利用IDFT实现OFDM调制

OFDM基带复信号：$s(t)=\sum_{k=-\frac{N}{2}}^{\frac{N}{2}}[x_k(t)+jy_k(t)]e^{jk\omega_0 t}$，$k\neq 0$，$T_0=\frac{2\pi}{\omega_0}$.

令 $d(k)=x_k(t)+jy_k(t)$.

则 $s(t)=\sum_{k=-\frac{N}{2}}^{\frac{N}{2}} d(k)e^{jk\omega_0 t}$ T_0时间内采N个样点.

$s(t_n)=\sum_{k=-\frac{N}{2}}^{\frac{N}{2}} d(k)e^{jk\omega_0 nT/N}$

↓

记 $s(n)=\sum_{k=-\frac{N}{2}}^{\frac{N}{2}} d(k)e^{\frac{j2\pi kn}{N}}$ 形式类似IDFT.

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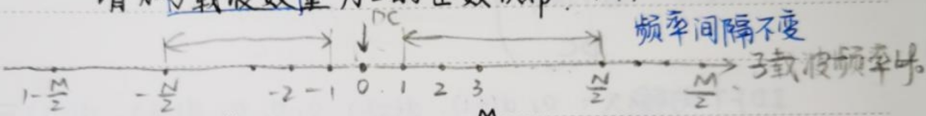
增加子载波数量为2的整数次幂 $=M$. 空子载波



$$s(t)=\sum_{\substack{k=-\frac{N}{2}\\ \cancel{k\neq 0}}}^{\frac{N}{2}} d(k)e^{jk\omega_0 t}=\sum_{k=1-\frac{M}{2}}^{\frac{M}{2}} d(k)e^{jk\omega_0 t}.$$

$$s(n)=\sum_{k=1-\frac{M}{2}}^{\frac{M}{2}} d(k)e^{\frac{j2\pi kn}{M}}\quad(0\leq n\leq M-1).$$

$d(k)$ 以M为周期延拓

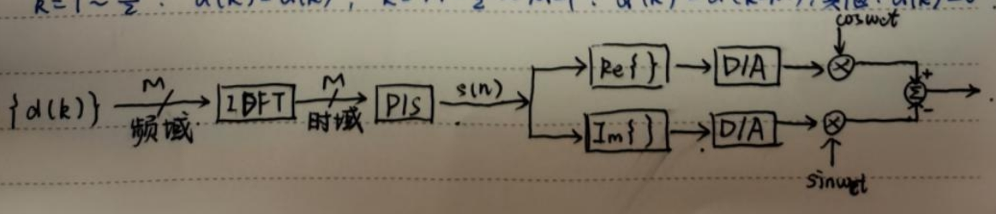
$$=\sum_{k=0}^{\frac{M}{2}} d(k)e^{\frac{j2\pi kn}{M}}+\sum_{k=1-\frac{M}{2}}^{k=-1}\tilde{d}(k+M)e^{\frac{j2\pi kn}{M}}$$

$$=\sum_{k=0}^{\frac{M}{2}}\tilde{d}(k)e^{\frac{j2\pi kn}{M}}+\sum_{k'=\frac{M}{2}+1}^{M-1}\hat{d}(k')e^{\frac{j2\pi k'n}{M}}.$$

$$=\sum_{k=0}^{M-1}\tilde{d}(k)e^{\frac{j2\pi kn}{M}}\quad \boxed{\text{IDFT!}}$$

$$=M\cdot \mathrm{IDFT}[\hat{d}(k)]$$

$k=1\sim\frac{N}{2}$：$\hat{d}(k)=d(k)$，$k=M-\frac{N}{2}\sim M-1$：$\hat{d}(k)=d(k-M)$，其他：$\hat{d}(k)=0$.



举例:

发送数据: 0,0,0,1,1,0,1,1.

调制方式: QPSK. $\downarrow$ 00, 01, 10, 11

$\frac{1}{\sqrt{2}}+j\frac{1}{\sqrt{2}}$, $-\frac{1}{\sqrt{2}}+j\frac{1}{\sqrt{2}}$, $\frac{1}{\sqrt{2}}-j\frac{1}{\sqrt{2}}$, $-\frac{1}{\sqrt{2}}-j\frac{1}{\sqrt{2}}$

被调制到 $-2f_0$, $-f_0$, f_0, $2f_0$ 的子载波上. 即

$$\left.\begin{aligned} d(-2) &= \tfrac{1}{\sqrt{2}}+j\tfrac{1}{\sqrt{2}} \\ d(-1) &= -\tfrac{1}{\sqrt{2}}+j\tfrac{1}{\sqrt{2}} \\ d(+1) &= \tfrac{1}{\sqrt{2}}-j\tfrac{1}{\sqrt{2}} \\ d(+2) &= -\tfrac{1}{\sqrt{2}}-j\tfrac{1}{\sqrt{2}} \\ &\text{DC} \end{aligned}\right\} \text{5个子载波}, N=4 \rightarrow M=8.$$

IDFT 的输入: 0, $d(+1)$, $d(+2)$, 0, 0, 0, $d(-2)$, $d(-1)$ $\Rightarrow s(n)$

☆: 相当于对 OFDM 符号的采样

$\boxed{\text{利用 DFT 实现 OFDM 解调}}$

$$s(n) = M\cdot \mathrm{IDFT}[\hat{d}(k)] \xrightarrow{\mathrm{DFT}} \mathrm{DFT}[s(n)] = M\cdot \hat{d}(k)$$

则 $\hat{d}(k) = \frac{1}{M}\mathrm{DFT}[s(n)]$, $(k=0,1,\ldots,M-1)$ $\Rightarrow d(k)$.

OFDM 的采样率: $2f_{max} = f_s$. $\Rightarrow$ 因为正频率载波数比负频率多1, 不会混叠