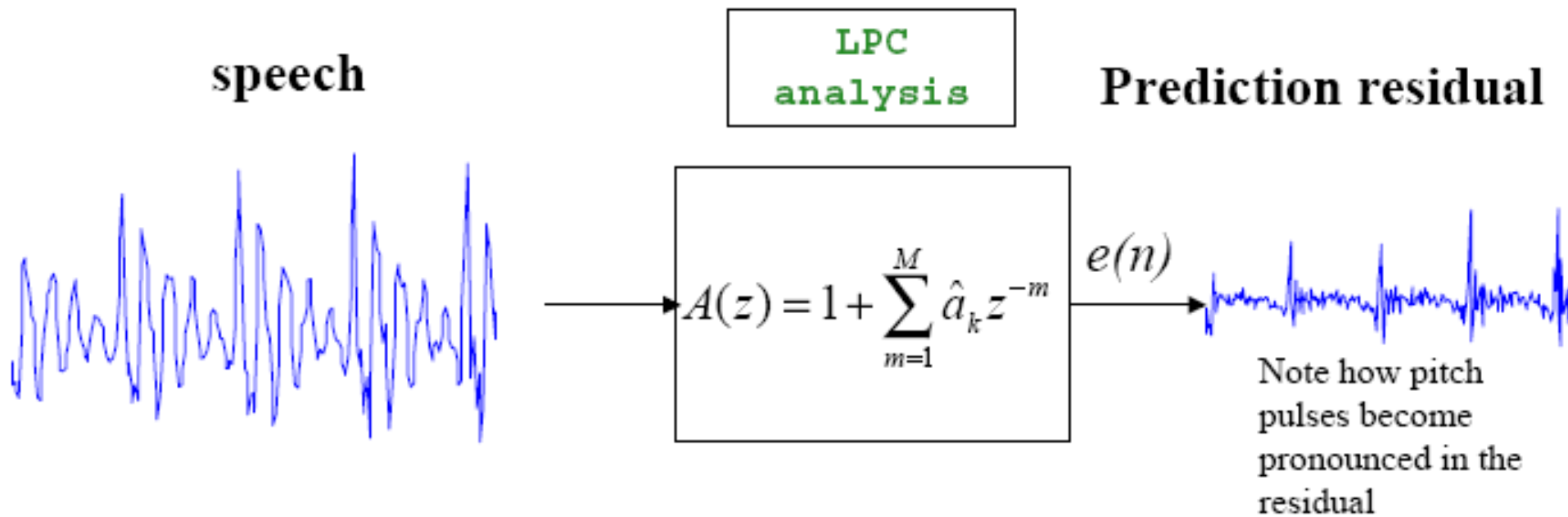


"CROSS" LPC SYNTÉZA

12. listopadu 2015

- **Vzájemná syntéza (Cross Synthesis)**
- **Lineární predikce LPC (Linear Prediction Coding)**
 - LPC analýza
 - LPC spektra
 - signál chyby predikce
 - odhad řádu AR modelu
 - LPC syntéza
 - **Aplikace:**
 - LPC vokodér s různým typem buzení
 - změna časového měřítka a pitch shifting
 - "cross" syntéza
 - modelování s využitím impulsní charakteristiky

LPC analýza



LPC analýza

- FIR filtr, který predikuje aktuální vzorek řeči z kombinace předcházejících vzorků
- kombinace koeficientů filtru pro LPC syntézu
- predikce chyby obsahuje informaci o hlasivkovém tónu
- z predikce chyby lze získat informace o znělosti a o základní periodě
 - typická délka okna při analýze je 20 až 30 ms
 - překrytí 0 až 20 ms

```
% několik period samohlásky E - 512 vzorků  
signal1=sig(33001:34024);  
N1=length(signal1);
```

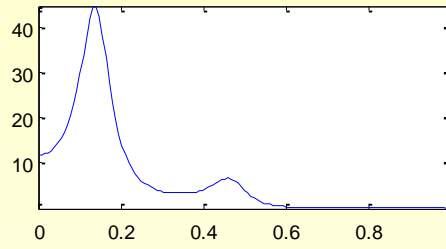
```
% jedna perioda samohlásky E 40 vzorků  
signal2=sig(33171:33210);  
N2=length(signal2);
```

```
% iniciální T - 256 vzorků  
signal3=sig(36631:36886);  
N3=length(signal3);
```

