Version 1.1.1

Instructions

for the

Lemon Rx LM0051 and LM0052

DSMX-Compatible 7-Channel Integrated Telemetry Receivers

Contents

Introduction

The Lemon Rx 7-Channel Integrated Telemetry Receivers LM0051 and LM0052 combine in a single compact package the functions of a high performance DSMX-compatible radio control receiver and a full-range telemetry unit that supports Spektrum® and compatible telemetry-enabled transmitters.

The LM0051 sends back real time data to the transmitter on receiver voltage, temperature and RSSI (signal strength), and, with the included V/I external sensor, provides voltage, current and used capacity readings for the flight pack of an electric powered model. The LM0052 does all this and also provides altitude and vertical speed (vario) data from a built-in barometric sensor.

Note that there are also "U" versions of both receivers that do not include the V/I sensor; the sensor can be ordered from Lemon Rx as a separate item at a later date, but then calibration by the user is required.

The various parameters of telemetered data are displayed on the transmitter screen and can trigger audio tones or haptic alarms. Data values and alarms can be spoken by voice-enabled transmitters, including most second generation and above Spektrum units, as well as the FrSky Taranis/Horus, Turnigy 9XR Pro and others. The spoken read-out is virtually essential to take full advantage of telemetry, which becomes a significant distraction if it requires the pilot to look away from the aircraft while flying.

Throughout these notes, the two telemetry receivers will be referred to collectively as LM0051/52, except when discussing the altitude and vario features found only in the LM0052.

This manual is organized as follows:

Part 1: Essential Instructions provides all the information most people will require to use the LM0051/52 with a compatible Spektrum transmitter.

Part 2: Information for Advanced Users supplies additional material that some users may need.

Annex A: Voltage and Current Calibration explains how to reset the receiver to a V/I sensor.

Annex B: Voltage Sensing Wire Attachment offers options for connecting to the flight pack.

Annex C: Transmitters other than Spektrum covers the use of Lemon telemetry equipment with OpenTX or ErSky9x firmware in transmitters such as the FrSky Taranis and Turnigy 9XR Pro.

Annex D: Servo Output Timing explains the sequence in which control pulses are sent to the servos.

Overview of the LM0051/52

Performance

- Both the radio control receiver and the telemetry transmission functions of the Lemon LM0051/52 give exceptionally good range, operating to the normal limits of unaided visual flight and beyond. This is achieved by using efficient circuit design, as well as dual antennas and antenna switching to ensure maximum signal reliability in both directions.

- The low noise amplifier (LNA) in the receiver front end ensures maximum sensitivity to detect weak radio frequency signals. Users should experience a noticeable improvement in range compared to most other DSM2 and DSMX receivers and compatibles. Independent testing has shown this receiver to have significantly more range in a standard reduced power range test than several other comparable receivers tested under identical conditions. Performance of the LM0051/52, particularly telemetry, has been improved over the earlier LM0041 telemetry receiver.
- The unit has dual diversity antennas of the extended type for versatile placement in many types of application, including use in models with carbon fiber components. The active receiving/transmitting element is the last 32mm of the antenna cable, which has semi-transparent silver/white PVC shielding.
- In addition, a DSMX satellite receiver can be attached to the LM0051/52 to enhance signal security. Satellites with and without diversity switched antennas are available from Lemon Rx.

Compatible Transmitters

- Telemetry from the LM0051/52 can both be displayed on-screen and spoken by recent Spektrum telemetry-enabled transmitters: DX6G2/3, DX7G2, DX8G2, DX9 (all versions), DX10t, DX18 (all versions except the first), and DX18t. The new iX12 transmitter is fully telemetry-enabled.
- The current DX6e, as well as the older first generation DX8 and the original DX18, can display telemetry data on-screen and have some limited alert beeps and vibration, but lack voice capability and therefore cannot speak alarms.[1]
- Older Spektrum radios, such as the original DX7 and the DX6i have no telemetry functionality, and neither do such JR radios as the X9503.
- A general summary of the telemetry capability of Spektrum transmitters can be seen in this table.
- Of particular importance for many LM0052 users will be the functionality of the vario/altimeter feature with various Spektrum transmitters. It's important to understand the difference between "vario", which is a variable series of tones indicating rate of change of height (i.e., vertical speed up or down), and "altitude", which is a simple height-above-ground value that can be displayed or spoken. Both use data from the same barometric sensor in the LM0052.

When it comes to support for Altitude and Vario telemetry, there are basically four categories of Spektrum transmitter:

1. Older (up to about 2011) transmitters, including the original DX6, DX6i and DX7, as well as the JR X9303/9503, do not support any kind of telemetry.
2. The Generation 1 radios, DX8 and DX7s, can display altitude but not vario.
3. All the Generation 2 and above radios, from DX6 and DX6e to DX20, audibly support vario. That is they produce a tone variation when the model is rising or descending. They can also display the vertical speed and height on screen.
4. In addition, all speech-enabled transmitters can announce the height as well as display it, and also have better quality vario tones.

[1] Unlike the Lemon stand-alone telemetry unit, this receiver does not work with the now obsolete Spektrum TR1000STi Telemetry Interface for iPad and iPhone.

So for example, the low cost DX6e can display height and has adequate audible vario tones but cannot announce the height, as it is not speech enabled.

- The LM0051/52 also operates successfully with the Multiprotocol 4in1 and iRange add-on transmitter modules for the FrSky Taranis, Turnigy 9XRPro and other transmitters that accept a "JR" format external RF module. Recent versions of both OpenTX and ErSky9x firmware support telemetry, but the telemetry setup is somewhat different with such transmitters (see Annex C). The OrangeRX transmitter module can control the LM0051/52, but as supplied it does not support telemetry. It can be reflashed to do so with Multiprotocol firmware.

Telemetry

- Built-in sensors in the LM0051/52 provide receiver voltage, internal temperature and RSSI (signal strength). In addition, the LM0052 also includes a precision barometric sensor that reports altitude and vertical speed (vario).
- The included external sensor wires measure flight pack battery voltage for electric models (when connected to the positive side of the battery) and give a more accurate external temperature reading that automatically replaces the default internal value. The flight pack voltage sensor wire is only used when the voltage/current (V/I) sensor is not connected.
- The LM0051 and LM0052 include a voltage/current (V/I) sensor that measures up to 30V and 60A. This can be ordered in T-Plug, XT60 and bare wire versions. When the receiver is NOT supplied with a factory calibrated V/I sensor it is called an LM0051U or LM0052U. If an external V/I sensor is added to a U version at a later date, the receiver must be calibrated by the user.
- The unit sends an RSSI (Received Signal Strength Indicator) value, which starts at 100 when the receiver is right next to the transmitter and declines as the signal drops off with distance; the value is displayed as parameter "A" on the transmitter screen.[2] Fades, holds, etc. are not transmitted.
- RSSIout for support of an on-screen display (OSD) is also available from the receiver in the form of an analog voltage ranging from 3V (=100%) down to 0V. This can be accessed by using the third wire in the supplied external temperature lead.
- No separate airborne telemetry unit is required with this receiver. Nor can such a unit, Lemon or other, be connected, as the second data stream would interfere with that of the integrated receiver.

Failsafe

- The LM0051/52 offers a choice of three types of failsafe:
  - **No Pulse**: If no action is taken to set failsafe, the unit defaults to emitting no pulses on loss of signal. On an electric model, this normally results in the motor stopping within a second or so. Servos will tend to stay where they are but are not locked into position. The green LED is **OFF**.
  - **All-channel Preset**: Pressing the Failsafe button briefly while the receiver is in bind mode selects a failsafe mode in which, on loss of signal, all channels go to the position they were at when the button was pushed. The green LED is solidly **ON**.
  - **Throttle-only Preset**: A second brief press on the button gives a failsafe mode in which only the throttle goes to the position it was at when the button was pushed; all other channels hold their current position. The green LED is **FLASHING**.

---

[2] The Lemon RSSI values are not directly comparable to Spekrum or FrSky RSSI values.

LED Receiver Status Indicators

- There are three lights in the receiver:
  - **RED**: **Solid** – successful bind RF link to transmitter; **Flashing Rapidly** – bind mode.
  - **GREEN**: **Off** – No Pulse on signal loss; **Solid** – All-channel Preset failsafe; **Flashing Slowly** – Throttle-only Preset failsafe.
  - **BLUE**: Only used for user calibration of V/I sensor.

Operation

- The unit requires a power supply of **4.5V to 8.5V**. **It is important to note the minimum voltage**, which is higher than required by most Lemon receivers. In particular, this receiver cannot be operated from a single LiPo cell. It can be operated from a 2S LiPo or LiFe battery, however.
- The pins labeled Bind/AUX2 do double duty as bind pins and Channel 7 (AUX2) servo output; when a bind plug is present, the receiver shuts down servo output on these pins. Thus, the servo can be either: (1) connected when the bind plug is removed after binding; or (2) plugged into to one branch of a Y-cable, with the bind plug inserted into the other branch and then removed after binding.[3]

What You Get in the Package

The LM0051/52 comes with all necessary sensors, as shown in Figure 1. The flight pack Voltage/Current (V/I) sensor shown uses XT-60 connectors, but T-Plug and plain wire versions are also available.

The V/I sensor is included with the LM0051/52 as a standard factory calibrated item. When the V/I sensor is used, the Pack Voltage wire is not used.

The LM0051U and LM0052U versions do not include the V/I sensor. It is available separately, but when purchased as an add-on, the receiver has to be recalibrated by the user, as explained in Annex A. (Incidentally, the V/I sensor is the same as that used with the LM0041 receiver and LM0030 stand-alone telemetry unit.)

Figure 2 (below) shows what the LM0052 receiver looks like without its case and identifies the various connections. Weight without the case is 5.4 g (compared to 9.9g with case). The LM0051 is identical, except for the absence of the barometric sensor.

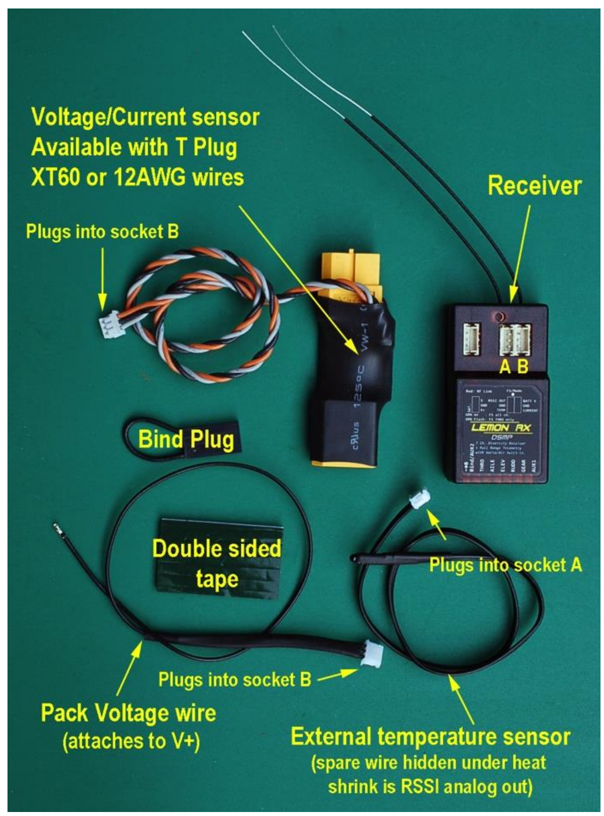


Figure 1: What's in the package

[3] Issues with previous Lemon receivers where low impedance electric retracts or servos on channel 7 (Aux2) would occasionally cause the receiver to go into bind mode have been addressed with this receiver.

