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DCF 77 GIVING AUTOMATIC TIME MARK

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Abstract

The DCF-77 time signal transmitter transmits time data in a coded form. A receiver with a loop antenna and an AGC and a decoder that gives a one-second-long time mark once an hour suitable for timing of recordings have been designed.

1. *Introduction*

One way to get an automatic time mark for recordings expecially in remote stations is to use the DCF 77 coded time signal. To get a suitable time mark output one needs only an antenna, a 77.5 kHz receiver and a decoder. The DCF 77 decoder gives the desired time mark with high accuracy with no adjustments and with minimum service. The limitation of the DCF decoder is that in noise conditions it may give false time marks or these may fail. These limitations may be removed to a certain extent by means of a suitable design.

This paper describes a DCF 77 receiver and a decoder giving a one-second-long time mark once an hour for riometer recordings.

2. *DCF-77 coded time signal*

The time signal and standard frequency transmitter DCF 77 in Mainflingen West-Germany has transmitted from summer 1973 the time information in a coded form in accordance with MET (Mean European Time) at a frequency of 77.5 kHz and 27 kW radiated power. The initial accuracy of the DCF 77 is better than ∓ 5 μs at any

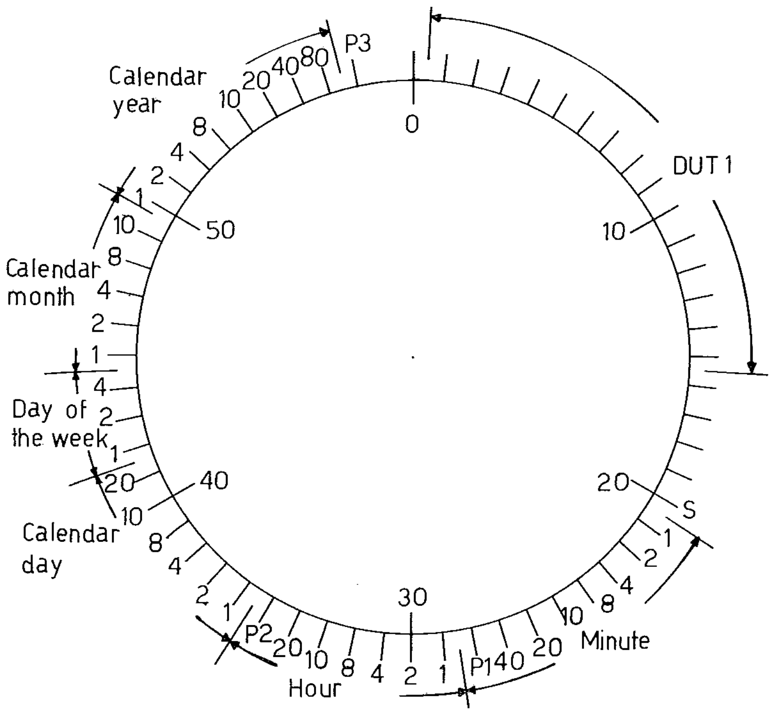

Figure 1. Time code of DCF 77. P1, P2, P3 are parity bits. 0.2 s long bit S is the beginning of time data.

time. The code contains information about DUT1, minute, hour, calendar day, day of the week, calendar month and calendar year, figure 1 [1].

The DCF 77 transmits one bit a second using pulse length modulation. 0.1 s long pulse corresponds to binary zero and 0.2 s long pulse to binary one. The time data is BCD-coded and contains also three parity bits. The 59th second pulse fails and the next pulse zero is the beginning of a minute. The beginning of a second or a minute is the beginning of the pulse.

Figure 2 represents the path delay of DCF 77 in Finland calculated by K. KALLIOMÄKI and J. KAKKURI [3].

