Solutions

1. 9 alternations (9)

2. None of the argument against it being optimal are valid for a bandpass filter. Error is equalripple in the three specified bands, but we can't know if it is optimal without knowing filter order M, or polynomial order, L, and the weighting function $W(\omega)$, so... (e)

3. For an optimal BPF there are between $L+2$ and $L+5$ alternations, Thus $L+2 \le 9 \le L+5 \rightarrow 4 \le L \le 7$. there are 5 certain local extrema (we don't know about $\omega=0$ or $\omega=\pi$) so $L-1 \ge 5 \rightarrow L \ge 6$. thus
$6 \le L \le 7$. The longest filter is
$L = 7 \rightarrow N = 2L+1 = \underline{\underline{15}}$ (5)
This ***is*** an $N=15$ tap optimal filter.

4. (c) will capture the errant transition band ripple, but this will cause specified band ripple to increase, Thus you must also do (b). (e)

5. $\delta_s / \delta_p \simeq 1/_{1/3}$ so $W(\omega = 0.95\pi) = 3$ (e)

6. Since $A_e(e^{j\omega}) \neq 0$ at $\omega = 0, \pi$, $\rightarrow$ Type I (a)

7. Zero crossing occur at $\omega = .06\pi, .17\pi, .26\pi, .92\pi$
These will be mirrored in the negative frequence half plane of $H(z)$, for a total of (8)

8. $\beta = 0.5842(40-21)^{0.4} + 0.7886(40-21) = 3.\underline{3}953$

(3)

9. $M \approx \left\lceil \dfrac{40-8}{2.285(0.38\pi - 0.3\pi)} \right\rceil = \lceil 55.7 \rceil = \underline{56}$ (6)

10. $\omega_{S_2} = \dfrac{\omega_2 + \omega_1}{2} = 0.34\pi = 1.\underline{0}68$ (0)

11. (h) is a property of a windowed filter design, not Parks-McClellan. (a) – (c) and (e)-(f) are either untrue or apply to both methods. Only d) is a real issue. (d)

12. $$H(z) = \frac{1+j3z^{-1}}{1-\frac{1}{5}z^{-1}} = \frac{1+\left(\frac{1}{j3}\right)^* z^{-1}}{1-\frac{1}{5}z^{-1}} \cdot \frac{1+j3z^{-1}}{1+\left(\frac{1}{j3}\right)^* z^{-1}}$$

$$= \frac{1+j\frac{1}{3}z^{-1}}{1-\frac{1}{5}z^{-1}} \cdot \frac{j3(z^{-1}-j\frac{1}{3})}{1+j\frac{1}{3}z^{-1}}$$

$$= \underbrace{\frac{-z^{-1}+j3}{1-\frac{1}{5}z^{-1}}}_{H_{min}(z)} \cdot \underbrace{\frac{z^{-1}-j\frac{1}{3}}{1+j\frac{1}{3}z^{-1}}}_{H_{ap}(z)}$$ (6)

13. Since $H(z)$ is causal-stable, and the only zeros are at the origin, $H(z)$ __is__ minimum phase, with all poles and zeros inside the unit circle. $H_{min}(z) = H(z)$, $H_{ap}(z) = 1$, and $H(z)$ = all terms from $C(e^{j\omega})$ with poles + zeros inside the unit circle.

d

14.

i

15. $\Omega_c = \frac{2}{T_d} \tan(\omega_c/2)$, $\frac{1}{RC} = \frac{2}{T_d} \tan(\frac{\pi}{4} \div 2)$

$T_d = (100)(2 \times 10^{-6})\, 2 \tan(\pi/8) = 1.657 \times 10^{-4}$

6

16. $H(z) = H_c(s)\Big|_{s = \frac{2}{T_d}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)}$

$$= \frac{\frac{2RC}{T_d}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)}{1 + \frac{2RC}{T_d}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)},$$

$$= \frac{\frac{2RC}{T_d}(1-z^{-1})}{1+z^{-1} + \frac{2RC}{T_d}(1-z^{-1})}$$

$$= \frac{\frac{2RC}{T_d}(1-z^{-1})}{\left(1+\frac{2RC}{T_d}\right) + \left(1-\frac{2RC}{T_d}\right)z^{-1}}$$

d

17. $M = 5$ odd,

$h[n] = h[M-n] \rightarrow$ GLP Type II (b)

18 GLP type II systems must have a zero at π. Also, $\sum_n h[n] \neq 0$, it is not zero average, so (a) is not a candidate. (d)

19. $grd\{H(e^{j\omega})\} = \frac{M}{2} = \underline{\underline{2.5}}$ (2)

20, d (d)