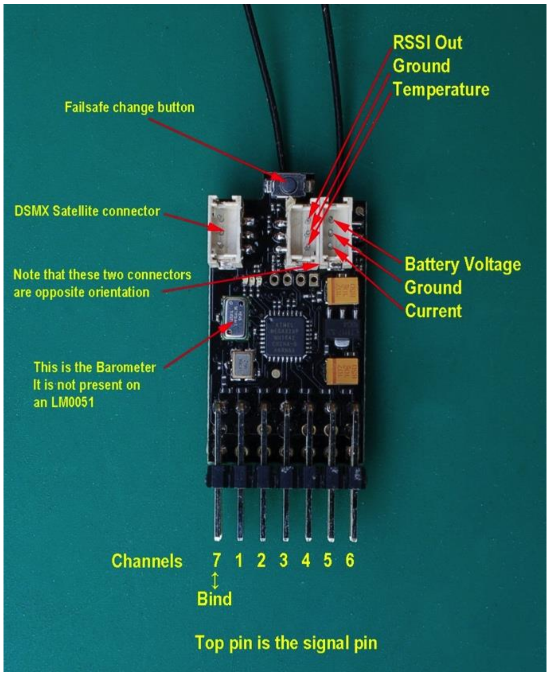


Figure 2: LM0052 with Case Removed

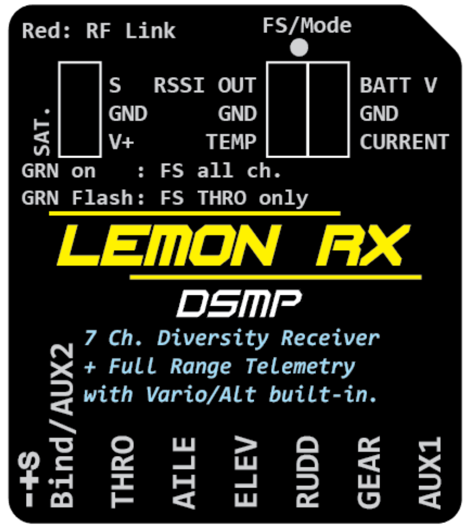


Figure 3: LM0052 label

The three white connectors for the satellite and the two telemetry leads are identical and when plugged in are not all oriented the same way. Note that the wires are not color-coded.

Take special care to follow the label on the case (Figure 3) when plugging in the connectors. Be especially careful if using the voltage sense wire, as connecting the pack voltage to the wrong pin will almost certainly cause damage. The label clearly identifies all the connectors, including their individual wires.

PART 1: Essential Instructions

A. Basic Requirements

Transmitter

To provide both radio control and telemetry, this receiver requires a Spektrum DSMX telemetry-enabled transmitter or compatible (see current list of suitable Spektrum transmitters on page 2). For use with a non-Spektrum transmitter, such as the FrSky Taranis or Turnigy 9XR Pro, see Annex C.

The receiver provides output to the servos at 22mS frame rate, even if the transmitter has been forced into 11mS mode. If the screen shows binding at DSMX 11mS, this only means that the connection from transmitter to receiver is operating at the higher frame rate (giving the advantage of more frequent reception of data packets). The receiver converts the rate down to 22ms when it outputs the information, thus ensuring maximum compatibility with any kind of servo.

The LM0051/52 will function as a receiver only (no telemetry) with a wide range of other Spektrum transmitters and modules, including older DSM2 units, as well as with various compatible transmitters and modules. With a DSM2 transmitter, or a DSMX transmitter in DSM2 mode, the receiver will automatically switch to DSM2 when it detects the bind signal.

Power Supply

This receiver requires a higher minimum voltage power supply than most other Lemon receivers, although it will recover well from brief low voltage brownouts. Ensure that under load your BEC or receiver battery does not fall below the 4.5V minimum at any time.

Be aware that some cheap "3A" BECs, especially those integrated into ESCs, are optimistically rated and can easily be overloaded by multiple servos and other high drain devices such as are found in some modern park flier size "Ready to Fly" aircraft equipped with retracts, flaps, lights, sound systems, etc. In addition, stabilizers, now used with increasing frequency, add to the load generated by the servos.

Some 4.8V NiMH receiver packs also have limited current capability and may drop voltage significantly under load; be sure to use cells that can deliver adequate current for the load placed on them.

See Annex D for a discussion of how the receiver outputs information to the servos and the possible implications of this for power requirements.

B. Binding the Receiver

Binding requires that the receiver be put into bind mode (red light flashing) and that the transmitter then be powered up in its bind mode (see the transmitter manual for specific instructions).

Procedure

1. With transmitter OFF and no power connected to the receiver, insert the bind plug into the first set of pins, labeled Bind/AUX2 (Figure 4). If a satellite is to be used it must be connected while binding.
2. Provide power via ESC, BEC or separate receiver pack (here an ESC is connected to channel 1). Once the battery is connected, a rapidly flashing RED LED beneath the receiver (and on the satellite if used) indicates bind mode. Do not proceed to step 3 unless the light is flashing correctly.
3. Turn on the transmitter in bind mode approximately 2 meters away from receiver. The receiver LED should change to slowly flashing, then to steady RED indicating successful bind (see Figure 5). If you don't get a solid red light on the receiver (and satellite if used), see the advice below.
4. For **default operation** of the receiver, remove the power and bind plug at this point;

   OR, to set Failsafe leave power connected and bind plug in place (see Section E, below).

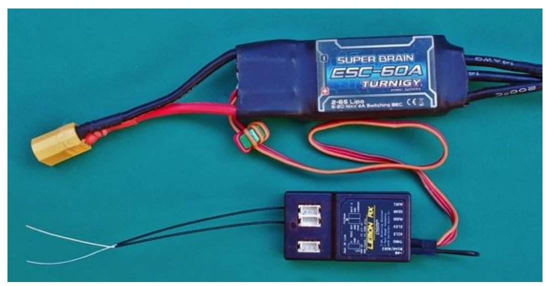


Figure 4: Bind plug inserted, no power.

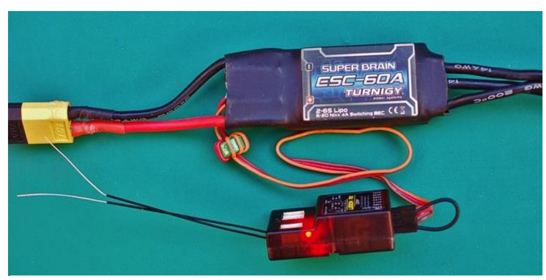


Figure 5: Solid red light indicates successful bind

Binding Problems

It is not unusual to encounter difficulties binding DSM-type receivers, with the receiver either continuing to flash rapidly or starting the bind process but never attaining the solid light that indicates a link. Being very sensitive, the Lemon RX Telemetry Receiver may be a little fussier than usual about bind conditions.

Bind problems can usually be overcome by simply increasing the distance between transmitter and receiver during bind. Even then, more than one try may be needed to achieve success. For each try, repeat the entire sequence, starting with both receiver and transmitter powered down.

If binding fails at 2 meters, start again, moving further away before turning on the transmitter in bind mode, and have your body between the transmitter and receiver to attenuate the signal further. When binding, stay away from metallic objects (such as cars, wire fences and steel tables), as well as damp ground and other conductive surfaces. Wireless routers and other WiFi sources can also inhibit binding.

C. Installation

The receiver should be installed using normal good practices for 2.4 GHz equipment. Particular attention should be paid to the location and orientation of the active portions of the dual antennas (the last 32mm of the cable, from which the outer sheath has been removed to expose the silver/white inner cable). The two antennas should be routed so as to achieve wide separation and the active portions should be approximately at right angles to each other. Do not align the antennas side-by-side or in line.

The active portions of the antennas should be reasonably straight for optimum receiving and transmitting performance, but the rest of the cable can be curved gently as required. The coaxial cable used for antennas is fragile and must not be kinked or allowed to flop around or vibrate excessively.

The active portions of the antennas should not be immediately adjacent to conductive items such as wiring, ESC, battery or carbon fiber that could block the signal (note that non-conductive materials like most foam, balsa, ply, etc. pose no problem[4]). The antennas should be located so that, regardless of the attitude of the aircraft, at least one of them has a clear line of sight to the transmitter. For example, it is important to avoid locating the active portions of the antennas where both can be simultaneously blocked by the battery from receiving a good signal.

A more comprehensive treatment of these issues can be found Parts 2A and 2B of these Instructions.[5]

D. Testing

It is important to conduct a rigorous reduced-power range test before the first flight. The model should be placed up off the ground on a wooden table or similar non-conductive support. Put the transmitter into Range Test mode (see transmitter manual). With the receiver turned on, walk away about 25m (30 paces) and then circle the model while testing control. If there are any points at which control is reduced or lost, go back and review the installation. In this mode, the receiver should provide full control well beyond 25m, while at normal transmitter power in the air the range will typically be about 30 times that seen in Range Test mode. This should be more than adequate for all normal visual flying.

If telemetry is functional, the RSSI value should be monitored during the range test; this will help to identify any problems with the installation. There is more information about RSSI in Part 2A.

At the beginning of each subsequent flying session, a brief reduced power test at 25m should be done to check that all is working properly. There is no need to repeat the circling of the model.

---

[4] Some foam plastic and heat shrink tubing is conductive and can interfere with reception. To test a material, zap it in a microwave oven for a few seconds. If it warms up, it should not be used near the receiver or antennas. To avoid overloading the microwave, put a cup of water into the oven at the same time.

[5] Further information can also be found in the Lemon Stabilizer PLUS Reference Guide under “Appendix1: Diversity and RSSI”.

E. Failsafe

The receiver will enter failsafe mode whenever it is unable to receive a control signal from its bound transmitter for about one second or more (this should be a very rare event). Once a valid signal is again detected, the receiver will resume transmitter control. Three types of failsafe behavior can be selected for the LM0051/52:

No Pulse: If failsafe is not deliberately set, the default action when signal is lost is for the receiver to cut off pulses on all channels. This will cause most modern electric speed controls (ESCs) to shut down the motor within a second or so and will leave servos wherever they happen to be at the moment (but not actively driven by the receiver). In this mode, the green LED on the receiver is **OFF**.

> ***WARNING**: The default No-pulse failsafe is unsatisfactory for IC (fuel) powered models, as the engine will continue to run at the power set by the throttle servo when the signal was lost.*

All-channel Preset failsafe, indicated by the green light solidly **ON**, provides specific outputs on each of the seven channels in the event of signal loss.

Throttle-only Preset failsafe, indicated by the green light **FLASHING**, sends the throttle to the position it was at when the receiver was bound and failsafe set. All other channels hold their position as it was at the moment of signal loss.

The two Preset Failsafe modes (all-channel and throttle-only) are activated as follows:

1. For electric models, remove the propeller(s) or otherwise ensure that the model is safe.
2. Follow the bind steps previously specified (on page 6) from 1 to 4. DO NOT remove the bind plug or power down at this point.
3. For **All-channel Preset**, adjust the sticks, switches, etc. to the desired failsafe outputs.

   For **Throttle-only Preset**, set the throttle stick to LOW.

