Inside DistoX2

Leica Disto X310 based DistoX, Firmware Version 2.1 - 2.4

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Introduction

This document describes some internals of the DistoX upgrade board for the Leica X310.

The DistoX Wire(less) Protocol

The DistoX uses the Bluetooth Serial Port Profile (SPP) to communicate to a PDA or PC. The Bluetooth connection is always set up by the PDA. SPP offers a simple bidirectional byte oriented channel. There are two kinds of communications: Disto initiated and PDA initiated.

Disto initiated communication consists of a data packet sent from the Disto to the PDA and an acknowledge packet sent from the PDA to the Disto. Data is resent continuously in intervals of 5 seconds until a valid acknowledge is received.

PDA initiated communication consists of a command packet sent from the PDA to the Disto followed by a reply packet sent from the Disto to the PDA in most cases. The PDA side should repeat the command if no reply is received.

Data Packets

All data packets have a length of 8 bytes.

Measurement Data Packet:
Byte 0: bit 7: sequence bit, bit 6: bit 16 of distance, bits 0-5: 000001 (packet type)
Byte 1: low byte of distance
Byte 2: high byte of distance
Byte 3: low byte of declination
Byte 4: high byte of declination
Byte 5: low byte of inclination
Byte 6: high byte of inclination
Byte 7: high byte of roll angle

The sequence bit is complemented for each new packet. A packet with the same contents and the same sequence bit as the preceding packet is a wrongly repeated packet. It should be acknowledged and discarded.

The 17 bit distance is in mm for distance <= 100m. Above 100m the resolution changes to cm: 99999 = 99.999m, 100000 = 100m, 100001 = 100.010m, 110000 = 200m.
The angles are in radiant * 2^15 / Pi (full circle = 2^16).
For declination: 0x0000 = north, 0x4000 = east, 0x8000 = south, 0xC000 = west.
For inclination: 0x0000 = horizontal, 0x4000 = up, 0xC000 = down.
Display orientation: 0x0000 = up, 0x4000 = left, 0x8000 = down, 0xC000 = right.

Vector Data Packet:
Byte 0: bit 7: sequence bit, bit 6: reverse, bits 0-5: 000100 (packet type)
Byte 1: low byte of absolute value of the acceleration
Byte 2: high byte of absolute value of the acceleration
Byte 3: low byte of absolute value of the magnetic field
Byte 4: high byte of absolute value of the magnetic field
Byte 5: low byte of dip angle (inclination of the magnetic field)
Byte 6: high byte of dip angle (inclination of the magnetic field)
Byte 7: low byte of roll angle

The Vector packet is sent after the Measurement packet to provide additional information about the measurement. It is primarily used for quality checking and post processing of measurement errors. There is no specified unit for the absolute values of the field vectors. They can only be used relative to each other.
The 16 bit angles are in radiant * 2^15 / Pi (full circle = 2^16).
The dip angle is 0 at the equator, positive in the southern hemisphere, and negative in the north.
The full roll angle can be reconstructed by concatenation of Measurement packet byte 7 and Vector packet byte 7. The orientation is as stated above (display left = 0x4000).
The reverse bit is set if the data is measured with the backsight option.
The Vector packet must be acknowledged separately.

Calibration Data Packet 1 (Acceleration Sensor):
Byte 0: bit 7: sequence bit, bits 0-6: 0000010 (packet type)
Byte 1: low byte of Gx sensor
Byte 2: high byte of Gx sensor
Byte 3: low byte of Gy sensor
Byte 4: high byte of Gy sensor
Byte 5: low byte of Gz sensor
Byte 6: high byte of Gz sensor
Byte 7: calibration measurement number (1, 2, …)

Calibration Data Packet 2 (Magnetic Field Sensor):
Byte 0: bit 7: sequence bit, bits 0-6: 0000011 (packet type)
Byte 1: low byte of Mx sensor
Byte 2: high byte of Mx sensor
Byte 3: low byte of My sensor
Byte 4: high byte of My sensor
Byte 5: low byte of Mz sensor
Byte 6: high byte of Mz sensor
Byte 7: calibration measurement number (1, 2, …)

For each calibration measurement an acceleration packet is sent followed by a magnetic field packet. The two packets must be acknowledged separately.

Acknowledge Packet

An acknowledge packet consists of a single byte:
Byte 0: bit 7: sequence bit, bits 0-6: 1010101

The sequence bit of the acknowledge byte must match the sequence bit of the corresponding data packet.

Command Packets

The following commands may be sent from the PDA to the Disto:

Start Calibration (1 byte):
Byte 0: 00110001

Stop Calibration (1 byte):
Byte 0: 00110000

Start Silent Mode (1 byte):
Byte 0: 00110011

Stop Silent Mode (1 byte):
Byte 0: 00110010

Power Off (1 byte):
Byte 0: 00110100

Switch Laser On (1 byte): (version 2.3 & higher)
Byte 0: 00110110

Switch Laser Off (1 byte): (version 2.3 & higher)
Byte 0: 00110111

Trigger Measurement (1 byte): (version 2.3 & higher)
Byte 0: 00110101

Read Memory (3 bytes):
Byte 0: 00111000
Byte 1: low byte of address
Byte 2: high byte of address

Write Memory (7 bytes):
Byte 0: 00111001
Byte 1: low byte of address
Byte 2: high byte of address
Byte 3: data byte 0
Byte 4: data byte 1
Byte 5: data byte 2
Byte 6: data byte 3

Read and Write commands read or write 4 bytes of memory starting at the given address. For the interpretation of the address values see below. A memory read reply is sent by the Disto for each read and write command. The read reply following a write command may be used to check the correctness of the written data. There is no reply for the 1 byte commands.

