ARCAM

DELTA BLACK BOX 1 & 2
D/A CONVERTOR
SERVICE MANUAL

ARCAM DELTA BLACK BOX 1 & 2 SERVICE MANUAL

Issue 2 18.10.91 Serial No 001-

Arcam Drawing Number H04/0013

CONTENTS

System description

The Black Box has been designed to connect to any compact disc player having a digital output conforming to the Philips-Sony standard. The high quality audio outputs are suitable to drive any integrated amplifier or pre-amplifier with a CD or line level input. The plug in input board extracts a clean data signal and clock waveform from the incoming serial data stream. The Black Box 2 input board provides for optical input coupling and the 48 kHz sampling rate used by DAT machines. The data and clock signals are processed by the Arcam "Black Chip" custom integrated circuit (IC304). A phase-locked loop is used to provide a precise clock output. IC304 converts the incoming data into a serial digital audio signal conforming to the Philips I^2S format. The I^2S digital audio data controls the four-times-oversampling digital filter (IC305) which in turn sends oversampled data to the 16-bit dual DAC (IC306). The analogue outputs of this drive current input amplifiers having automatically switched de-emphasis networks, followed by a further low pass filter and driver stage.

Circuit description

Input board (Black Box 1)

L301 and its associated components provide impedance matching and decoupling for the incoming signal. IC301 amplifies the data to TTL level and provides an output to the main board. The data signal and its inverse control the edge-triggered resonator based around L302, Q301 and Q302. When tuned into the data signal the output of L302 gives a strong 5.6448 MHz output that is amplified by IC302 and passed into the main board. This is labelled as the incoming clock. The digital input data stream is bi-phase mark encoded. On models with serial no's 321 onward a switch is provided to invert this data stream and so enable the unit to be used with CD players having an inverted digital output.

Input Board (Black Box 2)

IC1 (TORX172) and IC2 (NE529) receive the optical and coaxial data respectively and convert it to TTL level. The interface always defaults to the optical input if signals are present on both inputs. Q1 etc. detect the presence of optical data and switch CMOS transmission gates IC4 from coaxial to optical data accordingly. DATA & DATA are buffered by IC3a & IC3f and are passed to the main board via SW1. They also trigger the two edge-detecting networks based around Q2/3/L3 and Q4/5/L4. L3 is tuned to resonate at 6.144 MHz to correspond with DAT data rates and L4 to 5.6448 MHz for CD data. Q6 and Q7 detect the levels of these clock signals which are then compared by IC6 (LM311). The output of IC6 directs the relevant clock signal via CMOS transmission gates to IC7 where it is squared-up to TTL levels.

Phase-locked loop

The incoming clock is phase-locked to a Voltage Controlled Oscillator (VCO) IC303. R301, R302 and C301 set the frequency range of the VCO. Doubling of the clock to the 11.2896 MHz required to drive the overall system is achieved by dividing the VCO output by two before passing it onto the phase detector.
The output of the phase detector (IC304 pin 4) shows how far the incoming clock and VCO are out of synchronisation. This is low pass filtered by R303, C302 and R304 to provvide the VCO control voltage. When the input is disconnected the output of the filter is nearly 0V. A buffered version of this is used to mute the data via Q304 and Q305 whenever this is so.

Custom chip/Digital filter/DAC

The Arcam custom integrated circuit IC304 demodulates and decodes the bi-phase data into the I^2S format required to drive the digital filter. The incoming data stream contains pre-amble and sub-code information from which can be extracted:-

i) the word select signal, WSAB, ie. left/right channel switching
ii) error flag indication, EFAB, high level to indicate unreliable data
iii) de-emphasis signal, DEEM, low level whenever the disc being played has been pre-emphasised (very rare).

The absolute phase inversion function is provided at pin 10 of IC304, R307 and C316 de-glitch the de-emphasis signal. IC304 also contains the phase detector and clock dividing circuits and provides the master clock output to IC305. The I^2S format audio data consists of a three signal bus: DAAB, CLAB, WSAB. DAAB is the audio data in two's complement binary format. CLAB is the clock associated with DAAB. WSAB defines whether the data present on DAAB contains left or right channel audio information. The digital filter IC305, commonly referred to as the "B-chip" performs the digital filtering and four-times oversampling. This means that the I^2S output from the B-chip to the DAC, DABD, CLBD, WSBD are at four times the frequency as those from the custom chip to the B-chip. The DAC requires 3 supplies to operate correctly, +5V, -6V, -15V. Also a series of averaging capacitors for the bit-switches in each channel of the DAC are necessary for good linearity and low distortion. Left and Right audio samples on DABD are separated by use of WSBD and are decoded to become an output current to the audio stages, proportional to the value of the audio samples.
Note that this current output means that it is not possible to directly monitor this output point with an oscilloscope. The first audio stage must be used to convert this current to a measureable voltage.

Audio stages

The audio output filter/amplifier is in two stages. The first stage consisting of Q1-Q7 forms a long-tail pair with Q5 as the output amplifying stage. Q3/4 and Q6/7 are two current sources. The feedback network from the collector of Q5 back to the base of Q1 determines the amplifier gain. R10 sets the gain in the audio band while C4 progressively reduces it above 20kHz, this being the first stage of filtering. A network consisting of R13,

C5, C6 can be switched in to provide a de-emphasis rolloff in the audio band for discs with pre-emphasis. FET Q12 is used as a switch for the de-emphasis circuit. The second stage is a two transistor pair, Q8/9 with current source Q10/11. Audio band gain is set by R19/20. Outside the audio band the stage acts as a 2 pole filter set by R15/16 and C7/8. This filter, combined with the first stage roll off forms a 3 pole Bessel characteristic linear phase filter, - 3dB point set at 42 kHz. IC1 with C10 and C11 forms an integrator with high d.c. gain and acts as a D.C. servo so that the D.C. offset on the output stage is very low. For this reason IC1 is an LF411 op-amp with very good offset specification. The audio output is shorted by relay, RLA1, until the audio stages have stabilised on switch on. This delay period is set by a time delay in the mute circuit. A second audio output, attenuated by R30 and R31, is set to normal line level. This is suitable for connection to an amplifier's tuner or auxiliary input, and is especially useful for amplifiers not equipped with a CD input.