   In either case, for most powered models, the critical requirement is that throttle go to LOW.
4. For **All-channel Preset**, press the Failsafe button on the receiver briefly ONCE (less than 1 second); the green light should now be solidly **ON**.

   For **Throttle-only Preset**, press the Failsafe button briefly AGAIN (i.e., press TWICE in quick succession); the green light should now be **FLASHING.**

   Note that pressing the button cycles through the three options: OFF, All-channel, Throttle-only.
5. Power off the receiver and **remove the bind plug**. Failsafe will not work if the plug is still in place.
6. Power up again to test failsafe. Set the throttle to some position above low so the motor is running or the throttle servo is not at low. Turn off the transmitter, wait a short time and verify that the throttle control goes to zero (and for All-channel Preset, other controls go to their set positions).
7. Turn the transmitter back on and verify that transmitter control resumes after a very brief pause. Note that if the transmitter is turned off, recovery from failsafe will not occur until the transmitter is again fully operational and linked to the receiver, which may take some time (so don’t do this test in the air!).

To cancel a Preset Failsafe setting, repeat the process, starting by powering up the receiver in bind mode and proceeding to press the button repeatedly until the green light is OFF.

Normally, failsafe status and channel settings are retained by the receiver until deliberately reset. However it is possible to change the setting unintentionally while calibrating the V/I sensor (see Annex A). Always check the failsafe setting after such operations.

F. Telemetry

The following assumes the use of a telemetry-enabled Spektrum transmitter.[6] For non-Spektrum transmitters, see Annex C.

For setting up telemetry, the receiver must be bound to the appropriate model in the transmitter and powered up with all sensors connected. Go to Function List or System Setup and choose Telemetry.

Fields

The following parameters will be normally be displayed, depending on the availability of sensors:[7]

- **Receiver voltage**. Automatic, no external sensor or lead required. Note that this is not the flight pack voltage.
- **RSSI** – signal strength. Automatic. Displayed on transmitter under parameter "A".[8]
- **Temperature.** Automatic transmission of internal temperature. For maximum accuracy, however, the external temperature sensor provided should be connected.
- **Battery voltage** (flight pack). If a V/I sensor is not used, this requires a connection to the battery positive using the voltage sensing wire provided.

  HINT: To monitor flight pack voltage without modifying the high current power wiring, attach the voltage sensing wire to the most positive pin of the LiPo balance connector.
- **Battery current** (flight pack). Requires that the V/I sensor be inserted into the main power lead.[9] The V/I sensor then replaces the voltage sensing wire and provides both current and voltage information, as well as Flight Pack Capacity (mAh) used.
- **Altitude** (LM0052 only). Automatic, no external sensor or lead required.
- **Vertical Speed** – commonly called Vario (LM0052 only). Automatic, no external sensor or lead required. Not available on a DX8 Gen1 transmitter.

In addition, **RSSI** is available for use with an OSD (On Screen Display) used with an FPV (First Person View). The RSSIout value is present on the spare wire of the external temperature sensor cable. The analog voltage output varies in proportion to RSSI from 3.0V down to 0V as the signal diminishes.

WARNING: Do not plug the voltage sensor cable into the temperature sensor socket! *If a battery is attached, doing so is almost certain to damage the receiver.*

---

[6] For best telemetry support, make sure you update the transmitter to the latest available Airware version (currently 1.20 for most transmitters).

[7] There may be differences in the display of telemetry for first generation DX8 and DX18 transmitters.

[8] Not to be confused with the Spektrum Signal % parameter, which is also a measure of RSSI but not directly comparable.

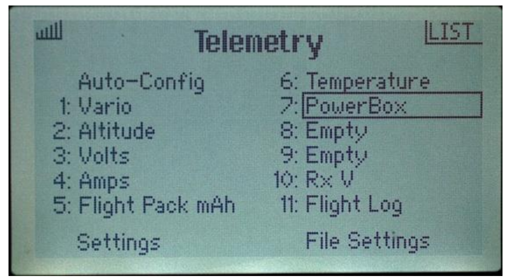
[9] This sensor is included, factory calibrated, with the LM0051 and LM0052 receivers. It can be purchased separately and added to an LM0051U or LM0052U, but must then be calibrated (see Annex A).

Note that **PowerBox** fields are available to, but not normally required by, modern Spektrum transmitters. They can, however, be used by the first generation DX8 and DX18 (which do not have a Battery Capacity field).

Setup

The first item in the ***Telemetry*** menu is **Auto-Config**. In most cases, selecting this will recognize and configure the available parameters, but individual items can be reconfigured separately as required.

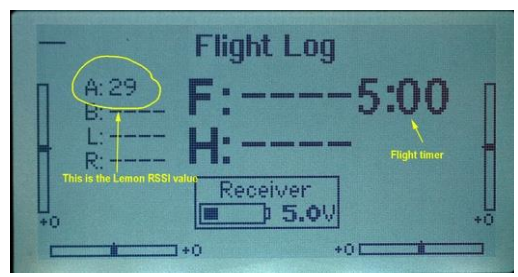
Auto-Config provides basic setup for on-screen telemetry display. It does not enable the voice and tone signals that are an essential part of using telemetry effectively without the pilot having to look away from the model. To set these, it is necessary to go to the relevant items on the Telemetry page and select how they will be reported.



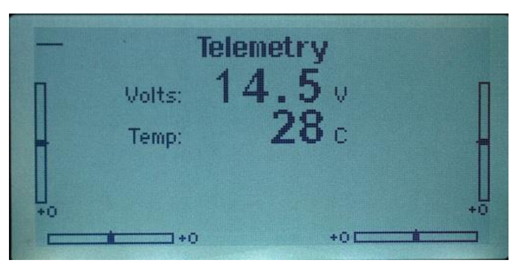
Use the roller to move between the fields and click to select one. You can then choose what is displayed. For example, under most items, the menu allows that particular parameter to be displayed or inhibited, sets minimum and maximum values for purposes of triggering a tone or voice alarm, and determines whether status and warning reports are issued at intervals of 5 to 60 seconds. The Vario item presents a different set of options, in keeping with the audible and graphical nature of the readout; the delay in reporting can be selected from ¼ second to 3 seconds, the on-screen graph can be set to a width of 5 to 60 seconds, and the minimum lift or sink speed to be indicated by audible beeps can be adjusted from 1 to 9.9 m/Sec (3.2 to 32.4 Ft/Sec).

On the Telemetry screen is also a **Settings** item, which leads to a choice of how the telemetry display is selected and whether metric or US units are used.

The **File Settings** item on the Telemetry page allows the filename and method of activation to be set for data logging.

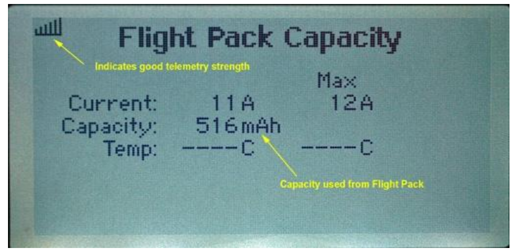


The various display fields are generally self-explanatory but there are some differences between Spektrum and Lemon telemetry. In particular the LM0051/52 provides none of the Fade, Frame loss or Hold information normally found in the Spektrum ***Flight Log*** display. Instead Lemon provide a single RSSI number (100->0) in the "A" field that shows received signal strength.

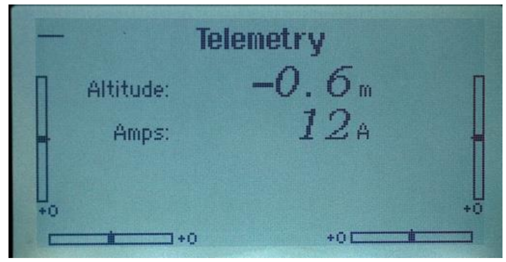


Assuming that the V/I sensor is installed in the main power cable, the ***Telemetry*** screen will show Flight Pack Volts. The Temperature reading will use the internal sensor unless the external sensor is plugged in, in which case the reading from the sensor at its tip will be displayed.

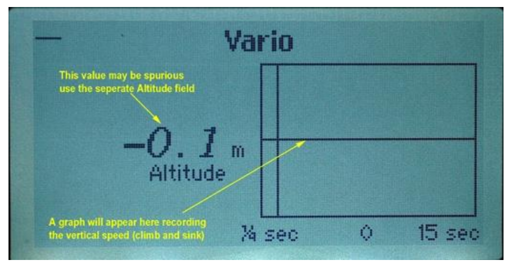
The ***Flight Pack Capacity*** screen uses the Current reading from the V/I sensor to measure the usage of battery capacity in terms of milliampere-hours (mAh). The display is set to zero when the receiver is plugged in and counts up as power is consumed (very slowly when the receiver is just idling). This screen also displays Imax, the maximum current recorded to this point in the flight. The Temperature fields on this screen are not used by Lemon telemetry.



A further screen labeled ***Telemetry*** provides Altitude (in m or ft) and flight pack current (in Amps).

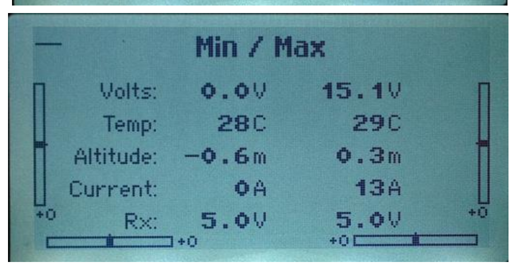


The ***Vario*** display presents a graphic readout of Vertical Speed over a chosen period of time. It also includes an Altitude number, the value of which may differ slightly from that displayed on the Altitude/Amps screen. This is of no practical significance and either value may be used.[10,11] The altitude displayed is Above Ground Level (AGL).



The altitude automatically resets to zero when power is applied, but due to atmospheric fluctuation a small negative value for Altitude is often displayed while on the ground.

The *Min/Max* screen gives a summary of values recorded during the flight.



G. Connecting Servos

The receiver outputs standard PWM (Pulse Width Modulation) servo signals, with the signal for each channel available at the corresponding pin, as marked on the case. This allows servos to be plugged directly into the receiver in the usual way.

The LM0051/52 operates at 22ms frame rate and can drive both analog and digital servos.

Channel 7 (Aux2 in Spektrum terms) pins do double duty as bind pins and servo output pins.

Unlike the older LM0041, the LM0051/52 does not have the option of a PPM output.

---

[10] For technical details, see “Why you may get two slightly different altitude values”, page 20.

[11] On some Spektrum transmitters the reading may just fluctuate around zero – if so use the main Altitude field.

PART 2. Information for Advanced Users

A. RSSI (Signal Strength)

The RSSI (Received Signal Strength Indicator) number is sent back from the model by telemetry and displayed in the "A" field on the transmitter screen. It represents the strength of the radio signal available from the receiver front end for control of the model. It should read close to 100 when the transmitter is next to the model and drop with distance until, at a value typically around 20-30, the telemetry signal is no longer strong enough to convey the data and the display freezes. The telemetry range of the LM0051/52 is significantly better than the earlier LM0041. The receiver has excellent sensitivity and reliable control will continue well beyond this point.

