OSCILLATOR STABILITY TESTS ON BOARD ARMORED VEHICLES

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Abstract

In several field tests and experiments, the authors have shown that armoured vehicles are demanding platforms of electronic or microwave oscillators. Recent measuring efforts evaluating these problems are related to the armoured vehicular installation itself and stability issues. The paper shows some tested alternatives, test and recording arrangements and selected examples of measured three dimensional vibration spectra.

1. Introduction

Much of the performance of military electronics is coupled to the characteristics of respective time- or frequency-defining oscillators [1]. However, the environment of mobile armoured vehicle oscillators, either used in communication or computation systems or in radars [2], may well be one of the harshest [3]. Temperature extremes are frequently met. Vehicle speeds exceed 80 km/h also in severe terrain. Only coarse suspension is typically at hand and thus shocks and vibration tend to be a major concern [4]. This is particularly true if we e.g. want to maintain a synchronous fast frequency hopping VHF radio network, where we have to take care of a number of interacting oscillators [5]. A similar situation arises if our mobile radar performs moving target processing down to low Doppler frequencies [6] and we still need to maintain full speed due to tactical reasons. Additional stress of varying vibration spectra is caused by the weapon launch. Already proper protection of electronics against destruction due to brute collisions requires careful design. Unfortunately indeed, signal intelligence can make use of distorted oscillator spectra as a way of identifying units individual weapon platforms through their electronic fingerprints [7]. Despite armoured vehicles are physically large when compared to many electronics packages under consideration, we seldom find enough empty and unobstructed mounting space inside [8] whereby shock absorbing or vibration damping gets complicated.

2. Armoured vehicle as an oscillator platform

The authors have experimented with various armoured platforms in oscillator stability tests. An example of demanding vehicles is the Russian T-72 main battle tank, because of limited space and the severe vibration of platform.

Figure 1: T-72 main battle tank

There is not enough space inside the armored vehicle for mounting electronic systems or test equipment. For additional measurement devices is the turrets upper surface the only suitable mounting place.

Vibrations of the platform were measured in field tests carried out in true operational environment. There were 7 acceleration analyzer mounted on the turret of the vehicle (Fig. 2). The acceleration values were measured in typical operational situations.

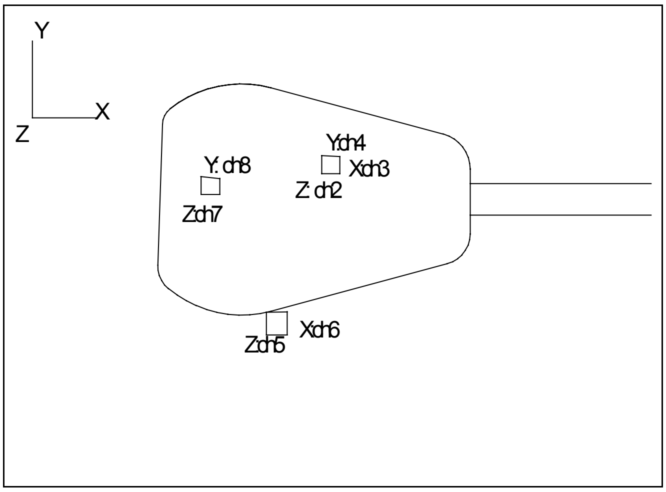

Figure 2: Example of the placement of acceleration analyzers on the turret surface

Measured vertical acceleration peak values exceed 10 m/s^2 with averages of 5-7 m/s^2 and typical time constants of 0.5-2 seconds, of course depending on terrain profile and speed. Momentary frequency offsets have been found to be up to 1 x 10^{-5} and shock-based drift around 1 x 10^{-7}/s.

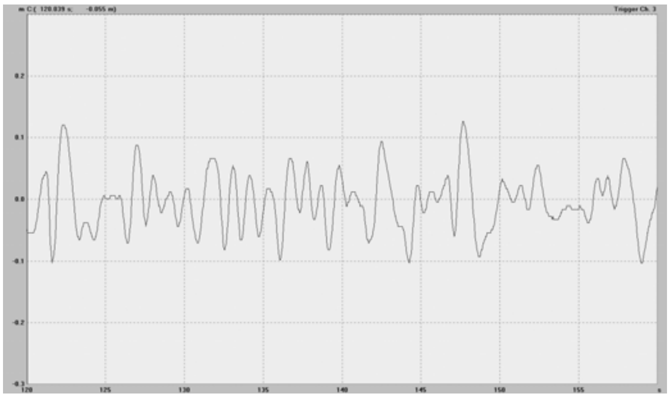

Figure 3: Vibration of the platform in vertical direction when the platform is moving in the operating environment

3. Oscillator stability test arrangements

Laboratory instruments and indoor vehicle test platforms are everyday facilities used in military oscillator work. Computer simulation tools enabling circuit development and mechanical vibration analysis have been available for a couple of decades. More recently we have seen dynamic simulation tools for moving vehicles. Despite these advances, oscillator performance evaluations continuously require extensive and well-prepared experimenting out in the field, in the particular foreseen operating environment. This implies that the frequency-generating device under test is seldom tailored to the available mobile platform and we have to take unprotected hardware out to the range. Often quite provisional arrangements are needed in order to make such experiments [9].

