5.1 SYNCHRONISATION SIGNALS

- Both the FDD and TDD versions of LTE broadcast Synchronisation Signals in the downlink direction:
  - Primary Synchronisation Signal (PSS)
  - Secondary Synchronisation Signal (SSS)
- Synchronisation Signals are broadcast within every 10 ms radio frame
- The UE uses the Synchronisation Signals to:
  - achieve radio frame, subframe, slot and symbol synchronisation in the time domain
  - identify the center of the channel bandwidth in the frequency domain
  - deduce the Physical layer Cell Identity (PCI)
- Detecting the Synchronisation Signals is a prerequisite to measuring the cell specific Reference Signals and decoding the Master Information Block (MIB) on the Physical Broadcast Channel (PBCH)

5.1.1 PRIMARY SYNCHRONISATION SIGNAL

- The Primary Synchronisation Signal (PSS) is broadcast twice during every radio frame and both transmissions are identical
- In the case of FDD:
  - the PSS is broadcast using the central 62 subcarriers belonging to the last symbol of time slots 0 and 10
- In the case of TDD:
  - the PSS is broadcast using the central 62 subcarriers belonging to the third symbol of time slot 2 (subframe 1) and the third symbol of time slot 12 (subframe 6)
  - subframe 1 is always a special subframe so the PSS is sent as part of the Downlink Pilot Time Slot (DwPTS)
  - subframe 6, may or may not be a special subframe, depending upon the uplink-downlink subframe configuration. It is a special subframe for configurations 0, 1, 2 and 6. Otherwise it is a normal downlink subframe
- The PSS is used to:
  - achieve subframe, slot and symbol synchronisation in the time domain
  - identify the center of the channel bandwidth in the frequency domain
  - deduce a pointer towards 1 of 3 Physical layer Cell Identities (PCI)
    - PCI are organised into 168 groups of 3 so the Primary Synchronisation Signal identifies the position of the PCI within the group but does not identify the group itself
- The PSS cannot be used to achieve radio frame synchronisation because both transmissions within the radio frame are identical and equally spaced in time

5.1.2 SECONDARY SYNCHRONISATION SIGNAL

- The Secondary Synchronisation Signal (SSS) is broadcast twice within every radio frame. The two transmissions of the SSS are different so the UE can detect which is the first and which is the second
- In the case of FDD:
  - the SSS is broadcast using the central 62 subcarriers belonging to the second to last symbol of time slots 0 and 10
- In the case of TDD:
  - the SSS is broadcast using the central 62 subcarriers belonging to the last symbol of time slot 1 (subframe 0) and the last symbol of time slot 11 (subframe 5)
  - both time slots 1 and 11 are always within normal downlink subframes
- The SSS is used to:
  - achieve radio frame synchronisation
  - deduce a pointer towards 1 of 168 Physical layer Cell Identity (PCI) groups
    - allows the PCI to be deduced when combined with the pointer from the PSS

★ Figure 75 illustrates the position of the Primary and Secondary Synchronization Signals in both the time and frequency domains for the FDD 3 MHz channel bandwidth. Only the fist half of the radio frame is shown (time slots 0 to 9). The position in the frequency domain is the same for TDD

