Title: METHOD TO OVERCOME SELF-INTERFERENCE IN A TDD SYSTEM

Abstract: The present invention discloses a method to overcome the self-interference in a TDD radio communications system, utilizing the known DL signals and UL signals to calculate the CIR, then deducting the convolution of the new CIR and the DL signals. The method comprises the steps of: establishing an equation system about how the reflection is constituted assuming that the CIR is known, solving this equation system with respect to the channel impulses response, making the judge by cutting the insignificant channel impulse response taps to zero, calculating the distortion again, then using the post processed CIR and the aforementioned equation system. To eliminate the influence of a strong SYNC1, performing the steps of: reconstruct the detected Sync1, and average the reconstructed SYNC1, feedback the output signal of the reconstructed SYNC1 to supplement the input signal of the next frame signal in the secondary interference elimination algorithm.
before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

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Description

Method to overcome self-interference in a TDD system

Technical area

The present invention relates to the method of modifying the communication quality in TDD system, more specifically relates to a method to overcome the self-interference arising from down-link signal reflections in TDD system.

Background technology

A particularity of TDD (Time Division Duplex) systems is that UL (uplink) and DL (downlink) are transmitted on the same carrier. This means that the involved entities (e.g. a base and a mobile station of a mobile radio system) have to switch between receiving and transmitting. E.g. after a base station has transmitted the DL it has to receive the UL signals.

Due to reflections of the radio waves by the surrounding environment it can happen that the DL signal is reflected and returns with a considerable propagation delay at the antenna of the transmitting station which is switched to receive the UL signal then. In the receiver the reflected DL signal can cause severe degradation of the receiver performance and block communication in the UL.

Up to now TDD systems like HCR TDD (high chip rate TDD) (standardised in 3GPP) and DECT have been intended basically for indoor and micro cellular use. This means that the base stations have a rather low elevation. The created mobile radio environment evokes that the range of the base stations is rather low and that, consequently, the delays (propagation time of the signal to the reflecting object and back to the transmitting station) are rather small. For mobile stations this effect applies in most of the cases anyway. Conse
sequently, this effect is negligible and thus not processed for these systems.

At present the Chinese TD-SCDMA is being standardised within CWTS (Chinese Wireless Telecommunication Standard), ITU (International Telecommunications Union) and 3GPP (Third Generation Partnership Project). TD-SCDMA is - unlike the other TDD systems - also intended and specially suited to macro cell deployment. This means that there are cells with very big ranges and accordingly very big delays for the aforementioned effect.

The TD-SCDMA system is described in TD-SCDMA technical specifications CWTS TS C101 v3.0.0, TS C102 v3.0.0, TS C103 v2.2.0, TS C104 v3.0.1, TS C105 v3.0.0.

Figure 1 illustrates the TDD self-interference effect for the TD-SCDMA system. The reference number 1 stands for base station A, 2 stands for base station B, 3 means a reflector. It could be seen in the Fig. 1 that as a signal transmission needs time, a DL signal and the RX signal received from the same base station do not fall coincidence in the time regard. That means when base station A receives the DL signal at the final stage, the then frame of DL signal has been emitted completely. In TD-SCDMA all the base stations can be synchronised and there is however, an effect in-between the base stations. When system is operating, Base station A transmits a DL signal (TX) which is reflected and then received at the same base station (RX). The textured part of the signal cannot be received (but nevertheless still arrives at the base station) because the base station is still transmitting at this time, and cannot receive. Only the non-textured part of the RX signal is actually received later on.

As the TD-SCDMA network is usually synchronised, the reflections of the TX signal of base station A can also be received at base station B wherein it also impacts the performance on.
Due to distance and radio propagation condition, the amplitude of the reflection signal is usually smaller than at base station A.

In general more than one reflector are involved, it makes the data processing even more complicated, needing at least the appropriate algorithm and the more powerful processor.

In TD-SCDMA there is only one transition between UL and DL where this effect can happen. It is after the DwPTS (Downlink Pilot Time Slot). This is illustrated in Figure 2.