Power supplies

The Black Box is equipped with two power transformers, driving in total seven stabilised supply rails. The analogue transformer (T201) has a 16.5-0-16.5V secondary and the digital (T301) a 9-0-9V secondary. Both are rated at 12VA. The analogue supply is rectified by D201-4 and smoothed by the RC networks formed by C201/R213/C202 and C221/R214/C222. These give unregulated outputs of +20V and -20V. The +11V and -11V rails required by the audio stages are regulated by Q201-4 and Q205-8 respectively. D205 and D206 provide the necessary reference voltages. IC311 provides the -15V supply for the DAC (IC306). The digital supply is rectified by D301-4 and smoothed by C341 and C342, providing unregulated outputs of +12V and -12V. IC308 regulates the main 5V supply for the non-noise sensitive components ie. the input board, front panel display, B-chip (IC305) and custom ASIC I.C. (IC304). The supplies to IC304 and IC305 are however filtered by inductors L303 & L304. IC309 and IC310 are also 5V regulators and supply sensitive parts of the circuit ie. the VCO (IC303) and the DAC (IC306) respectively. The single negative regulator (IC307) provides -6.2V for the input board and DAC.

Servicing operations

Disassembly for servicing

The lid is removed by undoing the two screws at the top of the rear panel, and then lifting away. The input board can be removed for upgrading by undoing the two screws holding it down to the chassis and unplugging from the main PCB. All testing of the unit can be performed without removing any of the PCBs or power transformers. However should it be necessary to change a component in the main PCB proceed as follows:

SWITCH OFF THE UNIT AND DISCONNECT FROM THE MAINS

i. Remove the input board by removing the two screws holding it down to the chassis and unplugging it from the main pcb.

ii. Disconnect the three trailing leads from their sockets in the PCB.

iii. Undo the screws in the rear panel that attach to the four-way phono socket (1 screw) and the heatshunt (2 screws).

iv. The six snap-in PCB spacers can be released by pressing the end of an empty BIC biro over the top of the spacer and lifting the PCB over the locking tabs.

v. Reassembly is a straight reversal of the above procedure. Ensure that the trailing leads go into their correct sockets.

The mains transformers are held by two nuts and washers each. Removal will also require desoldering of the wires to primary/secondary windings.

In the unlikely event of a fault in the switch/LED assembly undo the three screws holding it to the front panel and pull off the switch buttons, then ease the whole assembly out. On re-assembly ensure that the insulator is secure and align the LEDs and switch buttons carefully in their slots whilst tightening the screws.

Input board alignment

For Black Box 1 follow steps 2, 3, 4 and read " co axial data lead" for "optical data lead.

Equipment required :

Frequency counter
CD/DAT compatible Black Box
DAT player (Not required for Black Box 1 set up)
CD player with optical output & lead
Oscilloscope (50 MHz with *10 probe)

1. Plug the optical interface board into the Black Box and switch on.

2. Plug in the optical data lead from the CD player. Check that data is present at the output (TP6).

3. Align the CD coil for maximum signal on TP1. (N.B. Use the 'scope with *10 probe). Now fine-tune the coil as follows: Monitor the Word Select signal (TP9 on the main PCB) and adjust the coil clockwise so that this signal is moved further towards it's stable region. N.B. Do not turn the coil more than 60 degrees away from the peak.

4. Insert the DAT coaxial data lead into the coaxial input. Measure the clock frequency (TP5) ; 5.6448 MHz +/- 10 kHz.

5. Remove the optical connector. Align the DAT coil for maximum signal on TP2. Now fine-tune the coil as described in "3" above.

6. Measure the clock frequency (TP5) ; 6.144 MHz +/- 10 kHz.

7. Measure the WSAB (word select) output frequency from TP9 on the Black Box main board ; 48 kHz.

VCO alignment

1. Supply a standard CD digital audio signal to the input of the Black Box.

2. Connect an oscilloscope to TP9 (WSAB) or alternatively play some music through the system.

3. Turn the preset resistor R302 fully counter-clockwise. Then slowly turn it clockwise until a steady square wave of 44.1 kHz is present on the 'scope or until the music is undistorted.

4. If there is no effect even with R302 fully clockwise, repeat the exercise with the rear panel polarity switch in its other position.

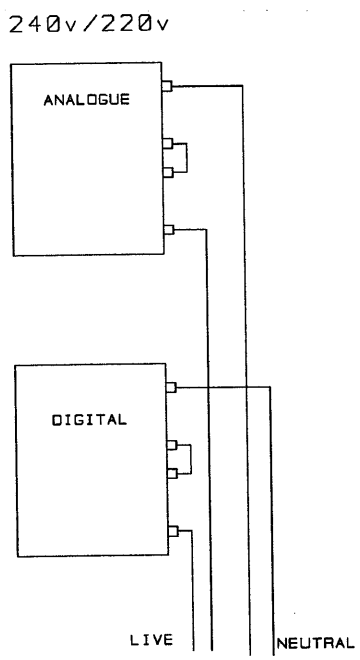
5. If there is still no jitter-free square wave or audio then replace the VCO chip, IC303. Should this not cure the problem then the unit will need more extensive diagnosis.

