A SHORT PULSE BLANKER FOR WIDE BAND RADIO SPECTROSCOPY

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I. INTRODUCTION

Radio Frequency Interferences (RFIs) are a major concern for most radioastronomy observations longward of 30 GHz.

On the one hand, the radio spectrum is heavily congested with transmitters of all kinds on the ground , airborne or satellite born.

On the other hand, astronomers often need to tune their receivers outside of the few protected bandwidths either to observe redshifted spectral lines or newly discovered transitions which have no protection even at their rest frequency.

Last but not least,the need for higher sensitivity often requires integration times in excess of hours while the detrimental limits set by the ITU several decades ago (eg ITU-Recommendation 769) are based on only 2000 seconds integration.
But the situation has radically changed in recent years: sporadic RFIs tend to become more and more present with ever increasing levels. The r.m.s fluctuation then fails to decrease inversely proportional to the square root of the integration time.

Among the many ways to deal with RFIs, one of them consists in using shorter and shorter time constants and rejecting corrupted samples in real-time or off-line analysis. For practical reasons, the frontier is of the order of a few seconds eg for autocorrelator backends.
Without a priori knowledge on the interferer, the only way to operate a blanker is to delay the incoming signal for an ajustable amount of time sufficient to perform a quick analysis and decide whether the sample is corrupted or not.

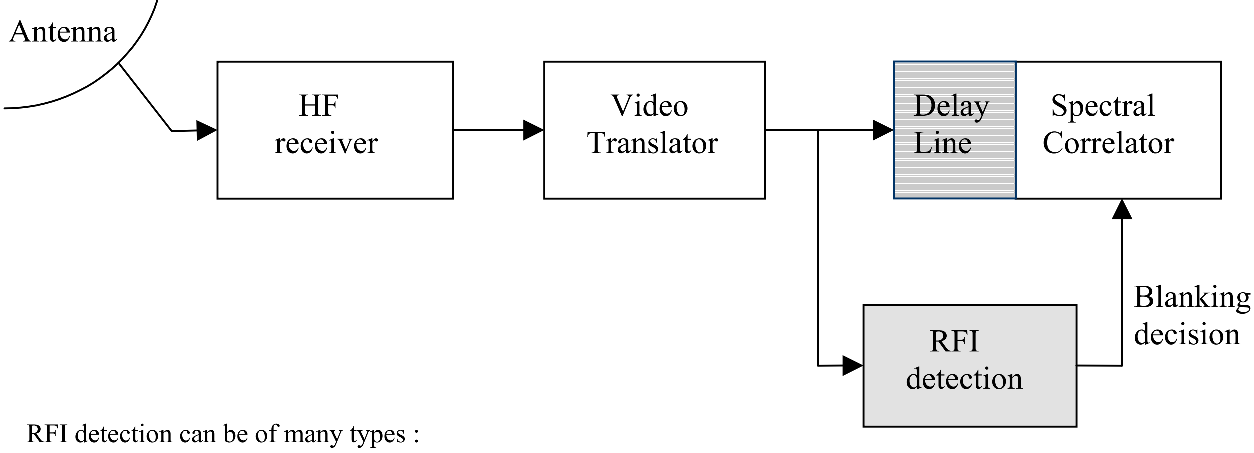
The device that we propose is based on this principle. It assumes that the RFI is not always present and that there are time slots during which the receiver statistics is white noise.

In the past, we have successfully observed OH megamasers through mobile satellite signals near 1623 MHz [1]. Likewise, Weber et al. have proposed a blanking device based on recognition of cyclic signals [2].

Strong RFIs like radar signals may have a twofold detrimental effect on receiver fluctuation. First the spectral information is lost at the radar frequency. Second the radar pulse may be so strong that the receiver response is distorted due to the hysteresis of the active components. On the other hand, the duty cycle of a radar is very small and an appropriate blanking device should be able to allow observations between pulses.

II. GENERIC PRINCIPLE OF A REAL TIME RFI BLANKER FOR RADIOASTRONOMY

Shown below is a simplified diagram of the signal path of a radiotelecope with added stages (in grey) needed to blank RFI :

