. If `NULL` is given here, then the filter Filter_GlobalOrWorkingSetOrDestinationSpecificToMe() will be used.

**`pointer1`**
Instance information, that will be passed to the handler via the `Foundation_PacketHandler_Node_S`. If none is needed then set this to `NULL`.

**`pointer2`**
More instance information. If none is needed then set this to `NULL`.

### `MAKE_Foundation_T()`

This macro is used to initialize the Foundation_T type

### Signature

```
MAKE_Foundation_T(sw_timer_list, network, addressclaim, name, transport,
language_callbacklist, ecu_id, software_id, product_id, diagnostics,
dtc_list, functionalities, certification, memory, packet_handlers, request,
acknowledge)
```

**Parameters** `sw_timer_list` : Pointer to the SoftwareTimerList used by this App

**`network`**
Pointer to the Network used by this App

**`addressclaim`**
Address Claim data structure for this App

**`name`**
8 byte array to hold the CAN Name for this application

**`transport`**
Transport Protocol structure (including Extended TP)

**`language_callbacklist`**
Linked list of callbacks

**`ecu_id`**
ECU ID structure

**`software_id`**
SW ID structure

**`product_id`**
Product ID structure

**`diagnostics`**
Diagnostics services structure

**`dtc_list`**
List of DTCs

**`functionalities`**
Functionalities services structure

**`certification`**
Certification structure

**`memory`**
Memory function pointer structure

**`packet_handlers`**
Allows registration of packet handlers

**`request`**
Allows registration of Request handlers

**`acknowledge`**
Allows registration of Acknowledgement handlers

### `MAKE_Foundation_PacketHandler_List_S()`

This macro is used to initialize a struct Foundation_PacketHandler_List_S

#### Signature

```
MAKE_Foundation_PacketHandler_List_S(queue_ptr, global_filter, priority)
```

#### Parameters

**`queue_ptr`**
Pointer to optional Queue_T structure (NULL = no queue)

**`global_filter`**
Global filter applied to all packets received by this Foundation structure

**`priority`**
Highest priority of the tasks that access this structure

### `MAKE_ISOBUS_AddressClaim_S()`

This macro is used to initialize an ISOBUS_AddressClaim_S structure

### Signature

```
MAKE_ISOBUS_AddressClaim_S(sa_primary,choose_sa_fn,priority)
```

### Parameters

**`sa_primary`**
Primary application source address

**`choose_sa_fn`**
Function pointer to choose next source address (NULL to use built-in function)

**`priority`**
Priority of calling function

## `MAKE_ISOBUS_Certification_T()`

This macro is used to initialize the ISOBUS_Certification_T type

### Signature

```
MAKE_ISOBUS_Certification_T(year, rev, lab_id, lab_type, reference_number,
min_ecu, tecu_1, tecu_2, tecu_3, class3_ecu, virtual_terminal, vt_ws_master,
vt_ws_member, task_controller, tc_ws_master, tc_ws_member, file_server,
gps_receiver)
```

### Parameters

**`year`**
Year of the compliance test protocol to which the certification test was performed

**`rev`**
Revision of the compliance test performed. In years where there are multiple revisions of the test protocol, an alphabetic suffix is used in addition to the certification year

**`lab_id`**
Manufacturer code of the laboratory that performed the compliance test. In the case of a self-certified ECU, this matches the manufacturer code contained in the address claim PGN. The value of this parameter is assigned by committee

**`lab_type`**
Approving body for the certification laboratory (3-bits)
000 - Non-certified laboratory/self-certification
001 - European Union certified laboratory
010 - North American certified laboratory
111 - Not available (not certified)

**`reference_number`**
Certification reference number assigned by a certification laboratory. This value can be used together with the Certification Lab ID and ECU Manufacturer ID to uniquely identify the test file of the certification laboratory