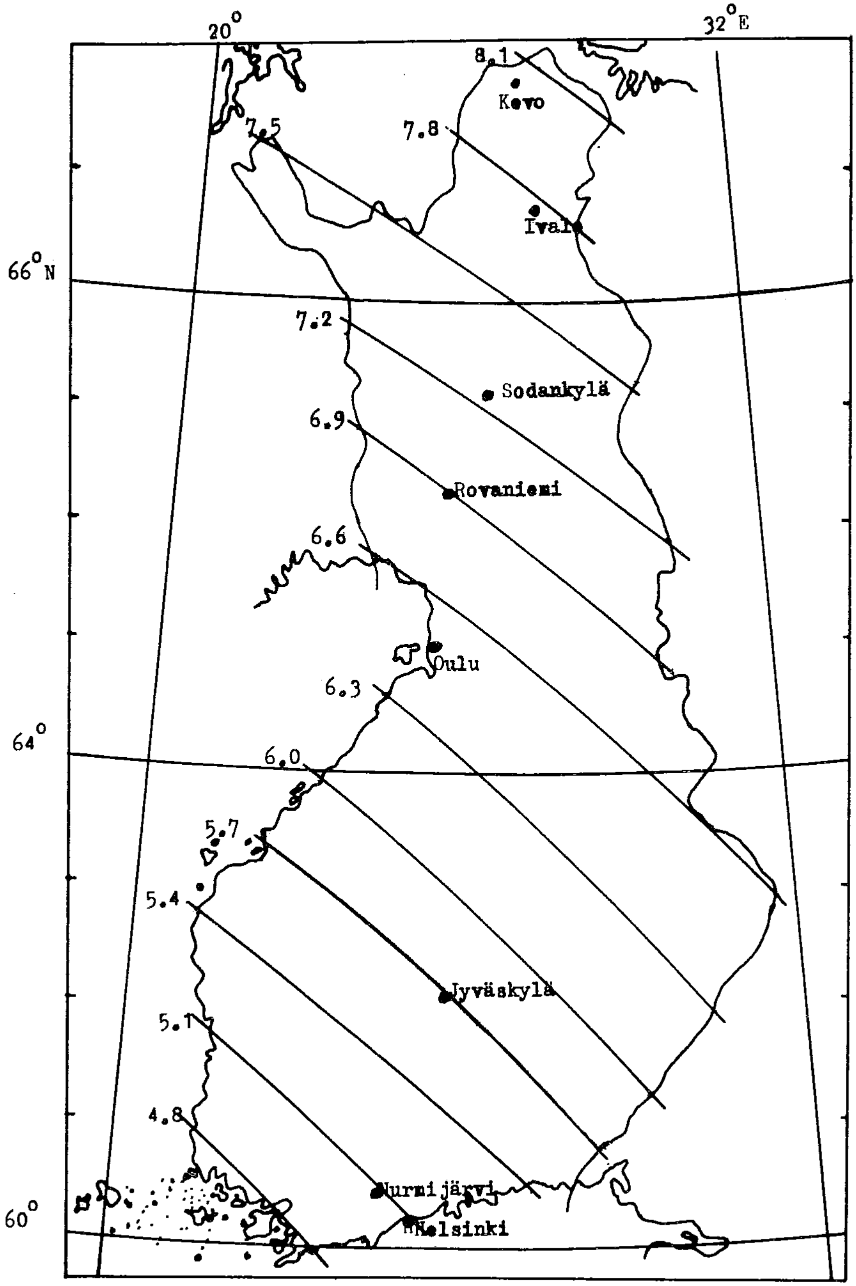

Figure 2. DCF 77.5 kHz path delay in milliseconds.

3. *Receiver*

A shielded loop antenna has been used with symmetrical feed. Antenna is tuned to the received signal 77.5 kHz. The receiver, figure 3, has three resonant circuits and an AGC. The bandwidth should be quite narrow B $\leqslant$ 1 kHz because of the low field strength expecially in northern Finland and the high interference level. After a diode detector there is a minimum detector that follows slowly a rising signal and rapidly a falling signal to cut out sharp noise spikes. The detected signal is amplified in a grounded-base transistor stage biased by a Ge-diode giving it small gain at DC and large AC gain. Then the signal is clamped, amplified and again rectified to take off sharp noise spikes and made to form a pulse with sharp edges by a Schmidt-trigger which has a large hysteresis. From the common emitters of the Schmidt-trigger the pulse is fed to the decoder.

