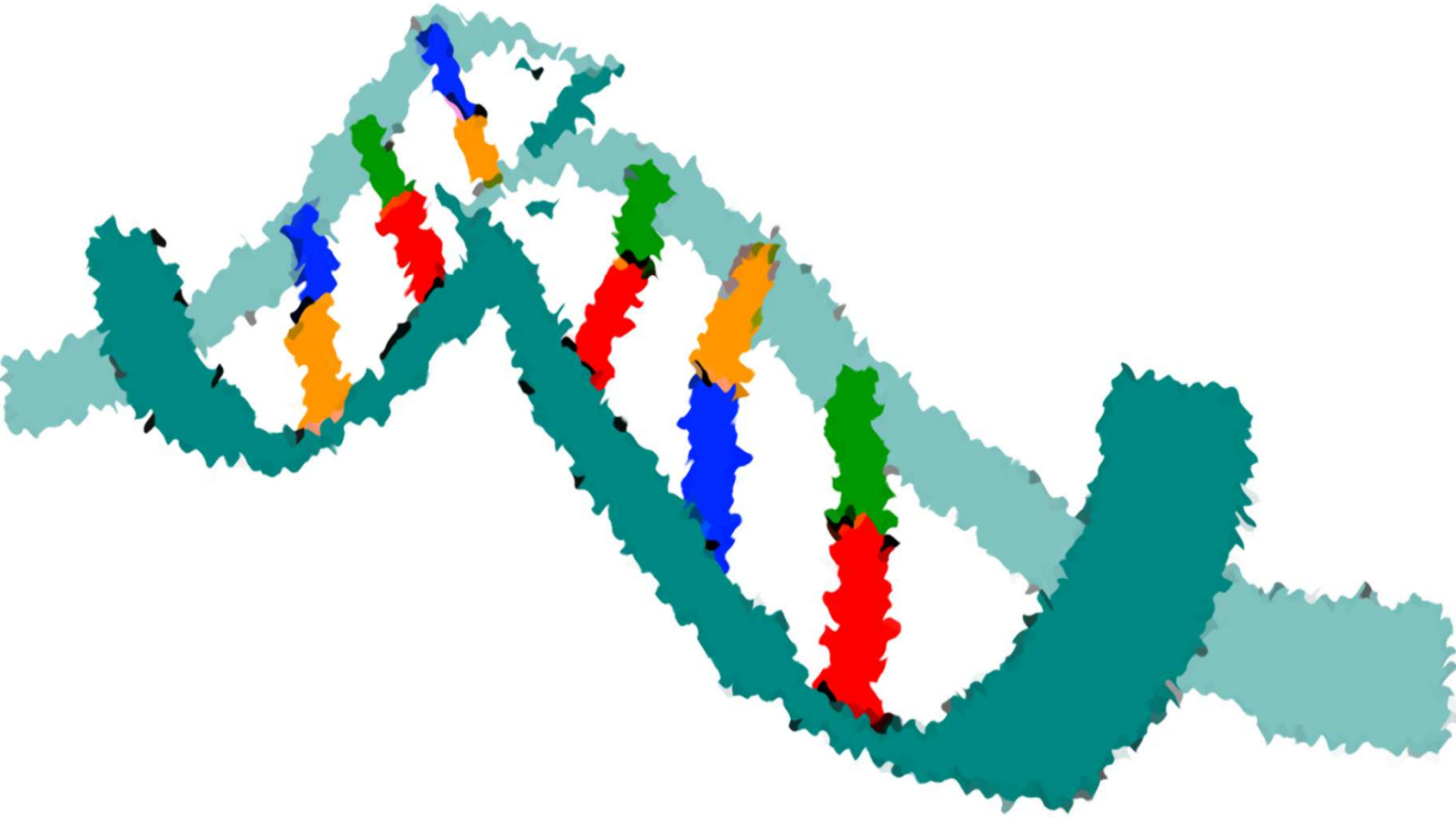
User Manual



Timed Animal Manipulation Data Logger (TAMDL)

Created by Peter Loës

11.02.2019

In order of the Max Planck Institute for Ornithology at Seewiesen (Germany)

Disclaimer

The Timed Animal Manipulation Data Logger (TAMDL) is to be used only as that described in this document. Any other method of usage is not permitted. If damage occurs due to incorrect usage, the manufacturer of the Timed Animal Manipulation Data Logger (TAMDL) is not liable.

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List of abbreviations

RFID	radio-frequency identification
EFM	Energy Friendly Microcontroller
PCB	printed circuit board
DCF	D for Deutschland (Germany), C for long-wave transmitter, F due to the vicinity to the Town Frankfurt
ARM	Advanced RISC Machines
SD CARD	Secure Digital Memory Card
PIT	Passive Integrated Transponder
LEUART	Low Energy Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
TAMDL	Timed Animal Manipulation Data Logger

1 System Overview

1.1 General Description of Functions

The Timed Animal Manipulation Data Logger (TAMDL) has mainly been developed to simplify the recording and manipulation of animal behaviour and to collect data, e.g. of weight by timing the activation and inactivation of several devices, for example, dashcams and scales. Up to three devices can be connected to TAMDL simultaneously.

One other possible device that could be activated by TAMDL is an RFID reader. That device can read out transponders in case an animal is equipped with one and thereby identify the individual. This technology can be used for every animal species on, or in which it is possible to attach a RFID transponder of the size of a rice grain. Within a population of several individuals carrying a RFID transponder, the Timed Animal Manipulation Data Logger can switch on the reading device to certain times, e.g. around sunset, to identity the animals sleeping in a nest box. Whenever an individual with transponder e.g. enters, its transponder code and the timestamp are saved on a SD-card. A thinkable combination of that function with other devices might be a scale. TAMDL could thereby not only record the individual sleeping inside the nest box, but also take its weight. Via the timer, another period to scale the individual could be set around dawn to eventually compare its weight before and after sleep. Furthermore, the bird's behaviour could be manipulated by switching on some light inside a nest box at a certain time before the actual sunrise to artificially elongate daytime. TAMDL could simultaneously switch on a camera to record the bird's reaction during that period of time and switch the camera off after some minutes. The control of the camera could also be related to a certain transponder code. This would enable researchers to only record the behaviour of certain birds and thereby efficiently decrease working time by providing much less video material to go through.

To achieve a flexible operation in the field, the Timed Animal Manipulation Data Logger is supplied with electrical energy by a rechargeable accumulator. The huge advantage of TAMDL is that it can activate connected devices for a pre-set time and thereby save a lot of energy. These periods of time can also be in the middle of the night – sparing biologists nightshifts.

The use of electronic devices in the field and nature requires special features in order to operate correctly. Special developments are needed in order to cope with changes in ambient temperature, humidity, pressure and when the electrical power grid is unavailable. However, such developments can be time-consuming and cost-intensive. Much iteration in the development is required in order to ensure a stable functioning of electronic products in the wild. A key strength of the Timed Animal Manipulation Data Logger is that it runs autonomously. During the development, special attention was paid to developing an energy saving operation, so that a battery pack would only have to be changed every two weeks up to several months, depending on the activity of the connected devices. The SD cards used have enough memory space to save data for several months of data collection. These low operating expenses make the Timed Animal Manipulation Data Logger (TAMDL) ideal for a use in isolated locations without grid connection. Also, TAMDL can be placed wherever needed. A special housing provides protection against any weather conditions.

Finally, biological data is optimally collected when disturbance to the animal's behaviour due to human presence is minimised. Compared with observations or manual handling, data generation is less error-prone and an increase of data volume is easily realizable. TAMDL also supports an activation and deactivation of video devices or cameras.

Thinking outside an ornithological context, the Timed Animal Manipulation Data Logger is very multifunctional. As it is developed to work outside and to time the functions of devices, it could be used in several outdoor/energy saving contexts.

Some examples of potential uses are:

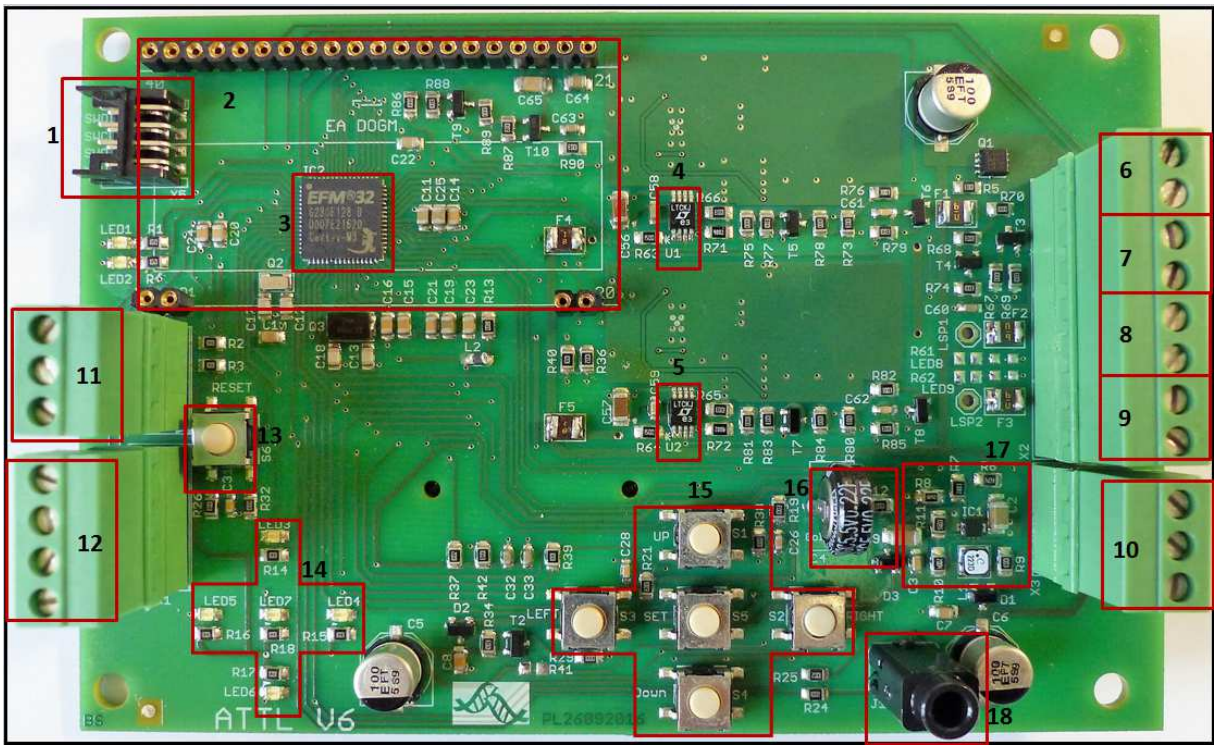
- control and manipulation of energy consumption (e.g. cooling boxes, dishwashers, etc.)
- timed activation/inactivation of sillcocks
- actuating trap releaser (e.g. 3x a day right before arrival of experimenter)
- targeted power-up, for example, of solar panels (only when sun is highest)
- control of flaps and automatic feeders (e.g. for cattle, zoo animals, pets, etc.)
- outdoor/energy solutions for up to 3 consumers
- manipulation and data collection of certain individuals in e.g. nest or roosting boxes (e.g. bats, birds)