**`min_ecu`**
Indicates whether the Minimum ECU compliance test was performed

**`tecu_1`**
Indicates whether the TECU Class 1 compliance test was performed

**`tecu_2`**
Indicates whether the TECU Class 2 compliance test was performed

**`tecu_3`**
Indicates whether the TECU Class 3 compliance test was performed

**`class3_ecu`**
Indicates whether the Class 3 ECU compliance test was performed

**`virtual_terminal`**
Indicates whether the Virtual Terminal compliance test was performed

**`vt_ws_master`**
Indicates whether the VT Working Set Master compliance test was performed

**`vt_ws_member`**
Indicates whether the VT Working Set Member compliance test was performed

**`task_controller`**
Indicates whether the Task Controller compliance test was performed

**`tc_ws_master`**
Indicates whether the TC Working Set Master compliance test was performed

**`tc_ws_member`**
Indicates whether the TC Working Set Member compliance test was performed

**`file_server`**
Indicates whether the File Server compliance test was performed

**`gps_receiver`**
Indicates whether the GPS Receiver compliance test was performed

### `MAKE_ISOBUS_DiagnosticProtocol_T()`

This macro is used to initialize an ISOBUS_DiagnosticProtocol_T

#### Signature

```
MAKE_ISOBUS_DiagnosticProtocol_T(protocol, priority)
```

#### Parameters

**`protocol`**
Selected ECU diagnostic protocol enumeration

**`priority`**
Highest priority of the tasks that access this structure

### `MAKE_ISOBUS_EcuId_T()`

This macro is used to initialize an ISOBUS_EcuId_T structure

#### Signature

```
MAKE_ISOBUS_EcuId_T(priority, fields)
```

#### Parameters

**`priority`**
Highest priority of the tasks that access this structure

**`fields`**
Name of the ECU ID fields (EcuIdFields_T) structure

### `MAKE_ISOBUS_Functionalities_T()`

This macro is used to initialize an ISOBUS_Functionalities_T structure

#### Signature

```
MAKE_ISOBUS_Functionalities_T(priority, functionalities)
```

#### Parameters

**`priority`**
Highest priority of the tasks that access this structure

**`functionalities`**
Array of Functionalities_T

### `MAKE_ISOBUS_Name_T()`

This macro is used to initialize the ISOBUS_Name_T type

#### Signature

```
MAKE_ISOBUS_Name_T(self_configurable, industry_group,
device_class_instance,device_class, function, function_instance,
ecu_instance, manufacturer_code, identity_number)
```

#### Parameters

**`self_configurable`**
Indicates whether a Control Function is self-configurable (1) or not (0)

**`industry_group`**
Defined and assigned by ISO, identifies NAMEs associated with industries (e.g. agricultural equipment)

**device_class_instance**
Indicates occurrence of a particular device class in a connected network; definition depends on industry group field contents

**device_class**
Defined and assigned by ISO; provides a common NAME for a group of functions within a connected network; when combined with an industry group, can be correlated to a common NAME, e.g "planter" with "agricultural equipment"

**function**
Defined and assigned by ISO; when this value is between 0 and 127 (inclusive), its definition is independent of any other field in the NAME; when this value is between 128 and 253 (inclusive), its definition depends on the device class; when combined with industry group and device class, can be correlated to a common NAME for specific CF, though not implying any specific capabilities

**function_instance**
Indicates specific occurrence of a function on a particular device system of a network

**ecu_instance**
Indicates which of a group of ECUs associated with a given function is referenced

**manufacturer_code**
Assigned by committee (see ISO 11783-1); indicates manufacturer of ECU for which the NAME is being referenced; independent of any other NAME field

**identity_number**
Assigned by the ECU manufacturer

## MAKE_ISOBUS_ProductId_T()

This macro is used to initialize an ISOBUS_ProductId_T structure

### Signature

```
MAKE_ISOBUS_ProductId_T(priority, fields)
```

### Parameters

**priority**
Highest priority of the tasks that access this structure

**fields**
Address of the ProductID list (SoftwareIdList_T) structure

## MAKE_ISOBUS_SoftwareId_T()

This macro is used to initialize an ISOBUS_SoftwareId_T structure

### Signature

```
MAKE_ISOBUS_SoftwareId_T(priority, list)
```

#### Parameters

**`priority`**
Highest priority of the tasks that access this structure

**`list`**
Address of the SwID list (SoftwareIdList_T) structure

### `MAKE_ISOBUS_Transport_T()`

This macro is used to create a ISOBUS_Transport_T that uses an array of transport sessions previously declared using the MAKE_TRANSPORT_SESSION macro.