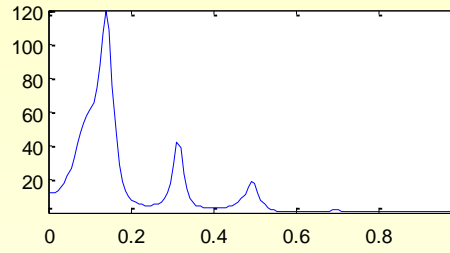
```
% SH - 1024 vzorků  
signal4=sig(14601:15624);  
N4=length(signal4);
```

LPC spektrum

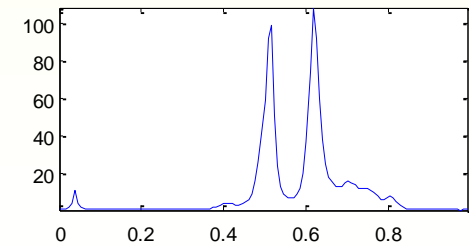
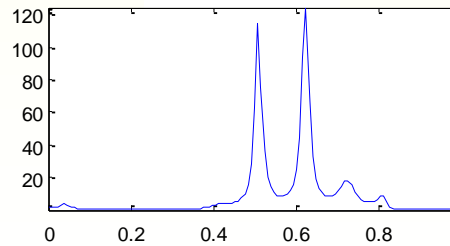
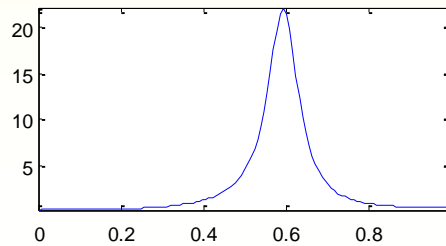
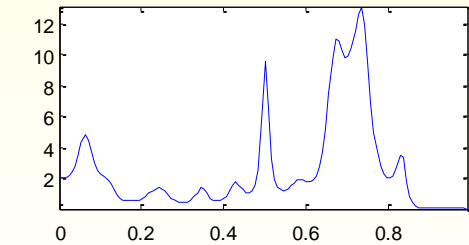
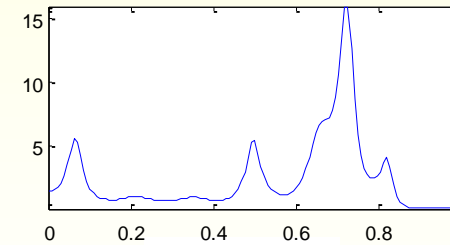
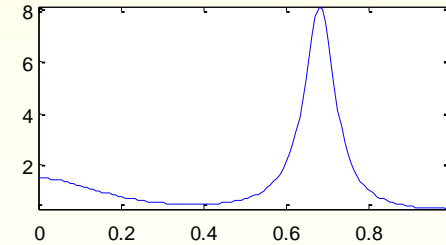
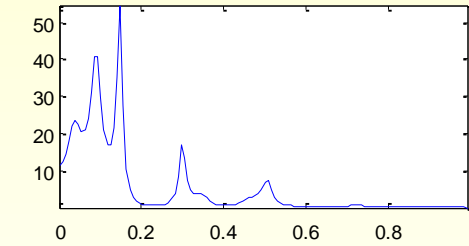
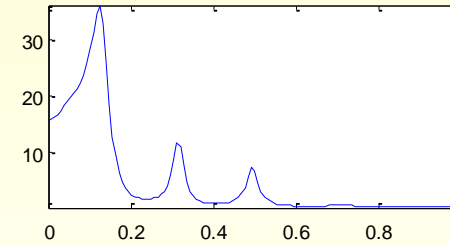
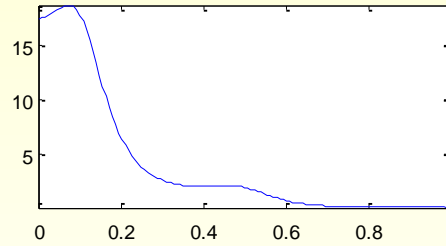
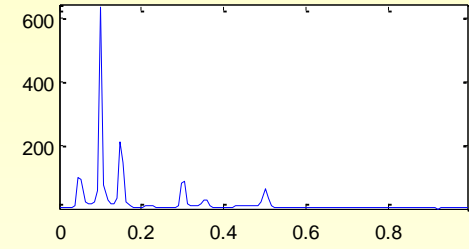
LPC spectrum 4