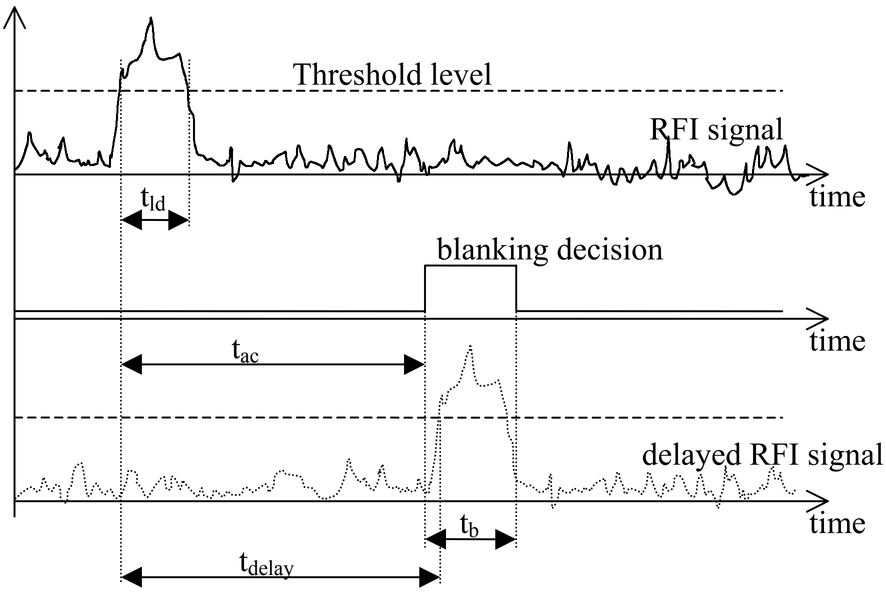


RFI detection can be of many types :

Level threshold

Signal processing algorithms (eg. for detection of cyclo stationnary waves)

Delay line compensates the time constant of the RFI detection system in order to time synchronize in the spectral correlator the blanking decision and the corrrupted signal.



t_{ld} : incoming signal is above the threshold level during this time, assuming RFI
t_{ac} : RFI detection system time constant
t_b : blanking pulse width
t_{delay} : delay of the programmable delay line to time synchronise the blanking pulse and the RFI signal in the correlator.

Time relationships for a proper blanking of the RFI signal :
With t_{rise} , t_{fall} respectively rising time and falling time of the RFI :

$$t_{delay} = t_{ac} + t_{setup}$$
$$t_b = t_{rise} + t_{ld} + t_{fall}$$

In the Nancay Spectral correlator, t_{delay} is realized by a programmable FIFO memory with a maximum delay of 1M samples (10.48 ms at 100 Msamples/s up to 42 ms at 25 Msamples/s).

III. APPLICATION WITH A THRESHOLD DETECTOR

The redshifted HI observations are perturbed by a strong civil radio navigation radar at 1366.375 MHz. Every 4.8 seconds, a burst of 5 to 15 pulses reaches amplitudes of several ten decibels above receiver noise (Fig.1).
The pulse repetition rate is 100 Hz. The time caracteristics of the detected pulse are typically 2.5 microsec. for the rise time, 1 microsec. for the fall time and 4 microsec. for the pulse width. While the spectral correlator itself is protected by diodes, the spectral shape is distorted over some 700 kHz centered at 1366.375 MHz. Furthermore, the radar likely causes ripples in the overall line profile.

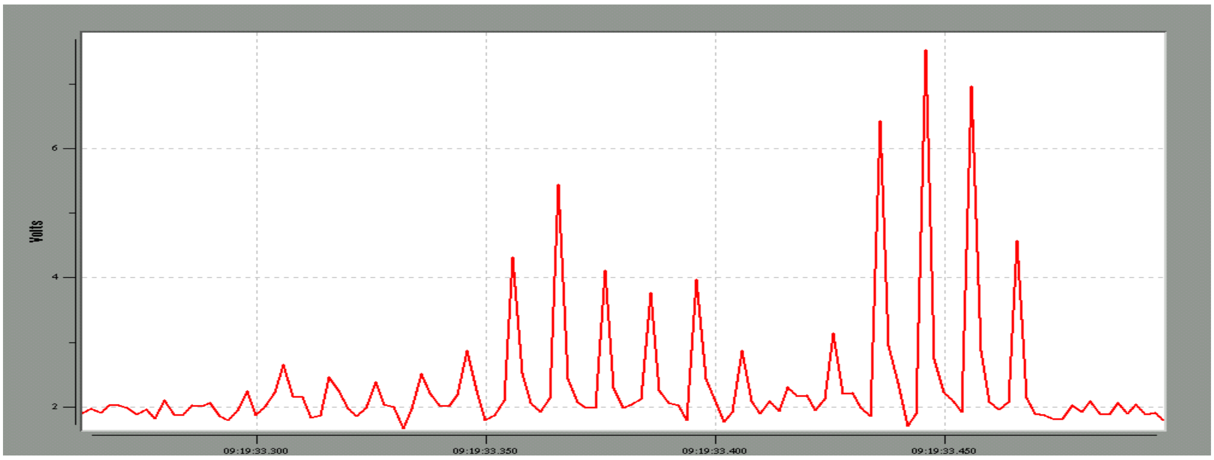


Figure 1: Bursts of the 1366.375 MHz radar observed in a 3 MHz video bandpass
and 2 millisec. time constant

The blanking signal which triggers the spectral correlator is generated by a threshold detector and an interface circuit which includes a reference voltage and a signal shaping (Fig.2). The test mesurements are carried out with a noise generator and a pulse generator in order to simulate a nominal video noise perturbed by a pulse in the amplitude range corresponding to the dynamical range of the detector.

