

SDR meteor detector

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Abstract

Construction of software defined radio meteor detector with possibility of advanced signal processing.



Contents

1	Technical parameters	2
2	Introduction	3
3	Description of construction	3
3.1	Antenna	3
3.2	SDR receiver	4
3.3	Time synchronisation	4
4	Software setup	4

1 Technical parameters

Parameter	Value	Note
Powering voltage for analogue part	$\pm 12V$	50mA
Powering voltage for digital part	+5V	300mA
Bias of optional LNA	9V	500 mA maximum ¹
Frequency range	0,5 - 200 MHz	Usually working at 143.05 MHz
Gain	90dB	Selectable by jumper and LNA configuration
Self noise number	< 30dB	

2 Introduction

The detection of meteors by radio is most readily accomplished by a method known as "forward scatter". This technique usually exploits the existence of a VHF radio transmitter intended for some other purpose (such as historically analogue radio or TV broadcasting) and which is preferably situated some way beyond the optical horizon so that the direct signal does not desensitise the receiving equipment. The radio signal reflects mainly from the ionised meteor trail as it forms and dissipates, causing a brief signal to be heard on or close to the transmitter frequency. The trails form in the ionosphere (i.e., the upper atmosphere) at a height of about 100 ± 20 km.

Direct reflection from the meteoroid itself is not so readily detected. Meteoroids are not necessarily reflective at radio frequencies, they are usually small (0.05 - 200mm) and they generally enter the ionosphere at supersonic velocities. Thus the direct signal is usually weak; and the initial Doppler shift is large, making it difficult to associate the signal with the transmitter. Sometimes however, a Doppler shifted signal is observed to slew onto or across the transmitter frequency at the beginning of the detection event. This is the reflection from the ball of plasma surrounding the meteoroid (as opposed to the trail left behind), and is known as the "head echo".

The term "radar" is sometimes used to describe the forward scatter detection method. Note however, that 'radar' is an acronym for 'radio direction and ranging' and so, although distance and direction information can be extracted from data aggregated from an array of receivers, a single receiver installation does not constitute a radar system. A single receiver can only strictly report an estimate of the number of meteoroids which enter the ionosphere in the region illuminated by the chosen radio transmitter. Other interesting aspects of the meteor strike can be inferred from the recorded signals, but apparently obvious information, such as the relationship between signal strength and meteoroid mass is complicated by issues such as signal polarisation, trajectory and transmitter coverage.

One advantage of radio detection is that it works when the sky is light or when the sky is dark but overcast. By choosing a sufficiently powerful host transmitter, it also possible to record meteors which are too faint for the human eye even in the darkest and clearest conditions. A figure of between 2 and 10 times as many meteors as can be seen by visual observation under ideal conditions is sometimes quoted; but this must depend on the transmitter power and radiation pattern.

3 Description of construction

This construction of radio meteor detector uses France GRAVES space-surveillance radar. The radar has transmitting power of several megawatts at frequency 143.05 MHz.

3.1 Antenna

The detector station usually uses modified ground plane antenna. Adjusted in angle of 30° to East this configuration seems to be optimal to detecting stations in the Czech Republic.

The received signal from antenna is amplified by specially constructed LNA. This step is needed for feeding the signal through relative long (several metres) coax RG58. Construction of LNA01A is described on MLAB project site.



Figure 1: Antenna used at detection station

3.2 SDR receiver

The SDR receiver used is MLAB system SDRX01B direct sampling receiver. This receiver has ideal performance for UHF and lower band radioastronomy. So this receiver can be used even for radio meteor detection.

3.3 Time synchronisation

Time synchronisation has crucial importance in any modern science measurement. There is possibility of using many synchronisation techniques. Such as NTP or GPS (see for our article at for our experiences)

Suggested method for time synchronisation of a measuring station depends on level of desired information which would be obtained from meteor reflection event.