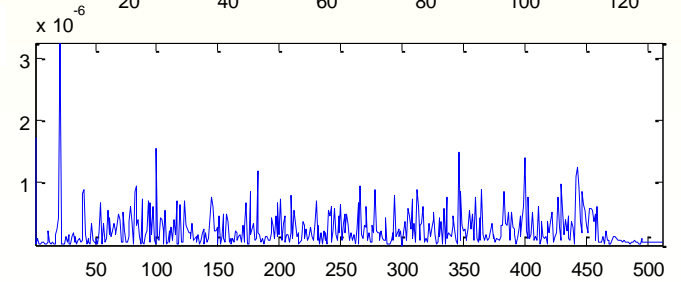
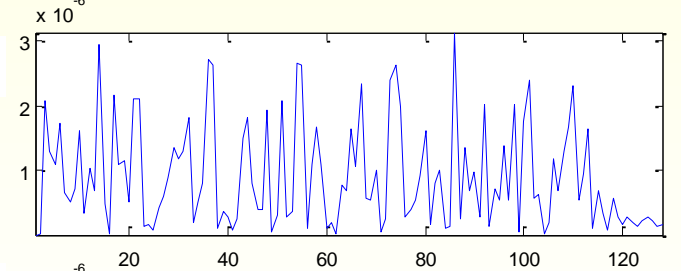
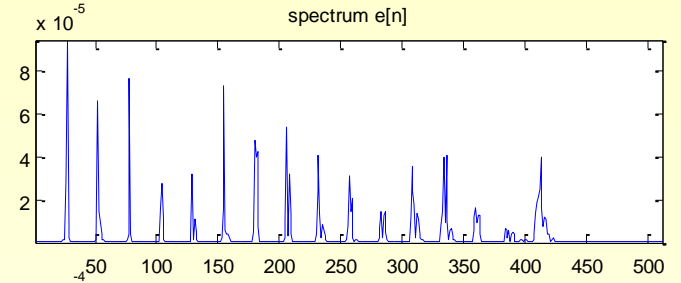
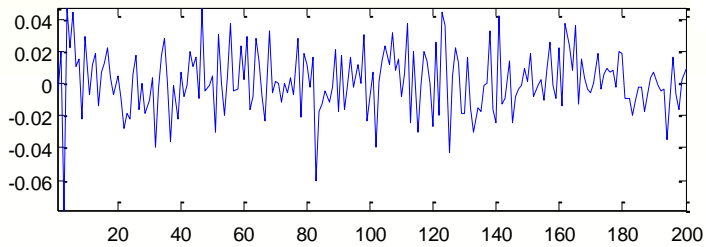
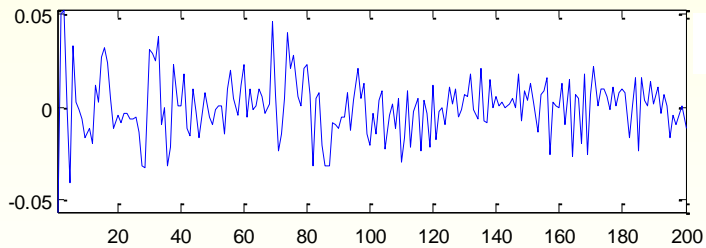
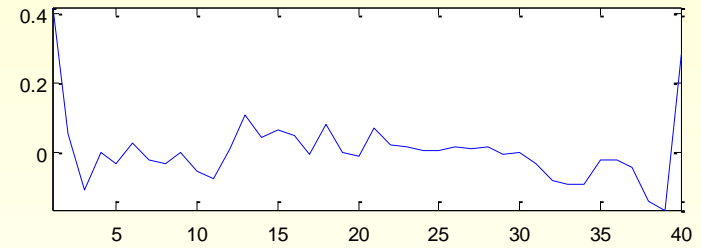
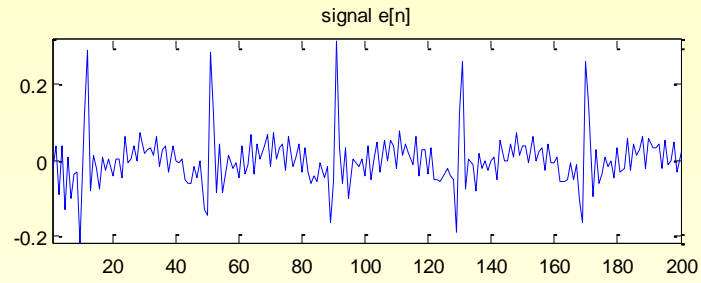
LPC spectrum 14