Figure 2 shows the time slots around the DL/UL switching point in a TD-SCDMA system. After the DwPTS the UpPTS (Uplink Pilot Time Slot) is received by the base station. The UpPTS is used during the random access procedure and can, according to the SS (synchronisation shift) of the transmitting mobile, arrive directly after the DwPTS. The described effect then severely distorts the reception of the UpPTS, and thus, is worsening the performance of the whole system. In this case the distortion is mostly coming from the DwPTS. The reflections are arriving in the guard period (G) of the TD-SCDMA frame.

This problem has been discovered in the master field trail of the TD-SCDMA system and been measured at base station A and base station B. Figure 3 and Figure 4 give the result wherein:

Figure 3 shows the reflected DwPTS signal at base station A, and
Figure 4 shows the reflected DwPTS signal at base station B (transmitter is switched off).

In Figure 3 the measurement was done using a spectrum analyser. For the measurement precautions were taken to attenuate the TX signal and to amplify the RX signal. This is why
TX signal (DL traffic time slot and DwPTS) and TX signal (reflection of the DwPTS) are visible in the same measurement. Form the measurement it can be seen that the reflections of the DwPTS can be up to 1000 times (30 dB) more powerful than the surrounding noise. Reflectors close to the base station create these positions of the distortion. Reflectors being far away form the base stations are more in number but also more far away from the base station. Their number is proportional to the distance while the receiving power is anti-proportional to the 4th power of the distance. Consequently the power of the reflections decrease the more the more time elapses between DwPTS and the receiving time. The length of the distortion is approximately 100µs, this corresponds to a reflector being 15 km form the base station. About 15 km has also been the peak range of this base station.

In Figure 4 the result at base station B is shown. For this measurement the spectrum analyser has just been connected to the antenna of this base station. It is receiving only while the base station itself is switched off. Now the reflections of both the DL traffic time slot and the DwPTS are visible. Shape and strength of the reflection is different. The reason is that the reflected waves have not only to travel to the reflector but also have to travel a different path back to base station B. At base station A the path back to base station A is easily ensured – it is just the same way as the signal travelled to the reflector. This is the reason why the strength of the reflection is declining faster than in Figure 3.

The effect was discovered to be that severe that it would endanger macro deployment of the TD-SCDMA system.

So far, this effect has not been considered for any TDD system. Accordingly, there is no solution known in the art up to now.
In radar technology there is a similar problem. For radar applications as well signals are sent by the radar station then the reflected signals are received in the time following period.

For many radar applications only the moving targets are of interest, but buildings, mountains, etc., create a fixed reflection. This reflection is averaged and then subtracted from the received signal such that only the moving targets are visible. This procedure is called fixed target elimination.

By the above process, the time invariant reflected signals are eliminated in order to receive time variant reflected versions of the signals generated by the same transmitter.

Contents of the invention

The present invention solves this problem with the features of independent claims 1 and 14 by eliminating the reflected signals in order to receive signals generated by a different transmitter.

Generally, the present invention adopts a scheme to recognise reflected versions or parts of the transmitted signals and eliminate them from the received signals, considering signal form and modulation of the transmitted signals as well as the properties of the mobile radio channel.

This can be done e.g. by calculation of the channel impulse response using the well known transmitted signal and the received signal and then eliminating (subtracting) the convolution of the channel impulse response and the transmitted signal from the received signal.

In case a single burst is used to calculate the channel impulse response and to process the same received signal, then
some decision has to be made such as what part of channel impulse response belongs to the reflection and what part does not belong to the reflection. The easiest way is to establish an equation system about how the reflection is constituted assuming that the channel impulse response is known. Then this equation system is solved with respect to the channel impulse response. The decision is then made by cutting the insignificant channel impulse response taps to zero. After the distortion is calculated again using the post-processed channel impulse response and the aforementioned equation system.

In case the channel impulse response is not changing significantly from frame to frame it can be averaged or the channel impulse response of the past frame can be used in order to reconstruct the reflected signal.

