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DiSEqC 1.0

DiSEqC 2.0

Digital Satellite Equipment Control (DiSEqC™)

APPLICATION INFORMATION FOR

LNBS AND SWITCHERS

VERSION 2

February 25, 1998

Reference Documents that define the DiSEqC System:

DiSEqC™ Bus Specification Version 4.2 (February 25, 1998)

DiSEqC™ Slave Microcontroller Specification Version 1.0 (February 25, 1998)

DiSEqC™ Logos and Their Conditions of Use (February 25, 1998)

Associated Documents:

Update and Recommendations for Implementation Version 2.1 (February 25, 1998)

Application Information for using a "PIC" Microcontroller in DiSEqC™ LNB and simple switcher Applications Version 1.0 (June 7, 1999)

Application Information for Tuner-Receiver/IRDs (April 12, 1996)

Application Information for LNBs and Switchers Version 2 (February 25, 1998)

Reset Circuits for the Slave Microcontroller (August 12, 1996)

Simple Tone Burst Detection Circuit (August 12, 1996)

Positioner Application Note Version 1.0 (March 15, 1998)

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0.   Introduction

This Application Note is a slightly revised version of that dated April 12, 1996. Significant changes are marked with change bars and generally concern the definition of the "Loop-through" characteristic for Switchers, and the circumstances when various pins of the Slave microcontroller should be earthed.

The DiSEqC™ system incorporates a number of novel features for future use, so the Bus and Slave Microcontroller Specifications contain much specific detail. Similarly, the Slave Microcontroller Evaluation Circuit Board includes a number of components to demonstrate some of the longer-term capabilities. However, this may have given a misleading impression of the amount of hardware, and the costs, of implementing a basic DiSEqC™ system.

This Application Note starts with a few fundamental aspects concerning the use of the DiSEqC™ Slave Microcontroller in general applications. It then describes a minimum application of the Integrated Circuit (but still offering considerably more switching capabilities than existing systems), and goes on to show how additional components may be added to extend the facilities.

1.   General Application Notes

The present DiSEqC™ Slave Microcontroller is a specifically programmed version of the Philips Semiconductors 8xC750 general-purpose micro-controller. Much application information is therefore available in the relevant data sheets and application notes. However, certain details are specific to DiSEqC™ requirements as follows.

1.1. Reset circuitry

The function of the reset circuitry is to ensure that the microcontroller starts from a defined state and does not attempt to perform any control functions until the power supply is fully established and the timing oscillator has a stable amplitude. In many microcontroller applications the initialisation time is not critical, so a relatively long reset time can be employed. However, most DiSEqC™ accessories are expected to be powered via the bus, and some "distant" ones (i.e. not connected directly to the cable to the Tuner-Receiver/ IRD) may receive power only when another device switches them in (for example when the user selects a new channel to view). In this case a rapid response is required, so attention must be paid to the hardware reset time.

It is recommended that all DiSEqC™ accessories which may have power applied as a result of a channel-change, should be operational within 100 ms of the nominal power supply voltage being reached. This requires that the supply voltage has a reasonably rapid rise-time, typically less than 5 ms. DiSEqC™ accessories which are not powered in this manner may have (or may need) a significantly longer power-on reset time.

The simplest way to achieve a reset time of approximately 50 ms with the 8xC750 microcontroller is to use a reset capacitor of typically 100 nF. However, the reset time is dependent on the reset current defined by the microcontroller, which has very wide tolerances. Therefore, the preferred arrangement is to use an additional resistor of typically 22 kΩ to ground, from the 1µF reset capacitor, as shown in the applications diagrams in this document.

1.2. Switching Control Pins

The DiSEqC™ Slave microcontroller has typically 8 pins available to provide 'TTL' logic levels (i.e. typically < ½ volt for a logic '0', and > 3 volts for a logic '1') to operate switches to select between various signal conditions or sources (e.g. Plane of Polarisation and Satellite orbital Position). The basic application is where each pin is allocated an independent "binary" function to select between two complementary (i.e. mutually exclusive) sources. Thus one pin can select Horizontal Polarisation if it is "high" (logic '1') and Vertical Polarisation if it is "low" (logic '0'). The convention used in DiSEqC™ documents is that the "high" condition is always stated first, and thus a pin labelled "Position B/A" means that Position B is selected when it is a logic '1', and Position A when logic '0'. Because the pins can be controlled completely independently of each other, the 8 pins potentially offer 2^8, or 256, possible combinations, although in practice many fewer will be used.

Although these "binary" outputs allow a large number of combinations to be signalled on a small number of pins, they are not ideal if the switching elements are of a simple "make-only" type, such as a simple reed relay or diode (electronic) switch. To accommodate these applications, the slave microcontroller may allocate the 8 output pins in other ways, for example giving four "Complementary Pairs" of pins, or giving a "1 of 8 decoder" function. Refer to the Specification or data sheets of the specific slave microcontroller for details of the availability and use of these modes.

The Complementary Pairs provide 4 control pins as described above, and 4 more with the same function but with the logic polarity inverted. For the polarisation pin "Horizontal / Vertical", its partner is thus defined as "Vertical / Horizontal". A logic '1' on the former pin can close a switch selecting the Horizontal antenna, and a logic '1' on the latter pin can close the switch selecting the Vertical antenna. Note that if the switches actually require a logic '0' to close them, then the connections to the complementary pins can be simply exchanged.

