Chapter 4
Fly-by-Wire Flight Control

4.1 Introduction

The introduction of fly-by-wire (FBW) flight control systems has been a watershed development in aircraft evolution as it has enabled technical advances to be made which were not possible before. One of the unique benefits of a FBW system is the ability to exploit aircraft configurations which provide increased aerodynamic efficiency, like more lift and lower drag, but at a cost of reduced natural stability. This can include negative stability, that is the aircraft is unstable over part of the range of speed and height conditions (or flight envelope).

The FBW system provides high-integrity automatic stabilisation of the aircraft to compensate for the loss of natural stability and thus enables a lighter aircraft with a better overall performance to be produced compared with a conventional design. It also provides the pilot with very good control and handling characteristics which are more or less constant over the whole flight envelope and under all loading conditions. Other benefits a FBW system can provide are manoeuvre command control, ‘carefree manoeuvring’ and not least the elimination of the bulk and mechanical complexity of the control rods and linkages connecting the pilot’s stick to the control surface PCUs and consequent weight saving.

Aircraft with FBW flight control systems first came into service in the late 1970s using analog implementation. Digital FBW systems have been in service since the late 1980s. The concepts are not new; in fact, all guided missiles use this type of control. What has taken the time has been the development of the failure survival technologies to enable a high-integrity system to be implemented economically with the required safety levels, reliability and availability. A major factor has been the development of failure survival digital flight control systems and their implementation in VLSI microcircuits. There are other technologies where development has been essential for FBW control, such as failure survival actuation systems to operate the control surfaces.

All new fighter designs exploit FBW control. Figure 1.2 (Chapter 1) illustrates the Eurofighter Typhoon as a typical example.
A recent development in military aircraft is the emergence of ‘stealth’ technology where the aircraft configuration and shape are specifically designed to reduce its radar cross-section. In general, the stealth features reduce the aircraft’s natural stability and damping, and FBW control is essential to achieve good handling and control characteristics.

The current generation of civil airliners exploit FBW control. Examples are the Airbus A319, A320, A330, A340, A380, and the Boeing 777 and 787.

Very many tens of millions of flying hours have now been accumulated by aircraft with digital FBW flight control systems, and their safety and integrity have been established.

### 4.2 FBW Flight Control Features and Advantages

#### 4.2.1 FBW System Basic Concepts and Features

Figure 4.1 shows the basic elements of a FBW flight control system.

Note:

- The total elimination of all the complex mechanical control runs and linkages – all commands and signals are transmitted electrically along wires, hence the name fly-by-wire.
- The interposition of a computer between the pilot’s commands and the control surface actuators.