1.2 System configuration main circuit board

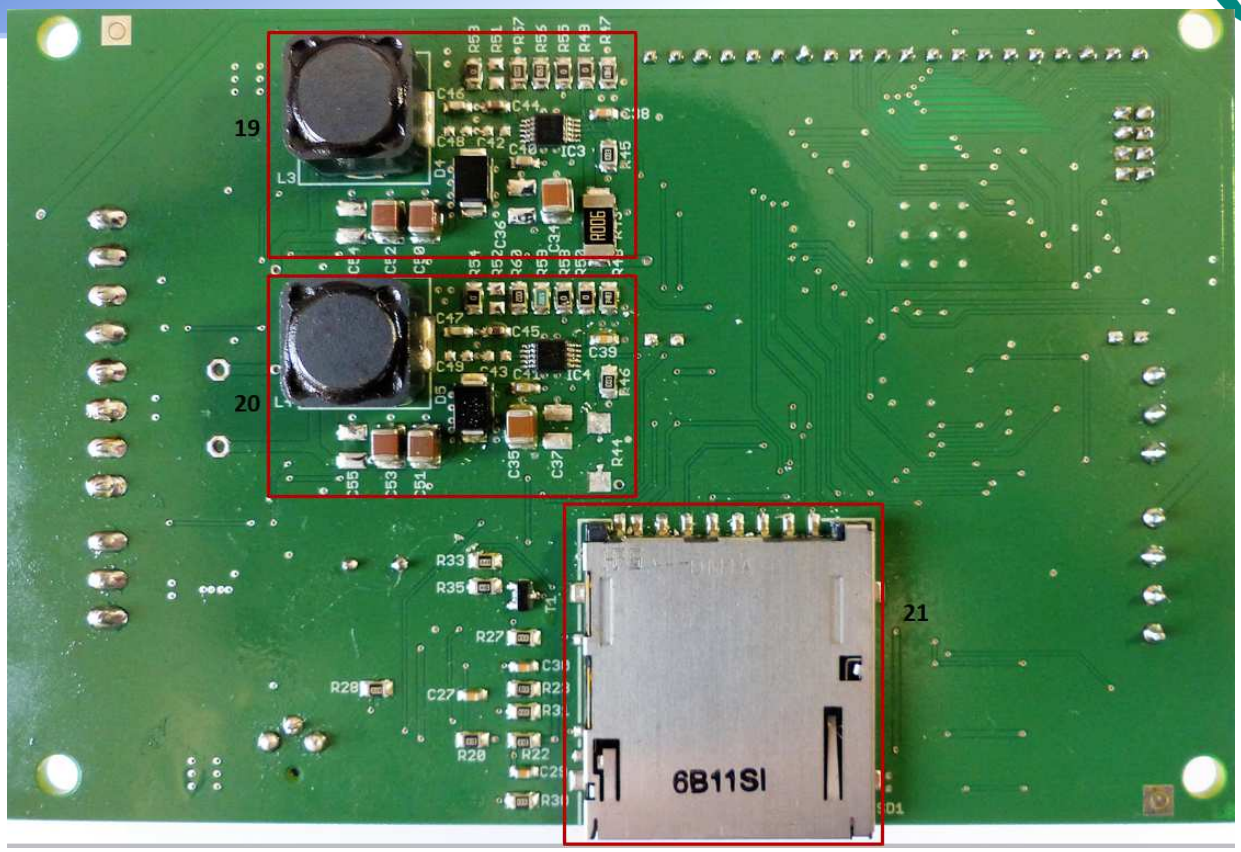
The smart feeder was developed over several years. After five years of development a reliable and efficient version was completed, which is described comprehensively in this manual. Additional detailed information, particularly concerning the electronic configuration, can be found in the datasheet.

1.2.1 Hardware Illustration (TAMDL)

Front side



Back side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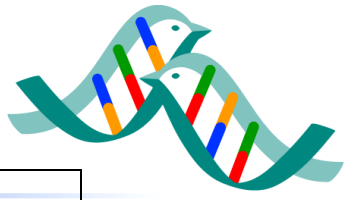
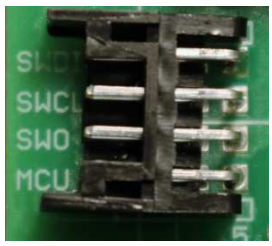


1	Debug Interface
2	LC Display
3	Microcontroller EFM32G230
4	Current Sense Amplifier U1
5	Current Sense Amplifier U2
6	Battery input
7	Battery output
8	UA1_OUT
9	UA2_OUT
10	Connections for buses of devices (e.g. scale, RFID reader, etc.)
11	Connections for the SMBus ‘System Management Bus’ of the battery pack
12	Connecting terminal for radio clock
13	Reset pushbutton
14	LEDs 3 to 7
15	Pushbuttons
16	Gold Cap Capacitor
17	Down converter
18	LEUART connector
19	Output voltage 3.5V-11V@ 2.5A for e.g. cameras
20	Output voltage 3.5V-11V@ 2.5A for e.g. cameras
21	SD memory card connector

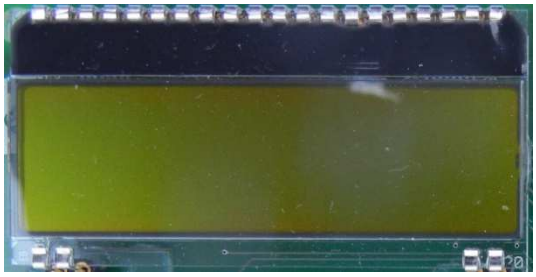
1.2.2 Debug Interface (DBG)



The debug interface software is stored on the microcontroller flash memory. Only after the flash memory contains this information, the hardware can be operated. The connection is either realised directly with a USB cable to the debug interface or with a debugging probe. If the connection is realized directly through the USB cable only HEX files and BIN files can be transferred.

1.2.3 Liquid Crystal Display (LCD)

This kind of display screen utilizes liquid crystals, which influence the polarization direction of light when a certain amount of electrical voltage is applied.



LCD's consist of segments which can independently change their transparency. This is done by a change in the orientation of each segment of the liquid crystals when an electrical voltage is applied. This then changes the permeability for polarized light, which is created by a backlight.

One can move through the results shown on the LCD via the pushbuttons (see chapter 1.2.13).

1.2.4 EFM32 Microcontroller

So called microcontroller (MCU) are flip chips that, at the same time, contain a processor and peripheral functions. In many MCUs, the internal and program memory are located partially or entirely on the same chip.

EFM32 is a family of microcontrollers offered by Silicon Laboratories. The EFM32 are 32-bit microcontrollers of different sub-families that use ARM cortex-M3 processors. The energy consumption received special focus during the development, which influenced naming: EFM stands for Energy Friendly

Microcontrollers. The low power demand makes the EFM32 microcontroller especially suitable for applications with battery supply. EFM32 microcontrollers contain several energy-saving modes that can be changed easily. Additionally, many peripheral devices can be plugged.

Within the Timed Animal Manipulation Data Logger the EFM32G230 microcontroller is used with 128 KB Flash Memory and 16 KB RAM Memory.

The EFM32 series is also known as ‘Gecko’ by the developer, as these animals consume only 10% of the energy used by a mammal of similar size.

Energy Micro states that benchmark measurements with other leading energy saving MCUs found that the EFM32-MCU consumes only a quarter of the energy consumed by the other 8-, 16-, or 32-bit-MCUs.

The EFM32 microcontroller based on the ARM Cortex processor is well suited for energy saving applications such as:

- electricity, gas and water-meters
- factory automation and building automation systems
- alarm and security technology as well as portable applications for medical engineering or within the fitness sector.

The ARM Cortex-M3 processor is developed by Energy Micro and has been bought by Silicon Labs. Since the used processor works with 32 bit, data processing is much faster than 8 and 16 bit CPUs. Therefore, tasks are completed with less clock cycles, thereby reducing the dwell time in an active mode substantially.

The EFM32G230 contains an UART-interface for communication with external systems, which is especially designed for energy saving. The interface is referred to as LEUART-interface. LEUART is a serial interface, a kind of bus system. Through the LEUART-interface, a jack connector and a USB cable can be used to establish a connection to a computer.

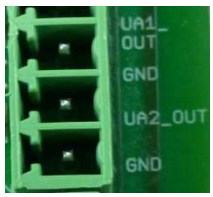
1.2.5 Current Sense Amplifier (U1 and U2)

The LTC6102 Current Sense Amplifiers are so called ammeters (from Ampere Meter), that measure the electric current – both from UA1 and UA2. Here, a current shunt measurement is applied. The current gets monitored via the voltage across an external sense resistor (shunt resistor). Internal circuitry converts input voltage to output current, allowing a small sense signal on a large common mode voltage to be translated to a ground-referred signal. Low DC offset allows the use of very low shunt resistor values and large gain-setting resistors. As a result, power loss in the shunt is reduced. LTC6102IDD-1#PBF Foto

1.2.6 Battery in- and output

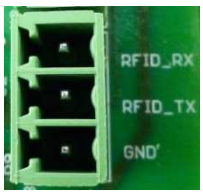
The battery output has an output voltage of more than 10 V and can be switched off.

1.2.7 UA1 and UA2 out



UA1 and UA2 create an output voltage of up to 11 V and are secured exits of the two output voltages (chapter 1.2.17).