LPC spectrum 30



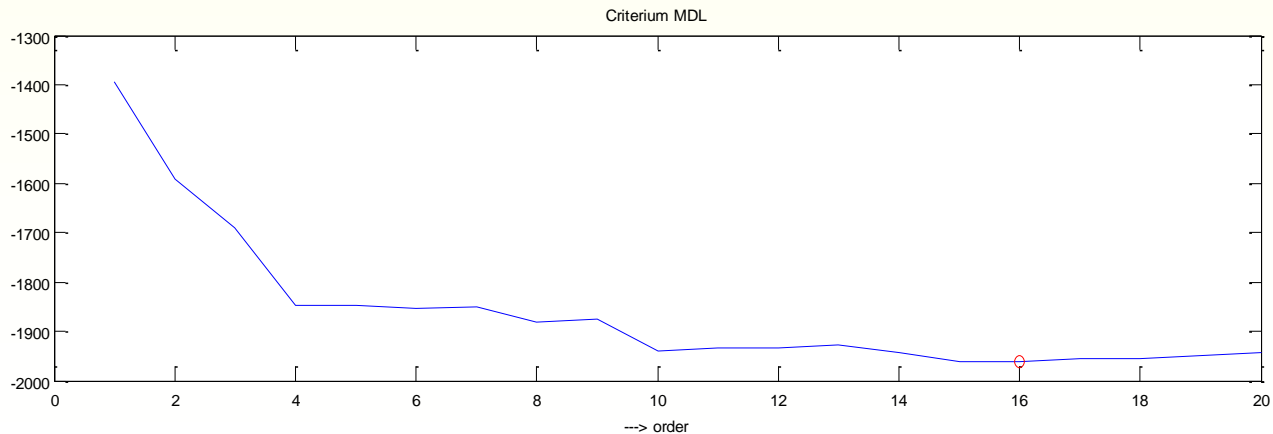
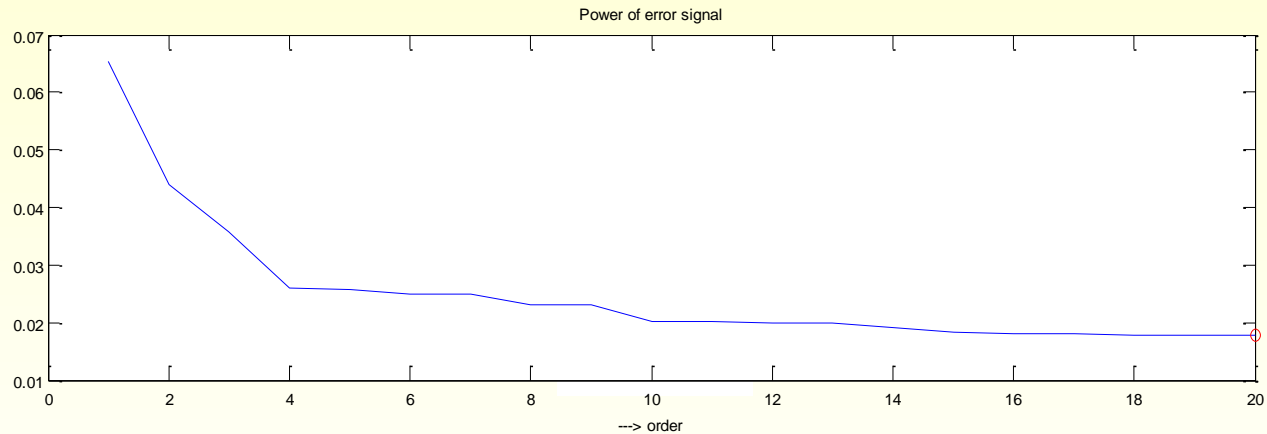
Chybový signál