The Complementary Pairs may be ideal where the basic switching functions are independent (e.g. Plane of Polarisation and High / Low Local Oscillator frequency), but not where a single source is to be selected, for example 1 of 8 inputs to a SMATV switch. For this application, the "Decoder" mode activates only one of the control pins at a time, to close just the appropriate switch for one of up to 8 input sources. However, these 8 pins now provide only as many switching combinations as can be carried on 3 of the original binary pins, so 5 "control lines" for which DiSEqC™ commands are defined are no longer available. The slave microcontroller offers various alternative decoding configurations, but it is not possible to provide for all combinations.
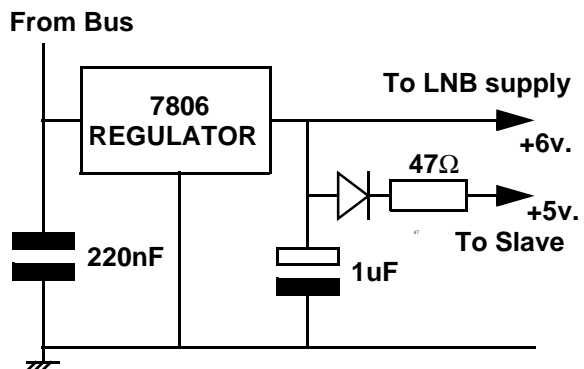
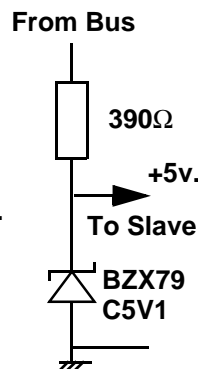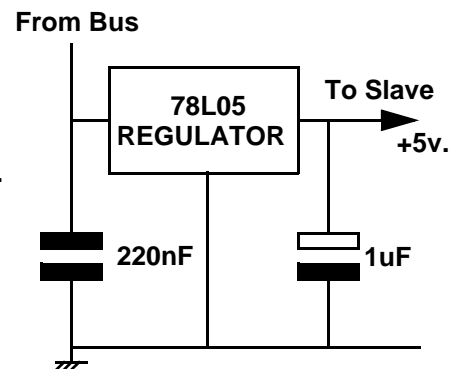## 1.3. Power Supply Arrangements

Figure 1a   Figure 1b   Figure 1c

Present versions of the Slave microcontroller require a power supply of 5 volts ± 10%, at up to about 10 mA, so generally some form of supply regulator is required. A typical LNB has a regulated rail of 6 volts already, so a simple dropper network such as a forward conducting diode (0.7 volt) and a resistor of about 47Ω should be adequate, as shown in *Figure 1a*.

In applications where there is at present no regulated supply rail, a simple regulator is required, as shown if *Figure 1b* and *Figure 1c*. The simple shunt zener diode (*Figure 1b*) may be adequate for '12 volt' applications, and has the advantage of not adding significantly to the capacitance on the bus, but such circuits tend to give marginal performance with wasteful power consumption. The preferred arrangement is to use a low power '3-terminal' regulator such as a 78L05 as shown in *Figure 1c*. These devices require a capacitance across their input to maintain high-frequency stability, but a value between 100 nF and 220 nF should be sufficient. This capacitance could be partly isolated from the bus with a resistor, for applications where excessive capacitance may be considered a potential problem (multiple Slaves on long cable runs).

2.   Basic Receive-only LNB (or Switcher)

Figure 3 shows a basic receive-only circuit (i.e. with no reply facility), as might be used in a Low Noise Block (LNB) or Switcher. However, although it is possible to use the slave microcontroller in a receive-only mode, just a few additional components are required to implement the reply capability (*see section 4.*), so we do **not** recommend the reply-only circuit to be used in practice. It is included here to assist with the understanding of the basic circuitry.