In case the part of the transmission signal being responsible for most part of the received reflection is not changing from frame to frame and the channel impulse response is not changing significantly from frame to frame, it is sufficient to average the reflected received signal and to subtract the average reflected received signal from the instantaneous received signal. This will eliminate the time invariant part of the signal and not significantly influence the time variant part of the received signal.

In case of TD-SCDMA the DwPTS is mostly responsible for the received reflected signal. The 64 chip of the DwPTS are modulated all the same and have 4 different phase positions. The channel impulse response stays the same from frame to frame for most of its shape. So here the algorithm is to invert the modulation of the received reflection by means of back rotating the signal according to the modulation phase and then to average the resulting signal.
For the reception the averaged signal is re-modulated again and then subtracted form the instantaneous received signal for the detection of the UpPTS.

However, if there is a strong SYNC1 signal, which will cause obvious distortion on the average value, then SYNC1 will be false detected in the subtracted value of next frame without SYNC1. Thus, the above described cancellation method must be modified further considering the influences due to strong SYNC1, therefore, the former cancellation is referred as the first cancellation stage, and the second stage compensation must be considered further as well.

The advantage of this algorithm is that it has a rather low complexity and that it can be implemented at a single location on the overall implementation such that all the other algorithms stay unchanged.

Another advantage of this algorithm is that it also eliminates received versions of the neighbouring base stations DwPTS signals automatically provided that the phases of the DwPTSs in all concerned base stations are modulated according to the same pattern.

In the example this algorithm is described in detail.

For all versions of this invention the performance of the receiver is enhanced by the elimination of the reflected signal.

The inventive steps of this invention are:
- To use the knowledge of the transmitted signal and the features of the mobile radio channel in order to eliminate the aforementioned TDD self-interference.
- To apply and to simplify this general algorithm to the particularities of the TD-SCDMA system.
• To modify and to transfer the fixed target elimination used for radar technology and to apply it for TDD communications systems.

5 Description of the drawings

The figures show the background and mechanisms of the present invention, wherein:

10 Fig. 1 illustrates the TDD self-interference effect, by means of TD-SCDMA system.
Fig. 2 shows the time slots around the DL/UL switching point in TD-SCDMA.
Fig. 3 shows the reflected DwPTS signal at base station A.
Fig. 4 shows the reflected DwPTS signal at base station B (transmitter is switched off).
Fig. 5 shows the result of the DwPTS self-interference elimination in the TD-SCDMA field trail.
Fig. 6 is the block diagram of frame structure.
Fig. 7 shows the block diagram of two stages of cancellation algorithm implemented in the invention.
Fig. 8 illustrates the post processing principle of SYNC1 detection.
Fig. 9 shows one example of simulation results for illustrating the effects of two cancellation stages in case that there is SYNC1 contained in the current received signal.
Fig. 10 shows one example of simulation results for illustrating the effects of two cancellation stages in case that there is SYNC1 contained in the previous received signal.

30 Embodiments

Taking TD-SCDMA as an example, the algorithm described below has been implemented in the field trail system. The following results have been measured inside the DSP (Digital Signal Processor) of the base station. They verify that the algorithm works.
Figure 5 illustrates the relative power of the guard period GP and the uplink pilot time slot UpPTS in the TD-SCDMA field trial, applying the present technical scheme. It could be seen that self-interference arising from the DwPTS has been eliminated. The horizontal axis of Fig. 5 represents the chip position by μs, and the vertical axis represents the relative power by dB. The relative black real curve stands for the initial receiving power, and the relative dark real curve stands for the post-processed receiving power. It could be seen from Fig. 5 that the signal fluctuation arising from the reflection by the DwPTS signal before about 100 μs in the initial receiving curve has been effectively eliminated.

Another problem arising from the solution of the present invention is the complexity influence of the algorithm the present invention uses. The following contents is the brief description and complexity analysis about algorithm of recursive mitigating interference caused by reflection of DwPTS, it shows that the complexity of this algorithm is of only a little importance compared with the joint detection algorithm.