Odhad řádu AR modelu penaltní kritéria

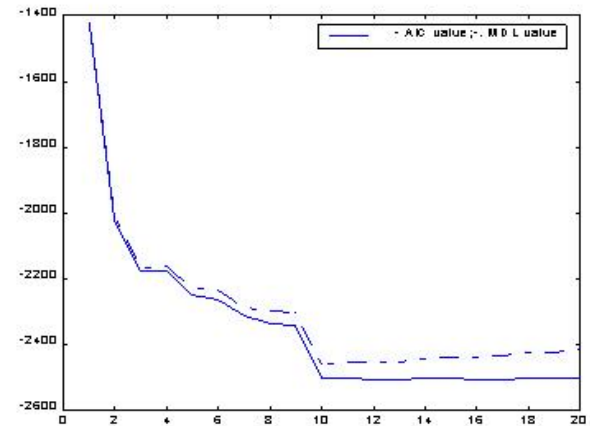
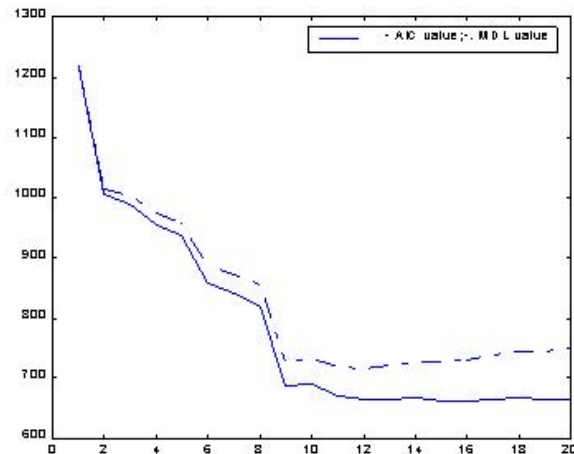
$$C(p) = N \ln s^2 + \alpha \cdot p$$

$$\text{MDL}(p) = N \cdot \log(P(p)) + \log(N) \cdot p$$



Odhad řádu AR modelu

- AIC
 - $AIC(k) = N \ln(\text{MSE}(k)) + 2 \cdot k$;
 - Tendence nadhodnocení řádu
- MDL
 - $MDL(k) = N \cdot \ln(\text{MSE}(k)) + k \cdot \ln(N)$;
 - Statisticky konsistentní



Odhad řádu AR modelu penalťová kritéria

```
[sig,fs]=wavread('why11.wav');  
signal=sig(33512:34024);  
signal=signal-mean(signal);  
signal=signal/max(abs(signal));  
N=length(signal);  
signal=signal(:);
```

```
M=20; % max order  
for m=1:M  
    [a,p]=lpc(signal,m);  
    P(m)=p;  
  
    MDL(m)=N*log(P(m))+log(N)*m;  
end;
```