Three 'TTL' level outputs are shown for High/Low Local Oscillator frequency, Horizontal/Vertical polarisation and two satellite locations. The microcontroller outputs have a weak current pull-up, so the external pull-up resistors may be needed with certain types of load. The pin numbers shown around the Slave microcontroller refer to the 24 pin Dual In Line or the SSOP package.
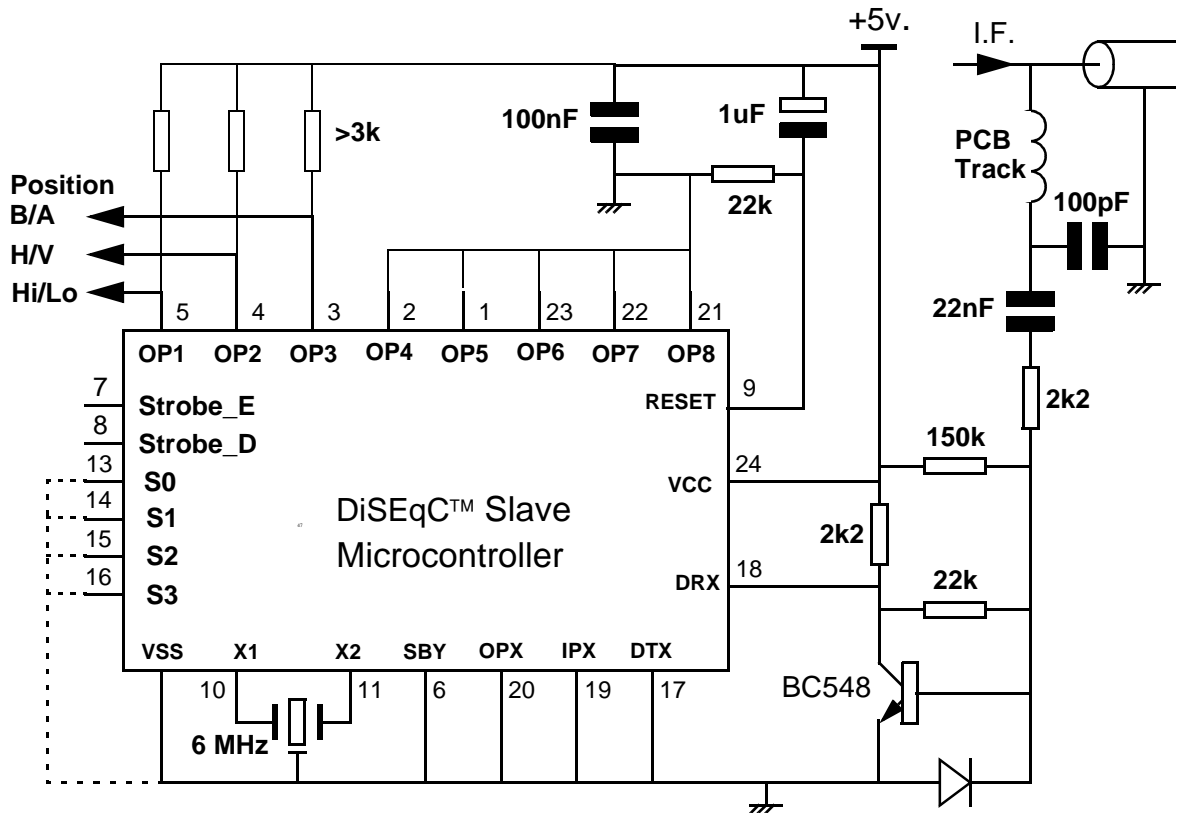

Figure 2

The five unused outputs are connected to earth (Vss) to signal to the microcontroller that they are not active. However, if there is no return-signalling (reply) hardware employed, the microcontroller cannot actually report the information. Similarly, it is not strictly necessary to make any connections to the Standby output (SBY) and the 'OPX' pin. Likewise, the connections to the selection inputs (S0 - S3) indicate the type of peripheral, and for a Switcher should be left not connected. A normal LNB can signal a "Standard Configuration" (*see section 8.*) with one or more of the 4 selection pins connected to earth, but a LNB with a non-standard Local Oscillator frequency should use diodes connected to the 'Strobe' pin(s) as defined in the data sheet. Since there is no 13/17 volt detection circuit shown in this application, the IPX pin should be tied low to ensure that the H / V output is in a predictable state (Vertical Polarisation) until the first DiSEqC™ command is received (*see section 5.*).

A 6 MHz three-terminal resonator for the microcontroller clock is shown, but a simple two-terminal type may be connected across the same pins, with additional capacitors of typically 22 pF from each pin to earth, as is shown later in *Figure 5*.