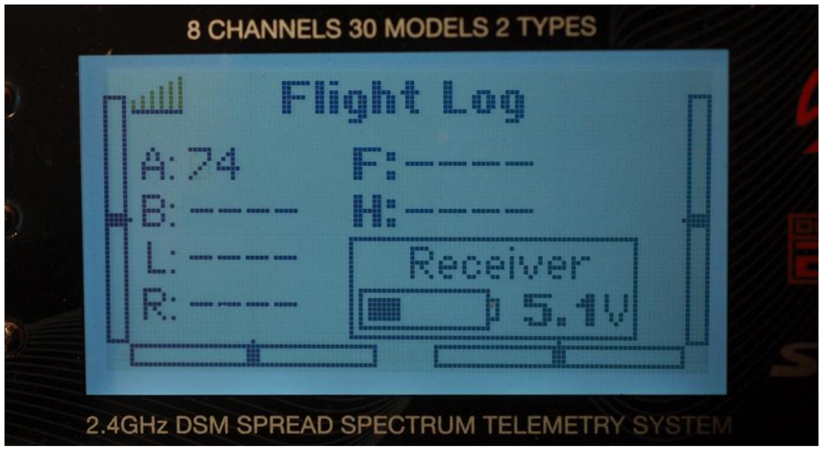


Figure 6: RSSI value of 74 displayed on a DX8G1 screen in the "A" field

The vertical bar symbol in the top left shows that telemetry is live and being received. Depending on the transmitter and Spektrum software the number of bars may give an indication of the telemetry signal strength.

While RSSI values below about 20 are unlikely to be seen on the transmitter telemetry screen, the RSSI voltage displayed on an OSD (On-Screen Display) may continue to be valid at much lower levels, as this form of display does not rely on the relatively low power telemetry transmission from the receiver.

Changes in the RSSI reading can be conveniently explored with the transmitter in Range Test mode. Note that putting a Spektrum transmitter into Range Test mode attenuates output power enough to reduce range by a factor of about 30.[12] Thus effective control at 35m (115 feet) in Range Test mode (which should be easily attained) should translate to about 1 km (3600 feet) range at full power. There are, however, many variables involved, so treat this as only a rough guide. There is a very good probability that you will get much greater range than this.

The Lemon RSSI number is a relative value and cannot be directly compared to other signal indicators such as antenna fades reported by Spektrum or the FrSky RSSI number. Lemon has stated that the maximum signal measured after the LNA front end when the transmitter and receiver are right next to one another is displayed as a value of 100. A drop in "RSSI" by one unit corresponds to a drop in signal strength of approximately 0.6dBm. At the Lemon recommended minimum reading of 20 the signal is therefore 0.6 x 80 = 48dB down. While the receiver has a lot of reserve sensitivity and should continue to work even beyond that point, it is not recommended that this be taken for granted.

An additional RSSI output (RSSIout) is available for FPV use where the RSSI value is transmitted back by the FPV camera/telemetry system. This RSSI signal can be accessed as an analog voltage varying from 3V

[12] Since range is related to the square of power, to reduce range by a factor of 30 requires a cut in power by a factor of about 900. Range test power is thus typically around 0.1 mw.

(max.) to 0V by using the supplied external temperature cable. A third wire is enclosed in the sensor harness and connects to the RSSIout pin. This wire can be as data input to an FPV setup.

B. Antennas and Satellites

This Lemon receiver is described as full range for both control and telemetry. In fact this receiver has a particularly sensitive Low Noise Amplifier (LNA) front end and should better the range of other comparable DSM2/DSMX receivers under the same conditions. However range is affected by the number of aerials (antennas) and their orientation, as well as by the installation in the model.

This receiver has two antennas, but only one is used at a time. An electronic switch determines which antenna is active and switches to the other antenna instantaneously if the signal strength drops below a certain threshold. No signal is lost during the switch-over. This antenna switching technique is commonly called “diversity” in the RC world, although in a broader context it is just one of several signal diversity strategies.

The LM0051/52 also has a connector to allow the use of a satellite receiver for additional signal robustness. This represents a further type of diversity, in that the main receiver can select the signal from its own pair of antennas, or that of the satellite.

Switching to a satellite takes a fraction longer than between the two main antennae, but is generally not noticeable. Switching time for the LM0051/52 has been further improved over previous Lemon receivers and is, for practical purposes, instantaneous under all conditions of antenna signal loss.

Dual diversity antennas and satellites do not increase the maximum possible range. Rather, they increase the probability that a reliable signal will be obtained no matter the orientation of the model. Note that satellites with diversity antennas are now available, giving up to four separate signal sources for the receiver/satellite combination.

The antennas we use for radio control radiate (and receive) in all directions, but the signal is much weaker off the ends of the antenna (the last 32mm that represents the active portion of the cable) than "broadside" to it. Think of an ancient naval battle where the ships had very little firepower fore and aft because most of their cannon were pointed out the sides.

To achieve the most reliable possible link to the model, therefore, we want to avoid situations in which the transmitter and receiver antennas are end-on to each other. For the transmitter, the traditional advice to the pilot is simple: don't point the antenna at the model.[13]

For the receiver, things are more complicated because the model is constantly changing its orientation in relation to the transmitter. A single receiver antenna will inevitably be pointed at the transmitter some of the time. This is where dual diversity antennas come in. If the receiver has two active antennas positioned at right angles to each other, they can never both be pointed at the transmitter simultaneously. The receiver can always switch to the antenna that is giving the better signal right now. That's what diversity switching does.

Diversity improves the reliability of the RF link in other ways. If the two receiver antennas are well separated, at least one should have a clear view of the transmitter, minimizing the risk of signal blanking. As well, with antennas at right angles one of them should be roughly parallel to the transmitter antenna, thus aligning polarization for a stronger signal.

---

[13] The most recent Spektrum transmitters use two antennas at right angles to avoid this issue. These “diversity” transmitters include the DX6G3, DX8G2, DX9, iX12 and DX20.

Conductive materials such as foil coverings, batteries, metal components and carbon fiber can absorb and shield the incoming radio signal. 2.4GHz systems have a very short wave length and are susceptible to this. Receiver aerials need to be placed so that this effect is minimized.

What all this means for the installation of the receiver is simple. Make sure its two antennas are separated as far as practical from each other and from conductive stuff like battery, wiring and carbon fiber, and keep the active portions (the last 32mm) reasonably straight and at right angles to each other.

If a satellite is connected for additional diversity, it should be well away from the main receiver, not right next to it. Align it so the satellite aerial(s) and at least one main receiver aerial are at right angles.

Don't get paranoid. The installation doesn't have to be perfect to support an adequately strong RF link. Our modern receivers do a remarkably good job of picking up the signal, even with just a simple single antenna, so diversity can be thought of as extra security for when the going gets tough.

C. Power Consumption and Voltage

This telemetry-integrated receiver draws approximately 60 mA with no servos connected, a somewhat higher current than some normal receivers. For comparison, the Lemon DSMX-Compatible 7 Channel Stabilized Receiver draws about 55 mA and the Lemon DSM2-Compatible 6 Channel Feather Light Receiver draws about 25 mA. None of these values is regarded as a significant current load compared with even a single servo however.

It is more important to recognize that the minimum operating voltage of the Telemetry receiver is 4.5V compared to 3.45V for other Lemon receivers. This means that this receiver cannot be operated directly from a single LiPo cell as used in some DLG applications but must use either a voltage booster or a higher voltage pack.

Lemon’s recommended upper voltage limit for the LM0051/52 is 8.5V, meaning that, unlike some previous receivers, the unit can be safely powered by a 2s LiPo battery (8.4V fully charged). A 2s LiFe battery or four or five cell NiMH battery can also be used.

D. Creating and Reading Telemetry Log Files

Spektrum telemetry-enabled transmitters can record on the SD card a log file of the data sent to the transmitter by the receiver. This is controlled entirely by the transmitter; no receiver setup is required.

The options available at the transmitter specify whether recording is enabled, if so, how it is to be started, and the name of the resulting file. Refer to your transmitter manual for specific instructions. You may want to assign a switch to start and stop logging, or you may prefer to have it start automatically as soon as the throttle is advanced.

The log files are saved on the SD card in the transmitter, along with the various audio files, model setup files, etc. The log files have the same name as the corresponding model files but with an extension of *.TLM* rather than *.SPM*. To read Spektrum log files you need a program specifically designed for the purpose. There are currently two choices:

1. The official Spektrum approved and supported *Spektrum Telemetry Viewer* software was written by ROBO Software for both Windows and Mac (OS X). It is available as a 30 day trial and to purchase for US$19.99.
2. The excellent and versatile *Tlmviewer* program was written by modeler Mike Petrichenko. This is a Windows-only program and is free but contributions are suggested.

Here is an example of the Altitude readings from a flight log of a motor glider. The log from the SD card is read and graphed by *Tlmviewer*, and there is a great deal of flexibility as to which variables are plotted and how they are presented on the graph.

It is also possible to export data from *Tlmviewer* as a *.csv* file and then import into Microsoft Excel, where it can easily be displayed in various alternative formats.

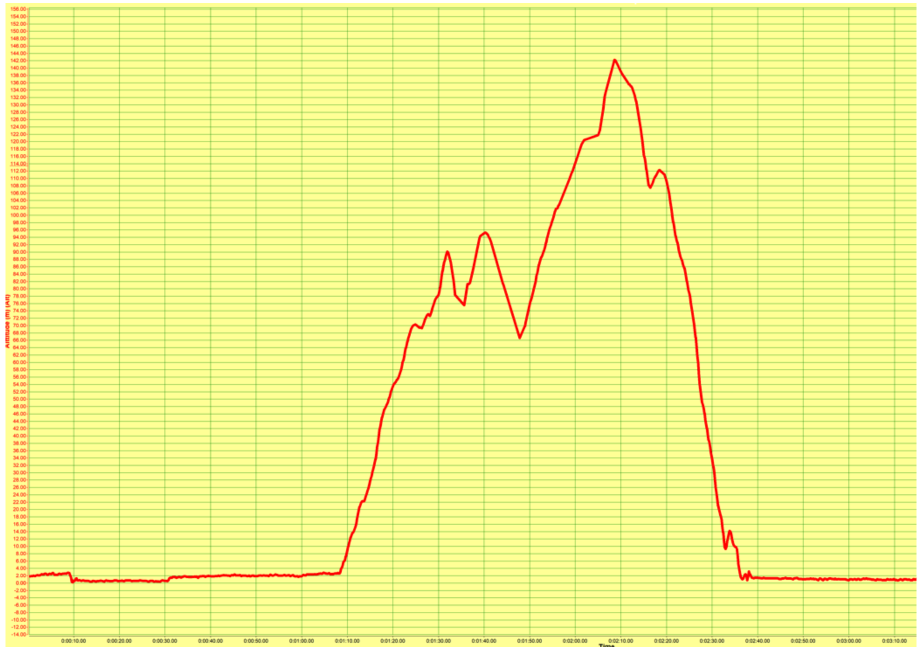


Figure 7: *Tlmviewer* graph of altitude (in meters) vs. time in flight

Annex A: Calibrating Voltage and Current

The LM0051/52 comes packaged with a Voltage/Current (V/I) sensor, to which it is specifically calibrated at the factory. Any time a receiver is paired with a new V/I sensor, it must be recalibrated. [14]

A voltage sensing wire is included with the receiver, to be used only when a V/I sensor is not present. The LM0051/52 is calibrated only to the V/I sensor and so **must** be recalibrated to use the wire.

The LM0051U and LM0052U are not calibrated from the factory and must be calibrated by the user if either the optional V/I sensor **or** the included voltage sense wire is to be used.