1.2.8 Connections for buses of devices



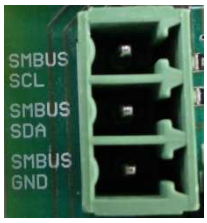
Several devices like scales, RFID readers, cameras, etc. can be connected to the TAMDL depending on the aim of the study.

1.2.9 Connections for the SMBus of the battery pack

TAMDL supports following standard communication bus systems:

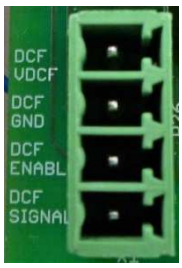
SMBus 'System Management Bus' (http://www.smbus.org/) as well as the **I²C 'Inter-Integrated Circuit Interface'** below a frequency of 100 kHz (https://en.wikipedia.org/wiki/I%C2%B2C).

The System Management Bus (SMBus) is needed for the communication between TAMDL and the microcontroller with 'Battery management system' (BMS).



For reading the single registers of the microcontroller with BMS via the SMBus, the software commands 'SBS Commands' were installed.

1.2.10 Connecting terminal for the radio clock

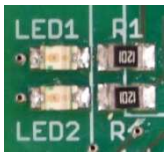


Another potential feature of the TAMDL can be a radio clock, which works in a similar way as a normal clock. In periodic intervals a signal to Europe from the long wave antenna in Mainflingen with a frequency of 77.5 MHz is received and synchronized. Long wave signals have been compared to short waves and medium waves, and have a relatively high range, making it is possible to receive the signal from Mainflingen with a range of up to 2000 km. On other continents, the time signals can be received as well, though with different frequencies.

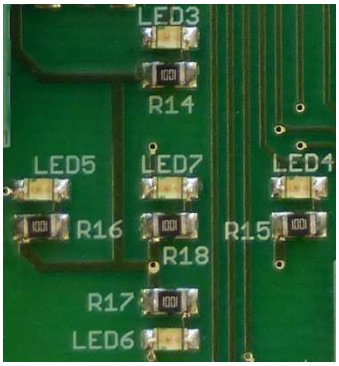
1.2.11 Reset pushbutton

A 'reset' pushbutton is installed on the mainboard of the Timed Animal Manipulation Data Logger, which restarts TAMDL.

1.2.12 LEDs



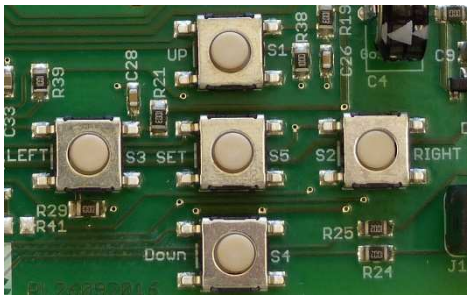
The Timed Animal Manipulation Data Logger is equipped with seven LEDs. If the red LED (LED 1) flashes, this indicates that the radio clock is transmitting a signal to the MCU. If the LED 1 blinks longer than 5 minutes or flashes continuously, this indicates a malfunction. The yellow LED (LED 2) indicates a communication with the SD card. When it flashes, the SD card can be removed or exchanged safely.



LEDs 3 to 7 (yellow) are equivalent to the pushbuttons and accordingly respond to their usage (see next chapter).

1.2.13 Pushbuttons

Besides the reset pushbutton (chapter 1.2.9), there are five pushbuttons installed on the mainboard of the Timed Animal Manipulation Data Logger: Up, Down, Left, Right and Set. They enable navigation through the information shown on the LCD.



1.2.14 Gold cap capacitor

A capacitor (German ‘Kondensator’) is a passive electric component with the ability to store electrical charge and electrical energy of a continuous circuit statically in an electrical field.

When the electrical power supply through the battery is missing, the capacitor ensures an alternate power supply for the Timed Animal Manipulation Data Logger (TAMDL). The capacitor is charged when the accumulator supplies energy to the system. This allows energy to be obtained for a certain time from the capacitor if it is required.

Especially the clock of the microcontroller continuous to be powered when there is no external electrical power supply.

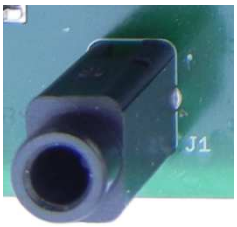
Some applications only become possible through double layered capacitors. Despite its large capacity, it is very small in size. The dielectric strength is not exceptionally high however, with only a few volts. Through its large capacity, the Gold Cap is present to maintain the power supply when the main energy source fails. In devices in which data storage should remain in switched off status, the Gold Cap is particularly well suited.

Life expectancy (battery life) is limited from roughly 8 to 10 years. When the operating temperature is above optimal or the discharge current is high, the life expectancy and the capacity begin to decline over time. The Gold Cap most appropriate when it is rarely discharged and used with low currents

1.2.15 Power supply TAMDL

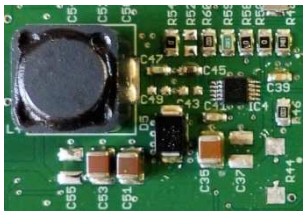
The TPS62125 from Texas Instruments is a high efficiency synchronous step down converter optimized for low and ultra-low power applications providing up to 300 mA output current. It has a wide range of input voltages, from 3 V to 17 V, supports four cell alkaline, and 1 to 4 cell Li-Ion batteries in series configuration as well as 9 V to 15 V powered applications. The device includes a precise low power enabled comparator which can be used as an input supply voltage supervisor (SVS), which addresses system specific power up and down requirements. The standby current is 13 µA.

1.2.16 Jack connector as interface to a PC



For the development of the Timed Animal Manipulation Data Logger an Interface for connection to a computer is intended. Through the data communication interface LEUART, which is provided by the microcontroller EFM32G230 (chapter 1.2.4). The jack connector is used to connect the signal of the LEUART interface with a PC. For this, a jack connector with 3.5 mm, found in many audio applications, is applied. Please regard a power supply of 3.3 V when buying cables.

1.2.17 Output voltages (Down converter)



The TPS62125 3.5 V - 42 V down converter from Texas Instruments is a highly efficient converter, which is optimized for low and ultra-low power applications of up to 2.5 A output current. If no load is recognised by the controller, the standby current is 138 µA. The controller is run by TAMDL in the Shutdown Mode. The Shutdown Current is 1.3 µA.

1.2.18 SD Memory Card Connector

The data from the RAM memory is stored in form of *.txt files on the SD-card, this is located in the SD Memory Card Connector. The size of the memory influences the energy consumption; the smaller the memory size is, the smaller the energy consumption. Therefore, it is recommended for the Timed Animal Manipulation Data Logger (TAMDL) to use a small SD memory size of 2 GB. Larger memory sizes increase TAMDLs Energy consumption. Memory sizes are supported from only 2 GB up to 32 GB. Not every event is written onto the SD card immediately. It is first waited for the provided memory to be full. The writing on the SD card consumes quite some energy, which is why the access to the SD card should occur as rare as possible.

1.2.19 Hardware illustration radio clock receiver

1.2.20 Radio clock

The radio clock works in a similar way as a normal clock. In periodic intervals a signal to Europe from the long wave antenna in Mainflingen with a frequency of 77.5 MHz is received and synchronized. Long wave signals have been compared to short waves and medium waves, and have a relatively high range, making it is possible to receive the signal from Mainflingen with a range of up to 2000 km. On other continents, the time signals can be received as well, though with different frequencies.

countries	designation	frequency
Germany	DCF	77.5 kHz
France	TDF	162 kHz
China	BPC	68.5 kHz
Japan	JJY	40 and 60 kHz
USA	WWVB	60 kHz
Russia	Beta	25 kHz
Great Britain	MSF	60 kHz

The time of the radio clock is prompted every 24 hours by default and gets transferred to the clock of the MCU. A non-standard detection takes place during a reset of the system or after energy supply has been restored, after the capacitor was discharged for too long to bridge power supply and in case of the voltage to come below 1.8 V.

The power supply of the clock is driven by the accumulator, which is also used for the other electric consumers and is described in chapter 1.7.

2 Smart Recorder (Hardware)

Peripheral devices are essential for the regular operation of the Timed Animal Manipulation Data Logger. Concerning the Smart Videotaping application these include an accumulator, a radio clock receiver, a RFID reader and a dashcam.

2.1.1 **Hardware illustration**

Outputs:

UA1 is the camera function which is in the top of the nestbox, using the configuration, the time at which the camera turns on and off can be manipulated.

UA2 is the RFID reader fitted to the bottom of the device and is either Short Range (SR) or Long Range (LR).

THREE POWER SOURCES- UA1, UA2 and BATTERY, determine the on and off times of the UA1, UA2, respective BATT and duration of on and off times and subsequent current and voltage measurements.

2.1.2 **RFID reader for transponders**

RFID (radio-frequency identification) describes a technology for transceiver systems that uses automatic and non-contact identification and localisation of objects and living organisms with radio waves.

A RFID system consists of a transponder that is located on or within the object or living organism and contains an individual label and a reading device with an antenna for the readout of that label.

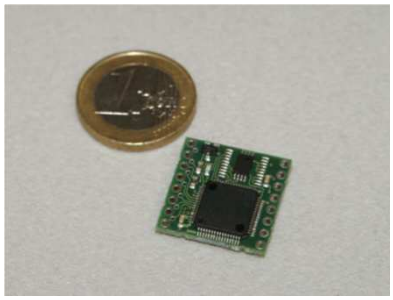
The coupling takes place via alternating magnetic fields produced by the reader within short range or via high frequency radio waves. Thereby, not only data is transmitted, but the transponder is also supplied with energy. Active transponders with a local power source are used to achieve longer ranges, but come along with higher expenses.

RFIDs are also used in other areas such as electronic locks and immobilizers, ski passes, cashless payment transactions and in libraries as theft protection.

The transponder frequency is not exactly the same as the RFID reader frequency. The RFID reader works with a frequency of 125 kHz and the transponder with 134.2 kHz. However, both systems are compatible and function together.

2.1.2.1 RFID receiver module

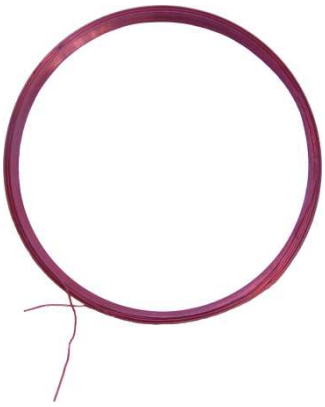
A RFID receiver module with a frequency of 125 kHz is used in the Smart Recorder application. The used receiver module from Elatec is designed with a small size, small price and versatile applications.