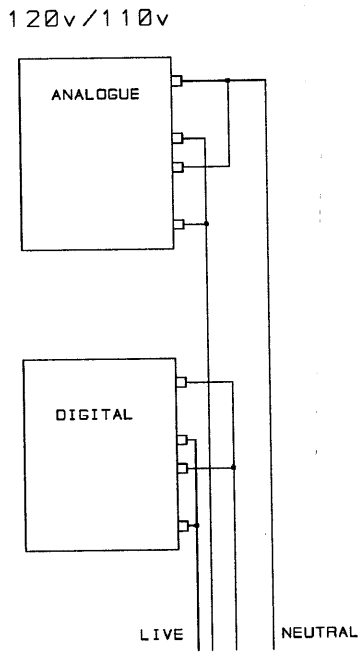
6. Assuming that the signal at TP9 is now correct, measure the voltage at pin 10 of the VCO - IC303. Adjust R302 until this voltage is 2.5 V +/- 0.2 V.

Change of mains voltage

The mains wiring of a 240/220V Black Box may be converted to 120/110V operation and vice versa. For operation at 100V however only transformers supplied with 100V primaries are suitable.
To proceed, turn off the unit and disconnect the mains inlet. Remove the adhesive labels covering the transformer terminals. Follow the appropriate wiring diagram shown below, using brown 16/0.2 wire (or similar) as required.

Ensure that all soldering is neat and that there are no dry joints. Replace the adhesive labels over their respective transformers.





