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# LIQUIDITY SUPPLY AND MONEY VELOCITY CO-MOVEMENTS IN THE EUROZONE – TIME-FREQUENCY DOMAIN APPROACH

S. Kapounek, J. Poměnková

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**Abstract**

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The authors focus on financial stability in the Eurozone and propose alternative indicator for macro-prudential policy implementation. Rapid growth of the shadow banking system biases increase in loans to identify financial instability. The velocity of money represented money demand in the economy. The empirical part of the paper applies wavelet analysis to identify cyclical co-movements in money velocity and liquidity supply. The authors provide recommendations for policymakers to stabilize global liquidity shocks and reduce procyclical effects by institutions which supply official liquidity in their domestic currency – central banks.

financial stability, macro-prudential policy, credit money creation, money endogeneity, wavelet analysis

Inflation targeting strategy is currently implemented by more than 24 central banks across the whole world, including the European Central Bank (ECB). The Czech National Bank switched to this strategy in the year 1998. However, the preference of inflation targeting before monetary analysis marginalized monitoring of the credit expansion effects. During the last years we can observe significant imbalances at financial markets, especially asset markets. These imbalances are accompanied by rapid increase of credit money creation. The evidence is given by indicator of total loans in the euro area which increased by 12% in January 2006, to 8% growth in money supply measured by monetary aggregate M3.

It is evident that the recent financial crisis and the subsequent debt crisis did not come from real but monetary sector. However, the causes are no in the area of price stability but financial stability. Major central banks (including the ECB) focused mainly on price stability, and were quite successful in keeping inflation low. They failed, however, to see the bubbles in asset markets that were threatening financial stability. Why central banks did not focus on the financial instability identification? The reasons are very pragmatic. Unlike price stability, financial stability is not easy to define or measure. The financial instability is not accompanied by movements in aggregate price indices (harmonized index of consumer prices did not exceed level of 4% during the last 20 years in the Eurozone).

However, the argument that one cannot identify financial instability ex ante is weak. Borio and Lowe (2002) define financial instability through an increase in loans, accompanied by growth in market prices of assets. The combination of these two indicators can be found already in the paper of Kindleberger (2000). Current discussions about the monetary policy implementation focus on lending channel and possible indicators. Minimum reserve requirements could be useful instrument to control bank credit, because these are strongly correlated with asset prices. The central bank could increase the minimum reserve requirements when bank credit is expanding too quickly. Alternative approach is macro-prudential control. Many economists and policy-makers recently discuss coordination of banking supervision, monetary policy and macro-prudential policy.

However, the euro area is specific low-inflation region. The banking system in the euro area is sensitive on money demand changes because upper limit of credit money creation is vanished in huge currency areas. The money demand significantly decreased during the financial crisis because of low investment activity. Therefore, during the years 2008, 2009 and 2010 credit money creation and broader money aggregates declined (the growth of the money aggregate M3 declined markedly throughout –0.4% in February 2010).

Since the intensification of the financial crisis in September 2008 and throughout 2009, the European Central Bank (ECB) continued to reduce official interest rates to 1.0 per cent, which corresponds to the lowest level observed among euro area countries in recent history. However, money demand and investment activity was not restored.

In October 2008 the banks in the Eurozone were gripped by a full-scale liquidity crisis. The Eurosystem stepped in with massive liquidity injections, using both open market operations and marginal lending facilities. However, the additional liquidity held by banks has not been transmitted to the real economy through credits. The excess of liquidity leaves at the balance sheets of commercial banks.

If the additional liquidity held by banks has not been transmitted to the real economy through credits, total amount of loans or credits is not optimal indicator for macro-prudential policy. This argument is also consistent with the research results of Financial Stability Board about the rapid growth of the shadow banking system (non-bank credit intermediaries). The study shows that the shadow banking seems to constitute some 25–30% of the total financial system and is around half the size of bank assets in the year 2011 (FSB, 2011). If so, all current official monetary statistics are biased.

Therefore, the main problem of financial stability consists in its implementation into the monetary policy strategy. There are two fundamental questions: (1) what kind of instruments and indicators have to be implemented by central banks or economic policy makers and (2) how should be macro-prudential policy coordinated with monetary policy and specific bank liquidity requirements.