1.1 Object

The BTSC is producing some self-interference in the Guard Period interfering the reception of the UpPTS. The interference is generated by reflection of the DwPTS with the environment. For a high elevated BTSC the duration of the distortion can take up to 100 μs. The algorithm discussed in this document is suited to mitigate this effect and to ensure reliable UpPTS detection.

1.2 Algorithm description

1.2.1 Frame structure
In TD-SCDMA system, the downlink will be switched to uplink at the border between DwPTS and GP. Due to delayed reflections and scattering of downlink DwPTS from neighboring obstacles, there must be interference on the receiving of UpPTS, which will degrade the performance of the system. See Fig. 6 which illustrate the frame structure of TD-SCDMA system.

Fig. 6 Frame structure in TD-SCDMA system

1.2.2 Block Diagram

The cancellation algorithm will be divided into two stages, in which the first stage cancels the interferences due to reflection of own DwPTS, and the second stage aims at compensating for the impairments due to strong SYNC1.

The signal of the detected SYNC1 is reconstructed according to the detected multiple path distribution (the same threshold as for the detection applies for the significant paths) and then averaged in the same way as done in the first stage. In contrast to the first stage the average is added to the instantaneous input signal. Thus the effect of the detected SYNC1 is removed from the input of the SYNC1 detector.

The advantage of this procedure is that the algorithm swings in faster and it only reacts to the SNYC1.

In conclusion, the algorithm can be divided into two parts:

A. Reflection cancellation will be implemented in first stage without considering possibly occurred SYNC1 code;
B. Detected SYNC1 code should be reconstructed, and then fed back into the second cancellation stage in order to remove influence of the average in the next frames.

Fig. 7 Block Diagram of Software description
1.2.3 Description of algorithm

1.2.3.1 Implementation of first stage

There are 256 chips including GP of 96 chips and UpPTS of 160 chips after DwPTS. According to the analysis and measurement, the average profile of interference will be stable and predictable, therefore, the interference can be subtracted easily from the signal received during the time of UpPTS to eliminate the impairments caused by DwPTS.

The algorithm for averaging the interference signal for each of the 256 chips of each antenna can be described in a recursive form, which can be expressed as follows:

\[
\text{av}_m(i) = \frac{(P-1) \cdot \text{av}_m(i) + \text{inst\_value}_m(i)}{P}, i = 1, 2, \ldots, 256
\]  

(1)

where \(\text{av}_m(i)\) and \(\text{inst\_value}_m(i)\) represent the averaged value and the received instant value including possible SYNC1 code of \(i\)-th chip in the \(m\)-th burst respectively, and \(\frac{1}{P}\) is the forgetting factor used in average, e.g., \(P=256\). In fact, \(P\) could be any one of \(2, 4, 8, \ldots, 256, \ldots\).

Considering the modulation phase of DwPTS which is known by the Frame Number, it must be eliminated during averaging operation by choosing '+' or '-' in Equ. (1) for the real and imaginary part respectively according to the DwPTS modulation phase used in current burst.

And finally, the modulation phase of DwPTS of the current burst will be recovered by subtracting the previous averaged value from the received signal, so the modified received value is:

\[
\text{modi\_value}_m(i) = \text{inst\_value}_m(i) - \text{av}_m(i), i = 1, 2, \ldots, 256
\]

(2)
Here again the sign of the real and imaginary part during this subtraction is chosen according to the DwPTS modulation phase. These alternative add and subtract operation ensure that the phase of the DwPTS is taken care of with virtually no complexity increase.

It should be noted that in equation (2), the previous average value $\text{av}_{m-1}(i)$ will be subtracted instead of the current calculated average value $\text{av}_m(i)$.