4. *Decoder*

The time data comes in serial form one bit a second. The beginning of a minute is coded by letting 59th pulse away and 60th is zero. To get accurately the information of the beginning of an hour only information of seconds and minutes is needed. When all of them are at zero there is the beginning of an hour. Seconds are counted directly by a divide-by-60 counter. For minute information 8 bits are needed including a parity bit, bits 21 – 28. These bits are selected by a gate and clocked serially to an eight-bit shift register. At the beginning of a minute the data is read out from the shift register. When minutes and seconds are at zero, a relay gives a one-second-long contact closure.

The decoder is in figure 4. The pulse coming from the receiver is first amplified to TTL level. The second counter (1C1, 1C2) counts the seconds from 0 to 58 (second 59 fails). The beginning of a minute is detected by UJT oscillator T3. The pulse repetition rate of T3 is about 1.5 s. Normally the second pulse biases T2 to discharge the timing condensator of T3 and it cannot trigger. When one pulse fails, triggering occurs and sets FF1. Next second pulse is the 60th and resets FF1. This transition is derivated by NAND gates to form a sharp pulse and this resets the second counter.

The code is decoded by a monostable multivibrator, 1C5 and a D Flip-Flop FF4. The pulse width of the monostable multivibrator is about 150 ms. The delayed edge of this pulse reads the instantaneus second pulse level to FF4. Then the decoded data is clocked by second pulses to the eight bit shift register, IC9, IC10. The shift register is gated to read only bits 21 – 28, the minute data. The gate is controlled by setting FF4 at second 21 and resetting it at second 29. The