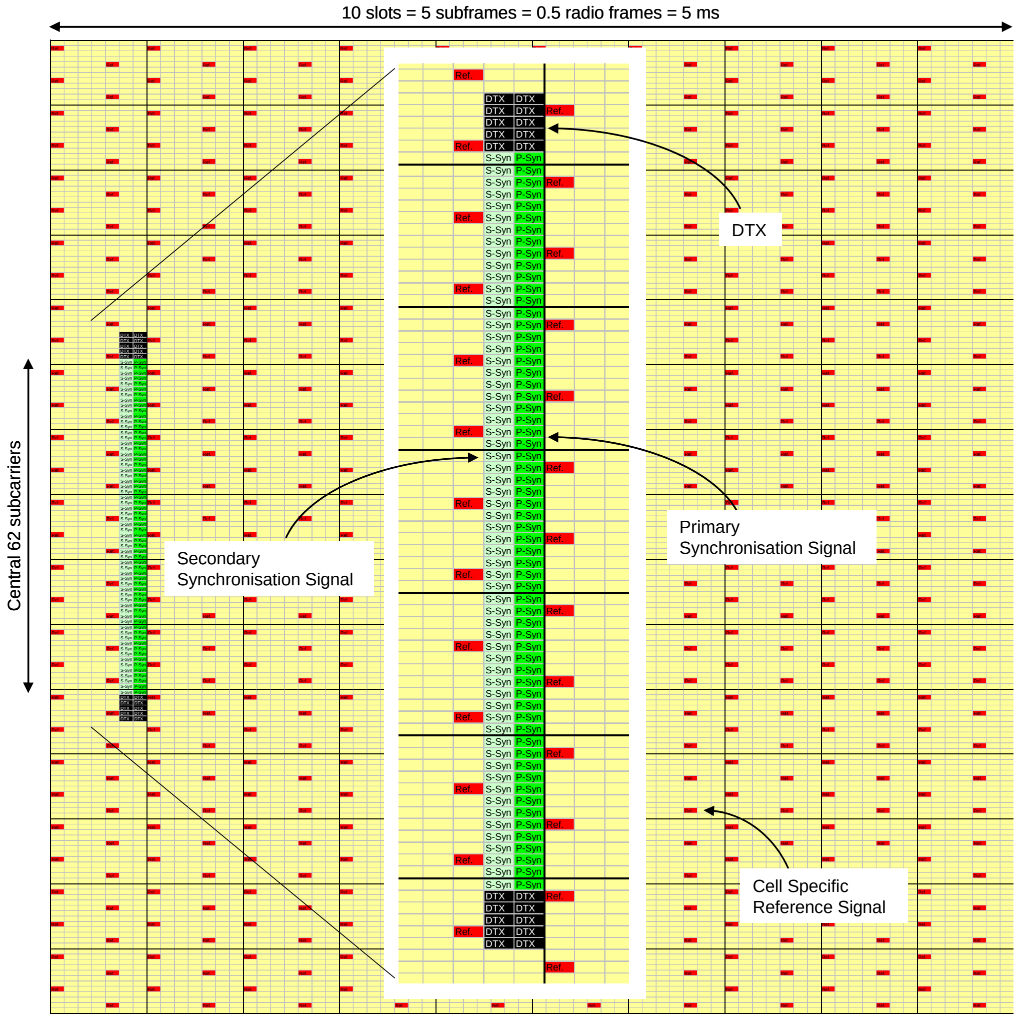

Figure 75 – FDD Synchronisation Signals within time slots 0 to 9 of a 3 MHz channel bandwidth

★ The 5 Resource Elements above and below the Synchronisation Signals are not used for transmission. They represent periods of Discontinuous Transmission (DTX). These are present for both FDD and TDD

★ The set of Resource Elements allocated to the Synchronisation Signals is independent of the channel bandwidth. The UE does not require any knowledge of the channel bandwidth prior to detecting the Synchronisation Signals. The downlink channel bandwidth is subsequently read from the Master Information Block (MIB) on the Physical Broadcast Channel (PBCH)

★ Figure 76 illustrates the timing of the PSS and SSS for FDD. This example assumes the normal cyclic prefix because there are 7 symbols within each time slot. The extended cyclic prefix follows a similar pattern except there are only 6 symbols within the time slot (the SSS and PSS remain within the last two symbols of the time slot)

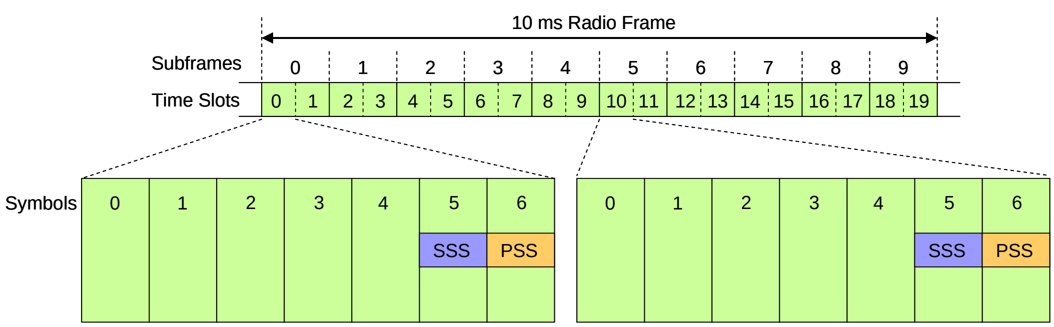

Figure 76 – Timing of Synchronisation Signals for FDD

★ Figure 77 illustrates the timing of the PSS and SSS for TDD. The example assumes the normal cyclic prefix, uplink-downlink subframe configuration 0 and special subframe configuration 0. The extended cyclic prefix follows a similar pattern except there are only 6 symbols within the time slot (the SSS remains within the last symbol of time slots 1 and 11, while the PSS remains within the third symbol of time slots 2 and 12)