The Intermediate Frequency (about 1 - 2 GHz) on the coaxial cable (download) is isolated from the Slave's circuitry by a track on the Printed Circuit Board which is a quarter-wavelength long and "shorted" by a capacitor of typically 100pF. The nominal 650 mV., 22 kHz tone on the bus is amplified by the transistor to drive the 'TTL level' input (DRX) of the microcontroller. The component values shown have been chosen so that the Slave does not respond to signals below about 300 mV. This can be beneficial because some LNBs are known to inject spurious noise or oscillations onto the cable, and devices such as Positioners may put an undulating power drain on the bus. However, some designers may prefer to use somewhat higher gain amplification to improve reception in conditions where an excessively high capacitive load is present on the bus.
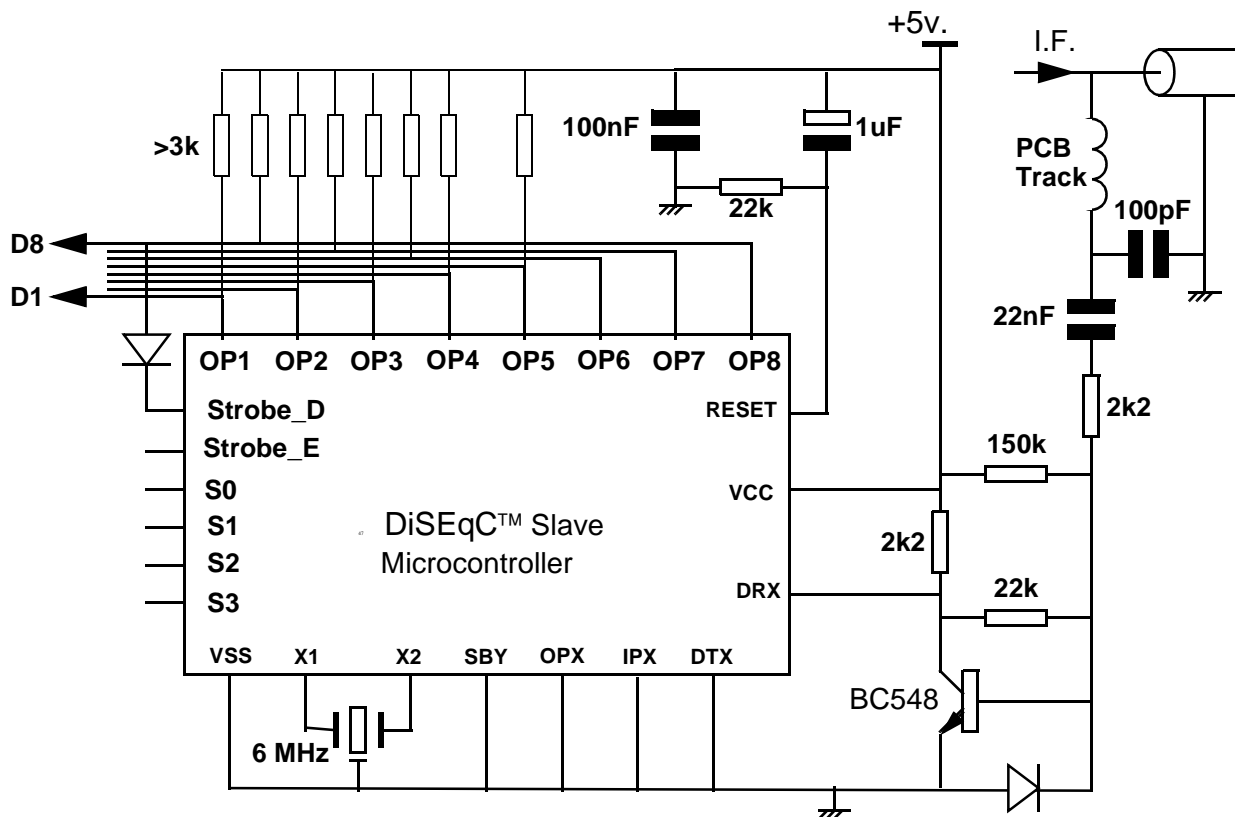
3. Basic Receive-only "Decoded" Switch

Figure 3

Figure 3 shows how the eight outputs of the microcontroller alternatively may be used in a '1 of 8' decoding format. In this mode, just one of the outputs at any time is 'true' and the other seven are 'false'. As before, the pull-up resistors may not be necessary. The method of selecting a decoder mode is by connecting one or more diodes between the Strobe_E pin and outputs OP 5 to OP 8. In the case shown, the single diode selects decoding of the 3 "virtual" lines which would normally feed OP 1 - OP 3 directly (i.e. those allocated to Hi/Lo frequency, H/V polarisation and satellite Position B/A). See the relevant slave microcontroller data sheet for details of other possible decoding modes, which may include the selection of either "active high" or "active low" for the 'true' output.

The eight outputs are controlled by exactly the same commands on the bus as the previous LNB example. Thus, to simplify installation, it is recommended that the (up to) eight input connectors of switching units are labelled with the equivalent signal parameters as shown in *Table 1*.

Switch Number	Satellite Position	Polarisation	Local Oscillator Frequency	Active Output Pin	Pin Number DIL / PLCC
1	A	Vertical	Low	OP 1	5 / 6
2	A	Vertical	High	OP 2	4 / 4
3	A	Horizontal	Low	OP 3	3 / 3
4	A	Horizontal	High	OP 4	2 / 2
5	B	Vertical	Low	OP 5	1 / 1
6	B	Vertical	High	OP 6	23 / 27
7	B	Horizontal	Low	OP 7	22 / 26
8	B	Horizontal	High	OP 8	21 / 25

Table 1: Decoded outputs mode

Version 1.0 of the slave microcontroller also supports decoding for a typical "Switcher" which selects between controllable LNBs, rather than pre-defined signal inputs. In this case, the switcher should ignore bus commands which control Hi/Lo frequency and H/V polarisation, because they are intended for the LNBs. Instead, the switcher should respond to the "Satellite Position B/A" and/or the "Switch Option B/A" commands. The method of achieving this is to connect additional diodes from the Strobe_E pin, as follows:

To include the "top" control line of the 4-bit port (i.e. the Switch Option line), a diode is connected to OP 5. This instructs the microcontroller to decode the 'SW 0 B/A', 'Position B/A' and 'H/V' control lines.

If the H/V polarisation line is not required, another diode is connected to OP 1 to indicate that the lowest of the 3 <u>decoded</u> input lines (i.e. H/V) is not to be used (and thus a 1 of 4 decoder is to be implemented). Similarly, a diode may be connected to OP 2 or OP 3 to indicate that either the Satellite Position or Switch Option lines respectively are not to be used.

Note that the commands to which a switcher is required to respond may depend on other devices in the system. Therefore, switch manufacturers are strongly recommended to ensure that their products can be simply configured at the production stage (or ideally by the installer), for example by using pin or solder-links, or even DIP switches.