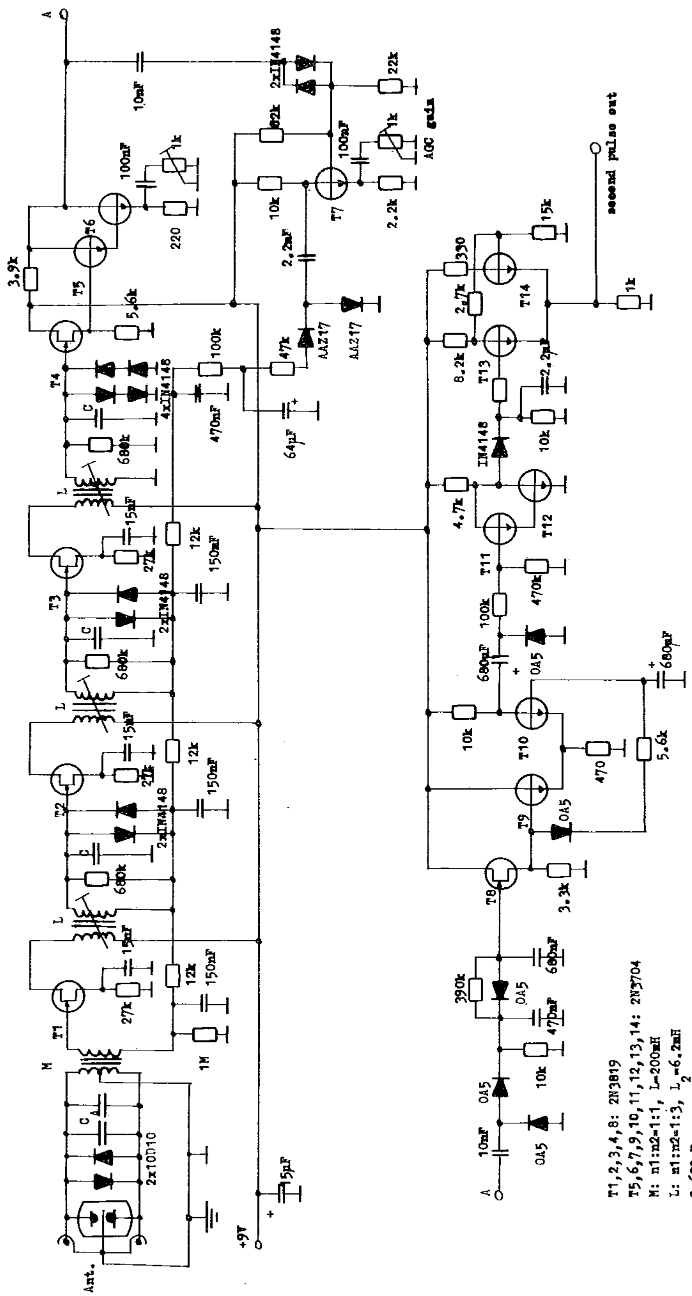

Figure 3. DCF 77 receiver.