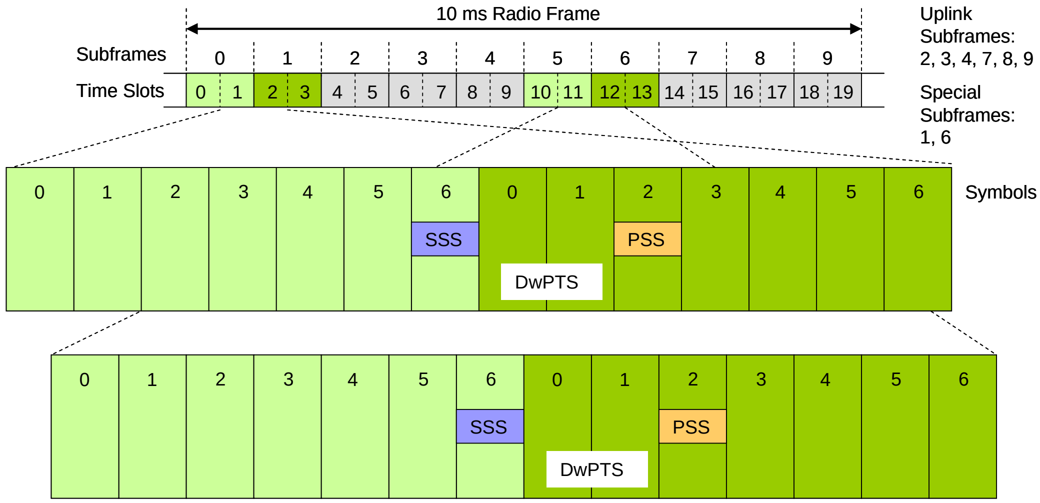

Figure 77 – Timing of Synchronisation Signals for TDD

★ In the case of TDD, the SSS and PSS are not in adjacent symbols. The first two symbols within time slots 2 and 12 are left available for the PCFICH, PHICH and PDCCH

★ Synchronisation Signals represent an overhead which reduces the number of Resource Elements available for user plane data

- o overhead decreases for larger channel bandwidths
- o overhead increases when using the extended cyclic prefix

★ In the case of FDD, the overhead generated by the Synchronisation Signals is presented in Table 31

	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Sync. Resource Elements per 10 ms Radio Frame	2×144 = 288	2×144 = 288	2×144 = 288	2×144 = 288	2×144 = 288	2×144 = 288
Normal Cyclic Prefix						
Total Resource Elements per 10 ms Radio Frame	10080	25200	42000	84000	126000	168000
Overhead	2.9 %	1.1 %	0.7 %	0.3 %	0.2 %	0.2 %
Extended Cyclic Prefix						
Total Resource Elements per 10 ms Radio Frame	8640	21600	36000	72000	108000	144000
Overhead	3.3 %	1.3 %	0.8 %	0.4 %	0.3 %	0.2 %

Table 31 – Overhead generated by Synchronisation Signals (FDD)

★ In the case of TDD, the overhead generated by the Synchronisation Signals is the same as that for FDD when calculating the overhead relative to the total number of Resource Elements (both uplink and downlink)

★ However, the overhead for TDD is greater when calculating relative to the number of downlink Resource Elements. This calculation is multi-dimensional because the number of downlink Resource Elements depends upon the cyclic prefix length, the channel bandwidth, the uplink-downlink subframe configuration and the special subframe configuration

★ Table 32 presents the overheads when assuming uplink-downlink subframe configurations 0 and 5. These configurations represent those with the highest and lowest overheads, i.e. uplink-downlink subframe configuration 0 has the least downlink Resource Elements, while uplink-downlink subframe configuration 5 has the most downlink Resource Elements

★ In the worst case of uplink-downlink subframe configuration 0, using the extended cyclic prefix and special subframe configuration 0, the overhead for TDD reaches 13.3 %

★ 3GPP References: TS 36.211