NOTE: Do not calibrate the sensors unless you have to. The procedure described below will not result in higher accuracy than factory calibration (which is very good) unless you have access to a high precision voltage source and current generating equipment.

1. Recalibrating the Receiver for the Optional V/I Sensor

The Lemon Rx V/I sensing module provides both battery voltage and current sensing and must be matched to a specific receiver. Recalibration of the receiver, as explained below, is needed whenever a V/I sensor is paired with a receiver for the first time.

If the receiver was supplied as the LM0051U or LM0052U, it is not calibrated and must therefore be calibrated to any V/I sensor purchased separately.

An adequate calibration can be performed using a two-cell fully charged LiPo battery and Wattmeter.

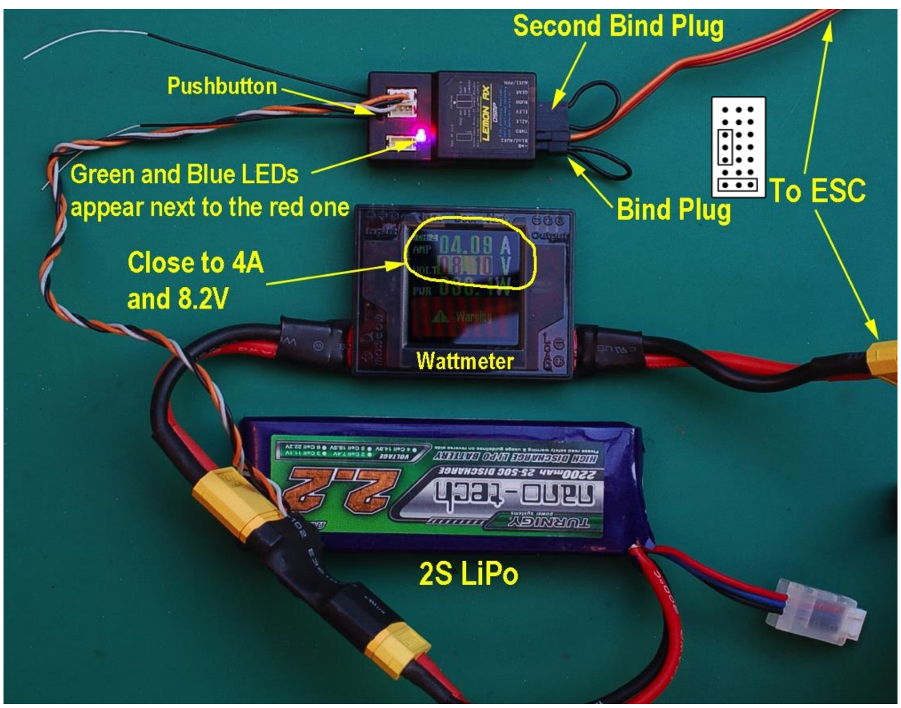
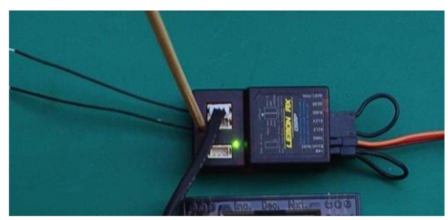


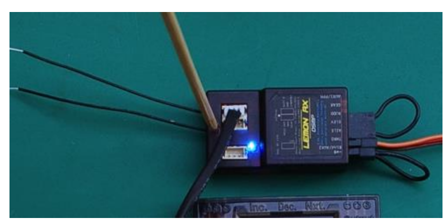
Figure A.1 – V/I sensor connected to battery output. Note positions of the two bind plugs.
The system is under load and the wattmeter is showing 8.10V and 4.09A.

[14] The calibration procedures presented here apply equally to sensors used with the LM0041 Telemetry Receiver and the LM0030 Telemetry System.

Procedure

1. First verify that, when powered, both blue and green lights on the receiver are OFF. If necessary, go back to the instructions for Failsafe (page 7) and reset.
2. Then with no power connected, insert a bind plug vertically on the bind pins. Insert a second bind plug horizontally between aileron and rudder signal pins (not throttle and elevator – see Fig. A-1).
3. Connect the V/I sensor to a fully charged two-cell LiPo battery. This will provide the necessary approximately 8.2V source under load.[15] Figure A.1 shows the meter connected in series. It must be able to measure current of at least 5A.
4. To draw an appropriate current for calibration of the sensor, connect the ESC to a brushless motor that is known to draw more than 4 amps. It may be necessary to install a propeller on the motor to create the necessary load – be VERY careful if this is done to ensure that the motor is safely mounted. Be sure to disconnect the motor when finished calibration.
5. Connect the ESC to the receiver throttle channel pins. If the ESC lacks an internal 5V BEC, a separate BEC can be used to provide receiver power. The receiver supply must be 5V as the Rx voltage value in the telemetry is calibrated at the same time as the flight pack voltage.
6. Connect the ESC (and separate BEC if used) to the 2S LiPo. Check that the RED LED beneath the receiver is flashing rapidly to indicate bind mode.
7. Turn on transmitter in bind mode approximately 1-2 meters away from the receiver with the throttle stick at low. The receiver should change from slowly flashing to steady red, indicating successful bind (see page 6 for details). Make sure transmitter telemetry is set up to display battery voltage and current.





8. Press the receiver button briefly (less than 1 second). A **GREEN** LED means the voltage reading is calibrated and current sensing bias is set at 0A. The transmitter telemetry page should display either 8.3V or 8.4V as battery voltage[16] and 0A for current.
9. Move the throttle stick to start the motor (be careful!) and adjust until the current draw shown on the meter is as close as possible to 4.0A.
10. Press and hold the receiver button until the **BLUE** LED turns on (about 1.5 sec), indicating that current sensing is calibrated.[17]
11. With the system still drawing 4A, check that the transmitter telemetry page shows a current reading of 3 or 4A.[18]
12. Turn off the receiver and **remove both bind plugs** to complete voltage and current calibration.

---

[15] The battery needs to be able to supply a 4A current without undue voltage drop. It is recommended that the battery be at least 1000 mAh with at least 20C rating. Although 8.4V is recommended for the voltage calibration, it is unlikely the LiPo will do better than 8.1-8.2V while supplying 4A.

[16] Note that 8.39v will display as 8.3v because of the lack of a second decimal digit in the Spektrum transmitter display. The more precise value is used internally and can be logged.

[17] If the button is released before the blue LED comes on, throttle off, briefly press the button a few times until the blue LED is off, and then start setup again at step 8.

[18] Note that 3.9A will display as 3A because of the lack of a decimal digit in the Spektrum display; this 1A precision is ample for most purposes. The more precise value is used internally and can be logged.

Don't forget to re-bind the receiver (with satellite attached, if used) and to reset Failsafe to suit your setup, if necessary.

HINT*: Calibration can be done in two parts. The receiver remembers the current calibration value even if you do the voltage calibration subsequently.*

First calibrate the current value with a constant 4A load. Any battery from 2s to 6s that is compatible with the motor and ESC can be used. Go through steps 1 to 7, skip step 8, then complete steps 9 to 10.

Next do the voltage calibration as in step 7 and 8, using either a 2s battery or a variable voltage supply and without a 4A current load. This will result in more accurate voltage calibration than if trying to do both calibrations at once.

Finally go to step 11 and 12 to complete the calibration process.

2. Recalibrating the Receiver for the Voltage Sensing Wire

A voltage sensing wire is provided as a standard item to allow Flight Pack Voltage to be measured without the use of the optional V/I sensor. If a V/I sensor is present, the voltage sensing wire cannot be used.

The LM0051/52 is pre-calibrated to use the V/I sensor. If the voltage sensing wire is used instead, it must therefore be recalibrated as explained below.

The LM0051U and LM0052U are not pre-calibrated to use either the V/I sensor or the voltage sensing wire.

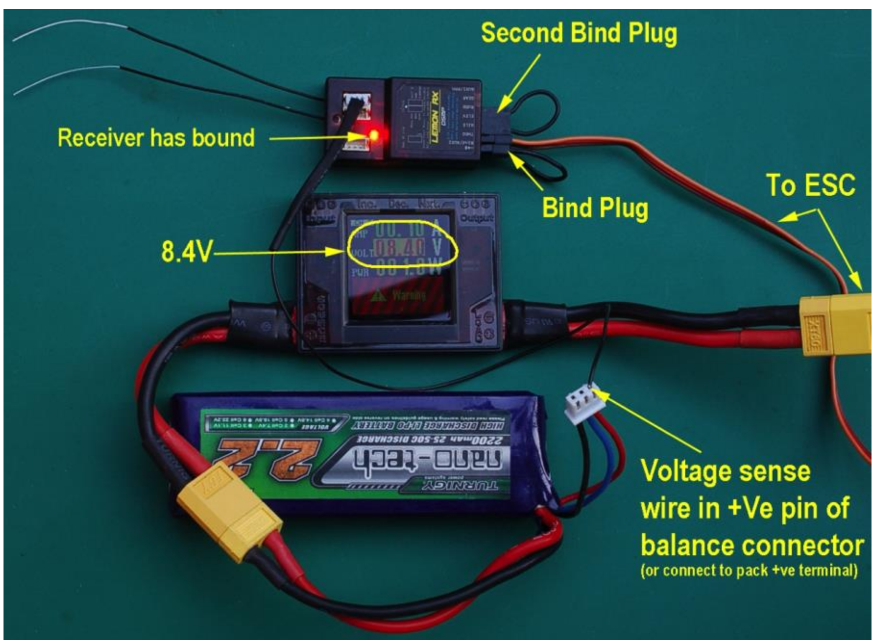
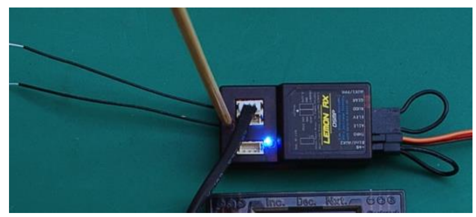


Figure A.2 – Voltage sensor wire connected to battery V+. Note the two bind plugs and wattmeter.

Procedure

1. First verify that, when powered, both blue and green lights on the receiver are OFF. If necessary, go back to the instructions for Failsafe (page 7) and reset.
2. With no power connected, insert a bind plug vertically at bind location, as in the normal bind procedure. Insert a second bind plug horizontally between aileron and rudder signal pins (top ones).

3. Connect the voltage sensing wire to the positive side of a 8.4V source. A fully charged two-cell (2s) lithium-polymer (LiPo) battery will provide an adequately accurate reference voltage. See Figure A.2.
4. With the battery disconnected, connect a speed control (ESC) with integral 5V BEC or a separate stand-alone 5V BEC to the receiver. Any available servo pins can be used (center pin is positive, lower pin is ground). The receiver supply must be 5V as the Rx voltage value in the telemetry is calibrated at the same time as the flight pack voltage.
5. Connect the ESC to the two-cell LiPo battery. The RED light should be flashing rapidly beneath the receiver to indicate bind mode.
6. Turn on the transmitter in bind mode approximately 1-2 meters away from the receiver. The receiver should change from slowly flashing to steady red, indicating a successful bind. Make sure transmitter telemetry is set up to display battery voltage.
7. Press the receiver button briefly (less than 1 second). A **GREEN** light means that the voltage reading is calibrated. The transmitter should display 8.3 or 8.4V on the Telemetry screen as battery voltage.[19]
8. Press and hold the receiver button until the **BLUE** light is on (about 1.5 sec). The blue light confirms that the receiver now knows that there is no current sensor attached.[20]
9. Turn off the receiver and remove both bind plugs to complete voltage calibration.