In the regulatory framework for liquidity management, Basel Committee on Banking Supervision (BCBS) run by the Bank for International Settlements (BIS) carried out a document (2009) named International Framework for Liquidity Risk Measurement, Standards and Monitoring. Its goals were creating a harmonised regulatory framework for liquidity management in the European scope. The fundamental part of the document is a draft of regulatory standards for measuring liquidity and monitoring instruments. The document states two basic regulatory standards for measuring quality – Liquidity coverage ratio (LCR) and Net stable funding ratio (NSFR).

Highly liquid assets and their value in stressed conditions (value of the stock of high liquid assets in stressed conditions) in relation with assumed outflow of financial means in 30 days play a very important role in the drafted concept. The document sets assets the banks may use for identifying the value of highly liquid assets. Regulators make pressure on strengthening the position of liquid assets in the whole concept of liquidity management.

The initiative of BCBS is a part of preparation of a new concept of capital adequacy, which is now being ratified, called Basel III. Apart from the standards for measuring liquidity, Basel III proposes introduction of a lever ratio as a complementary indicator to capital adequacy. The proposed measurements of banking liquidity management are to be implemented starting in 2015 after the ratification of the document by national regulators.

The current research only confirms the timeliness issue and the need for methodological framework. Gersbach and Hahn (2011) propose a solution in the form of interaction between micro-prudential supervision (capital adequacy of banks), macro-prudential supervision (to minimize fluctuations in the volumes of loans) and monetary policy (to minimize the loss function involving inflation and growth gap). Galati and Moessner (2011) highlighted the issue of coordination of macro-prudential policy and monetary policy. The Eurozone is unique in this own way. The monetary policy is at the transnational level, the micro-prudential control at the local level of each member state.

However, the key problem remains. If the credit supply is limited by willingness of commercial banks, the economic agents turn to the non-bank credit intermediaries. These credits are out of control any regulatory frameworks.

The authors of this paper focus on the money velocity and its linkages with liquidity supply during the economic recession in the years 2008–2010. The final parts of the paper focus on the macro-prudential policy discussions and propose alternative financial stability indicator.

## METHODS

Assume that investment and economic activity decline leads to low credit money creation by banking system. This process is accompanied by significant money velocity movements which equalize money demand and supply (Kapounek, 2010).

Suppose that the sources of cash provided by non-bank credit intermediaries are spent or saved within the economic system. All transactions are included in supply and demand interactions. Concretely, shadow banking market expansion could increase nominal output and money velocity in the economy without any changes in monetary aggregates. In the context of the financial stability assumptions, the credit growth monitoring is needed. The money

velocity movements hold important information not only about the credit money creation but also about the money demand.

Assume that velocity can be divided into transitory and persistent component, where the inverse of the transitory component is possible to be interpreted as monetary overhang or liquidity excess. Shocks that cause a deviation from the potential output will most likely be attributed to the cyclical components of money velocity. The return of money velocity to its equilibrium is accompanied by the return of the output to its potential. For purposes of this paper, assume that the money velocity movements are determined by money demand.

On the other hand, money supply is represented by liquidity achieved through open market operations of the ECB. The ECB calculates benchmark allotment amount for main refinancing operations (*MRO*) and it takes into account the liquidity effect of all non-standard measures. This benchmark allotment covers accumulated liquidity imbalance, future liquidity needs and liquidity which was already provided (ECB 2011):

$$MRO_t = \frac{1}{H_t - X_t}\left[D_t\left(RR + ER - \overline{CA_t}\right) + H_t\left(\overline{AF_t} + RR + ER\right) - H_t\left(L + P + F\right) - X_t M^{mat}\right], \quad (1)$$

