CLAIMS

1. A method of enhancing a noisy frequency-domain channel estimate ($\mathbf{H}_{in}$), including the steps of

transforming (S1) the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$) into a time-domain channel estimate ($\mathbf{h}$) that is virtually over-sampled by an integer factor m;

dividing (S2) the time-domain channel estimate ($\mathbf{h}$) into m de-interleaved sub-vectors ($\mathbf{h}_i$);

suppressing (S3) noisy taps from each de-interleaved sub-vectors ($\mathbf{h}_i$) to form m noise suppressed sub-vectors ($\mathbf{h}'_i$);

selecting (S4) a noise suppressed sub-vector ($\mathbf{h}'_{i0}$) associated with a highest signal-to-noise ratio (γ_i);

converting (S5) the selected noise suppressed sub-vector ($\mathbf{h}'_{i0}$) into a noise suppressed preliminary frequency-domain channel estimate ($\mathbf{H}'$); and

phase-adjusting (S6) the taps of the noise suppressed preliminary frequency-domain channel estimate ($\mathbf{H}'$) to form an enhanced frequency-domain channel estimate ($\mathbf{H}_{out}$).

~~2. The method of claim 1~~, wherein the suppressing step (S3) includes

determining (S14) a respective position of a peak power tap for each interleaved sub-vector ($\mathbf{h}_i$);

setting (S15+S16) a respective noise threshold ($T\varepsilon_i$) for each sub-vector ($\mathbf{h}_i$); and

suppressing (S17) taps with a power that falls below the respective noise threshold ($T\varepsilon_i$) and are positioned within a predetermined channel length (L) from the determined respective position as well as taps that are not positioned within the channel length (L) from the determined respective position, while leaving the peak power tap unchanged.

23. The method of claim 1 ~~or 2~~, wherein the phase-adjusting step includes phase shifting the taps H'_k of the noise suppressed preliminary frequency-domain channel estimate ($\mathbf{H}'$) in accordance with:

$$H'_k \cdot \exp\left(-j \cdot 2\pi \cdot \frac{i0}{m} \cdot \frac{k}{N}\right)$$

where:

k is the tap index,

N is the total number of taps in the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$), and

$i0$ is the peak position in the noise suppressed preliminary frequency-domain channel estimate ($\mathbf{H}'$).

34. The method of any of the preceding claims, wherein the selecting step (S4) includes

estimating (S15) a respective noise level measure (ε_i) for each de-interleaved sub-vector ($\mathbf{h}_i$);

estimating (S18) a respective total power measure for each noise suppressed sub-vector ($\mathbf{h}'_i$);

calculating (S19) a signal-to-noise ratio (γ_i) associated with each noise suppressed sub-vector ($\mathbf{h}'_i$) based on the corresponding estimated total power measure and the corresponding estimated noise level measure (ε_i); and

selecting (S20) a noise suppressed sub-vector ($\mathbf{h}'_{i0}$) associated with a highest calculated signal-to-noise ratio (γ_i).

45. The method of any of the preceding claims, wherein the dividing step (S2) includes forming m de-interleaved sub-vectors $\mathbf{h}_i$ in accordance with:

$$\mathbf{h}_i = \left[h_{0,i}, h_{1,i}, ..., h_{n,i}, ..., h_{N-1,i}\right], \quad i = -\max\left(\left\lceil \frac{m}{2} \right\rceil - 1, 0\right), .., \left\lfloor \frac{m}{2} \right\rfloor$$

where:

$h_{n,i} = h_{\mathrm{mod}(i+nm,\, mN)}, \qquad n = 0,1,\ldots,N-1,$

N is the total number of taps in the frequency-domain channel estimate ($\mathbf{H}_{in}$),

$\lceil\ \rceil$ is the ceiling function, and

$\lfloor\ \rfloor$ is the floor function.

56. The method of any of the preceding claims, wherein the transforming step (S1) includes:

zero-padding the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$)with $(m-1)\cdot N$ zeros, where N is the total number of taps in the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$); and

performing an $m \cdot N$ point inverse discrete Fourier transformation on the zero-padded noisy frequency-domain channel estimate ($\mathbf{H}_{in}$).

67. The method of any of the preceding claims 1-45, wherein the transforming step (S1) includes:

performing an N point inverse discrete Fourier transformation on the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$), where N is the total number of taps in the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$), to form a noisy time-domain channel estimate;

padding $m-1$ zeros after each sample of the noisy time-domain channel estimate; and

lowpass filtering the zero-padded noisy time-domain channel estimate.

78. The method of any of the preceding claims, wherein the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$) is obtained from an OFDM channel.

89. The method of claim 78, wherein the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$) is a linear minimum mean square error estimate.