#### Signature

```
MAKE_ISOBUS_Transport_T(priority, max_retries, max_packets_per_cts,
tp_sessions, tp_pipes)
```

#### Parameters

**`priority`**
Highest priority of the tasks that access this structure

**`max_retries`**
Maximum number of times to retry a single transport session (standard recommends 2)

**`max_packets_per_cts`**
Maximum number of data packets that can be sent in response to a single CTS (standard recommends 16). This is also the maximum number of packets that can be re-requested

**`tp_sessions`**
Name of the array of transport sessions

**`tp_pipes`**
Name of the pipe collection

### `MAKE_LanguageCallbackList_T()`

This macro is used to initialize a LanguageCallbackList_T structure

#### Signature

```
MAKE_LanguageCallbackList_T(priority)
```

#### Parameters

**`priority`**
Highest priority of the tasks that access this structure

### `MAKE_Memory_T()`

This macro is used to initialize an Memory_T structure

#### Signature

```
MAKE_Memory_T(read, write)
```

#### Parameters

**`read`**
Generic function to read arbitrary memory locations/devices

**`write`**
Generic function to write arbitrary memory locations/devices

### `MAKE_Network_PacketHandler_T()`

This macro initializes a Network_PacketHandler_T structure, which is used when setting up a single-packet callback. See Network_RegisterHandler() for details.

#### Signature

```
MAKE_Network_PacketHandler_T(handler)
```

#### Parameters

**`handler`**
The name of a function that will be called when a packet is received.

### `MAKE_Request_S()`

This macro is used to initialize a struct Request_S

#### Signature

```
MAKE_Request_S(priority)
```

#### Parameters

**`priority`**
Highest priority of the tasks that access this structure

### `MAKE_SoftwareTimer_T()`

This macro used to initialize a software timer of type [`SoftwareTimer_T`].

#### Signature

```
MAKE_SoftwareTimer_T()
```

#### Parameters

(none)

### `MAKE_SoftwareTimerList_T()`

This macro is used to create a list of software timers.

#### Signature

```
MAKE_SoftwareTimerList_T(period, priority)
```

### Parameters

**`period`**
Time between calls to the periodic task

**`priority`**
Highest priority of tasks that access the Software Timers in the list

## Structures

### `Foundation_PacketHandler_Node_S`

Structure used for registering packet handlers for a specific Foundation structure.

### Signature

```
struct Foundation_PacketHandler_Node_S
```

### Members

**`ISOBUS_PGN_T PGN`**
The PGN for which we will call the packet handler.

**`void (*PacketHandler)(const ISOBUS_Packet_T *packet, struct Foundation_PacketHandler_Node_S *packet_handler)`**
The packet handler function that will be called when we receive `pgn` and that packet successfully passes through `Filter`.

**`bool_t (*Filter)(const ISOBUS_Packet_T *packet, const Foundation_T *foundation)`**
The filter function to use on incoming packets, to deterime whether or not to call `PacketHandler()` (NULL = default = Filter_GlobalOrWorkingSetOrDestinationSpecificToMe()). For more information on filters, please see the Filtering section of this guide.

**`void *Pointer_1`**
Pointer to arbitrary data for use by callback

**`const void *Pointer_2`**
Pointer to more arbitrary data for use by callback

**`struct LinkedList_Node_S LinkedList_Node`**
The linked list node for registering this Packet Handler struct (this is set by `MAKE_Foundation_PacketHandler_Node_S()`).

### `Foundation_T`

Contains all Foundation Functionality information for an ISOBUS App

### Signature

```
typedef struct Foundation_S Foundation_T
```

### Members

**`SoftwareTimerList_T *TimerList`**
Pointer to the SoftwareTimerList used by this App

**`Network_T *Network`**
Pointer to the Network used by this App

**`ISOBUS_AddressClaim_T AddressClaim`**
Address Claim data structure

**`ISOBUS_Name_T Name`**
8 byte array to hold the CAN Name for this application

**`ISOBUS_Transport_T Transport`**
Transport Protocol structure (including Extended TP)

**`LanguageCallbackList_T LanguageCallbackList`**
Linked list of callbacks

**`ISOBUS_EcuId_T ECU_ID`**
ECU ID structure

**`ISOBUS_SoftwareId_T SW_ID`**
SW ID structure

**`ISOBUS_ProductId_T Product_ID`**
Product ID structure

**`ISOBUS_DiagnosticProtocol_T Diagnostics`**
Diagnostics services structure

**`DTC_List_T DTCs`**
DTC List structure

**`ISOBUS_Functionalities_T Functionalities`**
Functionalities services structure

**`ISOBUS_Certification_T Certification`**
ISOBUS Compliance Certification message

**`Memory_T Memory`**
Memory function pointer structure

**`Foundation_PacketHandler_List_T PacketHandlers`**
Packet Handler list

**`struct Request_S Request`**
Request packet handlers

**`struct Acknowledge_S Acknowledge`**
Acknowledgement packet handlers

### `ISOBUS_Callback_T`

This structure is used to notify a module when a packet has been sent. This is also used to pass arguments to the callback when it is called.