where $H_t$ represents number of days from (and including) day $t$ to (and including) the day before the settlement of the next *MRO*, $X_t$ is number of days from (and including) day $t$ to (and including) the day before the settlement of the *MRO* which the benchmark is calculated, $D_t$ represents number of days from (and including) the first day of the reserve maintenance period to (and including) day $t - 1$. *RR* represents daily average required reserves of the relevant reserve maintenance period, *ER* is forecasted daily average excess reserves for the relevant reserve maintenance period $\overline{CA_t}$, is average current account holdings since the beginning of the reserve maintenance period until day $t - 1$, $\overline{AF_t}$ estimates reflect pure autonomous factor forecast values, *L* represents expected daily average liquidity supplied by the longer-term refinancing operations in the period covered by $H_t$, *P* is expected daily average liquidity supplied by the covered bond purchase programme in the period covered by $H_t$, *F* is expected daily average liquidity provided/absorbed by other operations (e.g. fine-tuning operations) in the period covered by $H_t$ and $M^{mat}$ represents size of the maturing *MRO*. *The benchmark allotment is defined as the MRO allotment that will allow counterparties to smoothly fulfil their reserve requirements taking into account i) the future liquidity needs from reserve requirements, autonomous factors and excess reserves, ii) the future liquidity supply through other refinancing operations and other monetary policy instruments, iii) the accumulated liquidity imbalance recorded in the course of the maintenance period, and iv) an assumption that, on a forward looking basis, there will be zero net use of standing facilities (marginal lending and deposit facility) (ECB, 2011).*

## DATA

In the empirical analysis is used monthly data of benchmark allotment amount for main refinancing operations which is averaged into quarterly dataset (*MRO*). Money velocity movements (*V*) are calculated from the quantity equation of money in quarterly periodicity. The both data sets include 50 observations measured in time 1999Q1–2011Q2. Before analysis we transform input values in natural logarithm. Eurostat is the main datasource used for money velocity movements calculation. Benchmark allotment amount for main refinancing operations is provided by ECB in internal liquidity management dataset.

## METHODS OF EMPIRICAL ANALYSIS

Let us have a seasonally adjusted time series $y(t)$, $t = 1,\ldots, n$. We assume the time series contain long-term trend. Let consider additive decomposition in the following form:

$$y_t = g_t + c_t + \varepsilon_t, t = 1, \ldots, n, \quad (2)$$

where $g_t$ denotes long-term trend, $c_t$ is the cyclical component and $\varepsilon_t$ is the irregular component. If we focus on analysis of cyclical movements around its long-term trend, it is suitable to remove long-term trend applying some filtering method. From the wide range of filtering method we choose Hodrick-Prescott filter (1980) and first order difference (FOD) (Canova, 1998). The choice is motivated by the fact, that Hodrick-Prescott filter is high pass filter.

Subsequent analysis identifies co-movements between the money velocity and liquidity supply provided by ECB. The both time series consists of cyclical movements which vary with different investment and economic cycle phases. The short-term shocks, medium and long-term waves will be analysed in time-frequency domain by estimation of the spectra.

However, the co-movements between the both variables are changing during the financial crisis. Time-frequency analysis used for estimation of spectrogram by the wavelet approach provides a tool for monitoring the development of indicator not only in time, but also with regard to the frequency structure. The similar application was introduced in the paper of Poměnková, Kapounek and Maršálek (2011) focused on identification of economic activity regularities during and before financial crisis. In wavelet transform is used any mother wavelet defined on finite interval. Then, the properties that are described by certain value of spectrum can be related to the time and frequency interval. Note that the classical frequency transform does not allow that. When estimation of the spectra in frequency domain by periodogram is calculated, Fourier transform with harmonic basis functions which are nonzero on the whole time interval is used. Thus, estimate of the spectrum in each point is influenced by the whole time series. On the

other hand, the wavelet basis functions cover the time interval of the series per parts (wavelet basis function is time shifted and scaled), so that complete time-frequency information can be expressed. As the alternative approach to wavelet analysis the time-frequency analysis based on time-varying AR(p) process estimation can be taken (Šebesta and Maršálek, 2011).

Regarding the ability of temporal localization of events in the spectrum, then the wavelet transform to a certain extent, be likened to the Short Time Fourier Transform (STFT) with a moving time window (Ján, 2002).

The continuous wavelet transform of time series $y(t)$ with respect to the mother wavelet $\psi_{a,\tau}(t)$ is defined as

$$S_{CTW}(a,\tau) = \int_{-\infty}^{\infty} y(t)\frac{1}{\sqrt{a}}\psi\left(\frac{t-\tau}{a}\right)dt, \quad a>0, \tau \in R, \qquad (7)$$

where mother wavelet takes the form $\psi_{a,\tau}(t) = \psi\left(\frac{t-\tau}{a}\right)$, $\tau$ is the time shift, $a$ is the parameter of dilatation (scale), which is related to the Fourier frequency and numerator of the fraction $\sqrt{a}$ ensures the conservation of energy.