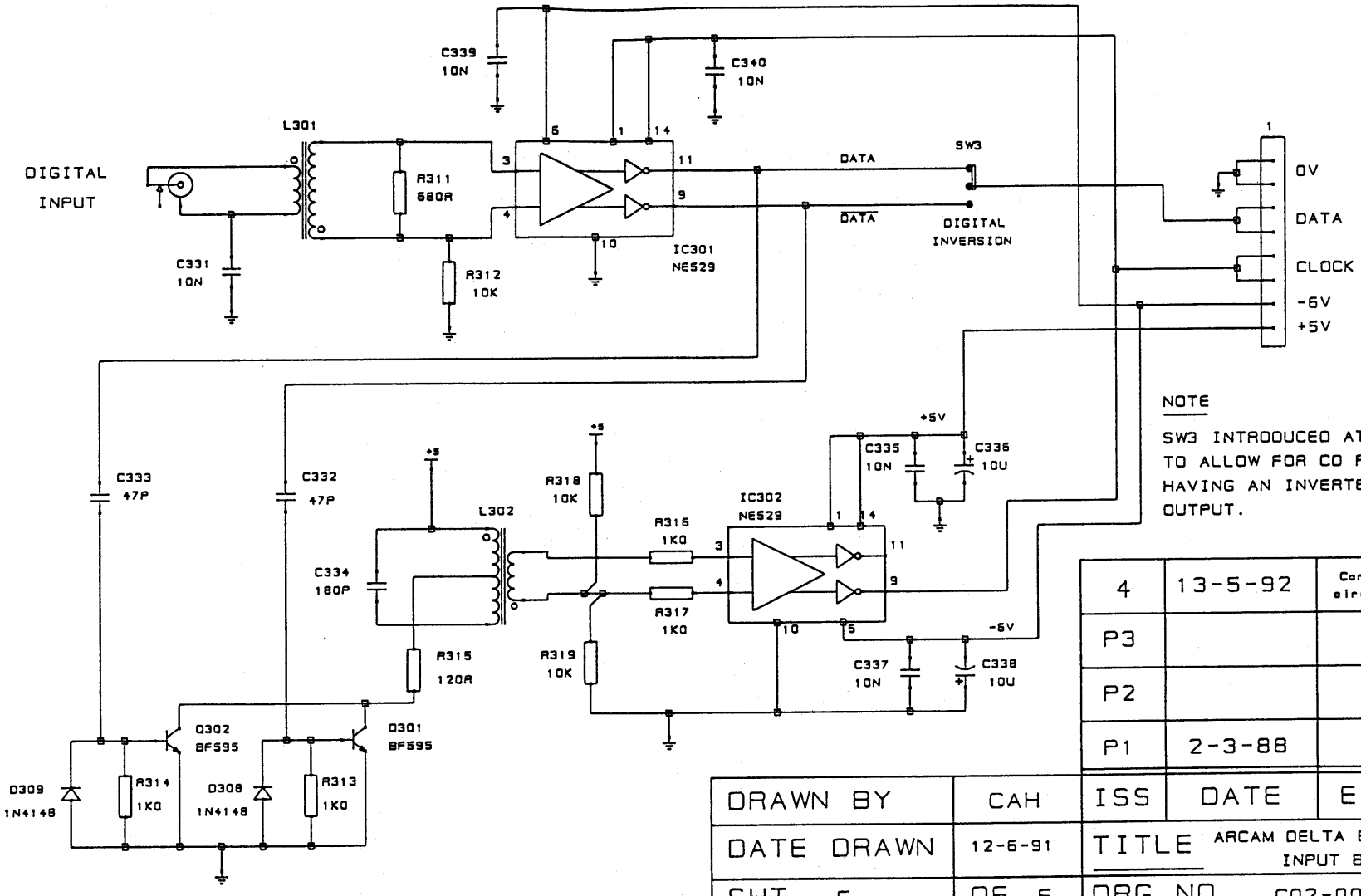
TEST POINTS

TEST POINT	FUNCTION	SIGNAL/VOLTAGE
1	Incoming Data	-
2	Incoming Clock	5.64MHz sq wave
3	VCO output	11.28MHz
4	Low pass filter output	-
5	Phase detector output	-
6	5.6MHz	5.6MHz sq wave
7	INV	-
8	DEEM	+5V OFF
9	WSAB	44.1KHz sq wave
10	CLAB	-
11	DAAB	-
12	EFAB	Error Flag
13	WSBD	176.4KHz sq wave
14	CLBD	5.64MHz sq wave
15	DABD	Oversampled data
16	Audio Current IN LHC	-
17	Audio Current IN RHC	-
18	Servo LHC	1.2V
19	Servo RHC	1.2V
20	1st audio stage LHC	1.0V
21	1st audio stage RHC	1.0V
22	Audio output L CD level	0V
23	Audio output R CD level	0V
24	Audio output L line level	0V
25	Audio output R line level	0V
26	Mute relay coil voltage	+12V on
27	Audio 0V	0V

TEST POINT	FUNCTION	SIGNAL/VOLTAGE
