A “Dumb” Differential GPS Converter

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The circuit described here takes the audio signal from a SSB/CW receiver tuned to a marine DGPS beacon and converts it to correctional data for a GPS receiver. You can also connect it to a computer to monitor these radio stations. In this case, you need a so-called RTCM decoder. RTCM decoding programs can be found on the Internet as shareware or freeware [3]. The converter has originally been published in FUNKAMATEUR 4/2000 [5] and is shown here with a few minor modifications. The format of differential GPS data is specified in [1], some details are given in [2].

Receiving prerequisites

Marine DGPS beacons operate in the 284 - 325 kHz frequency range. They are placed along the coasts and have rather weak transmitters. At locations far off the coast, there will be probably no beacon with reasonable field strength. For station lists see [3, 4].

The beacons employ 200 or 100 bps minimum shift keying (MSK), a narrow bandwidth FSK mode. For 200 bps, a receiver bandwidth of 250 Hz is sufficient; at 100 bps it can even be reduced to 130 Hz. SSB bandwidth will only work with really strong beacon signals. I have tested the converter with an Icom R72 with 500 Hz CW filter, as well as with a homemade direct conversion receiver with about 250 Hz bandwidth, but rather poor filtering.

The converter circuit is designed for a center input frequency of 500 to 1000 Hz, i.e for a receiver operating in CW mode. In the R72, the audio was centered at 700 Hz, while the homemade receiver had a center frequency of 500 Hz.

Circuit description and alignment

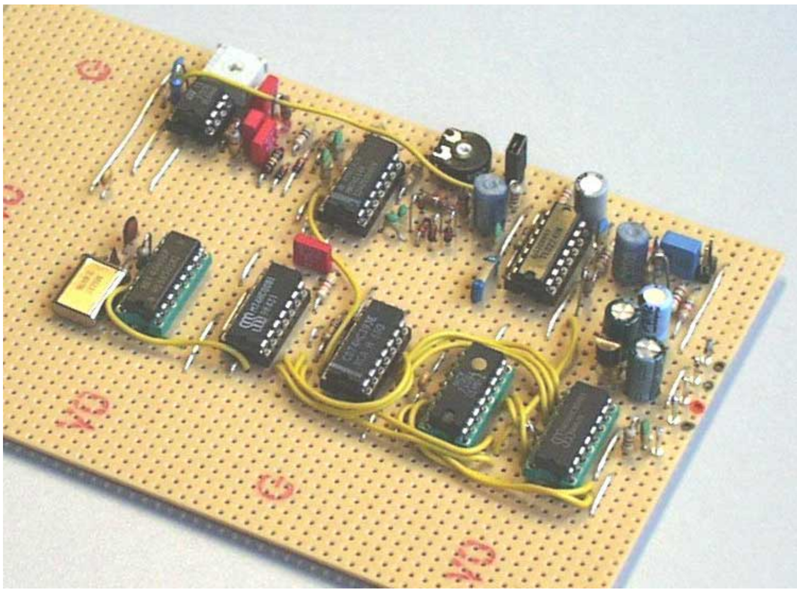
The audio signal from the receiver is applied to terminal “RX”. A voltage-to-frequency converter is made of U1 and U2A...C. With an input frequency 500 Hz, the DC level at the output of U1B should be 2.8 … 3 V. It drops to 0.8 … 1.0 V at 1000 Hz. The exact voltage is not critical and depends slightly on variations of U2. In can be adjusted within certain limits with R4. The digital data is available at the output of U1A, which is a comparator with floating threshold. This adds an AFC characteristic to the system. U1C and U1D form a fourth-order bessel lowpass filter. For 100 bps operation, an additional first-order filter can be inserted by closing S1A.