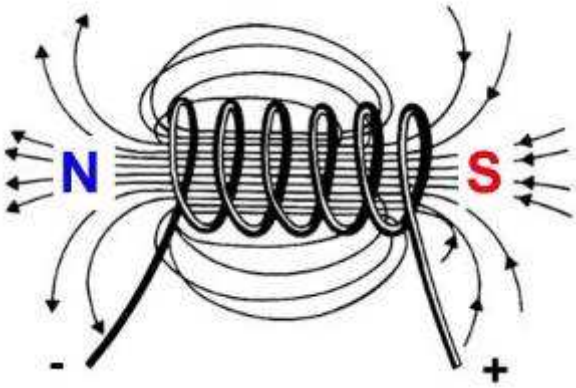
2.1.2.2 RFID antenna

The used RFID antenna has a diameter of 50 mm and is directly soldered on the RFID receiver module. If a voltage source is connected to the antenna, which is an

air core coil with an inductivity of 490 µH and current begins to flow, an electric field is generated. The electric field is the energy source for the transponder.



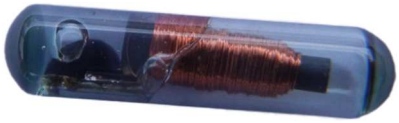
If a transponder with its own antenna transmits a signal at a certain frequency, the RFID reader's antenna collects the signal and transmits it.



2.1.2.3 RFID transponder

The used transponder is the highest performing passive transponder currently available on the market. These transponders are encapsulated in biocompatible glass and provide 100% unique identification. Because of the small size of 8 mm x 1.4 mm and a very low weight of only 30 mg the tagged animals are minimally affected. So it is possible to tag even very small animals such as red ants.

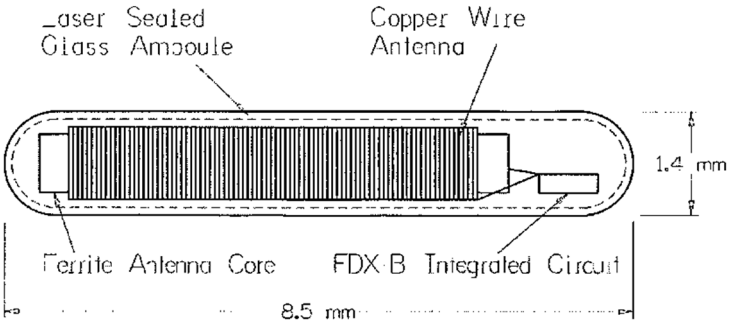
The transponder contains a non-volatile flash memory. A combination of letters and numbers is stored on the flash memory during the production of the transponder.



The transponders are known as FDX-B MINIHPT8 and are made by the company Biomark. The FDX-B indicates that the full duplex technique is used.

In duplex mode operating systems the electric field is always present and the transponder sends its signal as soon as it enters the

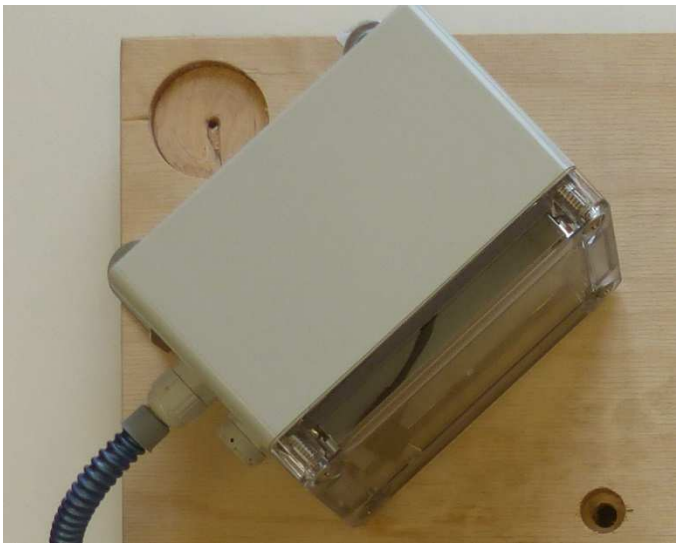
reception area of the reader. The FDX transponder sends its ID continuously and can therefore be received relatively rapid.



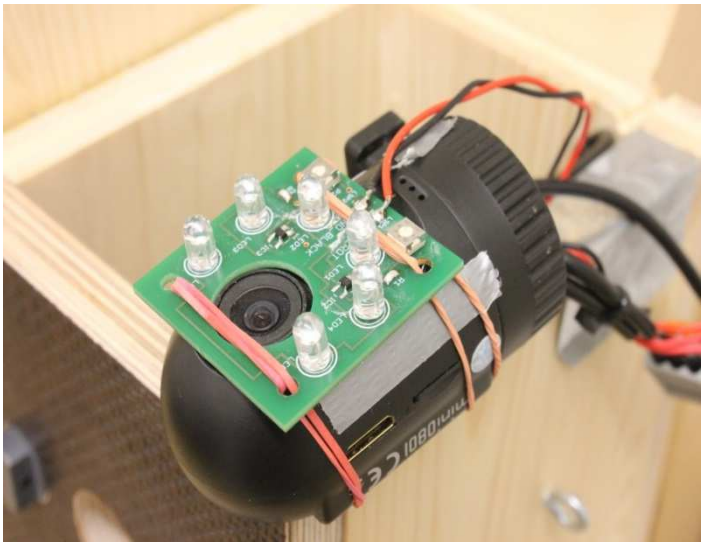
2.2 **Dashcam**

Video recording device with 12 V battery terminal.

Housing for camera

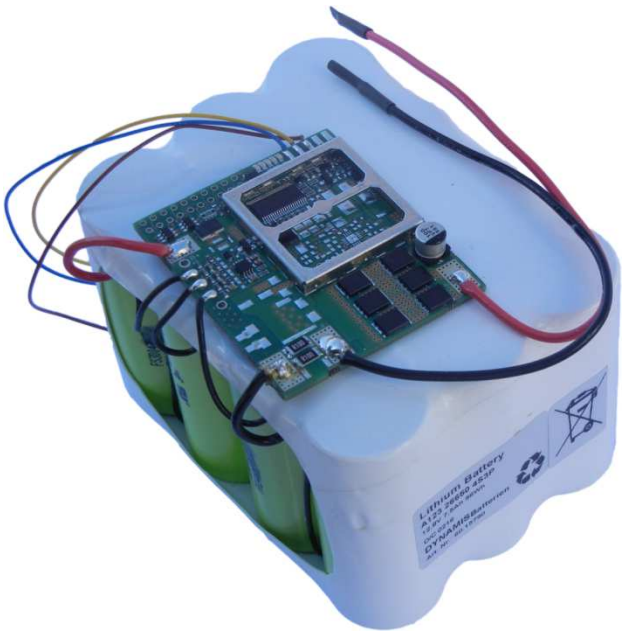


Full HD Car DVR with GPS



2.3 **Accumulator**

The lithium-ion battery from the company ‘Dynamis Batterien’ supplies Timed Animal Manipulation Data Logger (TAMDL) with electrical energy. The capacity was chosen to ensure that there is enough energy to supply the Smart Recorder in a very active period for two weeks. Through the little specific energy of the lithium-ion battery of approximately 108 Wh/kg, the change of the accumulators is much less energy-sapping than with lead-acid batteries with a specific energy of 30 - 60 Wh/kg.



The three LEDs on the accumulator’s board indicate the state of charge. One lit LED indicates that the accumulator is fully charged. Two LEDs indicate the accumulator is halfway charged. Three LEDs indicate an almost empty state of charge.

The lithium-ion battery has its own board, which can communicate with TAMDL via a bus system. Currently, the temperature of the accumulator, the capacitance values and the latest current drain of the Smart Feeder are prompted from TAMDL.

2.4 Housing

2.4.1 Housing for the main board

The housing from the main board consists entirely of opaque polycarbonate. The lid is lockable with bayonet locks which are quick and easy to use. The screws are secured from falling, preventing any loss.

2.4.2 **Housing for the accumulator**

The housing of the accumulator consists entirely of polycarbonate with the lid being made of transparent polycarbonate, so that there is no need to open the lid in order to see the LEDs. The lid is lockable with bayonet locks as well. The same screws are used here and are also secured against falling out.

3 General working conditions

Component designation	Timed Animal Manipulation Data Logger Smart Feeder Application
Manufacturer	MPIO http://www.orn.mpg.de/
Dimensions main board (L X B x H)	121 mm x 81 mm x 1,5 mm
Overall temperature range	-10°C to 70°C (DCF77)
Storage temperature range	-20°C to 60°C
Overall moisture	Relative moisture 35% to 85% (at 5 to 35°C)

Detailed information, in particular concerning the electrical properties of the Timed Animal Manipulation Data Logger can be found in the datasheet.

The working conditions from single devices can be found in the datasheets in chapter 8.

4 Energy supply

The Timed Animal Manipulation Data Logger (TAMDL) is especially designed to have low energy requirements. The electrical power requirements are explained more precisely in this chapter.

The EFM32G230 has five different economical energy modes, where only two of which are used for TAMDL. These are the Deep Sleep Mode and the Sleep Mode whereby the Sleep Mode is the Active Mode and the Deep Sleep Mode is the Inactive Mode. In these energy modes different consumers are active. The Smart Feeder application of the Timed Animal Manipulation Data Logger switches between the Active Mode and the Inactive Mode through light barrier activity. If the RFID reader and the light barrier detect no activity for 6 minutes, the Smart Recorder switches into the Inactive Mode again to save energy.

The energy-intensive consumers, like the RFID reader, are only supplied with electrical Energy when required. The RFID reader is the largest consumer of electrical energy in the Smart Feeder application, when no camera is connected.

Electrical properties and, to some extent, battery drain, can be drawn from the datasheets of the built-in components. The datasheets are linked in chapter 8.

In the following sections, the current supply and the voltage supply will be examined separately.

4.1 Current supply

4.1.1 ARM Cortex Processor

From the five available modes of operation only the Deep Sleep Mode and the Sleep Mode are used.