28	Main 0V	0V
29	+12V unregulated	+12V
30	-12V unregulated	-12V
31	+20V unregulated	+20V
32	-20V unregulated	-20V
33	+5V B chip,ASIC supply regulated	+5V
34	+5V VCO supply regulated	+5V
35	+5V DAC supply regulated	+5V
36	-6V DAC supply regulated	-6V
37	-15V DAC supply regulated	-15V
38	+11V audio supply regulated	+11V
39	-11V audio supply regulated	-11V

CIRCUIT DIAGRAMS

No.	Title of Circuit
1	Black Box 1 & 2 Audio Stages
2	Black Box 1 & 2 Power Supplies
3	Black Box 1 Input Board s/n 321 onwards
4	Black Box 1 & 2 VCO, DAC & Digital Filter
5	Black Box 1 Input Board s/n 001 - 320
6	Black Box 2 Input Board



NOTE

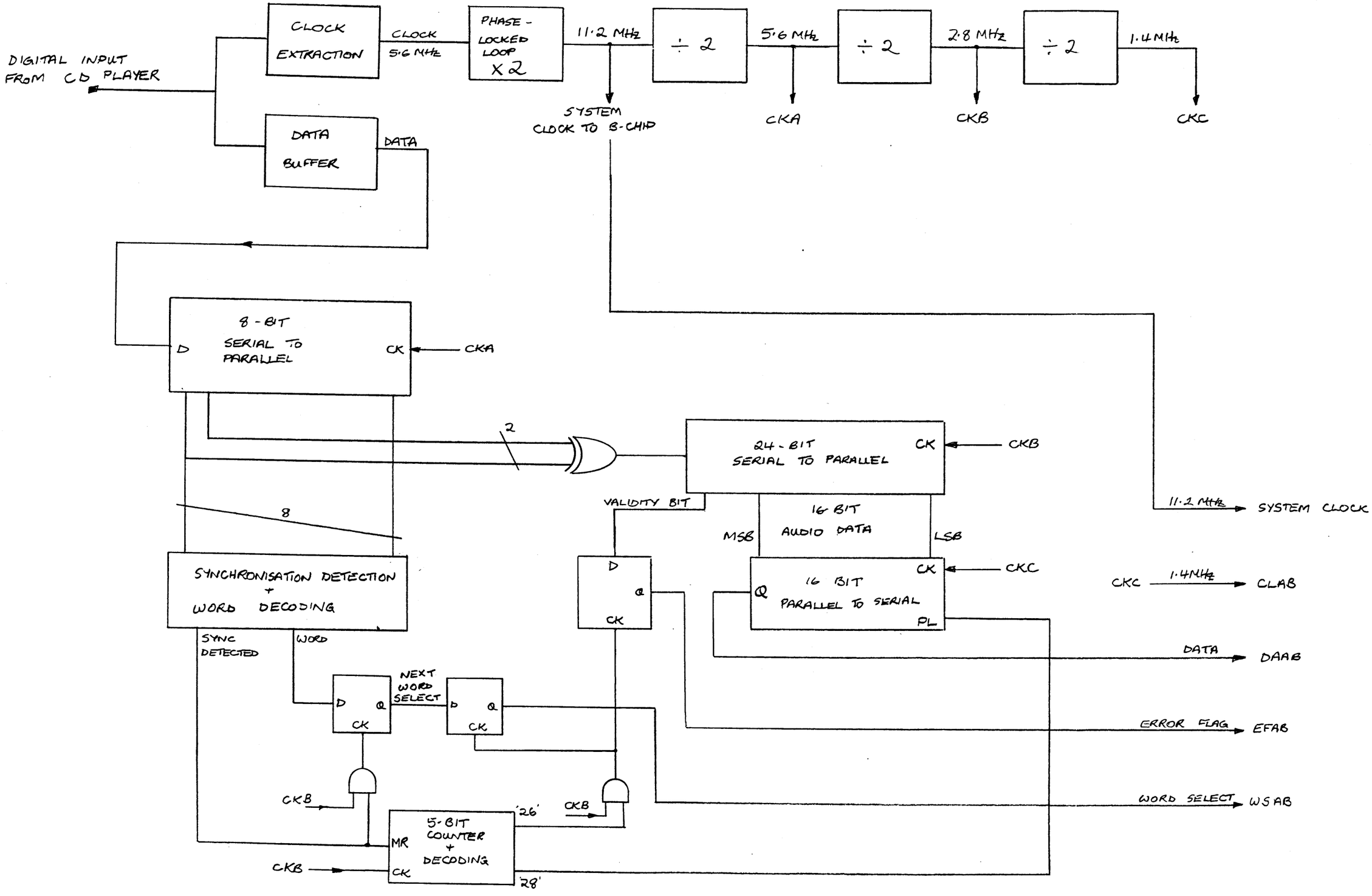
SW3 INTRODUCED AT ISSUE P2 TO ALLOW FOR CD PLAYERS HAVING AN INVERTED DIGITAL OUTPUT.