For example: If we need hour count data only. We can use PC system time without any synchronisation. But if we have one more station and we would like to compare data with another stations then NTP syncing would be good choice. Highest level is trail parameters determination which need true radar signal processing and most precise time synchronisation which could be achieved by GPS receiver.

4 Software setup

For simple PC based monitor station we are using SpectrumLab software with our configuration and detection script.



Figure 2: Example of meteor detector receiver setup

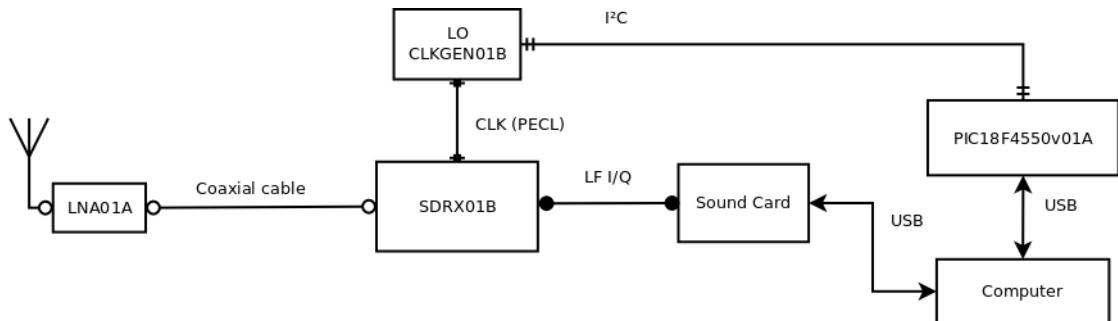


Figure 3: Schematic drawing of complete meteor detector

Observer : kaklik Hvezdarna_Svakov Location : 014°4130 East
 Country : Czech Republic 049°1538 North
 City : Sobeslav Frequency : 143.050 MHz
 Antenna : 1/4 GP Az. : 270° El. : 30°
 RF Preamp Low Noise home made with ATF-53189
 Receiver : SDRX01B www.mlab.cz
 Computer : eee1000H

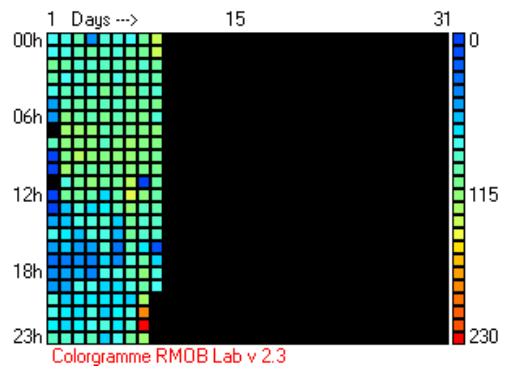
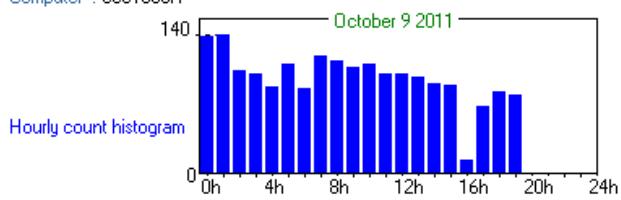


Figure 4: Example of measured hourly count of meteor showers

Local oscillator of SDRX01B is a CLKGEN01B module with frequency tuning controller PIC18F4550v01A can be set up from PC or can be programmed for fixed start up frequency. If fixed start up frequency is correctly saved the only step for tuning the LO is provide power through USB cable from PC and then press the RESET button of tuning microcomputer module. After that the LO should be tuned on saved start up frequency. This frequency can be changed by

References

- [1] Spectrum Lab <http://www.qsl.net/dl4yhf/spectra1.html>
- [2] Radio Meteor Detection <http://www.gb2nlo.org/index.php/articles/meteordet>
- [3] Meteor distance parameters <http://www.amsmeteors.org/richardson/distance.html>