If necessary, reset Failsafe to suit your setup.

3. V/I sensor accuracy and precise calibration

The above instructions will produce results of sufficient accuracy to cover the practical needs of most modelers. For greater precision, more advanced equipment is needed to generate the necessary voltage and current values. Detailed information on the accuracy and linearity of the V/I sensor and how it can be calibrated for maximum precision is provided in a separate, more technical document.

[19] Note that 8.39v will display as 8.3v because of the lack of a second decimal digit in the Spektrum transmitter display. The more precise value, however, is used internally and can be logged on the SD card.

[20] If the button is released before the blue LED comes on, briefly press the button a few times until the blue light is OFF. Then start setup again at step 7.

Annex B: Voltage Sensing Wire Attachment

To measure the voltage of the flight pack in an electric-powered model using the voltage sensing wire, there are three basic options. They all have pros and cons. Use the one that suits you best.

Note that the LM0051/52 receiver will need to be recalibrated to use the wire. See Annex A.

1. Attach Wire to the Main Power Lead

Cut off the little connector on the voltage sensing wire and solder the wire directly to the main positive (red) feed to the ESC or BEC. See Figures B-1A and B-1B.

Pros

- Fit and forget. Every time you plug in a flight pack you automatically get telemetry voltage.
- Rugged. The heat shrink and heavy duty power wire make it a very secure connection.
- Works with a pack having any number of cells.

Cons

- The voltage sensor wire is permanently attached and cannot be swapped around.
- Requires soldering to the main power wiring on which everything depends.

2. Attach via a Socket to the Balance Connector

Attach the voltage wire to a female JST-XH balance connector socket with the appropriate number of pins. See Figure B-2.

Pros

- Reasonably secure as the connectors clip together.
- Can be used in any model. The balance cable is always available.

Cons

- Bit clumsy and vulnerable.
- Only works for a single number of cells (unless you add multiple balance connectors).

3. Insert Single Pin into the Balance Connector

Use a pin that fits into the highest voltage wire on the LiPo balance connector. See Figure B-3.

The JST-XH balance connector used on most batteries will accept a single pin cut from a standard electronic 0.1" header. The existing connector on the voltage sense wire fits (with a bit of force) and can be soldered if you wish. Either way, slip some heat sink over it for protection.

Pros

- Can be used in any model. The balance cable is always there.
- Neater and smaller than using a female connector (see above). Soldering optional.
- Works with a pack having any number of cells.

Cons

- Least secure option – but it's not flight critical if it comes off.
- Plugging into the wrong wire will give a misleading reading (but won't hurt anything).

Option 3 is flexible and neat but any of the three will work just fine. If the receiver is expected to stay in the model for the long term, Option 1 may be preferable.

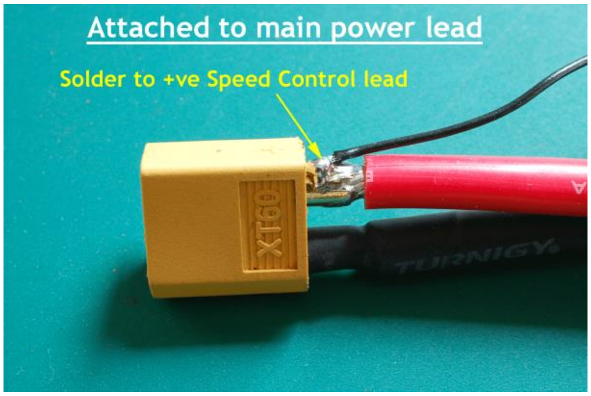


Figure B-1A: Main Power Lead

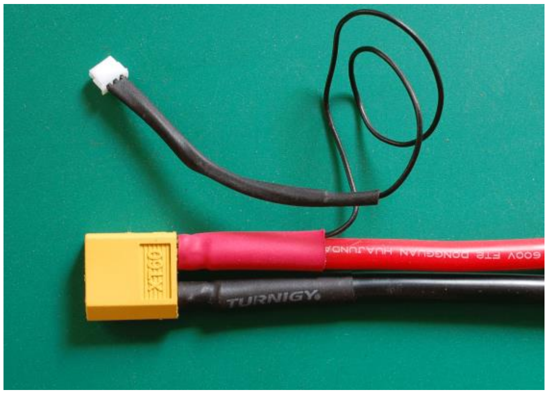


Figure B-2B: Main Power Lead

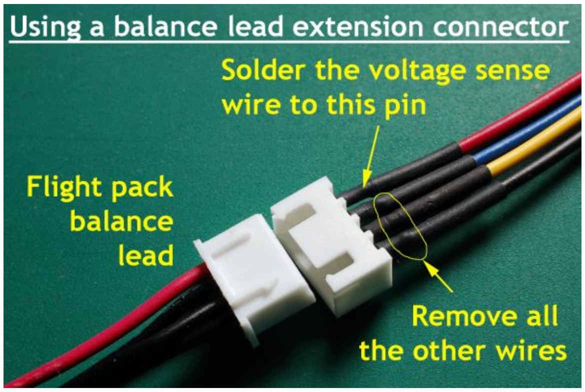


Figure B-2:Balance Connector

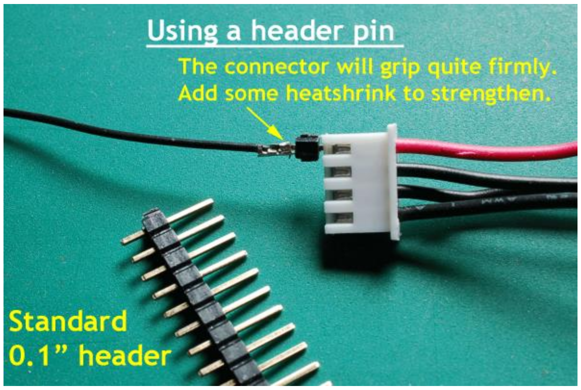


Figure B-3: Single Pin

Annex C: Using a Non-Spektrum Transmitter

1. Servo Pulse Widths

Users of OpenTX, ER9x and other open source transmitter software should recognize that these systems define the pulse width range -100 to +100% as 988uS to 2012uS. This contrasts with Spektrum transmitters, which define -100 to +100% as 1100uS to 1900uS.

This difference matters when setting up a model that was originally intended to be controlled by a Spektrum transmitter. If no adjustments are made, the control inputs from the open source transmitter will be some 25% greater than required. This can lead to over-control, non-linear throttle response and even servo damage (e.g., with the linear servos used in UMX models).

To avoid this, with such a transmitter the limits on all channels in use should normally be set to -/+80%.

The above is true for virtually all DSM modules used with open source software, including Spektrum DM8 and DM9, "hack" modules taken from Spektrum transmitters, the various OrangeRx DSM compatible modules, and Multiprotocol modules up to about the end of 2017. All such modules require that limits be set to 80% to emulate Spektrum control throws.

However starting with version 1.2.0.11 in January 2018, the Multiprotocol software includes an option in the *_Config.h* file that allows a choice between a 100% or an 80% scaling for output when using the DSM2/X protocol. With this new version of the software, selecting the 80% option means that setup in Open TX can be done with limits set to 100% travel. Note also that Multiprotocol normally uses AETR channel order for programming with all protocols; for DSMX/DSM2, it converts this automatically to the Spektrum standard of TAER for transmission to the model. The transmitter Channel Order must therefore be set to AETR.

Caution: Although 988/2012uS and 1100/1900uS define the value sent by the transmitter, it is the receiver that actually determines the final servo pulse widths. In general, Spektrum receivers and Horizon Hobbies Bind n Fly models comply closely with the standard values. The LM0051/52 and other Lemon receivers may show some variation. This is not normally a problem, but the servo throws and centring may need to be adjusted a little if you move receiver from one plane to another.

2. Telemetry

Several non-Spektrum transmitters can support Lemon telemetry using either OpenTX or ErSky9x firmware. They include the FrSky Taranis and Turnigy 9XR Pro, as well as the FlySky/Turnigy 9x upgraded with a Sky North, 9Xtreme or AR9X main board.

2a. Setting up Lemon Telemetry Using OpenTX Firmware

The LM0051/52 and other Lemon Telemetry equipment are compatible with Taranis and Horus transmitters using the Multimodule 4in1 or iRange RF modules. OpenTX version 2.2 or later will automatically recognize the Lemon telemetry data.

The procedure is as follows:

1) Go to the Telemetry setup screen on the transmitter.
2) Delete all sensors.
3) Discover all sensors.

You will end up with something that looks like the pictures below as the software attempts to recognize the defined Sensor IDs. Not all make valid sense for Lemon telemetry, but it is fairly obvious what they represent. You will need to select the Vario source (VSpd), Volts source (A3) and Altitude source (Alt) for the Top Bar.[21]

The following fields are valid:

- FdeA is the Lemon RSSI number (100->0)
- A2 is the Receiver voltage
- A3 is the Pack voltage (if the external V/I sensor or V sense wire is connected)
- Curr is the Pack current (if the external V/I sensor is connected)
- Tmp2 is the external temperature sensor.
- Alt is the Altitude
- VSpd is the vario output
- RB1V, RB1A and RB1C are the Powerbox values for Voltage, Current and Consumption.

The following fields are invalid; they should be ignored, as they will simply report an overflow maximum value:

- TRSS (the FrSky RSSI receiver value).
- FdeB, FdeL, FdeR, FLss, Hold (Spektrum specific signal quality values)
- RB1T, RB2V, RB2C, RB2A, RB2T (unrecognized Powerbox fields)

Figures C-1 and C-2 show how sensors are displayed on a computer running OpenTX Companion.

NOTE: Since the LM0051/52 does not report the same number as the FrSky RSSI value, the built in OpenTX RSSI Low and Critical alarms need to be adjusted to reflect the Lemon % values. An RSSI value of 20 is the absolute minimum recommended – but telemetry may have been lost before that value is reached. Alarm values of 35 or 40 for Low and 30 or 35 for Critical should work well for normal LOS flying. You can adjust these based on your own experience and comfort level. In any event the LM0051/52 will retain reliable control well after the RSSI reporting signal has been lost. When that happens the transmitter will announce “Telemetry lost” and the last value received will remain frozen on the screen until the telemetry signal is recovered.