Reply Packets

The format of read reply packets is similar to that of the data packets.

Memory Read Reply:
Byte 0: 00111000 (packet type)
Byte 1: low byte of address
Byte 2: high byte of address
Byte 3: data byte 0
Byte 4: data byte 1
Byte 5: data byte 2
Byte 6: data byte 3
Byte 7: 0 (not used)

Address Space

The 16 bit addresses used for read and write commands allow access to the following values:

0x0000 – 0x4BFF: Data store (read only)
0x8008 – 0x8009: Serial number (low/high)
0x8010 – 0x8027: G calibration coefficients
0x8028 – 0x803F: M calibration coefficients
0x8040 – 0x8042: non-linearity coefficients
0xC000 – 0xDFFF: CPU RAM
0xE000 – 0xE003: Firmware Version (Major/Minor/0/0, read only)
0xE004 – 0xE007: Hardware Version (Major * 10 + Minor, read only)
All other ranges: Reserved

The Data Store contains a circular buffer to store all measured data. It consists of 19 Flash memory blocks of 1 Kbyte each. Each block is divided into 56 segments of 18 bytes each. The layout of the segments is:
Bytes 0 to 7: first packet
Bytes 8 to 15: second packet
Byte 16: Hot flag for first packet
Byte 17: Hot flag for second packet
The layout of the packets is identical to the Data packets specified above. The sequence bit is zero. The Hot flags are 0xFF for new packets (not yet sent over Bluetooth) and 0 for old (already sent) packets. The first and last segments in the queue are separated by a range of erased segments (all bytes = 0xFF).
The device writes a segment consisting of a type 1 and a type 4 packet for each distance measurement or a type 2 and a type 3 packet for a calibration measurement.

Bootloader Command Packets

In bootloader mode, the device allows to read and write 256 byte blocks in the whole Flash memory. The bootloader itself is write protected.

Read Memory Block (3 bytes):
Byte 0: 00111010
Byte 1: bits 8..15 of address (24 bit address, 256 byte aligned)
Byte 2: bits 16..23 of address

Write Memory Block (259 bytes):
Byte 0: 00111011
Byte 1: bits 8..15 of address (24 bit address, 256 byte aligned)
Byte 2: bits 16..23 of address
Byte 3: data byte 0
Byte 4: data byte 1
…
Byte 258: data byte 255

Power Off (1 byte):
Byte 0: 00110100

A corresponding reply packet is sent by the Disto for each read and write command.

Bootloader Reply Packets

Memory Read Block Reply (264 bytes):
Byte 0: 00111010 (packet type)
Byte 1: bits 8..15 of address (24 bit address, 256 byte aligned)
Byte 2: bits 16..23 of address (currently always 0)
Byte 3-7: not used
Byte 8: data byte 0
Byte 9: data byte 1
…
Byte 263: data byte 255

Memory Write Block Reply (8 bytes):
Byte 0: 00111011 (packet type)
Byte 1: bits 8..15 of address (24 bit address, 256 byte aligned)
Byte 2: bits 16..23 of address (currently always 0)
Byte 3: low byte of checksum (16 bit sum of all bytes)
Byte 4: high byte of checksum
Byte 5-7: not used

Flash Memory Map

0x000000 – 0x0007FF: Bootloader (read only)
0x000800 – 0x00ABFF: Firmware
0x00AC00 – 0x00AFFF: Option Store
0x00B000 – 0x00B3FF: Configuration Store (calibration coefficients)
0x00B400 – 0x00FFFF: Data Store (1008 segments + 1 erased block)

Appendix A: Basic Communication Code

```
unsigned byte input[8]; // input buffer
int oldType, oldX, oldY, oldZ;  // previous packet

Read(input, 0, 8);  // receive 8 bytes
Byte type = input[0];
Int op = type & 0x3F;
if (op < 0x20) {  // data packet
    Write(type & 0x80 | 0x55);  // send acknowledge byte
    int x = input[1] + (input[2] << 8);
    int y = input[3] + (input[4] << 8);
    int z = input[5] + (input[6] << 8);
    if (type != oldType && x != oldX && y != oldY && z != oldZ) {
        if (op == 1) { // survey data
            // 17 bit distance
            distance = x + ((type & 0x40) << 10);
            // cm resolution above 100m
            if (distance > 100000) distance = (distance - 90000) * 10;
            azimuth = y;
            inclination = z;
            roll = input[7] << 8; // high bits of roll angle
        } else if (op == 4) { // vector data
            absG = x; // absolute value of G vector
            absM = y; // absolute value of M vector
            dip  = z; // dip angle
            roll += input[7]; // low bits of roll angle
            reverse = (type >> 6) & 1;
        } else if (op == 2) { // G calibration data
            Gx = x; // acceleration x sensor
            Gy = y; // acceleration y sensor
            Gz = z; // acceleration z sensor
        } else if (op == 3) { // M calibration data
            Mx = x; // magnetic x sensor
            My = y; // magnetic y sensor
            Mz = z; // magnetic z sensor
        }
        // ignore unknown packets
        oldType = type; oldX = x; oldY = y; oldZ = z;
    }
}
```