To satisfy assumptions for the time-frequency analysis, waves must be compact in time as well as in the frequency representation. There exist a number of wavelets which can be used, such as Daubeschie, Morlet, Haar or Gaussian wavelet (Gençay, Selçuk and Whitcher; 2002), (Adisson, 2002).

An inverse wavelet transformation is defined as

$$y(t) = \frac{1}{C_\psi}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\psi_{a,\tau}(t)S_{CWT}(a,\tau)\frac{da\,d\tau}{a^2}, \qquad (9)$$

where $\psi_{a,\tau}(t)$ is the mother wavelet and $S_{CTW}(a, \tau)$ is the continuous wavelet transform of time series $y(t)$ defined in relation (8). For $C_\psi$ hold

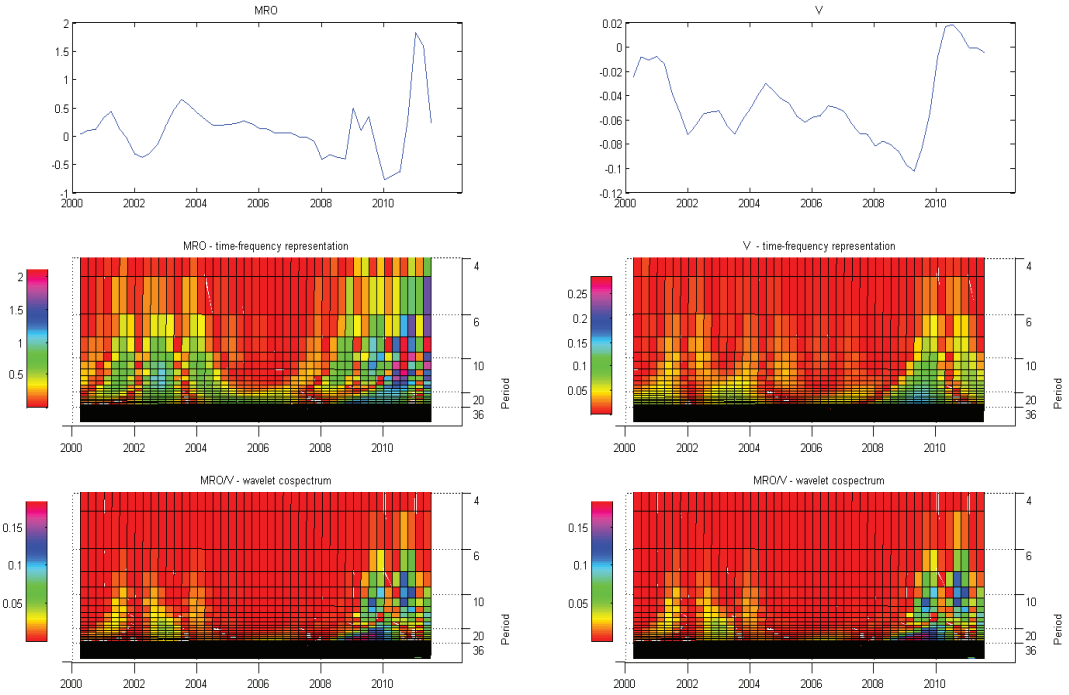
$$0 < C_\psi = \int_0^{\infty}\frac{|\Psi(\omega)|^2}{\omega}d\omega < \infty,$$

$\Psi(\omega)$ is the Fourier transform of $\psi_{a,\tau}(t)$.