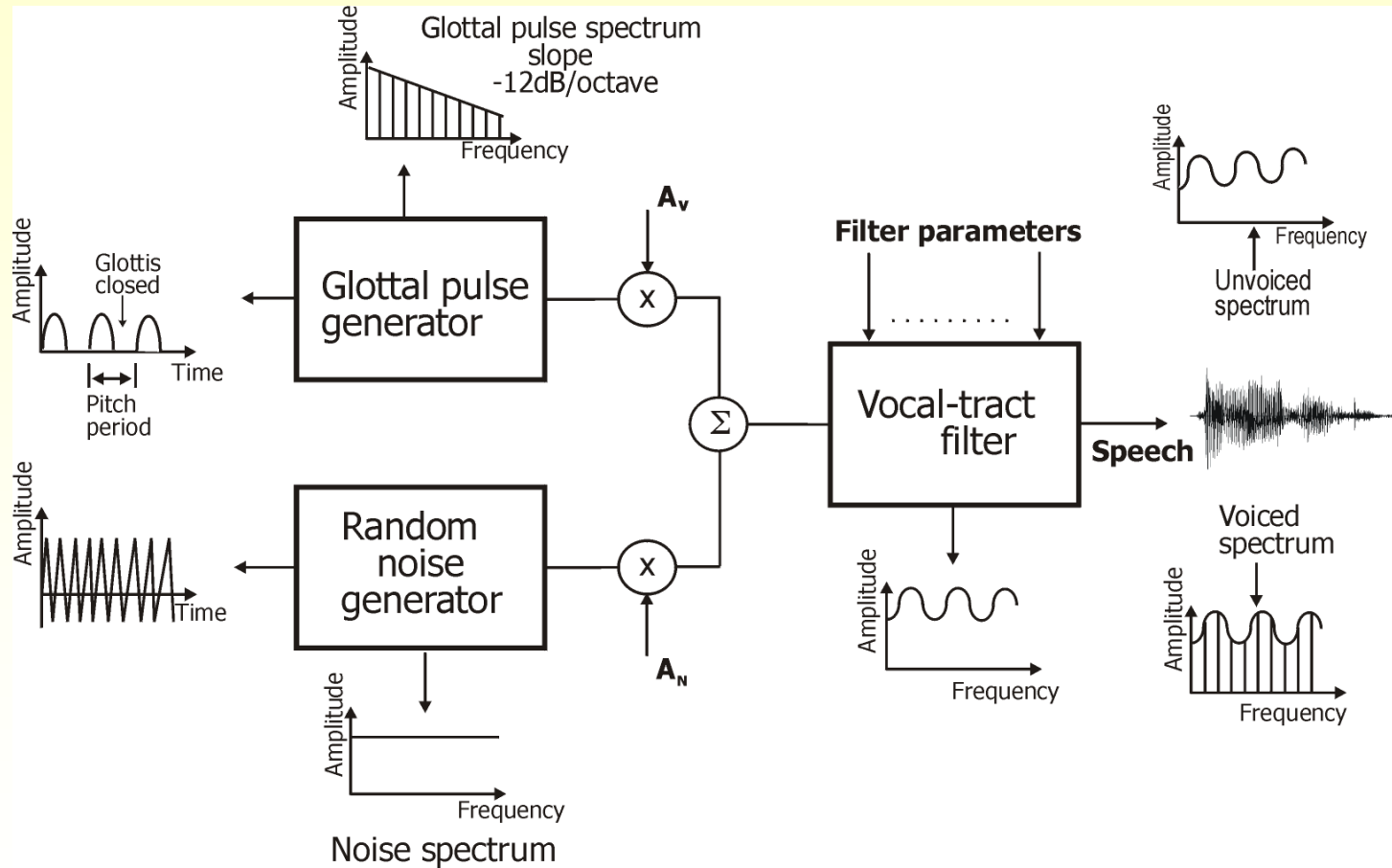
Odhad řádu AR modelu

penaltová kritéria

```
[i,minP]=min(P);  
subplot(211), plot(P), hold on, plot(minP,i,'or'), hold off  
title('Power of error signal')  
xlabel('---> order')
```

```
[i,rad]=min(MDL);  
subplot(212), plot(MDL), hold on, plot(rad,i,'or'), hold off  
title('Criterium MDL')  
xlabel('---> order')
```