0.9 µA @ 3 V Deep Sleep Mode, including Real Time Clock with 32.768 kHz Oscillator, Power-on Reset, Brown-out Detector, RAM and CPU retention

45 µA/MHz @ 3 V Sleep Mode

4.1.2 RFID

RFID on measured: 35,4mA

RFID off measured: 1,36mA

(from schematics)

4.1.3 Radio clock

The clock of the microcontroller is updated at a certain time every night through the time signal from Mainflingen. The radio time will be also updated when the system is reset.

Nominal current 100µA Quiescent current 5 µA

4.1.4 LED

Each LED has an electric current demand of 2 m. There are two built-in LEDs.

4.1.5 **Accumulator LEDs and self-discharge**

LEDs	electric current demand
Without	271 µA
Only LED1	308 µA
LED1 + LED2	343 µA
LED1 + LED2 + LED3	384 µA

The self-discharge by lithium-ion-batteries at 20°C is less than 2% per month.

4.1.6 **Overview of the nominal currents**

This table contains the maximum current demands of the most important devices. If all are active at the same time, the current demand behind the down converter at 3.3 V is 51 mA and with that the maximum power input before the down converter is around 0.1683 W.

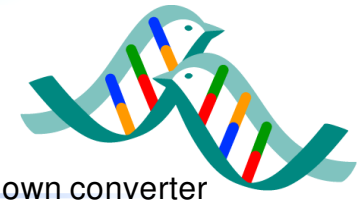
devices	currents
RFID	35.4 mA
2* LED	2 x 2 mA
ARM Cortex M3	45 µA/MHz (1.44 mA)
radio clock	0.1 mA
light barriers	2x 120 µA
Total current behind the down converter with 3.3V	42.2 mA (When all consumers are active at the same time without down converter losses)
Total input in front of the down converter with 12.8 V	155 mW (When all consumers are active at the same time with down converter losses)

4.1.7 **Overview of the currents in the different operating modes**

	Shutoff Mode	Stop Mode	Deep Sleep Mode	Sleep Mode	Run Mode
RFID	Not used	Not used	Off	Can be on	Not used
ARM Cortex M3	Not used	Not used	On	On	Not used
Radio clock	Not used	Not used	Can be on	Can be on	Not used
LEDs	Not used	Not used	Can be on	Can be on	Not used
Light barrier	Not used	Not used	On	On	Not used
Down converter	Not used	Not used	On	On	Not used
Accumulator board	Not used	Not used	On	On	Not used

	Deep Sleep Mode (inactive mode)	Sleep Mode (active mode)
RFID (with 3.3 V)	0	On (35.4mA)
ARM Cortex M3 (with 3.3 V)	0.9 µA	45 µA/MHz (1.44 mA)
Radio clock (with 3.3 V)	0.1 mA (once a day for approx. 5 min; also at reset and start)	0.1 mA (once a day for approx. 5 min; also at reset and start)
LED (with 3.3 V)	2 mA (2 units if on)	2 mA (2 units if on)
Down converter (3.3 V)	13 µA	13 µA
Total current behind the down converter (without down converter losses and 3.3 V)	0.0609 mA (2 x light barriers and MCU)	36.88 mA (RFID active, MCU active, light barriers, down converter)
Total input behind of the down converter (without down converter losses and 3.3 V)	0.0609 mA x 3.3 V = 0.000201 W = 201 x 10^-6 W	36.88 mA x 3.3 V = 0.122 W
Total input in front of the down converter (with down converter losses and 12.8 V)	(with η = 50%) 0.000201W/0.5 = **0.000402 W** = 402 x 10^6 W	(with η = 90%) 0.122 /0.9 = **0.136 W**
Total current in front of the down converter (with down converter losses 12.8 V) **(theoretical)**	(with η = 50%) **0.0314 mA**	(with η = 90%) **10.6 mA**
Measured **total current** in front of the down converter (with down converter losses 12.8 V) **(real)**	**0.22 mA = real measured inactive mode** (connected radio clock but inactive, controller in Deep Sleep Mode, Gold Cap, connected LED but off, buttons, down converter)	**11 mA = real measured active mode** (connected radio clock but inactive, controller, LED connected but off, gold cap, SD card, down converter, light barrier, RFID on)
Accumulator board with LEDs current demand	(0.271 mA – 0.384 mA)	(0.271 mA – 0.384 mA)
Total current with accumulator board	0.3024 mA – 0.4154 mA	10.87 mA – 10.98 mA
Total Input ink. accumulator board with 12.8 V **(theoretical)**	**0.00387 W – 0.00532 W**	**0.139 W – 0.141 W**
Total Input with measured value + theoretically accumulator board demand with 12.8 V **(real)**	**0.028 W – 0.0158 W**	**0.141 W – 0.142 W**

4.2 **Voltage supply**



All consumers are supplied with 3.5 Volts, which are provided by the down converter from the 12.8 Volts from the lithium-ion-accumulator. An input voltage of 5 V for the down converter is sufficient.

4.3 Electrical energy storage

The main power supply is ensured by the lithium-ion-accumulator. If the accumulator is removed, a capacitor ensures the supply.

4.3.1 Accumulator

If the whole capacity of a lithium-ion-accumulator is completely used it can have negative effects on the lifetime of the accumulator. Therefore, a certain percentage of the total capacity is not used. The accumulator of the Animal Presence RFID Data Logger uses 83% of the total capacity.

Roughly 17 % of the capacity of the accumulator is not used.

voltage	12.8 V
nominal capacity	7.5 Ah
total capacity	8.97 Ah
stored energy	96 Wh

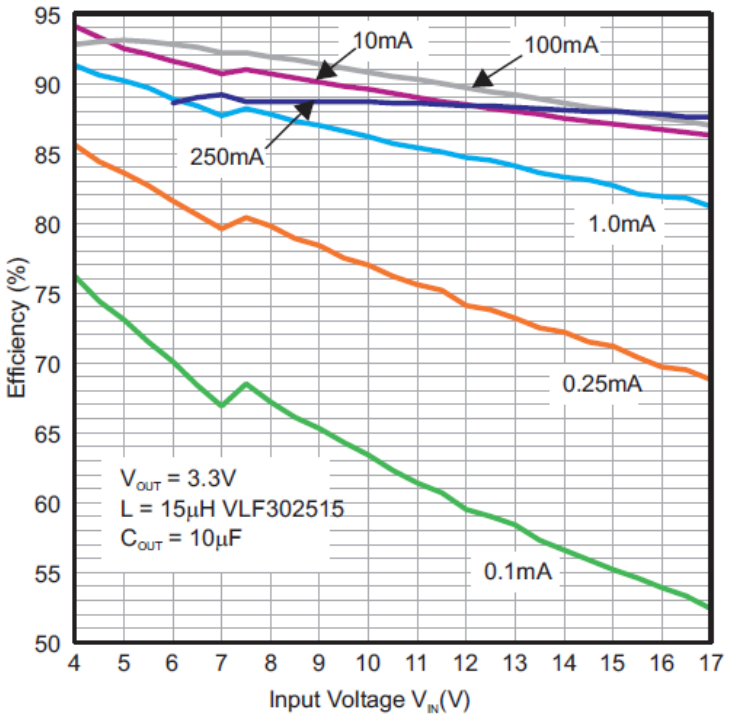
The lithium-ion-accumulator has its own board, which is able to communicate with the Animal Presence RFID Data Reader via a data bus.

4.3.2 Capacitor

If the energy supply from the accumulator is no longer available, a capacitor with 0.22 farad ensures the energy supply. The stored energy is enough to supply TAMDL for around 30 seconds. During the discharge, the voltage of the capacitor declines from 3.6 Volts to 1.8 Volts.

4.3.3 **Conversion losses**

The accumulator provides electrical energy with a voltage of 12.8 Volts. The EFM32G230 and other consumers require a significantly smaller voltage of around 3.3 Volts. This reduction of voltage is achieved by a down converter which is described in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. The down converter doesn't work with transformers but with resistors.



4.3.4 **Range estimation of the accumulator**

Range at maximum power (If the Timed Animal Manipulation Data Logger is always active and there is no maintenance, RFID)	96 Wh / 0.142 W = 676 hours = **28.16 days**
Range at minimum power (The Timed Animal Manipulation Data Logger is in the Deep Sleep Mode and there is no maintenance; radio clock and RFID off, 1x light barrier)	96 Wh / 0.0058 W = 16552 hours = **690 days** = 1.889 years

The value for the range at minimum power can only theoretically be achieved. In reality the self-discharge causes the accumulator to be discharged earlier. Moreover, an inactivity of more than two years is not intended for the application.

5 Operation of the Smart Recorder

The operation of the Timed Animal Manipulation Data Logger (TAMDL) with the Smart Feeder application will be explained in this chapter. This includes the information detailing accumulator replacement, SD card change, software updates, the loading of the accumulator and troubleshooting.

Menu Display

The menu display on the TAMDL firmware display shows the time, and all temporary messages such as SD insertion/removal or the registering of a transponder ID. It also allows the calibration of voltage and current to be measured of the UA1 and UA2.

The default screen (Home screen) shows the actual time in the first line and an „Info-Area“ in the second line of the LCD. All temporary messages are displayed there, e.g. when an SD-Card is inserted or removed. Transponder IDs are also displayed here.

After some time of inactivity or when asserting the **Set-Key** for more than 750ms, the menu returns to the home screen.