In oscillator stability tests the circumstances were really difficult. Tests were carried out in the desert. Temperature in test field varied between -10 to + 10 ºC. During this research, all environmental problems concentrated to moisture, variation in temperature and dust. To remove some of these problems, the computers and the other measuring devices were placed in a container or in warmed tent.

Figure 4: Container and tent for the research

The most demanding part of the arrangements was the electric power system. Electric power was produced by two aggregates. The aggregates were 4 kVA and 8 kVA. One aggregate (4 kVA) provided supply for the measuring devices and the other (8 kVA) for heaters, lightning and etc.

Figure 5: Aggregate (8 kVA) on duty under the cover

Figure 6: Aggregate (4 kVA) on duty on board the vehicle

4. Test transmitter integration to the armoured vehicle

Vibration is a demanding challenge, when a moving armoured vehicle is the oscillator stability tests platform. To eliminate vibration and for an exact alignment, the tank's stabilized main gun remains the only mounting place for the transmitter. By using the vehicle's fire control system, it is possible to point the transmitter beam exactly towards the receiver even when the vehicle is moving. In that way the authors could perform the experiments fluently.


Figure 7: The test transmitter was integrated on the armoured vehicle's main gun.

To integrate the transmitter to the main gun, a special stand had to be designed. The stand keeps the transmitter stable. Battery supply was included in the box of the transmitter.


Figure 8: Transmitter mounting on the main gun from the front side


Figure 9: Transmitter mounting on the main gun from the right side

5. Stability test

Oscillator reactions were tested in five situations. Those situations are most common in operational environment.

- standing vehicle (engine off)
- standing vehicle (engine on)
- forward moving vehicle
- reward moving vehicle
- forward moving vehicle (full speed)

In all cases the test arrangements were identical. The transmitter was integrated on the tank's main gun and the receiver was on a distant tripod. The receiver was aligned towards the moving vehicle as is shown in figure 10.

Figure 10: A view of the oscillator stability test runs

6. Results

The results of measurements in different operational situations are shown in figures 11 to 15. They describe frequency variations as a function of time.

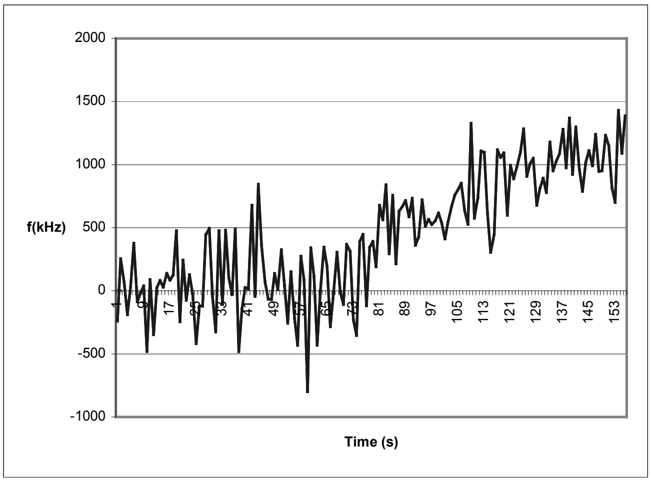

Figure 11: Standing vehicle (engine off)

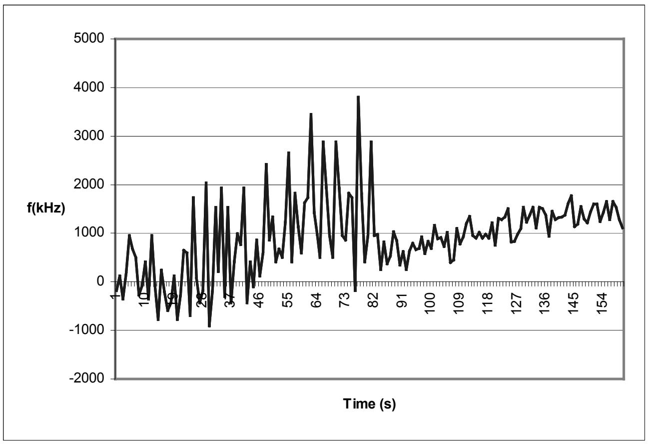

Figure 12: Standing vehicle (engine on)