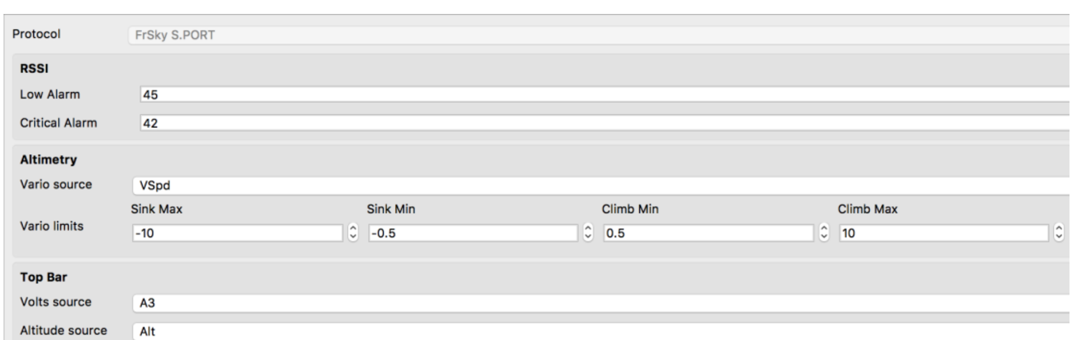
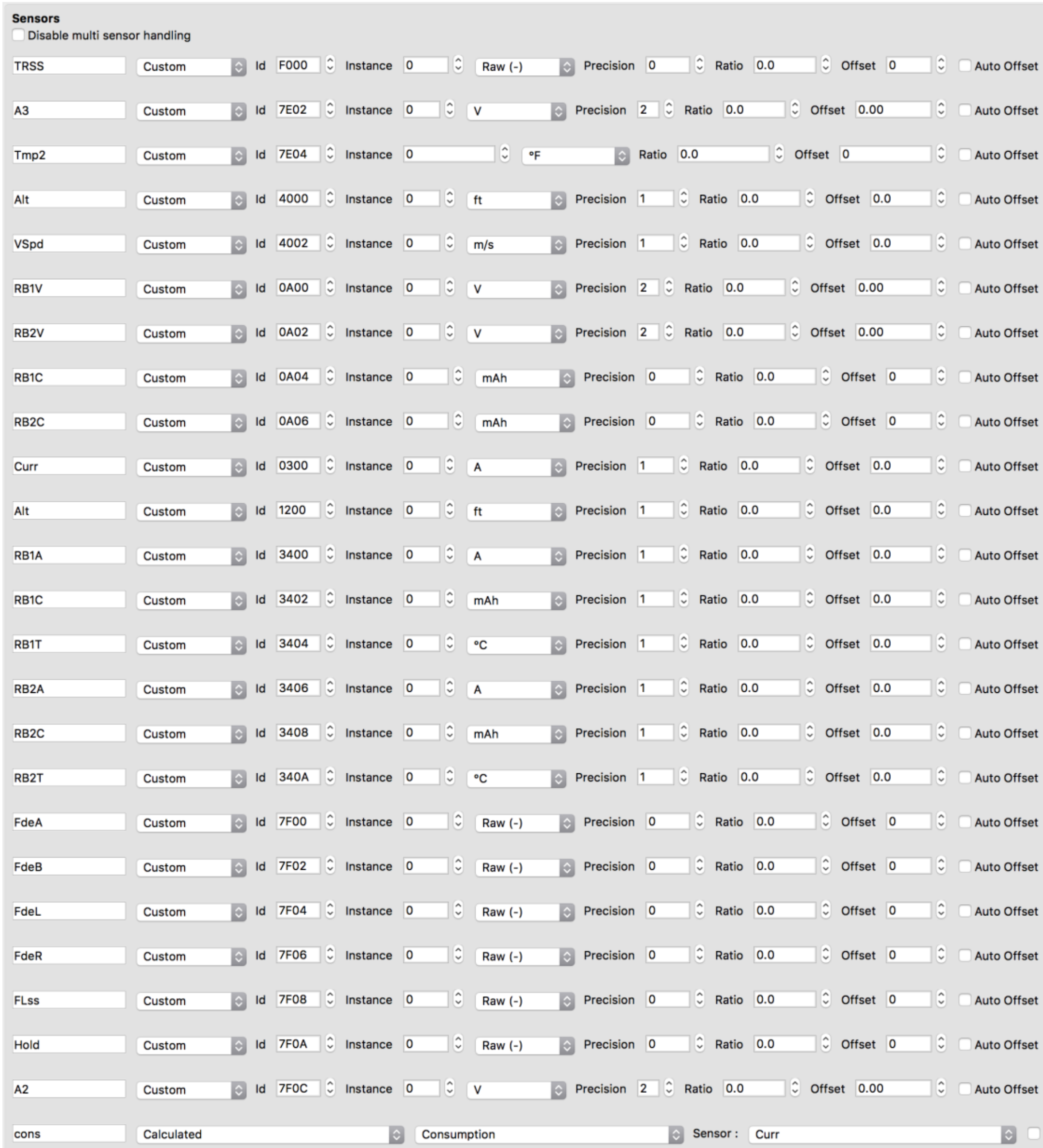


Figure C-1: RSSI (requires adjusting), Altimetry and Top Bar setup shown in OpenTX Companion

[21] References to Altitude and Vario apply only to the LM0052. The LM0051 lacks the required barometric sensor.



Sensors
Disable multi sensor handling

Name	Type	Id	Instance	Unit	Precision	Ratio	Offset	Auto Offset
TRSS	Custom	F000	0	Raw (-)	0	0.0	0	Auto Offset
A3	Custom	7E02	0	V	2	0.0	0.00	Auto Offset
Tmp2	Custom	7E04	0	°F		0.0	0	Auto Offset
Alt	Custom	4000	0	ft	1	0.0	0.0	Auto Offset
VSpd	Custom	4002	0	m/s	1	0.0	0.0	Auto Offset
RB1V	Custom	0A00	0	V	2	0.0	0.00	Auto Offset
RB2V	Custom	0A02	0	V	2	0.0	0.00	Auto Offset
RB1C	Custom	0A04	0	mAh	0	0.0	0	Auto Offset
RB2C	Custom	0A06	0	mAh	0	0.0	0	Auto Offset
Curr	Custom	0300	0	A	1	0.0	0.0	Auto Offset
Alt	Custom	1200	0	ft	1	0.0	0.0	Auto Offset
RB1A	Custom	3400	0	A	1	0.0	0.0	Auto Offset
RB1C	Custom	3402	0	mAh	1	0.0	0.0	Auto Offset
RB1T	Custom	3404	0	°C	1	0.0	0.0	Auto Offset
RB2A	Custom	3406	0	A	1	0.0	0.0	Auto Offset
RB2C	Custom	3408	0	mAh	1	0.0	0.0	Auto Offset
RB2T	Custom	340A	0	°C	1	0.0	0.0	Auto Offset
FdeA	Custom	7F00	0	Raw (-)	0	0.0	0	Auto Offset
FdeB	Custom	7F02	0	Raw (-)	0	0.0	0	Auto Offset
FdeL	Custom	7F04	0	Raw (-)	0	0.0	0	Auto Offset
FdeR	Custom	7F06	0	Raw (-)	0	0.0	0	Auto Offset
FLss	Custom	7F08	0	Raw (-)	0	0.0	0	Auto Offset
Hold	Custom	7F0A	0	Raw (-)	0	0.0	0	Auto Offset
A2	Custom	7F0C	0	V	2	0.0	0.00	Auto Offset
cons	Calculated	Consumption	Sensor : Curr	P				

Figure C-2: Sensors shown in OpenTX Companion

Setting the display

The Telemetry display using OpenTX is set in the usual manner. Pack consumption is derived by using a Calculated field, with Curr from the external V/I sensor as the data source. Figure C-3 below shows a typical example of a setup for the first Telemetry screen displaying RSSI (FdeA), Pack voltage (A3), Vario value, Pack current, Altitude, and mAh consumption so far.[22]

[22] You may see two slightly different altitude values. The reason is that in a complete telemetry sequence, two sets of data are sent in quick succession. An individual telemetry value is sent every 22ms and eight telemetry parameters are sent per set, so transmission of a set takes 8 x 22ms = 176mS (less than 1/5 second). Each of the two sets includes an Altitude value, but because the respective barometric sensor readings are taken 176mS apart, the values may differ slightly due to small variations in the barometric output. The difference is of no practical significance, so just select one of the two fields.

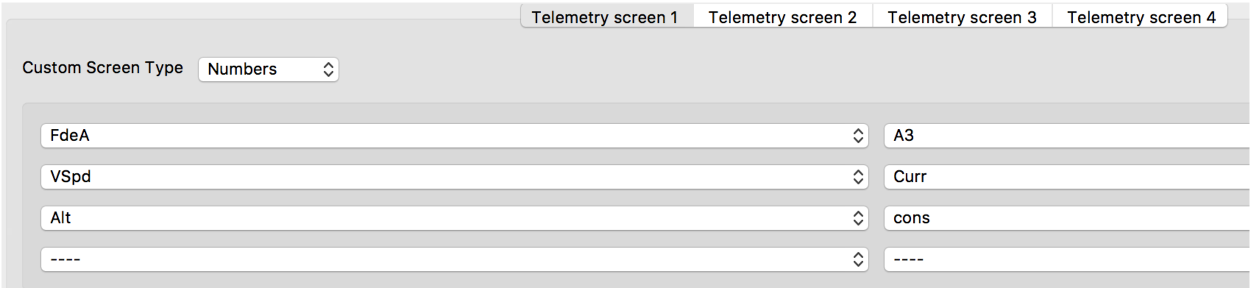


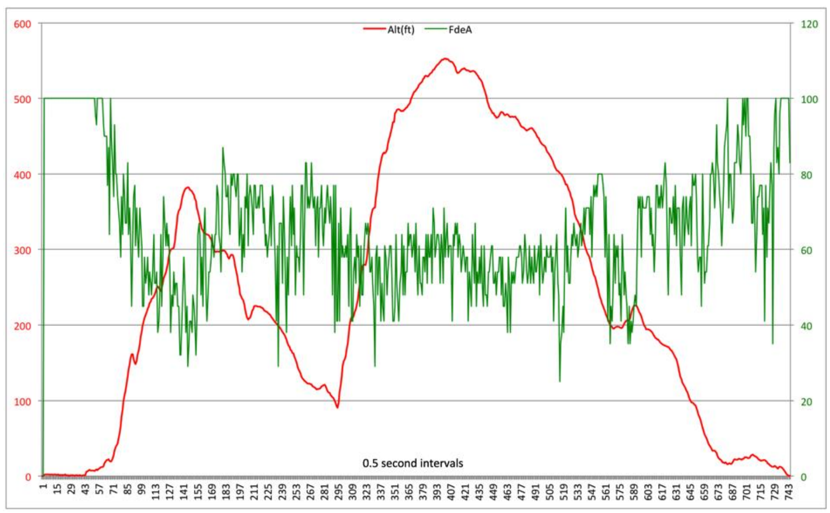
Figure C-3: Telemetry display settings

Plotting the telemetry log files

The OpenTX transmitters log all telemetry data to the SD card in standard *.csv* format. These files open automatically in Excel on a Windows or Mac computer and there can be used to plot values and create charts.

Figure C-4 shows an example of Altitude (ft) on the left axis (red) and RSSI readings on the right axis (green) from a flight log of a motor glider using the Chart facility of Excel. Excel also gives you a great deal of flexibility as to which variables to plot and how they look on the graph.

Figure C-4: Altitude vs. RSSI



2b. Lua Telemetry Scripts using OpenTX Firmware

Introduction

Lua is a scripting language by which OpenTX can be made to do things that are not part of the standard programming. It is designed as a simple way of extending the functionality of existing computer programs by "adding on" a self-contained routine that can be called by the main program. Lua scripts are written as text files which, when stored in the SCRIPTS folder on the transmitter SD card, can be run by the Open TX transmitter software.

The reference guide that explains how to write your own Lua scripts can be found here.

Although Lua is a simple language, it requires some familiarity with programming to write a satisfactorily functioning script – most people will simply use a script that is already written and tested. Among others, a user called RCdiy has a support website for OpenTX that includes working Lua scripts.