Home Screen with Info-Area

```
180327 23:58:10
{I n f o - A r e a}
```

Firmware Version and Date, also activates the RFID reader for test purposes.

```
V1.0 Mar 27 2018
↓:CLEAR Transp.#
```

Down-Key clears Transponder

Status of Power-Outputs

```
Power Output
[va1][VA2][bat]
```

Uppercase means **on**, lowercase **off**

```
VA1  9.3V 2385mA
SET: enable Pwr
```

```
VA2  5.0V 1230mA
SET: disable Pwr
```

```
BATT Output
SET: enable Pwr
```

Actual Battery Voltage and Current

```
Battery Status
13.1V     376mA
```

```
Remain. Capacity
        5637mAh
```

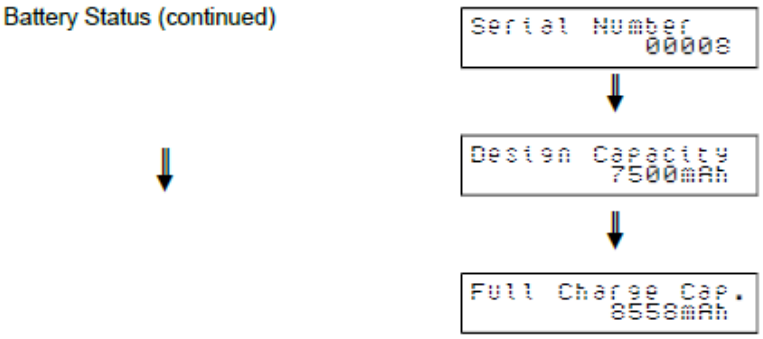
```
Runtime to empty
    >  6 weeks
```

```
Manufacturer
 Dynamis
```

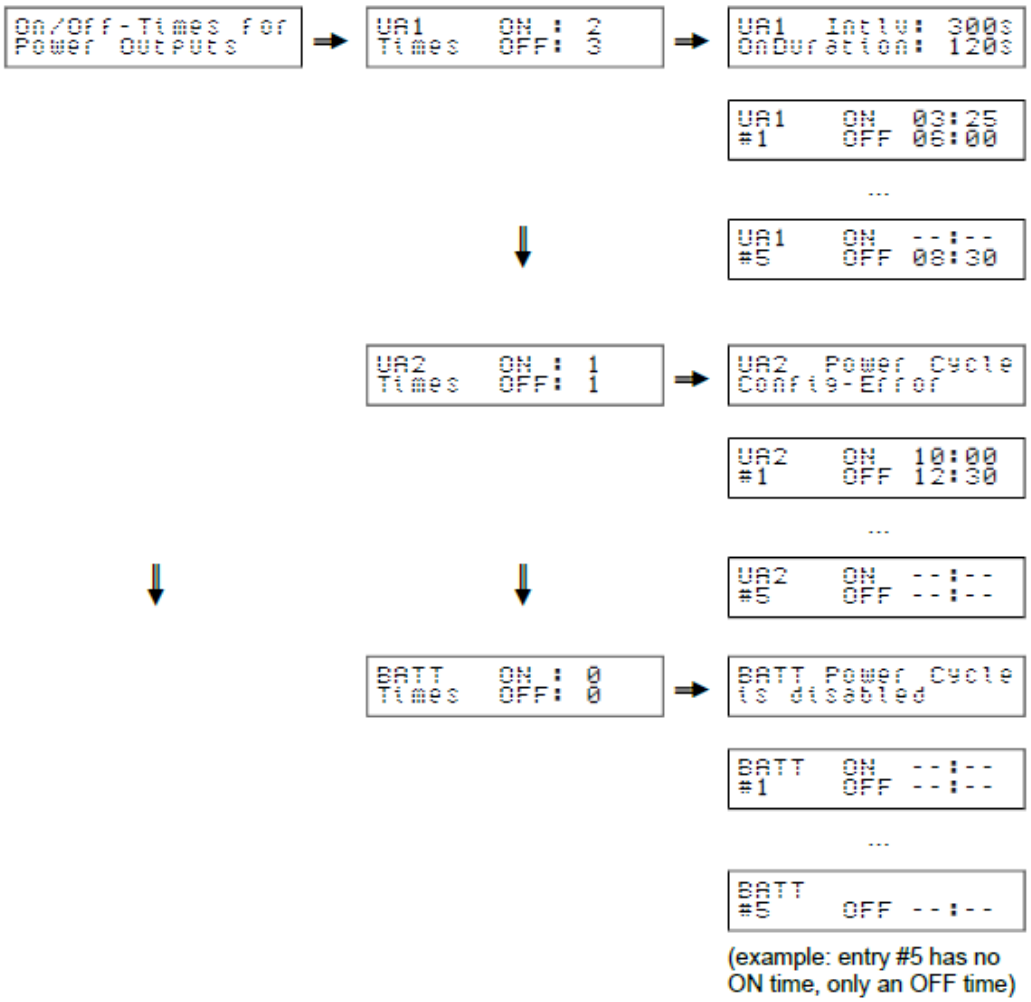
```
Device Name
 BMS2-4 V0.3
```

```
Device Type
 Lithium-Ion
```

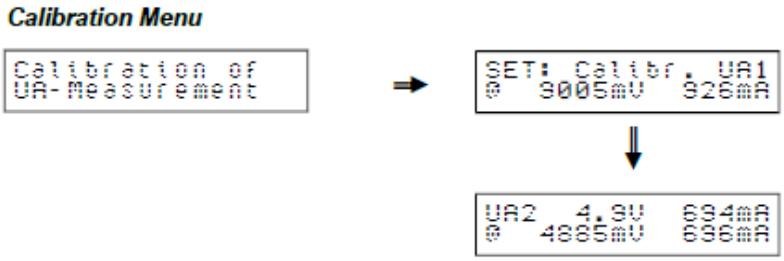

Battery Status (continued)



Power Output On/Off Times – Note: All times are local times, this may be MEZ or MESZ



(example: entry #5 has no ON time, only an OFF time)



Calibration Procedure

To calibrate the voltage and current measurement channels of the power outputs UA1 and UA2, follow these steps:

- Connect a constant load to UA1, and also a voltage and a current meter.
- Go to the calibration main menu, then further to the sub-menu for UA1. At this time the message UA1 CALIBRATION IS NOT POSSIBLE may be displayed if no calibration reference values exist in the configuration file, but this is not a problem.
- As long as you remain in this sub-menu, the respective power output is activated and you could measure voltage and current for this specific load.
- Write these values in the **CONFIG.TXT** file on an SD-Card. The variable names are **UA1_CALIBRATE_mV** and **UA1_CALIBRATE_mA**. After that, insert the SD-Card into the TAMDL board.
- The configuration file is read and the two values will be displayed.
- Verify if the voltage and current values are still valid, then assert the **Set-Key** to start calibration.
- The conversion factors will be calculated and the display now shows the actual voltage and current values together with the reference values.

- Proceed in the same way with UA2 by asserting the **Down-Key** to enter its sub-menu.

- After both channels have been calibrated, return to the calibration main menu by asserting the **Left-Key**. This will save the conversion factors to flash memory, so they can be loaded during the next start-up.

- If unsure you could abort this procedure by asserting the **Set-Key** for more than 750ms. The menu returns to the home screen and the power outputs are disabled.

Configuration

The configuration file allows you to change the voltage, time and activation of all outputs in the device. For example, setting the UA1 (camera) to turn on for 2 hours during the night and 4 hours during the day. This allows for flexibility, whereby the device can be set in advance without the need to set it each day.

5.1 Accumulator replacement

The accumulator has to be replaced in periodic intervals. The range of an accumulator depends on several factors, including ambient temperature, activity of the Smart Feeder and therefore energy demand of the Smart Feeder. The activity usually depends on the season of the year. As birds have a higher level of activity near the Smart Feeder (SF) during the breeding season, the SF is often in the active mode and needs much more energy than during other seasons.

5.1.1 Reasons for accumulator replacement

The accumulators have boards with three LEDs which indicate the state of charge. If three LEDs are blinking this shows that the accumulator is almost empty and should be exchanged as soon as possible. When two LEDs are blinking the accumulator is half full and one LED blinking indicates an almost full accumulator. If there are no LEDs blinking the accumulator is completely empty and no longer able to supply energy.

When all LEDs are lit permanently this indicates a defect at the accumulator or at the accumulator board. In this case the whole accumulator needs to be changed.

5.1.2 **Placement of the accumulator**

The wind and therefore also rain, snow and mist in Europe primarily come from the west. This can be seen visibly on trees where the western-facing sides are often moss-covered. Therefore, placement of the accumulator on the eastern side can minimize the possibility of damage due to oxidation.

Moreover, the accumulator can be placed in a way that water can drain away at an edge and does not accumulate at the connector or at the cable input.

If the accumulator becomes warm, it can age more rapidly or be damaged. The operating temperature range of the accumulator is between minus 30°C and 55°C according to manufacturer specifications. When the sun shines directly on the accumulator it is possible to exceed this range. Therefore, the accumulator should be protected against direct sunlight through e.g. placement on the north-facing side of a tree or by shading it in another way.

When placing the accumulator, one should be aware of these external environmental influences and place the accumulator appropriately, because of the high costs of the accumulators.

5.2 **SD card change**

The SD cards have a large memory size so that the memory may be filled only after several months or even years.

As continuous recording of data is desired and as unexpected malfunctions of the Smart Feeders are always a possibility, they should be visited and controlled regularly every couple of weeks. In doing so, SD cards can be exchanged and stored data can be checked. If there is unusual data on the SD cards, it could indicate a malfunction of the Smart Feeder. In this case, a maintenance should be arranged.

5.3 Software update

There are three possible methods to write software code on to the flash memory. The debug probe method from IAR systems and the debug interface method without debug probe are always possible. If software has already been written on the flash memory by either of these methods, an additional method using SD cards is also available.

The microcontroller EFM32G230 contains a flash memory with a memory size of 128 KB. This memory contains the software by which the microprocessor works. 128 KB of memory is a sufficient size for operation, even with very complicated applications of the Timed Animal Manipulation Data Logger. Update possibilities are described in more detail in chapter 7.1.

5.4 Loading the accumulator

The accumulators should be changed and charged in regular intervals. The accumulator has to be visually checked for damage when it is changed.

5.4.1 Recharger

Device description	Mascot type 2541 Li, 4 cell, 2A, Lithium Ion Battery Charger, 35W
Manufacturer	Mascot http://www.mascot.no/home/
Nominal power	35 W
Battery voltage	12V
Charging current	Up to 2 A
Recommended battery capacity	1 – 10 Ah
Loadable cells	4
Charging characteristic	IUoU

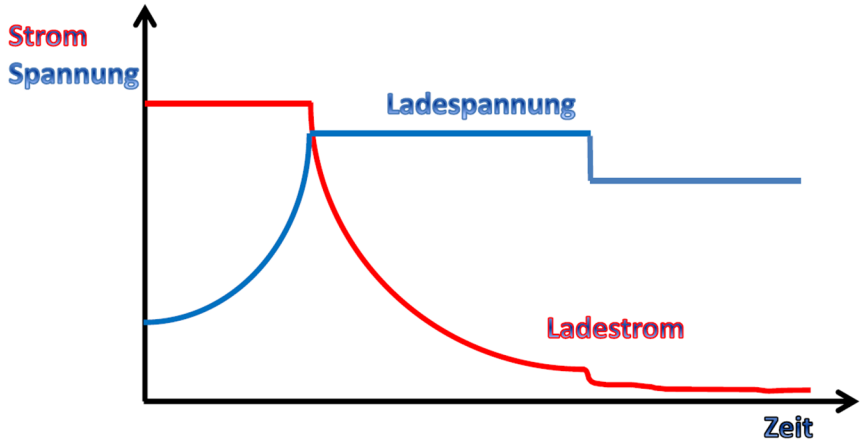
The charge process is separated in to three sections.