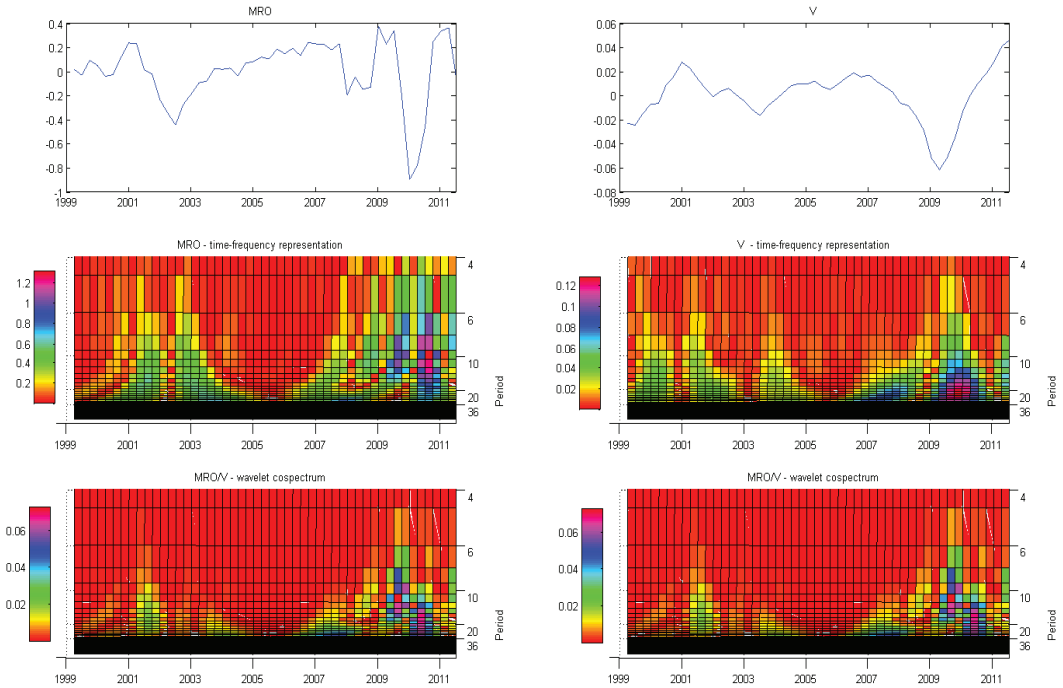
As stated by Ján (2002), the wavelet description of time series could be better than classical Fourier spectrum for a number of time series, as it provides a good time series approximation with only a small number of spectral components. The reason is that the time series may contain sharp edges or discontinuities that require more spectral coefficients in the classical spectra, while the wavelet representation can represent the same information with sufficient accuracy with only a small number of spectral components.

## RESULTS

For the empirical analysis we used data set described in the section "Data". As an input transformation we applied natural logarithm. Before application of time-frequency approach we made pre-filtering of input time series with the aim to obtain growth representation of time series around its long-term trend. For these we used




1: *Liquidity and money velocity in the Eurozone, FOD pre-filtering*




2: *Liquidity and money velocity in the Eurozone, HP pre-filtering*

Hodrick-Prescott filter with smoothing parameter for quarterly value and first order difference. For the wavelet analysis the choice of mother wavelet was motivated by the study of Rua (2010), which used this type of wavelet for analysis of co-movement of growth cycles in selected euro area countries. Therefore a Morlet wavelet is applied in our empirical analysis.

In presented charts we illustrate results of time-frequency approach. Each chart consists from six pictures divided into two columns and three rows. The first row is time domain representation of filtered time series, the second row is corresponding time-frequency representation and the third, last one, is cospectrum. In the left column of both charts we can find results for liquidity supply (*MOR*), in the right column there are results for money velocity (*V*).

The figure 1 presents result of empirical analysis for liquidity supply and money velocity pre-filtered in time domain by the first orded difference. Looking to the results we can see that both time series contain regular cyclical movements in the years 2009 and 2010. The highest value of spectrogram we can find in range between 6 and 20 periods (quarters). Liquidity supply movements contain shorter waves in this period as well. Other regularities we can see in movements of liquidity supply in the year 2001, 2003 and 2004. The cospectrum represents the co-movements of analyzed time series at different frequencies with respect to the time. We can identify co-movements in liquidity supply and money velocity in the period 2009–2011. Thus, we can say there are synchronized cyclical movements between 6–16 periods.

The figure 2 presents result of empirical analysis for liquidity supply and money velocity pre-filtered in time domain by the Hodrick-Prescott filter. There are similar results in comparison with figure 1. The cospectrum identified regular comovements in the period 2009–2011 in similar periods.

Presented methodological approach gives us an instrument to identified co-movements during the crisis periods. Regardless of pre-filtering technique we can see there are waves between 6–16 quarters (1.5–4 years). Liquidity supply and money velocity changes are synchronized during the financial crisis when investment, economy activity and credits decreased. We can assume that liquidity supply which is offered by ECB is synchronized with money velocity movements.