1.2.3.2 Implementation of second stage

In this stage, additional average value of reconstructed SYNC1 code, $\text{av\_sync1\_recon}_m(i)$, is added for compensating the impairment due to strong SYNC1. The previous calculated average SYNC1, $\text{av\_sync1\_recon}_{m-1}(i)$, can be added to (not be subtracted from) the output of the first stage, i.e., $\text{modi\_value\_1}_m(i)$, which is illustrated as following equation:

$$\text{modi\_value\_2}_m(i) = \text{modi\_value\_1}_m(i) + \text{av\_sync1\_recon}_{m-1}(i)$$  
(3)

And then, the SYNC1 can be reconstructed from the output of second stage according to the 5.2.3.3 description with output of $\text{inst\_sync1\_recon}_m(i)$, which can further be used in calculating new average value $\text{av\_sync1\_recon}_m(i)$:

$$\text{av\_sync1\_recon}_m(i) = \frac{(P-1) \cdot \text{av\_sync1\_recon}_{m-1}(i) + \text{inst\_sync1\_recon}_m(i)}{p}, i=1,2,\ldots,256$$  
(4)

If there is no SYNC1 code, then reconstructed $\text{inst\_sync1\_recon}_m(i)$ equals to zero.
It should be noted that in the above two equations, of course the signs of the real and imaginary additions should fit to the modulation phase of the DwPCH because there are phase modulation in the output signal of first canceller although SYNC1 code is not modulated. The phase changing rules are the same with the ones in the first stage.

1.2.3.3 Reconstruction of detected SYNC1 code

If the cyclic correlation is implemented in SYNC1 detection DSP, the correlation and correlation power of 8 detected SYNC1 codes can be outputted, which are:

\[
\begin{align*}
\text{sync1\_code\_256[j][1:128]} &= \text{sync1\_code[j][1:128]}; \\
\text{sync1\_code\_256[j][129:256]} &= 0; \\
\text{FFT\_code[j][1:256]} &= \text{FFT(syncl\_code\_256)};
\end{align*}
\]  

\[
\text{Rx\_value\_corre[ante][j][1:256]} = \text{IFFT(FFT\_code'[j][1:256].*FFT(modi\_value\_2[ante][1:256]))}
\]  

\[
\text{Rx\_power\_corre[ante][j][k]} = (\text{abs(Rx\_value\_corr[ante][j][k]))^2}
\]  

The correlation power should be post processed by a threshold to eliminate the influences due to noise, and also clear the correlation complex value on corresponded chips whose power are lower than the threshold, i.e.:

\[
\text{Post\_value\_corre[ante][j][k]} = \begin{cases} 
0, & \text{Rx\_power\_corre[ante][j][k]} < \text{threshold} \\
\text{Rx\_value\_corre[ante][j][k]}, & \text{elseothers}
\end{cases}
\]

\[
(8)
\]

Fig. 8 illustrates the principle of post processing.

And then, the SYNC1 code can be reconstructed by the following equation,
\[
\text{inst\_sync1\_recon}[\text{ante}][j][1:256] = \\
\text{IFFT}(\text{FFT}(\text{Post\_value\_corre}[\text{ante}][j][1:256])/\text{FFT\_code}^*\text{[j][1:256]})
\] (9)

Finally, the reconstructed SYNCl code \text{inst\_sync1\_recon} can be fed back to the second stage of cancellation.

Figure 9 and Figure 10 respectively illustrates the simulation results by the above described two stage cancellation algorithm, wherein Figure 9 and Figure 10 respectively shows an example of two stages cancellation in case of SYNCl code contained in the current and previous frame.

1.3 MATLAB coding example for the first cancellation

% This is brief illustration of the algorithm

Antenna\_Nbr=8; %antenna number
Chip\_Nbr=253; %chip number, the other 3 chips are used for delivering other information
Burst\_Nbr=256; %average burst number
Max\_Burst\_Nbr=10000; %the maximum received burst number
which is determined by the number of message given by CATT
p=1/Burst\_Nbr; %forgetting factor
%initialization of some buffer
average\_value=zeros(Antenna\_Nbr,Chip\_Nbr); %average interference value
instant\_value=zeros(Antenna\_Nbr,Chip\_Nbr,Max\_Burst\_Nbr); %received data value per antenna per burst per chip
DwPTS\_phase=zeros(Max\_Burst\_Nbr); %modulation phase of DwPTS
modified\_value=zeros(Antenna\_Nbr,Chip\_Nbr,Max\_Burst\_Nbr);