ISS	DATE	ECN NO.
4	13-5-92	Correction to circuit at L302
P3		
P2		
P1	2-3-88	

DRAWN BY	CAH	TITLE	ARCAM DELTA BLACK BOX INPUT BOARD
DATE DRAWN	12-6-91	DRG NO.	C02-0021
SHT. 5	OF. 5		

ARCAM. A & R CAMBRIDGE LTD, CB5 9PB

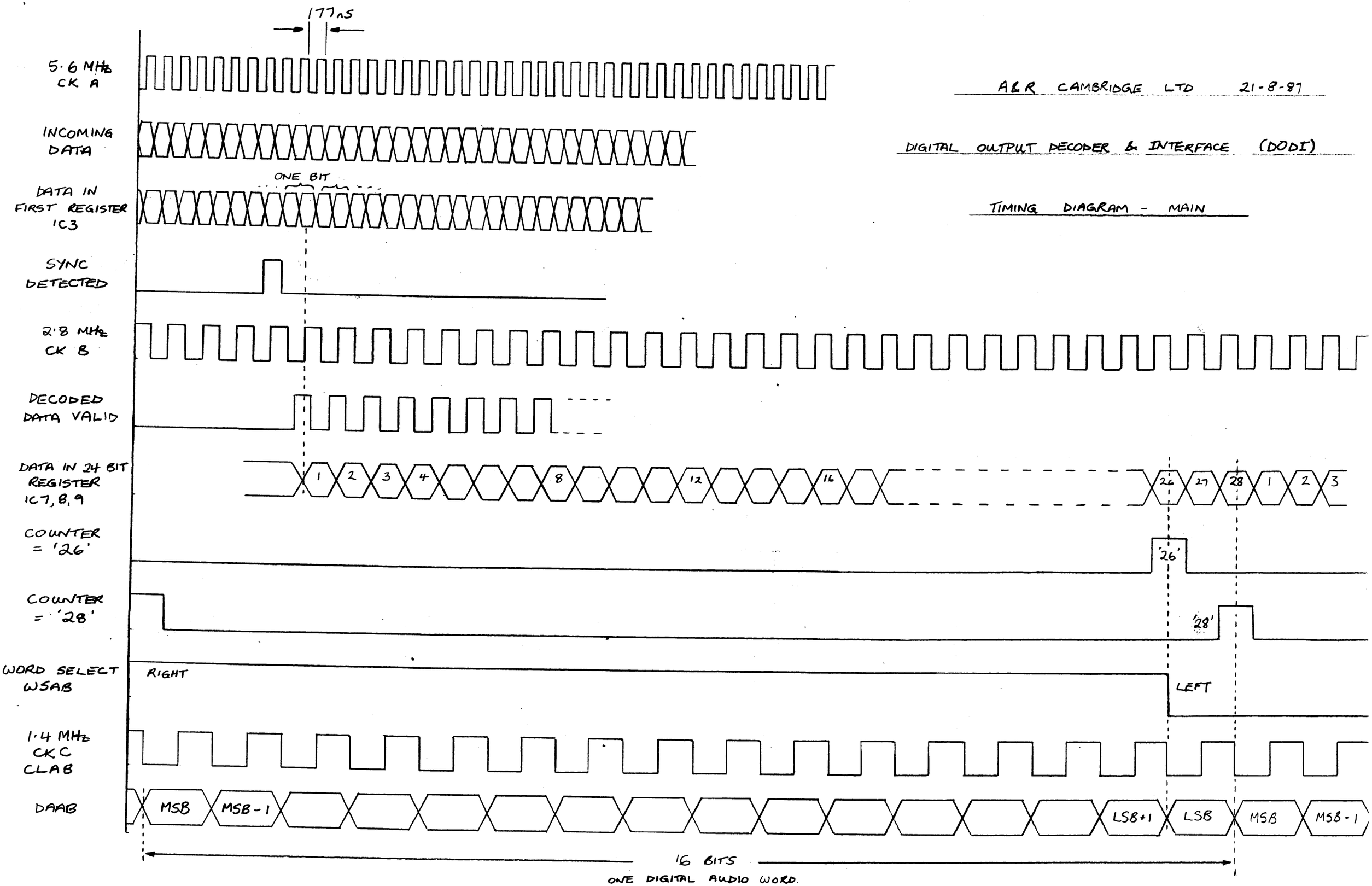
A&R CAMBRIDGE LTD. DIGITAL OUTPUT DECODER & INTERFACE (DODI) BLOCK DIAGRAM 4-8-87