Clock recovery is done with a “fly-wheel” circuit: Both rising and falling slopes of the data are fed to a band pass filter U3A. It is tuned to 200 Hz with S1B closed and to 100 Hz with S1B open. The lowpass filter R19, C15, R20 and C16 shifts the clock slope somewhat to the center of the data bits. For alignment, connect an oscilloscope to the output of U3A. If both 100 and 200 bps stations can be heard, proceed as follows: Tune to a 100 bps beacon, open S1B and adjust P1 to maximum output at U3A. Now tune to a 200 bps station, close S1B and adjust P2 to maximum. If no 100 bps station is available, set P1 to a mid value. If you do not want to receive 200 bps beacons, P2 needs not to be adjusted.

This clock recovery circuit works well with short interfering clicks and cracks (atmospherics), but cannot maintain synchronization when the signal is missing for a longer time. This is usually no problem, since longer interference periods will cause a loss of synchronization anyway. That is, the GPS receiver or the decoder software can no longer keep track of the messages, which are of variable length, and has to wait for the next message header.

Data bits are shifted into U5; their number is counted by U6B. After 6 bits, the data is latched and appears at the U5 outputs Q1 … Q6. Two additional bits (required by the RTCM standard [1]) as well as start and stop bits are added, and the data is sent out in MSB first order (also dictated by RTCM) through the multiplexer U5 at 4800 Baud. The 4800 Hz clock signal for this process is generated by U4.

The serial output (DB9 connector labeled "GPS") has a 0-5 Volts swing, rather than the much higher standard RS-232 levels. With a Garmin GPS II+, as well as with several PCs, new and old ones, no problems have been observed so far. The cable length for these tests was 3 m. For connecting a PC rather than a GPS device, a cable with crossing data lines 2 and 3 is required, an off-the-shelf null-modem cable for example.



The converter built on perforated board.

References and Internet addresses

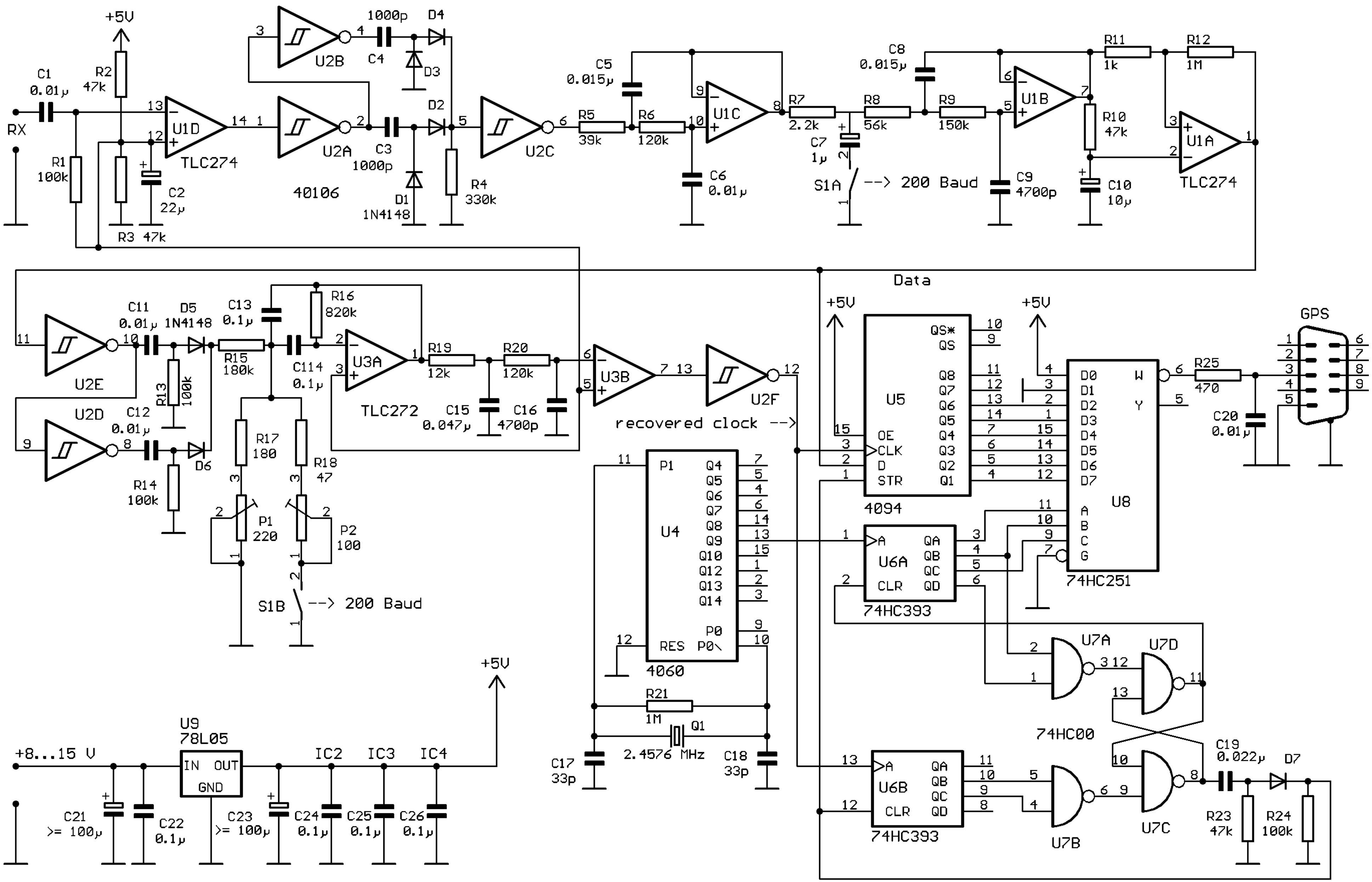
[1] Radio Technical Commission for Maritime Services: RTCM RECOMMENDED STANDARDS FOR DIFFERENTIAL GNSS (GLOBAL NAVIGATION SATELLITE SYSTEMS) SERVICE, Version 2.2. Alexandria, VA, USA, Januar 1998.