%output data

%end of initialization

%initialization of instant\_value and DwPTS\_phase

instant\_value=; %current received data
DwPTS_phase=[0,2,2,2, 0,1,1,2, 0,1,2,1, 0,3,2,3, 0,2,1,3, 0,2,3,3, 0,2,2,1, 0,2,2,3, 0,1,2,2, 0,3,2,2, 0,2,1,2, 0,2,3,2]; %current phase

5 %end initialization

for k=1:Max_Burst_Nbr
    instant_work(1: Antenna_Nbr,1: Chip_Nbr)=instant_value(1: Antenna_Nbr,1: Chip_Nbr, k);
    modified_work=zeros(Antenna_Nbr,Chip_Nbr);

    % the algorithms to be implemented in the BTSC start here!!!
    switch DwPTS_phase(k)

15 %to determine the modulation phase of the current burst based on Frame Number

    case 0 %++ (a+jb)*1=a+jb, pi/4
        for i=1:Antenna_Nbr
            for j=1:Chip_Nbr
                %to restore phase
                modified_work(i,j)=instant_work(i,j)-average_value(i,j);
                average_value(i,j)=average_value(i,j)*(Burst_Nbr-1)+instant_work(i,j);
            average_value(i,j)=average_value(i,j) >> 8;
        end
    end

20 case 1 %-- (a+jb)(-j)=b-ja, 3*pi/4
        for i=1:Antenna_Nbr
            for j=1:Chip_Nbr
                %to restore phase, average_value multiply j,
                (a+jb)*j=-b+ja
real(modified_work(i,j))=real(instant_work(i,j))+imag(average_value(i,j));

imag(modified_work(i,j))=imag(instant_work(i,j))-real(average_value(i,j));

real(average_value(i,j))=real(average_value(i,j))*(Burst_Nbr-1)+imag(instant_work(i,j));

imag(average_value(i,j))=imag(average_value(i,j))*(Burst_Nbr-1)-real(instant_work(i,j));

real(average_value(i,j))=real(average_value(i,j)) >> 8;

imag(average_value(i,j))=imag(average_value(i,j)) >> 8;
end
end

case 2 %-- (a+jb)(-1)=-a-jb, 5*pi/4
   for i=1:Antenna_Nbr
      for j=1:Chip_Nbr
         %to restore phase, average_value multiply (-1), (a+jb)*(-1)=-a-jb
         modified_work(i,j)=instant_work(i,j)+average_value(i,j);
         average_value(i,j)=average_value(i,j)*(Burst_Nbr-1)-instant_work(i,j);
         average_value(i,j)=average_value(i,j) >> 8;
      end
   end

case 3 %-- (a+jb)(j)=-b+ja, 7*pi/4
   for i=1:Antenna_Nbr
for j=1:Chip_Nbr
    %to restore phase, average_value multiply (-j), (a+jb)(-j)=b-ja
    real(modified_work(i,j))=real(instant_work(i,j))-
    imag(average_value(i,j));

    imag(modified_work(i,j))=imag(instant_work(i,j))+real(average
    _value(i,j));
end

real(average_value(i,j))=real(average_value(i,j))*(
    Burst_Nbr-1)-imag(instant_work(i,j));

15 imag(average_value(i,j))=imag(average_value(i,j))*(
    Burst_Nbr-1)+real(instant_work(i,j));

    real(average_value(i,j))=real(average_value(i,j)) >> 8;

20 imag(average_value(i,j))=imag(average_value(i,j)) >> 8;
end

otherwise
    disp('Wrong phase of DwPTS!');
end

% this is the end of the algorithm to be implemented in the
BTSC

30 modified_value(1: Antenna_Nbr,1: Chip_Nbr,k)=modified_work(1: 
    Antenna_Nbr,1: Chip_Nbr);
end

35 % this is the output of this algorithm, 1:Max_Burst_Nbr are
the effective value
1.4 Complexity analysis

1.4.1 First cancellation

The first step is to subtract the previous average from the RX signal.