A & R CAMBRIDGE LTD 21-8-87

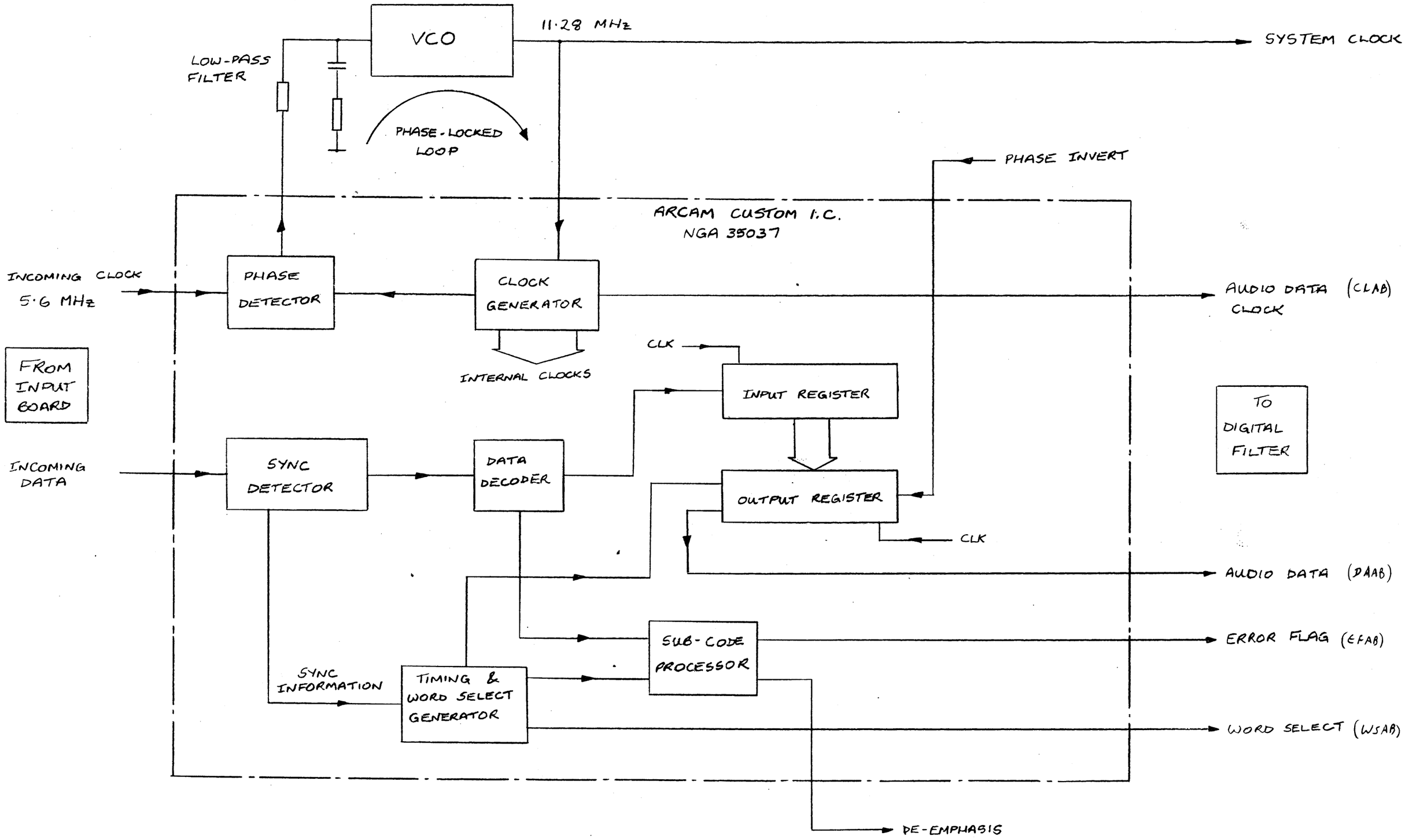
DIGITAL OUTPUT DECODER & INTERFACE (DODI)

TIMING DIAGRAM - MAIN



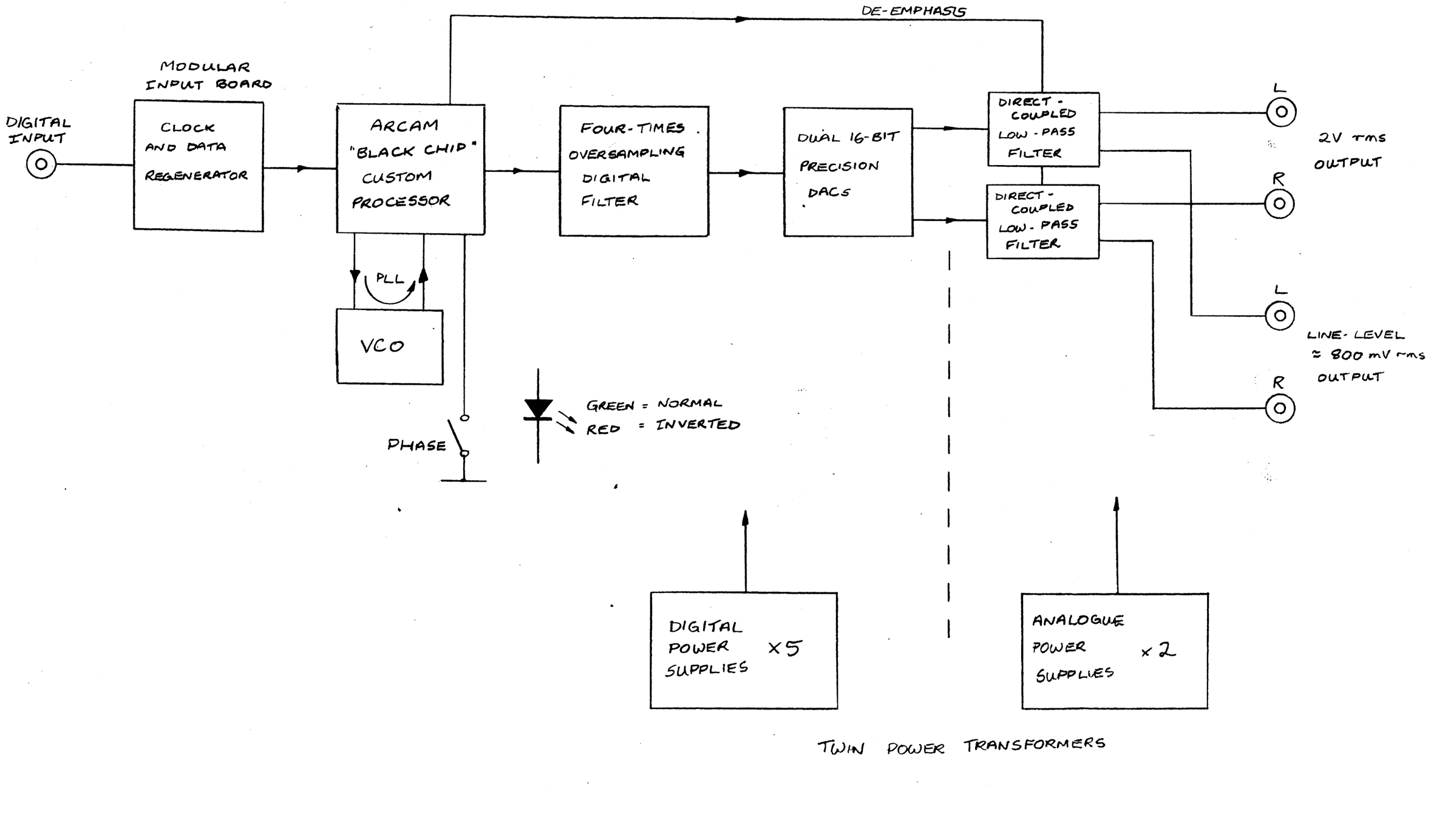
ARCAM DELTA "BLACK CHIP" FUNCTIONAL BLOCK DIAGRAM