1. Charging current is 2 A until the voltage reaches 14.7 V

2. Voltage will be held at 14.7 V; current declines slowly
3. A yellow display shows that the charging current declined beneath 1 A
4. If the charging current is below 250 mA the recharger switches off.
5. In the maintenance charging module the accumulator voltage will be kept at 13.7 V.

5.4.2 **Charging method IUoU**

IUoU means that the initial charging current is constant similar to the CCCV charging method until the final charging voltage is reached. Then the voltage is held at the charging end voltage. This constant high voltage can be harmful for the accumulator and reduce the capacity. Therefore, the voltage will be reduced after a certain amount of time; with that the maintenance charging is initiated. With the reduced voltage the accumulator can be charged permanently and the amount of current is roughly like the self-discharge. The ‘I’ in IUoU stands for constant current, ‘Uo’ stands for constant voltage with charging end voltage and ‘U’ for reduced constant Voltage



5.4.3 **Charge time**

The accumulators can be charged in roughly one day to ensure that the accumulators are securely fully-loaded.

Theoretically, a charging time of roughly 3 hours in both rechargers is enough for a complete loading.

The charging time at the IUoU can be marginally less, because the Uo phase at constant voltage with end-of-charge voltage can be higher than the CV voltage at the CCCV method.

7.5 Ah / 2A = 3.75 h

A discharged accumulator with 7.5 Ah requires a charging current of 2A for more than 3.75 hours, because the loading does not take place with a maximal current of 2A the whole time.

5.5 **Troubleshooting Smart Feeder**

The current version of the Smart Feeder has taken three years of development. Some malfunctions could be encountered and thus lead to experience in troubleshooting and development of specific procedures for malfunctions which may be detected.

5.5.1 Troubleshooting in the field

The field troubleshooting takes place after a malfunction is detected through information from the data collected in the SD cards. Incorrect data indicates a malfunction at the Smart Feeder.

5.5.2 Troubleshooting in the laboratory

Via the LEUART-interface the Smart Feeder can be connected to a PC. This makes it possible to transfer information transmitted by the Microcontroller. This allows for a detailed view into the Smart Feeder.

If the failure cannot be detected via the LEUART-interface, the Smart Feeder has to be measured electronically for further troubleshooting.

6 Software

The Software on the flash memory in the Timed Animal Manipulation Data Logger is programmed with the programming language C. This software is diverse for different applications and has to be regenerated for every application. It needs to be smaller than 128 KB for the flash memory. The software for the Smart Feeder application will be described in this chapter. It includes reset options, the reset process, how data is stored and what occurs when the SD card is changed. Also described is how regular queries are stored, what can be done with the built-in buttons on the board and the possibility of software updates.

6.1 Reset

The reset can be used to restart the system of the Timed Animal Manipulation Data Logger when an unknown failure occurs. The procedure for a reset is always the same. The reset is a new start and can be compared with the start of a PC.

6.1.1 Possibilities to perform a manual reset

The Timed Animal Manipulation Data Logger can be restarted manually in two ways:

- Via pushbutton
- Reset after electrical energy was not available for considerable time, so that the capacitor could not provide enough energy. The capacitor has enough energy to provide TAMDL for approx. 3 min.

6.1.2 Procedure after reset

After a reset the following procedure takes place:

1. Both LEDs (red and orange) will be illuminated to show that the hardware or software is active and the LEDs are working.

Only visible in a terminal program on a PC.

2. In case a SD card is recognised, its data system is mounted and the free space on the memory is displayed. This takes place at every exchange of SD cards during operation.

3. Afterwards it will be searched for a log file with the name 'BOX*nnnn*.TXT' (*nnnn* is a random decimal number). In case the file exists on the SD card, the name will be displayed on the LC display; otherwise the file 'BOX0999.TXT' will be created.

Furthermore, the DCF77 module is switched on to receive date and time. The red LED now flashes to the rhythm of the radio clock signal.

4. After date and time got synchronized, the red LED switches off.

6.1.3 **Reset protocol**

If a start or a reset of the Timed Animal Manipulation Data Logger is carried out some protocol lines are written on the SD card to comprehend the process of the maintenance.

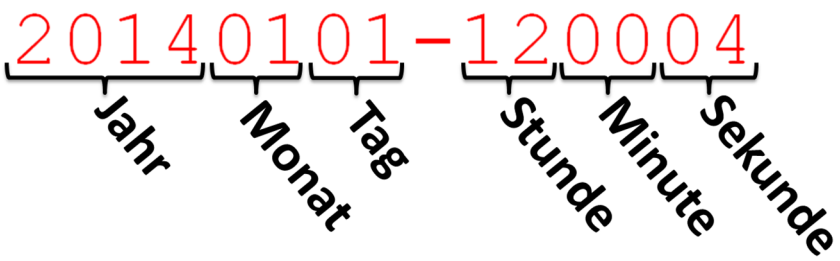
```
20190107-150721.183 SD-Card Removed

20190107-150722.135 SD-Card Inserted

20190107-150722.215 SD-Card Initialized

20190107-150722.215 SD-Card File System mounted

20190107-150722.468 SD-Card 1853MB free

20190107-150722.470 Media Change: BOX0999.TXT -> BOX0999.TXT

20190107-150722.497 MCU: EFM32G230F128 HW-ID: 0x247DBC085A3E2629

20190107-150722.528 Battery Manufacturer Name :  Dynamis

20190107-150722.554 Battery Manufacturer Data :  61.90002/15790

20190107-150722.580 Battery Device Name       :  BMS2-4_V0.3

20190107-150722.605 Battery Device Type       :  Lithium-Ion

20190107-150722.612 Battery Serial Number     : 00008

20190107-150722.619 Battery Design Voltage    : 3.300V per cell

20190107-150722.625 Battery Design Capacity   : 7500mAh
```

```
20190107-150722.632 Battery Full Charge Capac.: 8198mAh
20190107-150723.220 Battery Remaining Capacity: 3017mAh
20190107-150723.229 Battery Runtime to empty  : 1160min (0d)
20190107-150723.237 Battery Actual Voltage    : 13.1V
20190107-150723.243 Battery Actual Current    :  156mA
20190107-150723.483 Reading Configuration File CONFIG.TXT
```

6.2 Data storage

All important information from the RAM memory will be saved in a txt-file on the SD card. Every event or stored message begins with the date and time of the event.

Following the date and time there is a blank space. Then follows the actual status message



Procedure after SD card change

After a new SD card is plugged in the following procedure starts.

1. It displays that a new SD card has been detected.

```
20190107-150722.135 SD-Card Inserted
20190107-150722.215 SD-Card Initialized
20190107-150722.215 SD-Card File System mounted
```

2. The following line shows how much free space remains on the SD card.

```
20190107-150722.468 SD-Card 1853MB free
```

3. Afterwards it will search for a log file with the name ‘BOX*nnnn*.TXT’ (*nnnn* is a random decimal number). In case that the file exists on the SD card the name will be displayed on the LC display otherwise the file ‘BOX0999.TXT’ will be created.

```
20190110-133618.338 Using Filename BOX0999.TXT

20190110-133618.338 Media Change: BOX0999.TXT -> BOX0999.TXT
```

4. The hardware ID will be displayed, which is a unique number allocated to each Timed Animal Manipulation Data Logger

```
20190110-133618.363      MCU:      EFM32G230F128      HW-ID:
0x247DBC085A3E2629
```

5. The status of the accumulator is then displayed, including the manufacturer name, manufacturer data, device name, device type, serial number, design voltage, design capacity, total capacity, remaining capacity, remaining time at actual current and at least the measured actual voltage.

```
20190110-133618.394 Battery Manufacturer Name :  Dynamis

20190110-133618.420 Battery Manufacturer Data :  61.90002/15790

20190110-133618.445 Battery Device Name       :  BMS2-4_V0.3

20190110-133618.470 Battery Device Type       :  Lithium-Ion

20190110-133618.477 Battery Serial Number     : 00008

20190110-133618.483 Battery Design Voltage    : 3.300V per cell

20190110-133618.490 Battery Design Capacity   : 7500mAh

20190110-133618.497 Battery Full Charge Capac.: 7811mAh

20190110-133619.088 Battery Remaining Capacity: 7811mAh

20190110-133619.096 Battery Runtime to empty  : More than 6 weeks

20190110-133619.103 Battery Actual Voltage    : 13.4V

20190110-133619.110 Battery Actual Current    :    5mA
```

6. The configuration file CONFIG.txt is read.

RFID_TYPE [SR, LR]
RFID reader device type: SR is Short Range reader, LR is Long Range reader. If no type is specified (i.e. the variable is #-commented), the associated logic will not be activated.

RFID_POWER [UA1, UA2, BATT]
RFID reader power source, must be set to UA1 or UA2.
If no value is specified (i.e. the variable is #-commented), the associated logic will not be activated.

RFID_ABSENT_DETECT_TIMEOUT [s]
An RFID reader regularly re-sends the ID, as long as the transponder can be received. This is used to retrigger a "still present" timer. The value specifies the time in seconds, after which the transponder is treated as "absent" when its ID could not be received again.
A value of 0 disables the absent logic. This is useful for "fly thru" designs, e.g. with the Smart Nest Box.

UA1_ON_TIME_1~5,UA1_OFF_TIME_1~5,UA2_ON_TIME_1~5,
UA2_OFF_TIME_1~5,
BATT_ON_TIME_1~5, BATT_OFF_TIME_1~5 [hour:min] MEZ
These variables determine the on and off times of the UA1, respective UA2 power output. If an RFID reader is assigned to an output, the UART will be activated additionally.