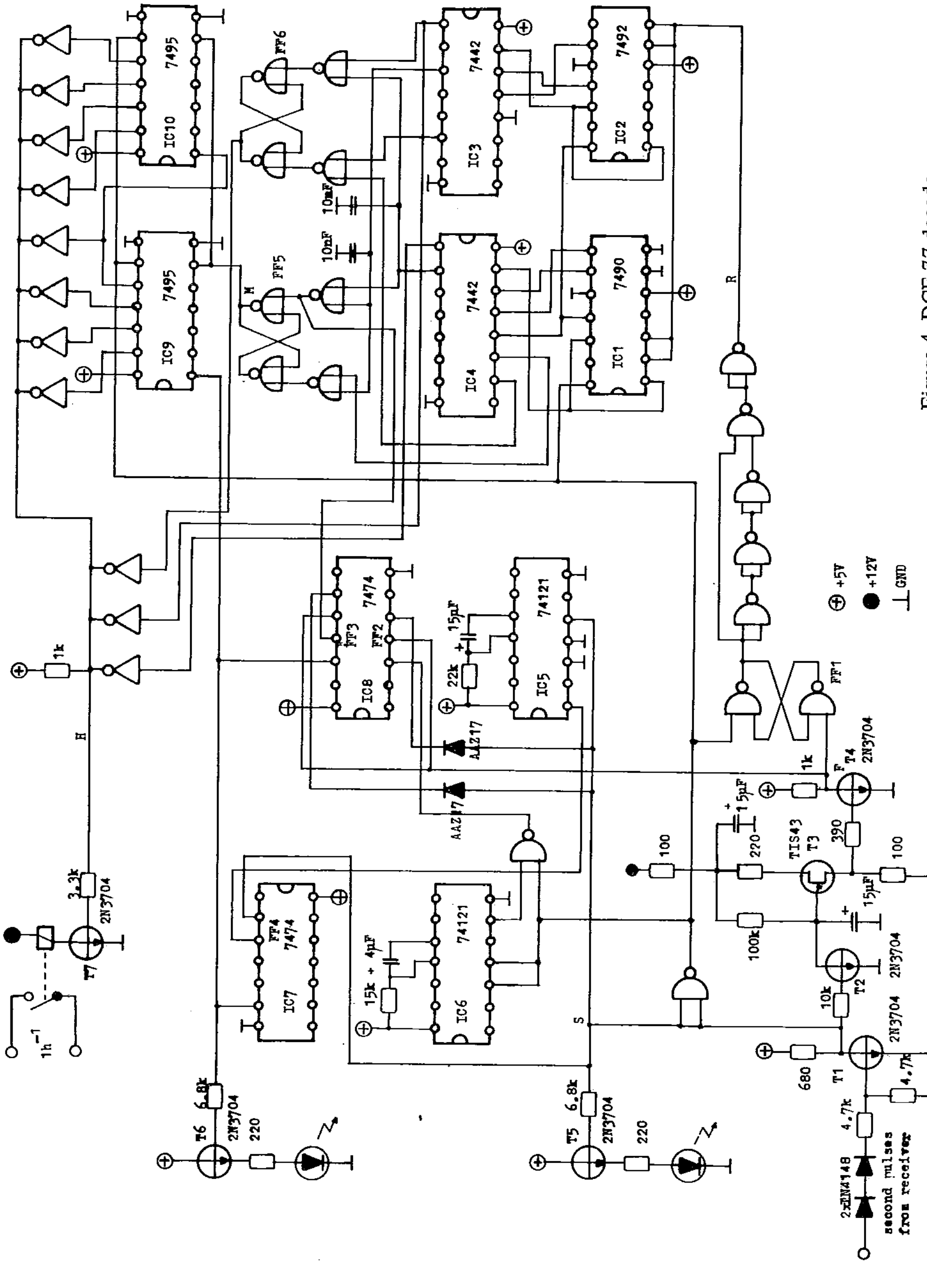

Figure 4. DCF 77 decoder.

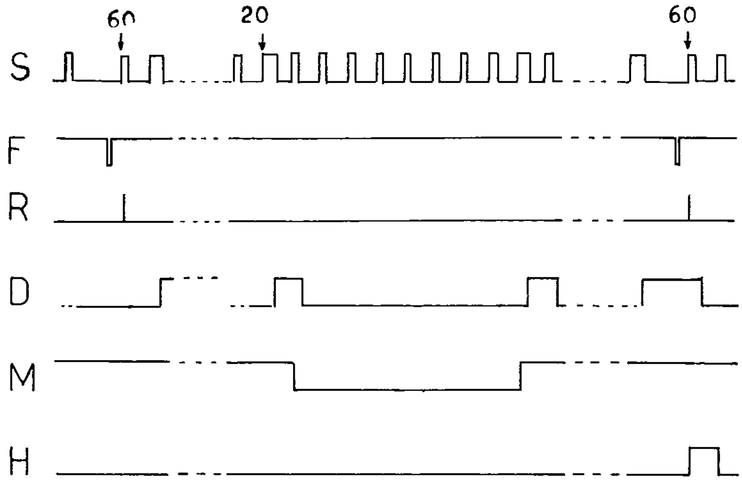

Figure 5. Pulse diagram.

outputs of the shift register are wired-ored by open-collector inverters. When all the minute data as well as the second data are zeros, T7 activates a relay to give contact closure of one second. Pulse diagram is in figure 5.

5. *Error protection*

The signal to noise ratio of DCF 77 signal is not good in northern Finland and additional noise is induced from local noise sources. To get an accuracy of about one second of the time marks some protection circuits are needed to prevent the occurring of false time marks. Three different error detection circuits have been added.

Should one pulse suddenly fail, the resetting of the second counter occurs. FF6 permits the reading of time data only after the 58th second pulse from the reset.

Sharp noise spikes could give false counts and data bits. Monostable multivibrator IC6 sets FF2 to short circuit the second pulse line until T3 sets FF1 to reset the second counter, if the lenght of a second pulse is shorter than 60 ms. FF3 does the same thing if the 20th second pulse is not binary one as it always should be.

6. *Discussion*

The DCF time signal receiver has been tested in Geophysical Observatory in Sodankylä for half a year and one receiver was installed in Tikkakoski, one in

Rovaniemi and one in Ivalo. The signal strength has daily and seasonal variations like other LF waves affected by the ionosphere. The signal strength depends strongly on solar radiation on the signal propagation path. The signal strength is at its minimum at noon and in the afternoon and at its maximum about midnight. The signal is stronger in winter than at summer time. In normal conditions these seasonal variations of signal strength are estimated to be not more than 20–30 dB. Stronger variations are believed to be seen less than once a week.

According to this relatively short experience the probability to get the time mark using DCF 77 receiver seems to depend strongly on local circumstances. This experience has showed that every day there fails at least one time mark, very seldom there may be no time mark in a day. In the month about 50 – 80 % of the time marks are recorded depending on the site of the receiver.

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