LPC syntéza



LPC syntéza

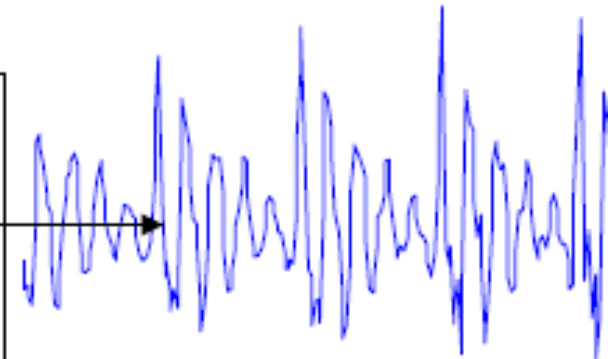
LPC synthesis (decoder) and LP residual



Note that residual is perfect excitation

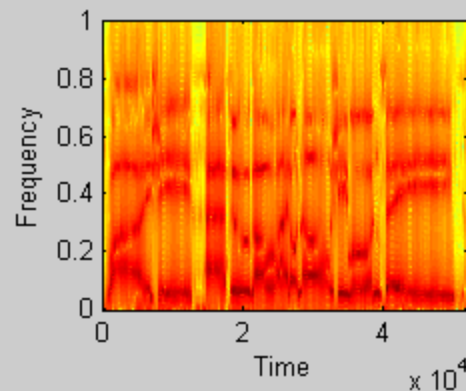
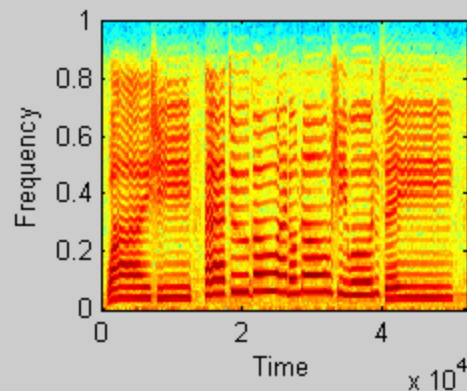
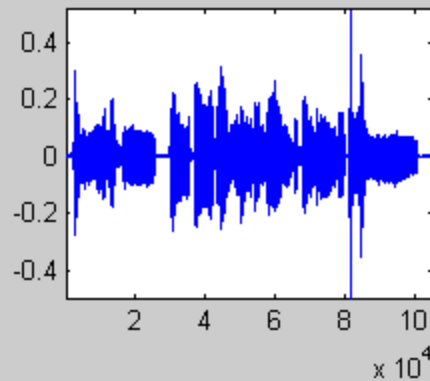
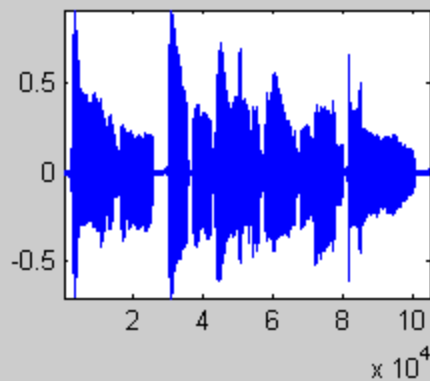


$$H(z) = \frac{1}{1 + \sum_{m=1}^M a_k z^{-m}}$$



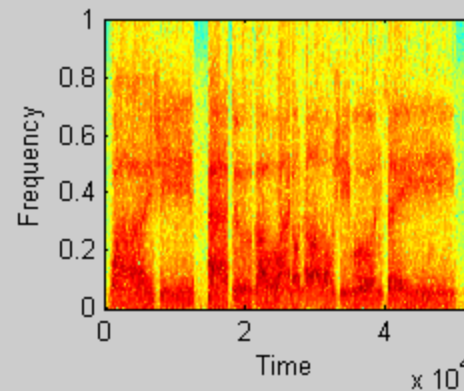
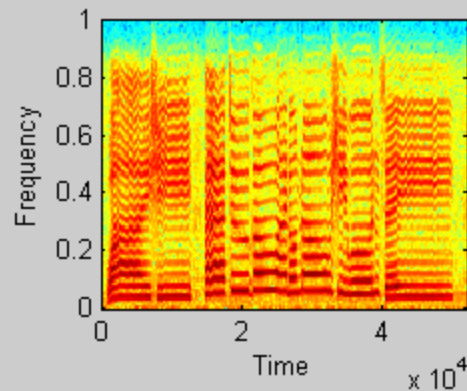
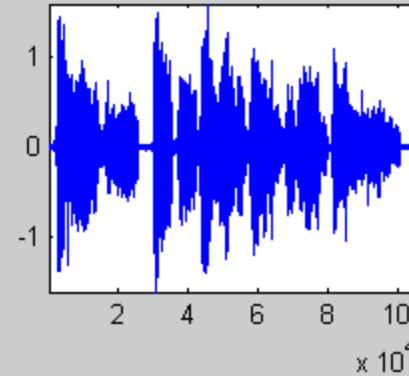
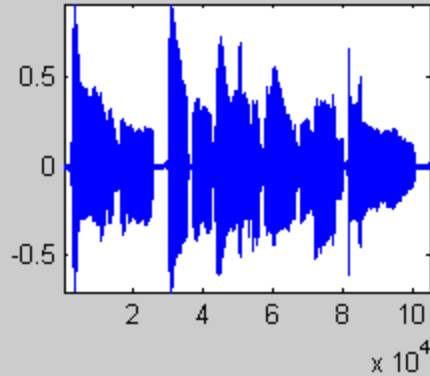
LPC vokodér

impulzní buzení



LPC vokodér

bílý šum



LPC vokodér

chybový signál