UA1_INTERVAL, UA1_ON_DURATION, UA2_INTERVAL, UA2_ON_DURATION, BATT_INTERVAL and BATT_ON_DURATION in [s]
These optional variables allow you to define a Power Cycle Interval within the on times of the respective power output. XXX_INTERVAL specifies the interval in seconds, XXX_ON_DURATION the power ON duration in seconds within this interval.
The OFF duration is calculated XXX_INTERVAL minus XXX_ON_DURATION.
There exists only one set of values per output. These are applicable for all five on/off-times.

UA1_MEASURE_FOLLOW_UP_TIME, UA2_MEASURE_FOLLOW_UP_TIME, and

BATT_MEASURE_FOLLOW_UP_TIME [s]
Duration in [s], the measurement of the respective power output is still performed. Additionally, BATT_INP voltage and current is measured via the battery controller. For the BATT output, only BATT_INP is measured.
UA1_CALIBRATE_mV, UA2_CALIBRATE_mV [mV]
Calibration reference voltage for UA1 and UA2, specified in [mV].

UA1_CALIBRATE_mA, UA2_CALIBRATE_mA [mA]
Calibration reference current for UA1 and UA2, specified in [mA].

```
  # Calibration values for UA1 and UA2 measuring
UA1_CALIBRATE_mV    = 9100
UA1_CALIBRATE_mA    = 228
UA2_CALIBRATE_mV    = 0
UA2_CALIBRATE_mA    = 0

   # RFID configuration
RFID_TYPE          = LR
RFID_POWER         = UA1
RFID_ABSENT_DETECT_TIMEOUT = 5

   # Follow-up times after measurement [s]
UA1_MEASURE_FOLLOW_UP_TIME  = 2
#UA2_MEASURE_FOLLOW_UP_TIME  = 0
#BATT_MEASURE_FOLLOW_UP_TIME = 0

   # Operating times for UA1 output [hour:min] MEZ
UA1_ON_TIME_1       = 08:00
UA1_OFF_TIME_1      = 18:00

   # Power Cycle Interval for UA1 output [s]
UA1_INTERVAL        = 20   # 10sec Interval
UA1_ON_DURATION     = 10   #  5sec.On Duration

   # Operating times for UA2 output [hour:min] MEZ
#UA2_ON_TIME_1       = 00:00
#UA2_OFF_TIME_1      = 00:00

   # Power Cycle Interval for UA2 output [s]
```


```
#UA2_INTERVAL       = 20
#UA2_ON_DURATION    = 10

   # Operating times for BATT output [hour:min] MEZ
#BATT_ON_TIME_1      = 00:00
#BATT_OFF_TIME_1     = 00:00

   # Power Cycle Interval for BATT output [s]
#BATT_INTERVAL       = 20
#BATT_ON_DURATION    = 10
```

```
20190110-133619.356 Reading Configuration File CONFIG.TXT
```

7. The time of the microcontroller is updated through the signals from the radio clock. This process usually only takes a few minutes.

```
20140101-120120.205 DCF77: Time Frame 1 is 20190110-132800

20140101-120220.205 DCF77: Time Frame 2 is 20190110-132900

20190110-132900.207 Initial Time Synchronisation

20190110-132900.000 DCF77: Time Synchronization 13:29:00 (MEZ)

20190110-132900.001 DCF77: Disabled
```

6.3 Periodic routine queries

6.3.1 Time update

Every 24 hours, during the night the time from the microcontroller is updated by the signals from the radio clock.

```
20190107-015500.000 DCF77: Enabled

20190107-015800.001 DCF77: Time Frame 1 is 20190107-015800

20190107-015900.001 DCF77: Time Frame 2 is 20190107-015900

20190107-015900.000 DCF77: Time Synchronization 01:59:00 (MEZ)

20190107-015900.000 DCF77: Disabled
```

```
Further outputs:

Log ("DCF77: Changing time zone from MEZ to MESZ");

Log ("DCF77: Changing time zone from MESZ to MEZ”);
```

If the DCF77 is not connected, there is no sync signal and no synchronisation.

6.3.2 Battery status query

At 11 a.m. and 11 p.m. the battery status is written on the memory as well as on the SD card. In addition, the current power demand is calculated. The range of the accumulator is calculated from data taken from the accumulator board. The remaining capacity and the current power demand are used for the calculation of the remaining range.

```
20190110-133619.088 Battery Remaining Capacity: 7811mAh

20190110-133619.096 Battery Runtime to empty  : More than 6 weeks

20190110-133619.103 Battery Actual Voltage    : 13.4V

20190110-133619.110 Battery Actual Current    :    5mA
```

6.4 **Recorded events**

One task of the Timed Animal Manipulation Data Logger is to record the behaviour of animals. In the Smart Feeder application this is achieved via recordings from the light barrier activity and transponder detections as well as via the closing of the shutter.

6.4.1 **Timer**

UA1_ON_TIME_1~5,UA1_OFF_TIME_1~5,UA2_ON_TIME_1~5, UA2_OFF_TIME_1~5,BATT_ON_TIME_1~5, BATT_OFF_TIME_1~5 [hour:min] MEZ

These variables determine the on and off times of the UA1, respective UA2 power output. If an RFID reader is assigned to an output, the UART will be activated additionally.

```
20190110-141100.001 Power Output UA2 enabled

20190110-141100.001 ADC is switched ON

20190110-141100.105 UA2     :  5.0V    1mA

20190110-141100.217 BATT_INP: 13.4V    1mA

20190110-141100.362 UA2     :  5.0V   29mA

20190110-141100.732 BATT_INP: 13.4V    1mA

20190110-141136.653 Transponder: 4B76C4B43A6F0001

20190110-141213.000 Transponder: 4B76C4B43A6F0001 ABSENT

20181218-124555.000 Power Output UA2 disabled

20181218-124555.000 RFID is powered off
```

6.4.2 **Standard recording**

In the following there are typical status messages:

```
20181122-152253.826 Power Output UA1 enabled

20181122-152253.853 UA1      :  0.0V  434mA

20181122-152253.956 BATT_INP: Battery Controller Read Error

20181122-152253.956 UA1      :  5.0V  515mA

20181122-152254.059 UA1      :  5.0V  461mA

20181122-152254.162 UA1      :  5.0V  513mA

20181122-152254.368 UA1      :  5.0V  531mA

20181122-152254.470 BATT_INP: Battery Controller Read Error

20181122-152254.882 UA1      :  5.0V  544mA

20181122-152254.985 BATT_INP: Battery Controller Read Error

20181122-152255.088 UA1      :  5.0V  581mA

20181122-152255.191 UA1      :  5.0V  570mA

20181122-152255.294 UA1      :  5.0V  534mA
```


6.4.3 **Power Good and Power Fail**

- Battery gets disconnected
- Power fail gets detected
- RFID Reader and CAM1 get switched off
- Battery gets reconnected
- normal function without reset, RFID Reader and CAM1 get reactivated on demand

```
4/18/2017 12:45:06.274 [RX] - 20170418-124506.221 Power-Fail: Received
interrupt (POWER FAIL)

4/18/2017 12:51:44.342 [RX] - 20170418-125144.296 LB1:ON

20170418-125144.402 LB2:ON

4/18/2017 12:51:45.030 [RX] - 20170418-125144.985 LB1:off

20170418-125144.986 LB2:off

4/18/2017 12:53:59.514 [RX] - 20170418-125359.436 Power-Fail: Received
interrupt (POWER GOOD)
```

6.5 Occurrences when it is not possible to write on the SD card

When the SD card is full or if there is no SD card is in SD card slot an error message is written on the LEUART-BUS. During a normal operation of the Smart Feeder application of the Timed Animal Manipulation Data Logger, it is not common that data is lost due to an absent or malfunctioning SD card, because the internal memory for events provides 2 KB, which should be sufficient for many events to be stored.

`ERROR: Log Buffer Out of Memory - lost 1 Messages` (only appears on HyperTerminal screen of the PC)

More error messages:

```
ERROR Config File - Line 131, pos 26, ID: OUT OF MEMORY
SMB_Reset: Try to recover from invalid state
SMB_Reset: Recovery failed, giving up
CfgRead: FILE OPEN - Error Code
CfgRead: FILE READ - Error Code
CfgRead: Line %d too long
Config File - Line %d, pos %ld: Invalid Variable Name
Config File - Line %d, pos %ld: Unknown Variable
Config File - Line %d, pos %ld: Unknown Variable
Config File - Line %d, pos %ld: Value expected
Config File - Line %d, pos %ld, %s: Invalid time
Config File - Line %d, pos %ld, %s: OUT OF MEMORY
Config File - Line %d, pos %ld, %s: Unsupported data type
Config File - Line %d, pos %ld: Garbage at end of line
LogError ("LogFileOpen: Error Code %d", res);
See if Log File is open */
LogError ("LogFlush: Init Failed");
LogError ("LogFlush: Error Code %d", res);
LogError ("LogFlush: Disk Full");
```

7 Procedure after button usage

The Timed Animal Manipulation Data Logger contains a button for conducting a reset.

After pressing the S1 button, the whole system will be restarted. The procedure of the restart is described in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**.

7.1 Update options

There are three possibilities to write software code on the flash memory.
The method of the Debug Probe and the one via the Debug Interface always work. If software was written on the flash memory via either one of these the methods examining the content of a newly inserted SD card and searching for software updates, a third method can be implemented.

7.2 IAR Systems Debug Probe

Through the debug probe from IAR systems it is possible to load compiled software code on the flash memory. The software from IAR for the debug probe is necessary for this.

IAR Systems also distribute the software IAR Embedded Workbench to create and compile C code. The compiled C code can be loaded on the flash memory by the debug probe.

7.3 With USB on 10-pole Debug Interface Connector

This method only allows HEX and BIN files to be transferred to the flash memory and has the benefit of the original C code not being readable anymore.

7.4 Via SD card and boot loader

If software has already been written on the flash memory by either of the methods from chapter 7.2 or 7.3 a third method through a boot loader is available. If the software of the flash memory contains the command to search for new software when recognizing a new SD card, this new software can be installed. (compare 0)

8 Contact details

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8. Links to the datasheets

Datasheets need to be saved within the folder ‘datasheets’, which has to be in the same content as the documentation. For every link there is a document within this folder.

EFM32G230

IAR J Tag ARM

LC display

SD card reader

Button

Capacitor

Lumbergstecker

USB cable

Down converter

LEDS

Radio clock

Light barrier

RFID reader

RFID transponder

Housing for the main board

Housing for the accumulator

Battery charger Fronius

Battery charger Mascot

Battery cell