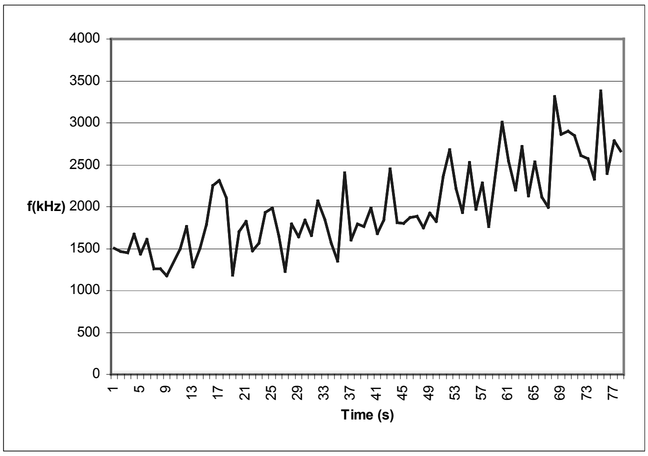

Figure 13: Forward moving vehicle

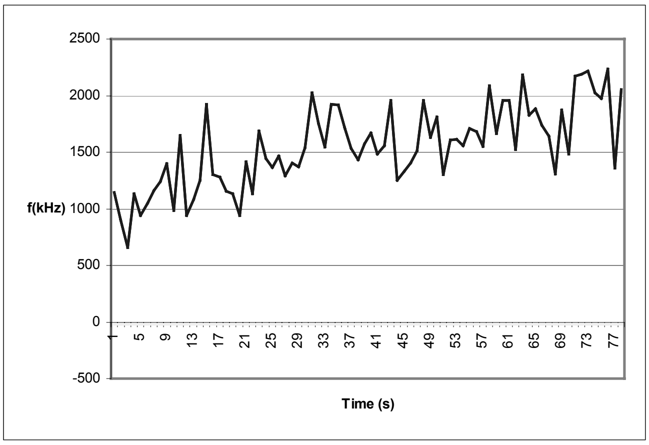

Figure 14: Reward moving vehicle

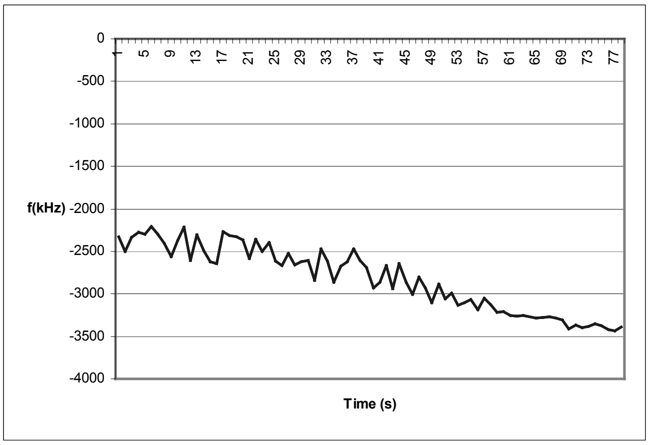

Figure 15: Forward moving vehicle (full speed)

The results are summarized in figure 16. The light curve presents frequency difference in ppm and the darker curve indicates vehicle motion. In chronological order steps are:

1. standing vehicle (engine off)
2. standing vehicle (engine on)
3. forward moving vehicle
4. reward moving vehicle
5. forward moving vehicle (full speed)

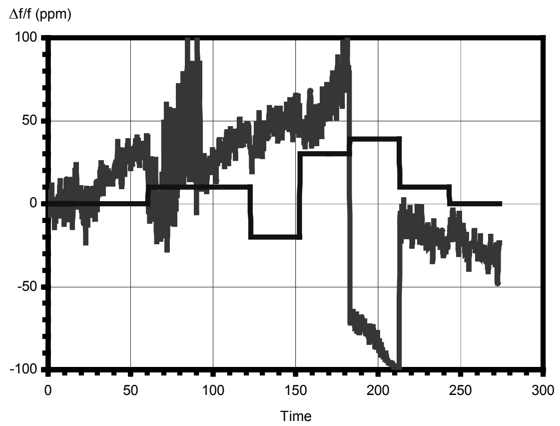

Figure 16: Results of the oscillator stability test

7. Conclusions

The hypothesis, that armoured vehicles are some of the harshest oscillator installation platforms seems to be right. The tests which were made in true operational environments and with an original armoured vehicle show that the most difficult situation for oscillator stability is forward moving with full speed in severe terrain.

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