4.   LNB / Switcher with "Reply" Capability

Figure 4 includes the few additional components needed for the slave accessory to transmit a reply to the master Receiver/IRD. The reply can be a simple acknowledgement that a command has been received, or the return of various types of data such as the frequency of the Local Oscillator, for automatic installation.

The source impedance of a DiSEqC™ master is nominally 15Ω (at 22 kHz), and the Slave can produce a typical 650 mV peak-peak carrier tone simply by switching an additional current drain of approximately 45 mA across the bus. With the configuration shown here, the carrier amplitude is proportional to the bus d.c. supply voltage, which is more suited to applications where the bus voltage is reasonably constant (e.g. over the range of 11 - 13 v.). However, even with a supply of 18 volts, the carrier is unlikely to exceed the 1 volt peak-peak upper limit which is recommended for DiSEqC™ applications, although the (current-drive) version in the next section is to be preferred.

Because the Slave microcontroller is now able to transmit data to the Master, attention must be paid to the data which is returned. Thus, the unused switching outputs (OP4 - OP8) must be linked to earth to indicate that they are "resources" which are not performing a function. However, if the Decoded Outputs mode is used, these pins are not earthed, but exactly the same "resources" reply is returned to the Master, because the internal software recognises that only control of the relevant signals (i.e. Hi/Lo, H/V and SW 0) is possible.
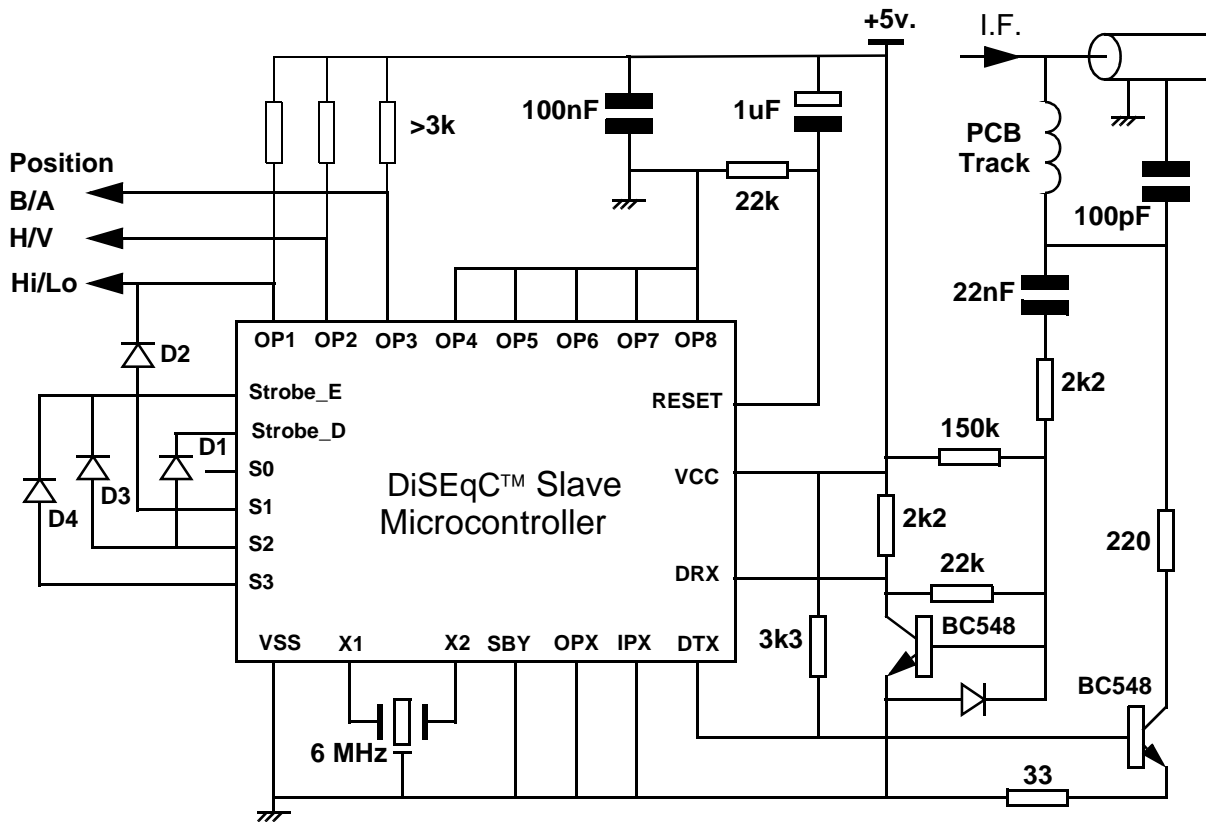
Figure 4

The data selection inputs (S0 - S3) are primarily intended to communicate the frequency of the Local Oscillator to the internal software. In the general case, this is done by connecting one or more diodes between the S0 - S3 inputs to the appropriate 'Strobe' pins, as defined in the relevant slave data sheet. The Strobe_D pin is used to signal the High (or only) L.O. frequency and the Hi/Lo pin is used as a strobe for the Low L.O. only when two frequencies are available. As an example, diode D1 shown in *Figure 4* signals a Low L.O. frequency table value of 2 (9.750 GHz) and D2 signals a High L.O. frequency table value of 4 (10.6 GHz). In practice, there is a more economical method of signalling this particular combination, as explained in *section 8.*

For a normal LNB, no connections are made between the Strobe_E pin and the selection inputs because the characteristics of a simple LNB have been designed to be signalled by the absence of diodes in these locations. However, a "loop-through LNB" (*see section 7.*) requires a diode (D3) to pin S2 to indicate that the LNB has the ability to disable the propagation of signals to or from other Slaves on the bus.