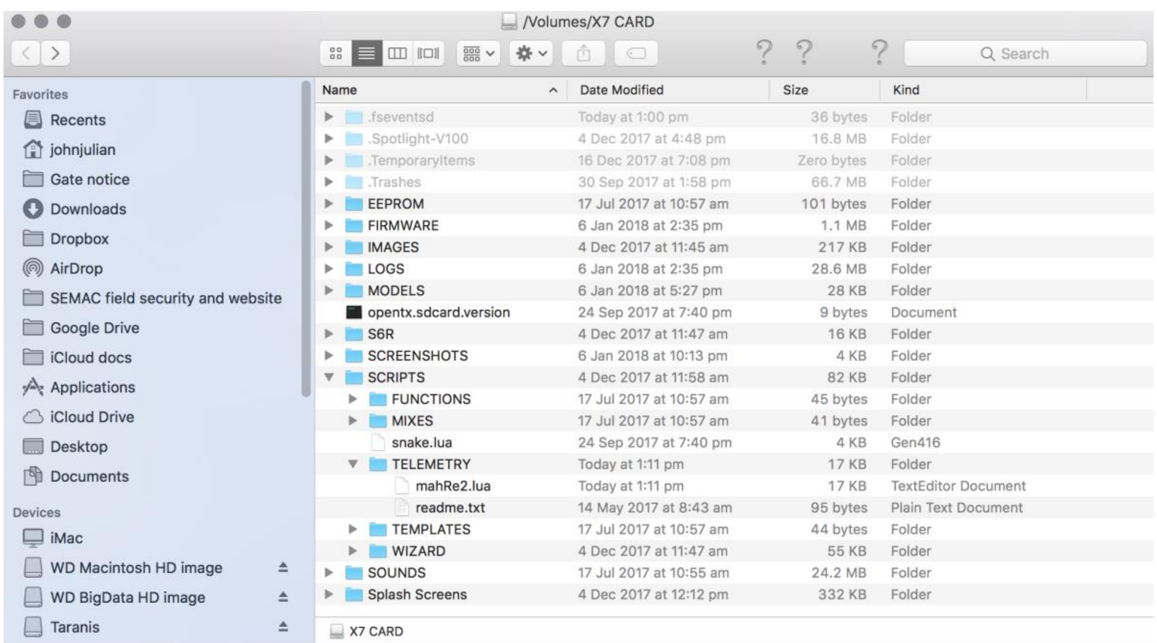
Lua scripts and the LM0051/52

There are several distinct types of Lua Script for OpenTX 2.2 and they operate differently. Most are concerned only with transmitter operation, so will operate with a Lemon receiver and module in exactly the same way as with an FrSky receiver and module. Unless you specifically need the functionality of the type called "Mixer Script", it is recommended that you NOT tick the *lua* and *luac* boxes in the Radio Profile Settings when downloading the firmware for your transmitter. Telemetry scripts do not need those options and by not enabling them you ensure that a script cannot inadvertently augment a mix on the transmitter.

Telemetry scripts depend on data returned from the receiver so may require adjustment; or not work at all, if the necessary data are missing. Essentially you need to ensure that any telemetry variables are available to the script and are correctly named. This should be straightforward as the Lua scripts are normally well documented in the code itself. Note that since Telemetry scripts may produce screen displays, there will normally be specific versions for different models of transmitter. Hence, for example, Taranis X9D, X7 and Horus scripts will typically be different. A script for the X7 may work on an XD9 or XD9+, however, as these transmitters have the same vertical screen resolution; the smaller horizontal size of the X7 will occupy the left 60% of the XD9 screen.

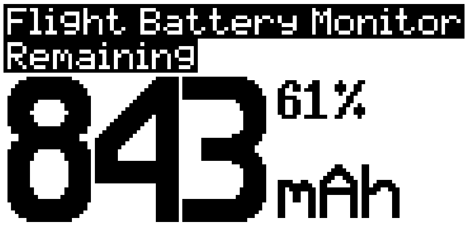
Telemetry scripts

A Lua telemetry script is a text file that is stored in the SCRIPTS/TELEMETRY directory on the SD card of the transmitter. Each model can have up to three active scripts as configured on the model's telemetry configuration page. The same script can be assigned to multiple models. The file name length must have no more than 6 characters plus a *.lua* extension. Any scripts are automatically activated when the model is loaded. The picture below shows the directory structure of the SD card. It is here displayed on a Mac but the structure is identical on other systems.

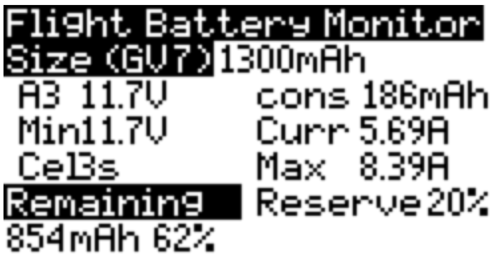


An example.

The RCdiy site has a number of Telemetry Scripts available for download. One is a very useful large display of the calculated remaining capacity in the flight pack. It is called *mahRe2.lua* and can be seen in the SCRIPTS/TELEMETRY folder.



This display can be toggled between this screen and a more detailed one by using a transmitter switch.



It can also use custom sounds stored in a SCRIPTS/TELEMETRY/mahRe2/ directory in addition to all the usual OpenTX sound files. It is written assuming an FrSky current sensor (FAS40S) but is simple to modify to use the LM0051/52 and its Energy Sensor, as everything the script does is very well documented in the code itself.

Here is the download site for this script.

NOTE: Any changes to a Lua script must be made in a pure text editor and saved as a pure text file. You do not need a sophisticated programmer's editor but you cannot use a word processor that will add hidden codes or formatting. *Wordpad* is commonly used for Windows. If you edit a script on a Mac, the *Textedit* application that is built into OS10 saves in RTF format by default. It must therefore be changed to *Plain Text* in the *Textedit Preferences*. There also are a number of free and paid pure text editors for the Mac and other systems but their sophistication is not really required for simple modification of an existing script.

For all systems you need to change the **.txt** extension of the output file to **.lua**.

Step 1: Identify the variables from the LM0051/2 that are the equivalent in the script

All the lines that start with "–" are comments. The actual script lines that need changing are few and all start with *local.*

Here are the lines in the script that identify the FAS40 variables:

-- Change as desired
local VoltageSensor = "VFAS" -- optional set to "" to ignore
local mAhSensor = "Cons" -- optional set to "" to ignore

From the table of recognized sensors in Section 1a above we see that the LM0052 returns A3 as sensor name for the pack voltage. So change VFAS to A3.

Step 2: Identify any calculated variables used by the script

"Cons" is a calculated telemetry field. You create that as usual in the OpenTX Telemetry tab as shown in Section 2a above. The name does not require changing.

Step3: Make any changes to suit your preferences

For example the default switch to toggle between the large and detail display is SF. If you happen to use that switch for Throttle Kill, then you can change it. In the example below it has been changed to SB↓.

```
--      Switch between simple and detailed display using a switch
--      SA to SH Taranis X9 series, Q X7 missing switches SE and SG
--      Use "sa" for switch A and so on.
--      Change as desired
local SwVerbose = "sb"  -- "" to ignore
local SwVerboseOnPos = "Down"   -- Up, Mid, Down
```

Step4: Ensure that you set up a Custom Screen Type on a Telemetry Screen to call the Lua Script.

3. Lemon Telemetry Using ErSky9x Firmware

ErSky9x firmware was developed from ER9x by Mike Blandford to support the Sky North enhanced programming board for the FlySky/Turnigy 9x transmitter. Since then it has evolved to support the Turnigy 9XR Pro, as well as 9x transmitters with 9Xtreme and AR9X boards. In addition, it now supports the FrSky line of transmitters, including both Taranis (QX7 and X9D) and Horus. It is a fully viable alternative to OpenTX and is telemetry capable with both FrSky and Lemon systems. It continues under active development by Mike and is well supported on OpenRCForums.

To function with Lemon telemetry, ErSky9x requires an RF module that supports DSMX and is capable of receiving and sharing data using Multiprotocol firmware, such as the *iRangeX 4in1*.

Broadly similar to OpenTX in its programming approach, ErSky9x is preferred by some users for its more structured menus, simpler configuration of inputs and rapid adaptation to new hardware developments.

For information on using this capability, go to the "Lemon Telemetry with ErSky9x" thread on OpenRCForums.

Annex D: Servo Output Timing

This section is about how the receiver puts out the information for the control channels: all channels at once, one after the other, or in some different manner. In PWM (Pulse Width Modulation), as used on the LM0051 and LM0052, the output for each channel is present on a separate pin. The receiver puts out channel pulses in two batches:

- First, Channels 1, 2, and 3 – Throttle, Aileron, Elevator - are output simultaneously.
- Then, 2.4mS later, Channels 4, 5, 6 and 7 – that is Rudder, Gear, Aux1, and Aux2.

This can be seen in the logic trace display shown in the Figure on the right. Note that Channel 0 on the logic trace is Channel 1 from the receiver and so on. The varying width of the pulses that represents control information is clearly visible, with the first channel (Throttle) at minimum (-100% or 1.1mS), the second (Elevator) at neutral (0% or 1.5mS), and so on.

This output scheme is different from that of many other receivers. The majority of low cost DSM2/DSMX receivers output the channels one after another (sometimes described as "round robin"), while some higher end receivers synchronize all or some of the pulses to ensure simultaneous signals for servo actions that should occur at the same time.

The advantage of synchronizing pulse outputs for two or more channels is that the corresponding servo actions are initiated together. The result may be noticeable in demanding precision applications, particularly helicopter rotor movements. In the case of the LM0051/52, the simultaneous Aileron and Elevator pulses would mainly be an advantage for elevon operation.

The down side of simultaneous pulses relates to the instantaneous power demand of the servos, which depends on the type of servos used. Digital and analog servos load the power supply in a different way. Digital servos are refreshed at fixed intervals, with no reference to the timing of incoming pulses. The power pulses are sent at high frequency compared with the incoming control pulses. So they always draw power, but at a fairly consistent rate.

By contrast, analog servos only drive the motor when they get a pulse, and they do it as soon as they get that pulse. If the control pulse requires the servo to move significantly, the result may be a demand for full current. During aggressive flying it's possible for several servos to be called on to change position at the same time, creating a huge demand on the power supply at that instant.

Thus while on average the total current for analog servos might be lower than for equivalent digitals, the instantaneous current draw could be very high. If the power supply is unable to meet this peak current demand, the voltage can be seriously depressed and cause a "brown-out" of the receiver.

For the LM0051/52, the main issue, if any, is likely to be Aileron and Elevator. This typically involves three servos (one elevator and two aileron servos on a Y-cable) being driven at the same moment. With analog servos, the instantaneous current could be very high (keep in mind that even miniature servos can vary greatly in maximum current draw from one brand to another).

In practice, most users with most applications don't need to worry about pulse timing. Choosing a standard receiver power setup with ample reserve will normally be enough to ensure reliable operation. However, it's just as well to understand the implications of different output timing schemes and so avoid potential problems.

NOTICE

This manual is provided to help you understand and use the Lemon Rx 7-Channel LM0051/LM0052 Integrated Telemetry Receiver. The authors are not associated with Lemon Rx and this is not a Lemon Rx publication.

Additional information about Lemon RX telemetry is available in the Official Lemon DSM2/DSMX Compatible Telemetry System Thread.

The Lemon RX website is here.

JJ604 and Daedalus66

February 2018