#### Signature

```
typedef struct ISOBUS_Callback_S ISOBUS_Callback_T
```

#### Members

**`void (*Function)(const struct ISOBUS_Callback_S *pointer)`**
Pointer to the callback function to be called.

**`void *Pointer_1`**
Pointer to arbitrary data for use by the callback.

**`const void *Pointer_2`**
Pointer to arbitrary data for use by the callback.

### `ISOBUS_Message_T`

This structure represents a single ISOBUS message. This differs from a packet in that a message takes a Pipe as data instead of an 8-byte array. This structure is used when sending/receiving message that *may* contain more than 8 bytes of data. If sending/receiving messages that are always single-packet, consider using ISOBUS_Packet_T instead.

Note: `ISOBUS_Message_T` structs sent with the DLC set to less than 8 will have the remaining unused bytes padded with `0xFF`.

#### Signature

```
typedef struct ISOBUS_Message_S ISOBUS_Message_T
```

#### Members

**`ISOBUS_PacketHeader_T Header`**
Packet/Message header representing 29-bit identifier

**`ISOBUS_DLC_T DLC`**
Data Length Code - Representing the total number of data bytes (not *strictly* the Data Length Code, if greater than 8, but rather the total bytes of the message)

**`Pipe_ReadHandle_T Data`**
The message data, expressed in a pipe.

### ISOBUS_MessageCallback_T

This structure is used to notify a module when something has happened with a message. See ISOBUS_MessageEvent_T for details on which events are possible.

#### Signature

```
typedef struct ISOBUS_MessageCallback_S ISOBUS_MessageCallback_T
```

#### Members

**`void (*Function)(const struct ISOBUS_MessageCallback_S *pointer, ISOBUS_MessageEvent_T event)`**
Pointer to the callback function to be called.

**`void *Pointer_1`**
Pointer to arbitrary data for use by the callback.

**`const void *Pointer_2`**
Pointer to (non-changing) data for use by the callback.

### ISOBUS_Packet_T

This structure represents a single ISOBUS packet. Typically used in conjunction with Network_SendPacket() to send CAN messages with 8 bytes of data or less. For sending larger messages, see Transport_SendMessage().

#### Signature

```
typedef struct ISOBUS_Packet_S ISOBUS_Packet_T
```

#### Members

**`ISOBUS_PacketHeader_T Header`**
Packet header representing 29-bit identifier

**`ISOBUS_DLC_T DLC`**
Data Length Code - Representing the number of data bytes in the Data portion

**`ISOBUS_PacketData_T Data[8]`**
Up to 8 bytes of data

### ISOBUS_PacketHeader_T

Defines the ISOBUS translation of the 29-bit identifier (with a few additional pieces of information)

#### Signature

```
typedef struct ISOBUS_PacketHeader_S ISOBUS_PacketHeader_T
```

#### Members

**`ISOBUS_PGN_T PGN`**
Parameter Group Number: contains the Data Page, PDUF, and PDUS (in that order, from MSB to LSB)

**`SourceAddress_T DestinationAddress`**
Destination Address populated for received packets and ignored when sending packets

**`NameTableIndex_T Destination`**
Destination Name Table Index

**`SourceAddress_T SourceAddress`**
Source Address populated for received packets and ignored when sending packets

**`NameTableIndex_T Source`**
Source Name Table Index

**`ISOBUS_Direction_T Direction`**
Transmitted or Received?

**`ISOBUS_PacketPriority_T Priority`**
This is used to optimize packet transfer in a system

## `Network_T`

Defines an ISOBUS network.

This is passed into the `MAKE_Foundation_T()` macro when initializing the foundation.

### Signature

```
typedef struct Network_S Network_T
```

### Members

**`struct LinkedList_List_S PacketHandlers`**
List of packet handlers for apps attached to this network.

**`NameTable_T NameTable`**
The NAME Table for this network

**`bool_t (*SendPacket)(const CAN_Packet_T*, const ISOBUS_Callback_T *)`**
A function pointer to the `SendPacket()` function for this network.