## DISCUSSION

There is homogeneous agreement among the theoretical economists, that economic activity impact money demand. Assuming the validity of endogenous money theory, money supply is determined by its demand. Therefore, liquidity-providing operations by central banks have to be related with investment and economic activity. Procyclical character of money velocity movements was already discussed by monetarists. It is not surprising that regular movements in money velocity were founded during the crisis period. The recent literature mostly focuses on the liquidity and systematic risk.

The official liquidity is created by central banks in their domestic currency. The financial crisis provided symmetric shocks which were transformed

into global liquidity shocks. These shocks require interventions by institutions with the ability to supply official liquidity and reduce procyclicality (Landau, 2011). Adrian and Shin (2009) summarize that balance sheet dynamics of central banks plays important role in ensuring of financial stability. They point out that monetary policy and financial stability policies are linked.

Sudo (2011) found that liquidity requirements shocks and household's discount factor are the key factors to explain money velocity reduction following the Japanese banking crisis. Gourinchas (2011) point out that financial instability is problem of global liquidity imbalances: … *Global liquidity imbalances track the liquidity mismatch across countries and over time, which may or may not result in current account deficits and surpluses.*

IMF (2011) contributes that in times of uncertainty, banks are likely to require a capital buffer in excess of regulatory frameworks. *Policymakers should now shift their focus from accommodative macroeconomic policies to more structural approaches to strengthening balance sheets and reducing debt burden (IMF, 2011).*

Macroprudential policy framework is the current topic of central banks which play key role in financial regulation and supervision because global liquidity shocks require interventions by institutions with the ability to supply official liquidity.

## SUMMARY

This paper point out that Eurosystem stepped in with massive liquidity injections, using both open market operations and marginal lending facilities because the banks in the Eurozone were gripped by a full-scale liquidity crisis in October 2008. However, the additional liquidity held by banks has not been transmitted to the real economy through credits. Economic (investment) activity decreased during the crisis period. The balance between the money demand and supply was reached by credit money creation changes. And, withal, total amount of loans increase was primary cause of financial crisis.

Assume that financial stability is the main condition for reducing the financial crisis emergence. The authors suppose that increase of credit money creation was followed by assets prices. The combination of these two phenomena threats financial stability. However, empirical study of Financial Stability Board shows that the shadow banking seems to constitute some 25–30% of the total financial system. Consequently, if non-financial intermediaries create significant share of credit money, there is no standard indicator of actual amount of credits. Therefore, the authors focus on aggregate indicator.

They suppose that money demand and supply are permanently balanced. Consequently, there is mechanism which reacts on money demand at financial market and provides additional liquidity. Based on money endogeneity arguments, upper limit of money creation in huge financial system is vanished. The appropriate indicator of financial instability, applied in macro-prudential policy, should include changes of money demand. Assuming a fixed money supply, increase of money demand is followed by money velocity changes.

The wavelet analysis identified that there are regularities in movements of money velocity. These regularities, explained as cyclical movements, are the most significant during the crisis periods. The cycles correspond to the length of 1.5–4 years. If money velocity consists of cyclical movements, money demand and supply is regularly balanced. This conclusion is not so surprising, because money supply is determined by money demand affected by investment cycles.

The similar regularities were found in liquidity supply (measured by benchmark allotment amount for main refinancing operations of ECB), concurently, the empirical analysis shows significant comovements between 6–16 periods as well. Movement in money velocity is accompanied by liquidity supply. The situation of last several years describes economic recession. However, if money velocity increases, financial markets are forced to provide more credits. A pro-cyclical influence results in a boom which is then followed by a bust is task for macro-prudential policy (anti-cyclical instruments). Identificator based on the money velocity movements has potential function to interrupt Post-Keynesian transmission mechanism and to prevent markets from its instability.

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Address

doc. Ing. Svatopluk Kapounek, Ph.D., Ústav financí, Mendelova univerzita v Brně, Zemědělská 1, 613 00 Brno, Česká republika, doc. RNDr. Jitka Poměnková, Ph.D., Ústav radioelektroniky, Vysoké učení technické v Brně, Purkyňova 118, 612 00 Brno, Česká republika, e-mail: skapounek@mendelu.cz, pomenkaj@feec.vutbr.cz