For the case of Switchers, diodes D3 and/or D4 may be required. A diode (D4) to pin S3 signifies that the "Backwards Compatible" 22 kHz continuous tone is to choose the selected Satellite Position rather than the normal Hi/Lo Local Oscillator frequency. A recent addition to the DiSEqC™ specification has been to extend the significance of the "Loop-through" flag to all Switchers. It is now recommended that any switch which can feed DiSEqC™ messages to more "distant" devices on the bus should be defined as a "Loop-through" device with the modified address 15h. This is obtained by installing diode D3 between S2 and Strobe_E. Thus the only Switchers which do <u>not</u> have D3 fitted should be those which block the transmission of the 22 kHz tone to devices further along the bus.

Diodes from S0 and/or S1 to Strobe_E can signal other application "families" such as "(magnetic) Polariser" and "Installation Aid" (see the relevant Slave Microcontroller Specification for details). A special application mode with a diode connected between pin S0 and Strobe_E can configure the 8 output lines to give both 'normal' and 'inverted' signals for the 4 selected Port-lines (i.e. either all "Committed" or all "Uncommitted" lines).

5. LNB / Switcher with Full Backwards Compatibility

The Slave software in the circuits described so far is able to detect the presence (and absence) of a continuous 22 kHz tone and provide a degree of "Backwards Compatible" switching. This means that until a valid DiSEqC™ command (except 'Reset') is received, a continuous tone automatically switches the Hi/Lo output pin in the same way as existing systems. To avoid any conflicting situations, this backwards compatibility ceases as soon as a DiSEqC™ environment is detected, until the Slave is reset by command or power-interruption.

Version 1.0 of the Slave software extends this compatible switching to control of the Satellite Position pin, either by connecting a configuration diode between appropriate strobe and select pins, or by the use of a modulated tone-burst during channel-changing.
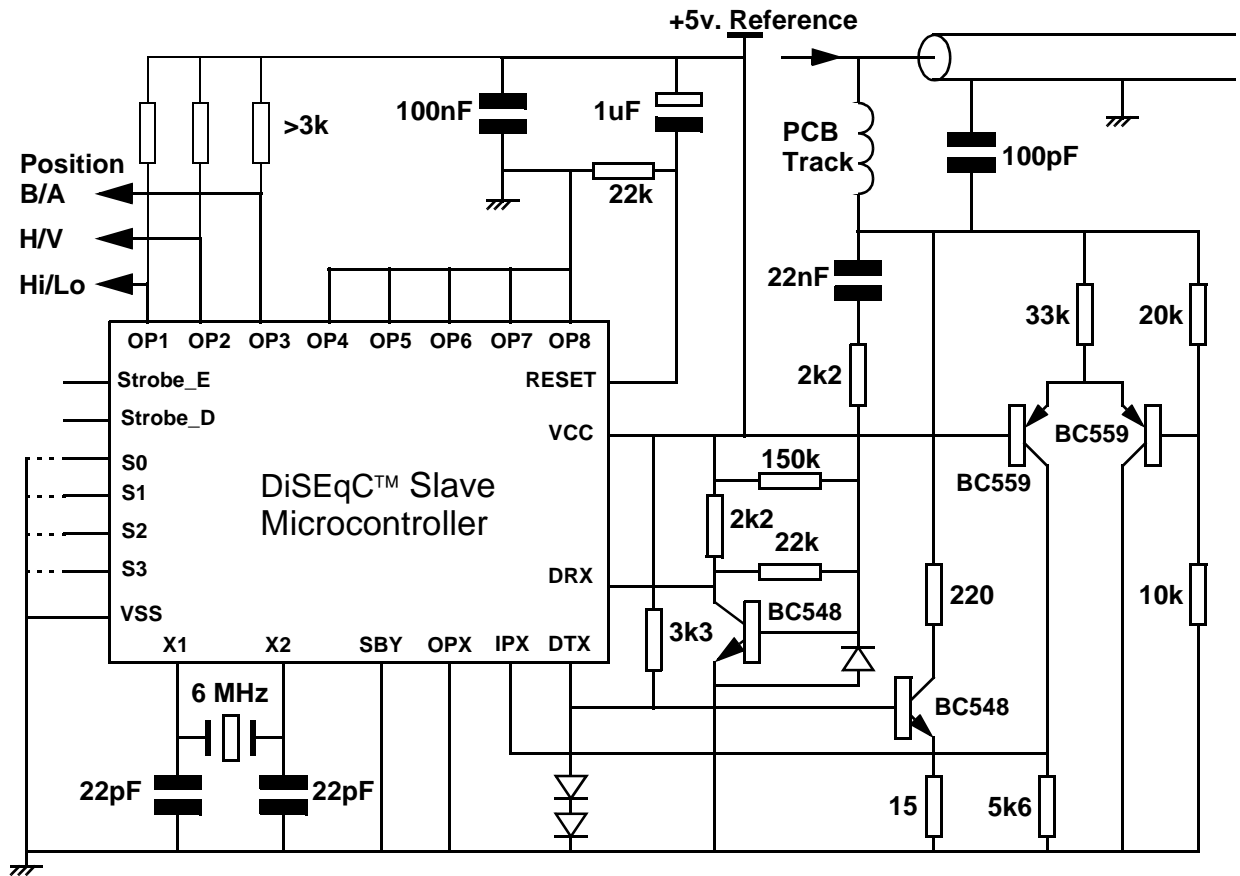
Figure 5

