

Solutions to Final Exam

Question 1

- (a) The loop current increases when a telephone set goes off-hook – the current flowing through the receiver and transmitter indicates to the CO that a call is being originated.
- (b) The voltages on a POTS loop are typically - 48 VDC (on ring) or 0 VDC (on tip) relative to ground.
- (c) The DTMF tone frequencies are not harmonically related.

Question 2

- (a) No. PPP's NCP (network control protocol) is not used to control the use of compression over the link since this is a link-layer feature that would be negotiated using LCP.
- (b) A DHCPDISCOVER frame could result in multiple DHCPDISCOVER responses from multiple DHCP servers.
- (c) A DHCP client typically renews its address lease about half-way into the duration of the lease.
- (d) A router may not pass ICMP echo requests if the TTL is 1 (e.g. as part of traceroute) or it could be blocked as a firewall policy for security reasons.

Question 3

- (a) An STS-1 carries $9 \times (86 - 1) = 774$ payload bytes per frame every $125 \mu\text{s}$ so it would be capable of carrying 774 64 kbps (DS0) phone calls. However, the payload is often a DS3 consisting of 28×24 64 kbps voice channels. Any answer that took into account at least the section overhead was considered correct.
- (b) A web server's TLS certificate typically contains:

- (i) a public key - this is the “payload” of the certificate
- (iii) identification information - this identifies the owner of the certificate
- (iv) a signature - this is the assurance that ownership information can be trusted

The private key (ii) would not be included because it must be kept secret.

Question 4

A signal containing frequencies from DC to f_{max} must be sampled at a rate of at least $2f_{max}$ to avoid aliasing.

Quantization at B bits per sample results in a quantization SNR that increases as $6B$. Since the type of signal was not specified, any reasonable calculation using an increase in SNR of 6 dB/bit was considered correct.

For a 50 kHz signal with 36 dB quantization SNR we would use a sampling rate of at least 100 kHz with at least 6 bits per sample.

For a 100 kHz signal with 60 dB quantization SNR we would use a sampling rate of at least 200 kHz with at least 10 bits per sample.

Question 5

A communication system using DMT (OFDM) uses a sampling rate of f_s , N -sample blocks (symbols) and a guard time T_g between DMT symbols:

- (a) The DMT symbol duration is $N/f_s = \frac{64}{4 \times 10^6} = \frac{128}{8 \times 10^6} = 16 \mu\text{s}$.
- (b) The frequency spacing between DMT subcarriers is the inverse of the symbol duration or $\frac{1}{16 \times 10^{-6}} = 62.5 \text{ kHz}$.
- (c) The DMT symbol rate, including the guard time overhead, is $16 + 4 = 20 \mu\text{s}$.

- (d) If half of the subcarriers ($N/2$) are used and each subcarrier transmits b bits every T seconds the bit rate is $\frac{N \times b}{T}$. Including the guard time, $T = 20 \times 10^{-6}$.
- For $N = 64$ and $b = 2$ the bit rate is $\frac{64 \times 2}{20 \times 10^{-6}} = 3.2 \text{ Mb/s}$.
- For $N = 64$ and $b = 4$ the bit rate is $\frac{128 \times 4}{20 \times 10^{-6}} = 12.8 \text{ Mb/s}$.
- (b) `nslookup -type=mx example.com` would result in an MX record with value "10 mail.example.com" (the mail exchanger is mail.example.com with priority 10).
- (c) `nslookup -type=ns example.com` would result in an NS record with value 192.0.2.2.

Question 6

An HFC system has a 33-meter co-ax drop from an 4-way splitter to a subscriber. The loss of the co-ax is 9 dB/100m. Assume the splitter is ideal (the sum of output powers is equal to the input power).

- (a) The loss of 33 meters of co-ax with a loss of 9 dB/100m is $9 \times \frac{33}{100} \approx 3 \text{ dB}$. The loss of an ideal N -way splitter is $10 \log \frac{1}{N} = -9$ and -6 dB for 8-way and 4-way splitters respectively. The total loss from the splitter to the customer would thus be $3 + 9 = 12$ and $3 + 6 = 9$ respectively and splitter input levels of $+12$ and $+9 \text{ dBmV}$ would result in levels of 0 dBmV .

- (b) The voltages would be $V = 10^{\frac{V_{dBmV}}{20}} = 10^{\frac{12}{20}} = 4 \text{ mV}$ and $10^{\frac{9}{20}} = 2.8 \text{ mV}$. Given an impedance level of 75Ω the power level can be found as $P = \frac{V^2}{R} = \frac{(4 \times 10^{-3})^2}{75} = 213 \times 10^{-9} \text{ W} = -37 \text{ dBm}$ and $\frac{(2.8 \times 10^{-3})^2}{75} = 104 \times 10^{-9} \text{ W} = -40 \text{ dBm}$.

You can also use the formula: $\text{dBm} = \text{dBmV}_{75\Omega} - 48.8$.

Question 7

An authoritative DNS server configured with the following resource records (shown in BIND format):

```
example.com.      NS      192.0.2.2
example.com.      MX      10 mail.example.com.
www.example.com.  A       11.1.2.3
```

- (a) `nslookup example.com` would result in a "not found" (NXDOMAIN) response because the default record type is A (address) and there is no data for this type of record with the key `example.com` (which is not the same as `www.example.com`).