[2] Day Watson: Article series on DGPS in WUN newsletter. WUNNEWS Vol. 4, No.5 June 1998; WUNNEWS Vol. 4, No.6 July 1998; WUNNEWS Vol. 4, No.7 Aug 1998. http://www.wunclub.com

[3] Communication Systems International Inc., Calgary, Alberta, Canada. http://www.csi-dgps.com

[4] http://www.iala-aism.org

[5] www.funkamateur.de



RX
+5V
C1 0.01µ
R1 100k
R2 47k
R3 47k
C2 22µ
U1D
TLC274
U2A
U2B
40106
C3 1000p
C4 1000p
D1 1N4148
D2
D3
D4
R4 330k
U2C
R5 39k
R6 120k
C5 0.015µ
C6 0.01µ
U1C
R7 2.2k
C7 1µ
S1A --> 200 Baud
R8 56k
R9 150k
C8 0.015µ
C9 4700p
U1B
R10 47k
C10 10µ
R11 1k
R12 1M
U1A
TLC274
Data
U2E
U2D
C11 0.01µ
C12 0.01µ
D5 1N4148
D6
R13 100k
R14 100k
C13 0.1µ
R15 180k
R16 820k
C114 0.1µ
U3A
TLC272
R17 180
R18 47
P1 220
P2 100
S1B --> 200 Baud
R19 12k
R20 120k
C15 0.047µ
C16 4700p
U3B
U2F
recovered clock -->
U5
4094
U4
4060
R21 1M
Q1 2.4576 MHz
C17 33p
C18 33p
U6A
74HC393
U6B
74HC393
U8
74HC251
R25 470
C20 0.01µ
GPS
U7A
U7B
U7C
U7D
74HC00
C19 0.022µ
D7
R23 47k
R24 100k
U9 78L05
+8...15 V
C21 >= 100µ
C22 0.1µ
C23 >= 100µ
C24 0.1µ
C25 0.1µ
C26 0.1µ
IC2
IC3
IC4