However, the previous circuits do not include the precision voltage-detection circuitry necessary to differentiate between the nominal 13 and 17 volt levels commonly used for Horizontal/Vertical polarisation switching in LNBs and similar equipment. *Figure 5* includes a simple comparator for performing this function. The reference voltage should be taken directly from a suitable regulator or voltage reference (not via any decoupling or voltage-dropping networks), and attention must be paid to system tolerances. The detection threshold needs to be 15 ± 1 volts, so the divider resistors should be accurate 1% values and the comparator transistors may need to be a matched pair in a single encapsulation. It may be necessary to closely specify the reference voltage or employ "adjust-on-test" techniques. An alternative implementation which meets these criteria is used in the DiSEqC™ Slave Evaluation Circuit Boards and described in the associated documentation.

Since the circuit of *Figure 5* is intended to operate from bus voltages at least over the range of 11 to 18 volts, the reply driver is adapted to constant-current operation. The voltage on the drive pin (DTX) is limited to about 1.4 volts by the two forward-biased diodes. Current is drawn from the bus so that about 0.7 volts appears across the 15Ω resistor, and thus 650 mV. across the source impedance in the Master.

6. LNB / Switcher with Power-down (Standby) facility

The DiSEqC™ system offers specific commands to selectively instruct accessories to power-down their active circuitry (i.e. enter "Standby"). The slave microcontroller itself must remain powered so that it can respond to further commands.
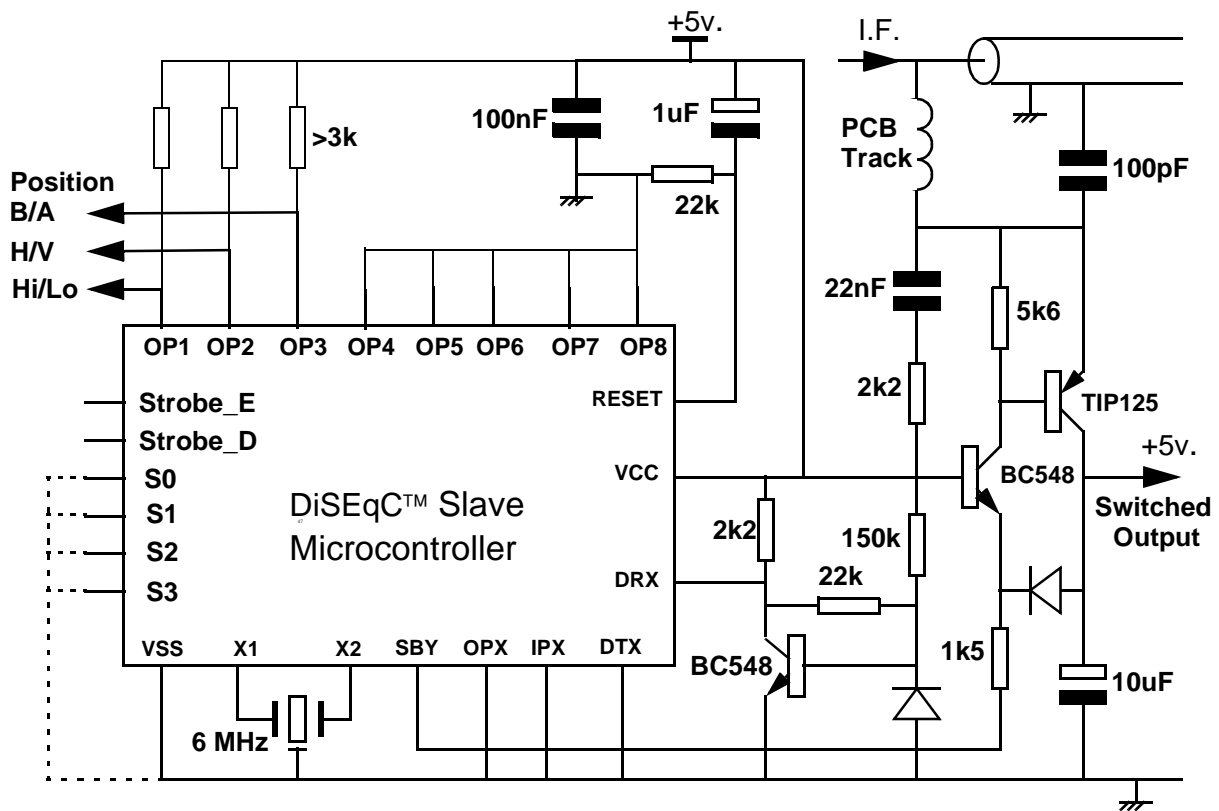
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Figure 6