And then, as variables $a^m$ and $\text{inst-value}^m$ are complex numbers, the calculation amount needed in one iteration is 2 real multiplication and 2 real additions which means 2 MACs in one chip.

The next step is the division in form of a binary shifting operation.

So altogether 4 MACs per chip have to be performed.

Consequently the complexity for the whole algorithm is:

Complexity=$4\times253\times\text{antenna number MACs}/0.005\ \text{s}$

(10)

For 8 antennas this is 1.62 million MAC/s.

For the memory requirement of 2 integers (real and imaginary part) are needed per recursive averager, therefore, 4 bytes are required per chip for averaging.

So the total memory requirement in first stage is:

Memory requirement=$4\times253\times\text{antenna number Byte}$

(11)

For 8 antennas this is 8096 Byte.

1.4.2 Second cancellation

The complexity and the required memory are the same with the ones in the first stage.
1.5 Conclusion

The complexity of this algorithm can be neglected compared with the Joint Detection algorithm which requires considerably more processing power. Consequently the algorithms is feasible to be implemented.
Claims

1. Method to overcome self-interference in a TDD radio communications system, the system comprising at least one base station, wherein the base station is enabled to transmit and receive signals respectively, the method comprises the following steps: the base station
(1) transmits downlink signals,
(2) receives signals, and distinguishes reflected versions of said transmitted downlink signals and uplink signals from the total received signals,
(3) eliminates the received reflected signals of the said transmitted downlink signals from the total received signals, and
(4) processes the remaining signals in order to detect the received uplink signals.

2. Method according to Claim 1, wherein the elimination of the reflected signals is done by
(1) identifying a channel impulse response of the received signals, using the transmitted signal and the received signal, and
(2) subtracting a convolution of the channel impulse response and the transmitted signal from the total received signal.

3. Method according to Claim 2, wherein
(1) a single burst is used to calculate the channel impulse response,
(2) to process the same received signal,
(3) to determine which part of the channel impulse response corresponds to the reflection and which part does not correspond to the reflection.

4. Method according to Claim 3, comprising
the further steps to implement the discrimination between a reflection-related carrier to interference ratio CIR and non-reflection-related CIR
(1) establishing an equation system about how the reflection is constituted assuming that the channel impulse response is known,

(2) solving this equation system with respect to the channel impulse response,
(3) making a judgement by cutting insignificant channel impulse response taps to zero,
(4) recalculating the distortion using the post-processed channel impulse response and said established equation system,
(5) repeating the steps (1) to (4), until the discrimination is sufficiently clear.

5. Method according to Claim 3 or 4, wherein when assuming that the channel impulse response is not changing significantly from frame to frame, the channel impulse response determined in the past frame is averaged.

6. Method according to Claim 3 or 4, wherein when assuming that the channel impulse response is not changing significantly from frame to frame, the channel impulse response of the past frame is used to construct the reflected signal.

7. Method according to Claim 3, wherein when assuming that the transmission signal being responsible for the most part of the received reflection is not modulated and the channel impulse response is not changing significantly from frame to frame,
(1) the reflected received signal is averaged, and
(2) the average reflected received signal is subtracted from the instantaneous received signal in order to eliminate the time invariant part of the signal.

8. Method according to one of Claims 1 to 7, wherein
the TDD radio communications system is a TD-SCDMA system, and wherein signals in a downlink pilot time slot (DwPTS) is mostly responsible for the received reflected signal, characterised in

5 (1) modulating the 64 chip of the downlink pilot time slot (DwPTS), wherein the phase relations of the chips are all the same, and having four different phase positions for the whole 64 chip of the downlink pilot time slot (DwPTS),
(2) assuming that the channel impulse response stays essentially the same from frame to frame for most of its shape,
(3) inverting the modulation of the received reflection by an algorithm of back rotating the signal according to the modulation phase and averaging the resulting signal,
(4) re-modulating and subtracting the averaged reception signal from the instantaneous received signal, and performing the detection of the uplink pilot time slot (UpPTS).