The threshold detector is based on a germanium diode HU25A at zero bias used in its linear zone. The choice of this detector meets the two following requirements (i) measure the total power of the video signal with good linearity in the dynamical range and bandwidth of the signal (ii) detect pulses in a large dynamic range and short time constant.
The actual response time is of the order of 1 microsec.

The interface circuit consists in a fast hysteresis comparator which compares the detected signal with a reference level above which the video signal is blanked. A delay generator extends the comparison signal by a fixed delay Tau to form the blanking signal. This delay takes into account the pulse rise time to reference level T1, the pulse fall time beyond reference level T2 and the time jitter due to the residual receiver noise fluctuation after detection. The latter depends on the video bandwidth and the pulse rise and fall times. With a video bandwidth of 50 MHz and pulse rise and fall time of the order of 1 microsec., the measured r.m.s. error is 270 ns.

Given the characteristics of the radar signal at 1366.375 MHz and the first tests in the laboratory, one may expect to reject the radar pulses with a total blanking time smaller than 10 microsec. every 10 millisec, thus loosing at most 1/1000 of the observing time.

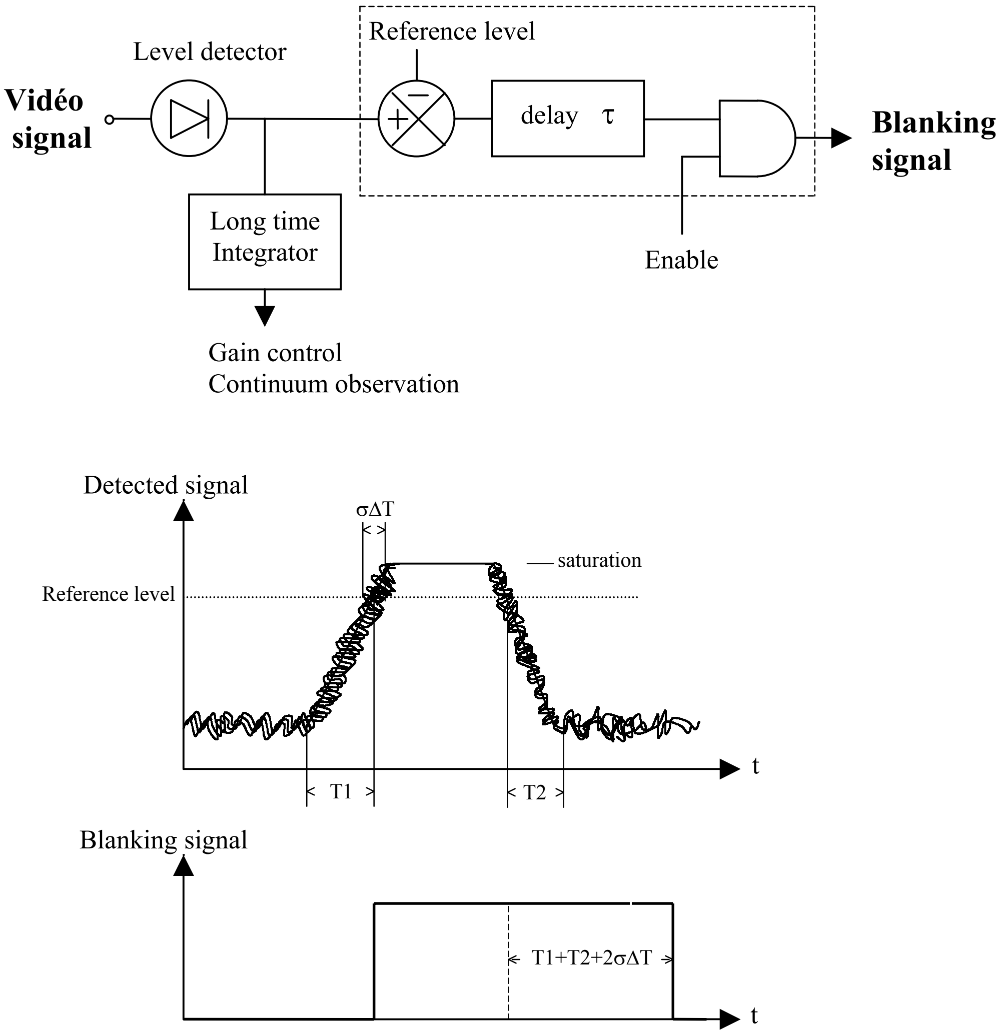


Figure 2 : principle of generating blanking signal with a threshold detector

References :

[1] V. Clerc, C. Rosolen, E. Gerard, A. Lecacheux, "Interference Tolerant Digital Spectrometer for Ground Based Radio-Astronomy", paper presented at the URSI XXVIth General Assembly, University of Toronto, Canada, August 13-21, 1999

[2] R. Weber, C. Faye, F. Biraud, J. Dansou, "Spectral detector for interference time blanking using quantized correlator" Astronomy and Astrophysics Supplement Series, 126, p. 161-167, November 1997