9~~10~~. A noisy frequency-domain channel estimate ($\mathbf{H}_{in}$) enhancer (24), including:

an over-sampler (30) configured to transform the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$) into a time-domain channel estimate ($\mathbf{h}$) that is virtually over-sampled by an integer factor m;

a de-interleaver (32) configured to divide the time-domain channel estimate ($\mathbf{h}$) into m de-interleaved sub-vectors ($\mathbf{h}_i$);

a suppressor (34) configured to suppress noisy taps from each de-interleaved sub-vectors ($\mathbf{h}_i$) to form m noise suppressed sub-vectors ($\mathbf{h}'_i$);

a selector (36) configured to select a noise suppressed sub-vector ($\mathbf{h}'_{i0}$) associated with a highest signal-to-noise ratio (γ_i);

a discrete Fourier transformer (38) configured to transform the selected noise suppressed sub-vector ($\mathbf{h}'_{i0}$) into a noise suppressed preliminary frequency-domain channel estimate ($\mathbf{H}'$); and

a phase-shifter (40) configured to phase-adjust the taps of the noise suppressed preliminary frequency-domain channel estimate ($\mathbf{H}'$) to form an enhanced frequency-domain channel estimate ($\mathbf{H}_{out}$).

~~11. The enhancer of claim 10~~, wherein the suppressor (34) includes

a position detector (52) configured to determine a respective position of a peak power tap for each interleaved sub-vector ($\mathbf{h}_i$);

a threshold detector (54) configured to detect a respective noise threshold ($T\varepsilon_i$) for each sub-vector ($\mathbf{h}_i$); and

a tap noise suppressor (56) configured to suppress taps with a power that falls below the respective noise threshold ($T\varepsilon_i$) and are positioned within a predetermined channel length (L) from the determined respective position as well as taps that are not positioned within the channel length (L) from the determined respective position, while leaving the peak power tap unchanged.

10~~2~~. The enhancer of claim 9~~10 or 11~~, wherein the phase-shifter (40) is configured to phase shift the taps H'_k of the noise suppressed preliminary frequency-domain channel estimate ($\mathbf{H}'$) in accordance with:

$$H'_k \cdot \exp\left(-j \cdot 2\pi \cdot \frac{i0}{m} \cdot \frac{k}{N}\right)$$

where:

k is the tap index,

N is the total number of taps in the frequency-domain channel estimate ($\mathbf{H}_{in}$), and

$i0$ is the peak position in the noise suppressed preliminary frequency-domain channel estimate ($\mathbf{H}'$).

11~~3~~. The enhancer of any of the preceding claims 9-10~~-12~~, wherein the selector (36) includes:

a power estimator (58) configured to estimate a respective total power measure for each noise suppressed sub-vector ($\mathbf{h}'_i$);

a signal-to-noise ratio calculator (60) configured to determine a signal-to-noise ratio (γ_i) associated with each noise suppressed sub-vector ($\mathbf{h}'_i$) based on the corresponding estimated total power measure and a corresponding estimated noise level measure (ε_i); and

sub-vector selector (62) configured to select a noise suppressed sub-vector ($\mathbf{h}'_{i0}$) associated with a highest calculated signal-to-noise ratio (γ_i).

12~~4~~. The enhancer of any of the preceding claims ~~10~~9-11~~3~~, wherein the de-interleaver (32) is configured to form m de-interleaved sub-vectors $\mathbf{h}_i$ in accordance with:

$$\mathbf{h}_i = \left[h_{0,i}, h_{1,i}, ..., h_{n,i}, ..., h_{N-1,i}\right], \quad i = -\max\left(\left\lceil \frac{m}{2} \right\rceil - 1, 0\right), .., \left\lfloor \frac{m}{2} \right\rfloor$$

where:

$$h_{n,i} = h_{\mathrm{mod}(i+nm,\, mN)}, \qquad n = 0,1,..., N-1,$$

N is the total number of taps in the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$),

$\lceil\ \rceil$ is the ceiling function, and

$\lfloor\ \rfloor$ is the floor function.

135. The enhancer of any of the preceding claims 109-124, wherein the over-sampler (30) includes:

a zero-padder (42) configured to zero-pad the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$) with $(m-1)\cdot N$ zeros, where N is the total number of taps in the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$); and

an inverse discrete Fourier transformer (44) configured to perform an $m\cdot N$ point inverse discrete Fourier transformation on the zero-padded noisy frequency-domain channel estimate ($\mathbf{H}_{in}$).

146. The enhancer of any of the preceding claims 109-124, wherein over-sampler (30) includes:

an inverse discrete Fourier transformer (46) configured to perform an N point inverse discrete Fourier transformation on the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$), where N is the total number of taps in the noisy frequency-domain channel estimate ($\mathbf{H}_{in}$), to form a noisy time-domain channel estimate;

a zero-padder (48) configured to pad $m-1$ zeros after each sample of the noisy time-domain channel estimate; and

a lowpass filter (50) configured to lowpass filter the zero-padded noisy time-domain channel estimate.

157. A radio communication system receiver including a noisy frequency-domain channel estimate ($\mathbf{H}_{in}$) enhancer (24) in accordance with any of the preceding claims 109-146.