For clarity, in *Figure 6* the additional components to regulate and control an auxiliary power rail (derived from the bus) have been added to the basic LNB circuit of *Figure 3*. In practice, the standby feature is more likely to be applied to full-featured DiSEqC™ devices

When the SBY pin is low ("Not Standby"), it pulls current (maximum about 3 mA) through the BC548 transistor from the base of the power transistor. If a high current switched supply is required (say > 100 mA) then a high gain (Darlington) transistor such as the TIP125 or a FET is required. The power transistor pulls up the output voltage until it is approximately equal to the Slave's supply rail (which only needs a small low-power regulator), where the voltage stabilises by "stealing" some of the base current. Unlike an integrated 3-terminal regulator this configuration need not add any significant capacitance to the bus.

7.   The "Loop-through" LNB

The loop-through LNB is a combined LNB and Switcher in a single module which is intended as a simple upgrade for existing systems, to add reception from another satellite (orbital location). If the new satellite location is reasonably close to the original one, it may be necessary only to fix the Loop-through LNB on a short outrigger arm next to the existing LNB. However, in general some re-alignment of the dish to optimise both signals will be beneficial. The existing downlead coaxial cable is moved over to the output connector of the new Loop-through LNB and a short cable connected between the output of the original LNB and the input connector of the new LNB.

In operation, the additional satellite is received by the new LNB normally, but when the original satellite is to be received, then the new LNB links together its input and output connectors so that the signal from the original LNB loops into the same downlead. Similarly, control signals (22 kHz tone and 13/17 volt switching) from the Tuner-Receiver/IRD pass up the cable and loop-through to control the original LNB.

The new LNB can be controlled by DiSEqC™ commands for Satellite Position B/A (the loop-through switch), H/V polarisation and Hi/Lo frequency (and also employ any other desired DiSEqC™ enhancements). It is possible to inter-mix these signalling schemes on the condition that short timing gaps are included between the continuous tone and DiSEqC™ commands.

To reduce power-loading on the bus, and avoid possible crosstalk between the Local Oscillators in the LNBs, the power supply (i.e. the d.c. connection) and the I.F. signal selection are switched in unison. When the "internal" LNB section is enabled, then no power is fed to the loop-through input. Conversely, when the loop-through input is selected then the internal LNB is not powered (but the DiSEqC™ slave microcontroller is). Thus the power control is achieved without the use of the "Standby" bus command and the 'SBY' control pin (described in *section 6.*), although these may be used optionally to save further power consumption by removing the supply voltage from both the LNB circuits when commanded.

If the Loop-through LNB has a Reply facility, a diode should be installed between Strobe_E and the data-selection pin S2, to inform a two-way DiSEqC™ Master that there is part of the system "hidden" from the bus by the LNB.

8.   "Standard Configurations"

The DiSEqC™ Slave microcontroller needs to gather a number of parameters concerning its "environment" (e.g. Local Oscillator frequencies, "family" type, pin functions, etc.). This is achieved by scanning a two-dimensional diode array connected between "Strobe" and "Selection" ports. However, there are some high volume applications where the cost of the diodes may be a significant factor, so an alternative arrangement is available. As well as scanning the Selection pins (S0 - S3) whilst lowering each of the Strobe pins in turn to logic '0', it also tests whether any of these pins are permanently held low. If one or more is held at logic '0' it uses the equivalent binary value as a pointer to a "Standard Configuration" setup.

This 4-bit "hard-wired" port arrangement can provide only 15 permutations compared with the many thousands definable by the diode array, so the programmed configurations must be carefully chosen. A full list of standard configurations also would consume a significant amount of program memory (ROM) space in the slave microcontroller. Therefore, only one basic Standard Configuration is defined in the version 1.0 Slave software. However, this configuration is defined by hard-wiring just one pin (S1) to earth, so that the 3 other pins are still able to be set either 'high' or 'low' to define the same functions as would normally be set by diodes from the Strobe_E pulse. Thus an extended list for the DiSEqC™ slave microcontroller version 1.0 is available, as shown in *Table 2*. It should be noted that it may not be possible to retain the extensions shown in italics in future versions of the controller.

Pin S3 linked to VSS	Pin S2 linked to VSS	Pin S1 linked to VSS	Pin S0 linked to VSS	Local Oscillator Frequencies (Lo) + (Hi) GHz	Address (family)	Swap tone function	Loop-through	Comple-mentary Outputs
		✓		9.75 + 10.6	11h	No	No	No
		✓	✓	9.75 + 10.6	11h	No	No	Yes
	✓	✓		9.75 + 10.6	12h	No	Yes	No
	✓	✓	✓	9.75 + 10.6	12h	No	Yes	Yes
✓		✓		9.75 + 10.6	11h	Yes	No	No
✓		✓	✓	9.75 + 10.6	11h	Yes	No	Yes
✓	✓	✓		9.75 + 10.6	12h	Yes	Yes	No
✓	✓	✓	✓	9.75 + 10.6	11h	No	No	No

Table 2: Standard Configurations