9. Method according to Claim 8, wherein in order to eliminate a possible synchronisation code (SYNC1) influence on the average signal value of the next frame of detected signals, performing a second stage elimination algorithm of reconstructing the detected synchronisation code (SYNC1), averaging the signal by the method of Claim 10, and providing the feedback of the output signal of the reconstructed synchronisation code (SYNC1) to supplement the first output signal.

10. Method according to Claim 9, wherein the second stage interference elimination algorithm is processed with the following steps:
calculate the multi-path correlated values and their powers of the detected synchronisation code (SYNC1),
post-process these correlated values, compare these correlating power values by threshold method by setting the values which are lower than the threshold value as zero, to eliminate the interference from the noise,
(1) calculate the average value of the synchronisation code
(SYNC1),
(2) post-process the said correlation values, comparing these
correlation power values with a threshold, setting the values
which are below the threshold as zero to eliminate the noise
interference,
(3) average the present reconstruction synchronisation code
(SYNC1) and the last average synchronisation code (SYNC1) to
obtain the present average synchronisation code (SYNC1) value
for the calculation of next frame of detected signals,
(4) add the last average synchronisation code (SYNC1) to the
output of the first stage, to obtain the output of the second
stage, wherein the output of the second stage could be the
output of the entire algorithm as well as the input of the
synchronisation code (SYNC1) detection, and
(5) repeat the calculation process of steps (1) to (4) for
consecutive frames.

11. Method according to Claim 10, wherein
the weight of said last average synchronisation code (SYNC1)
is (P-1) / P, and the weight of the present synchronisation
code (SYNC1) is 1 / P.

12. Method according to Claim 11, wherein
the path number of the synchronisation codes (SYNC1) is the
number of an antenna array.

13. Method according to Claim 11, wherein
the coefficient P which is used in the weighting averaging
processing is one of power of 2, i.e., 2, 4, 8, ...128, 256,...

14. Base station of a TDD radio communications systems, with
means for overcoming self-interference, comprising
(1) transmitting means for transmitting signals in downlink,
(2) receiving means for receiving signals,
(3) distinguishing means for distinguishing reflected versi-
ons of said transmitted downlink signals and uplink signals
from the total received signals,
(4) eliminating means for eliminating the received reflected signals from the total received signals, and
(5) processing means for detecting the received uplink signals from the remaining signals.
FIG 3

RBW 3 MHz
VBBW 10 MHz
SWT 1 ms

Delta 2 | T1 |
-0.20 dB

43.269231 µs

Marker 1 | T1 |
-27.16 dBm

706.730769 µs

Reflection of DwPTS

1 RM * CLRWR

Ref -20 dBm
Att 5 dB

DL traffic time slot

Center 2.0242 GHz
100 µs

noise power level
FIG 7

Rx: inst_value

The first stage of reflection cancellation

modi_value_1

Possible sync1 subtraction, obtain modi_value_2 & DSP
sync1 detection

SYNC1 reconstruction

inst_SYNC1_recon

Output correlation of detected SYNCE1

FIG 8

Exemplified threshold for reconstructing SYNCE1

Detected correlation power of SYNCE1 codes
FIG 9

noise + reflection + sync1 in 256 chips

received one
estimated using cancellation1
estimated using cancellation2
FIG 10

noise + reflection + sync1 in 256 chips

- Received one
- Estimated using cancellation1
- Estimated using cancellation2

Power vs. chip (256)
### INTERNATIONAL SEARCH REPORT

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC 7 H04B1/707 H04B1/12

According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, INSPEC

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<tr>
<th>Category</th>
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<th>Relevant to claim No.</th>
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<td>US 4 450 582 A (RUSSELL STEVEN P) 22 May 1984 (1984-05-22) column 1, line 37 - column 2, line 2 column 5, line 1 - column 8, line 11; figure 5 column 10, lines 32-68 claims 1,2</td>
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Further documents are listed in the continuation of box C.  

Patent family members are listed in annex.

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Date of the actual completion of the international search: 4 October 2004

Date of mailing of the international search report: 12/10/2004

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