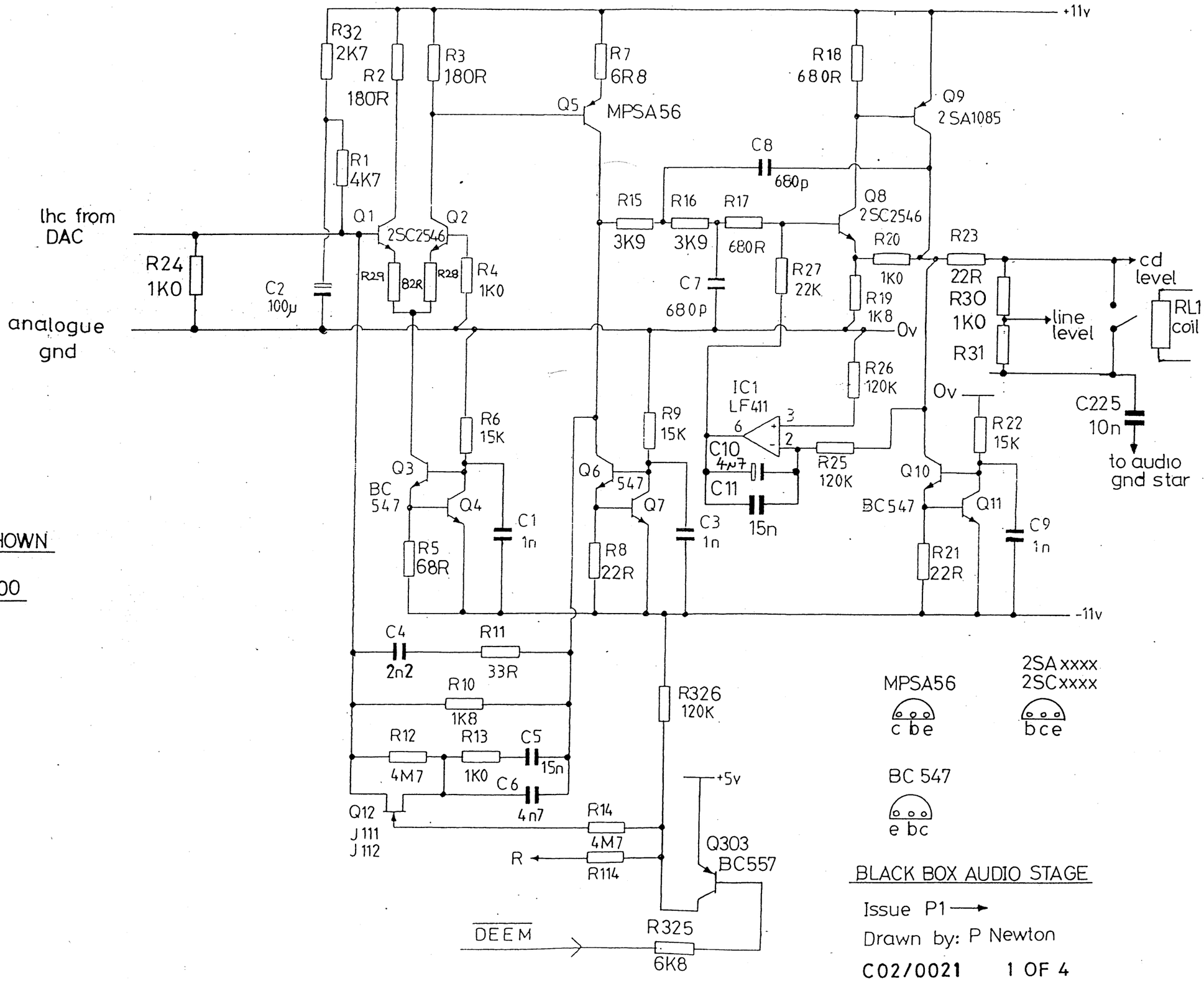
8-3-88 CAH



ARCAM DELTA "BLACK BOX" DIGITAL AUDIO INTERFACE - BLOCK DIAGRAM

8-3-88 CAH





LHC ONLY SHOWN

RHC ADD 100

R101

C101 etc

BLACK BOX AUDIO STAGE

Issue P1 →

Drawn by: P Newton

C02/0021 1 OF 4

L
N
SW1
FS1
T201
120
0
120
D201-204
4×BYD33G
R213
6R8
+20v
C203
1n
R201
68R
Q201
BC559
Q202
BC559
Q204
AARN/2SC2168
+11v
R312
180R
+5v
D306
PWR
To T301
SW2b
R310
220R
R327
470R
GREEN
D307
RED
0v
+5v basic
C224
100µ
0v
C223
220n
D208
1N4148
D209
R210
22K
D207
D211
BYD33G
R209
120K
Q209
BC557
D210
1N4148
C226
10µ
RL1
R211
-15v
C201
1000µ
C202
1000µ
R202
15K
Q203
BC549
C204
470p
D205
10v
C205
4µ7
R203
180R
R204
180R
C209
10µ
C211
4n7
C213
4n7
C215
10µ
C217
10µ
C219
1n0
C220
1n0
audio
0v
earth
star
R212
120R
CHASSIS
EARTH
MAINS
EARTH
R208
180R
Q207
BC559
R207
180R
R206
15K
C207
470p
D206
10v
C208
4µ7
C210
10µ
C212
4n7
C214
4n7
C216
10µ
C218
10µ
-11v
Q208
AARP/2SA958
Q206
BC549
C206
1n
Q205
BC549
R205
68R
C346
10µ
-15v
7915
IC 311
C221
1000µ
C222
1000µ
R214
6R8
T301
120
0
120
D303
D301
D304
D302
4×BYD33G
0v
C343
10µ
R309
470R
C342
1000µ
C344
10µ
IC307
LM
337
R308
120R
D305 1N4003
C341
6800µ
IC308
7805
+5v
C345 10µ
asic
Bchip
R320
6R8
TO INPUT
BOARD
front panel
IC309
7805
+5v VCO
IC310
7805
+5v DAC
0v
-6v

RL1 CLR	R211
ORANGE	68R
WHITE	68R
BLUE	180R

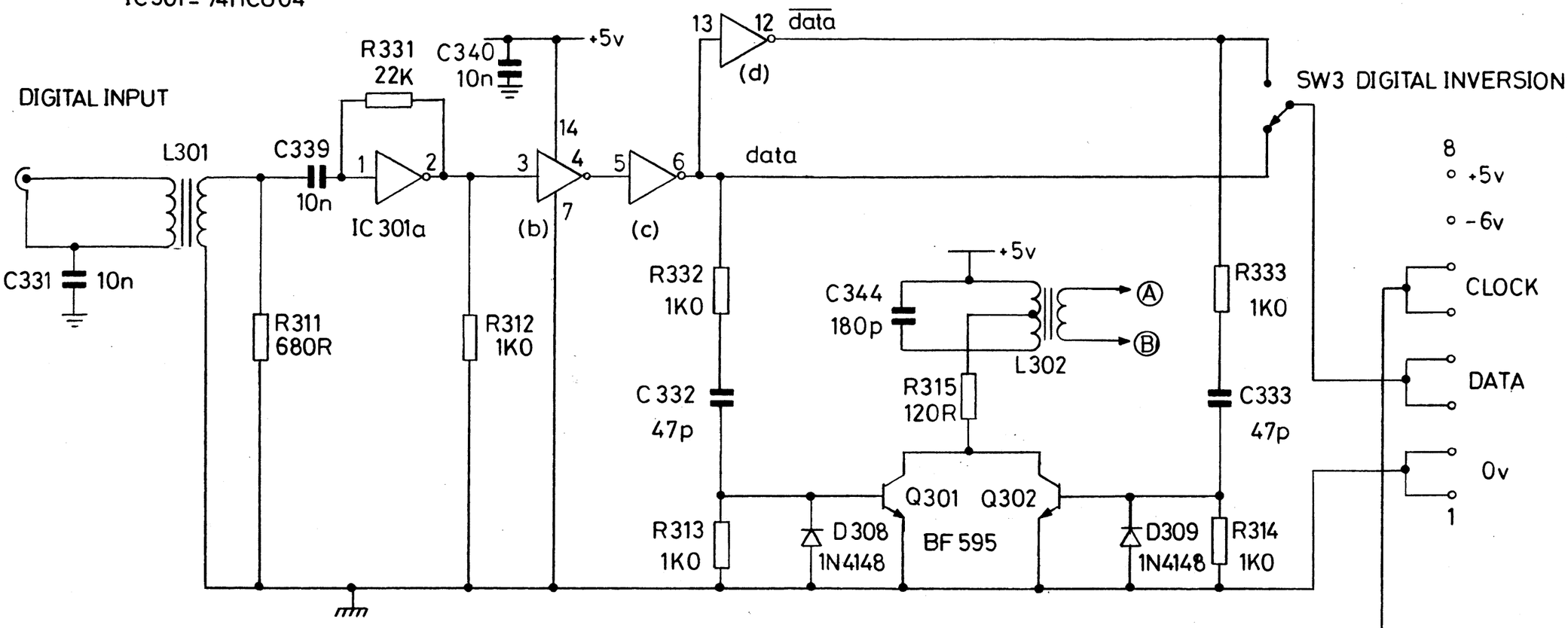
BLACK BOX POWER SUPPLIES

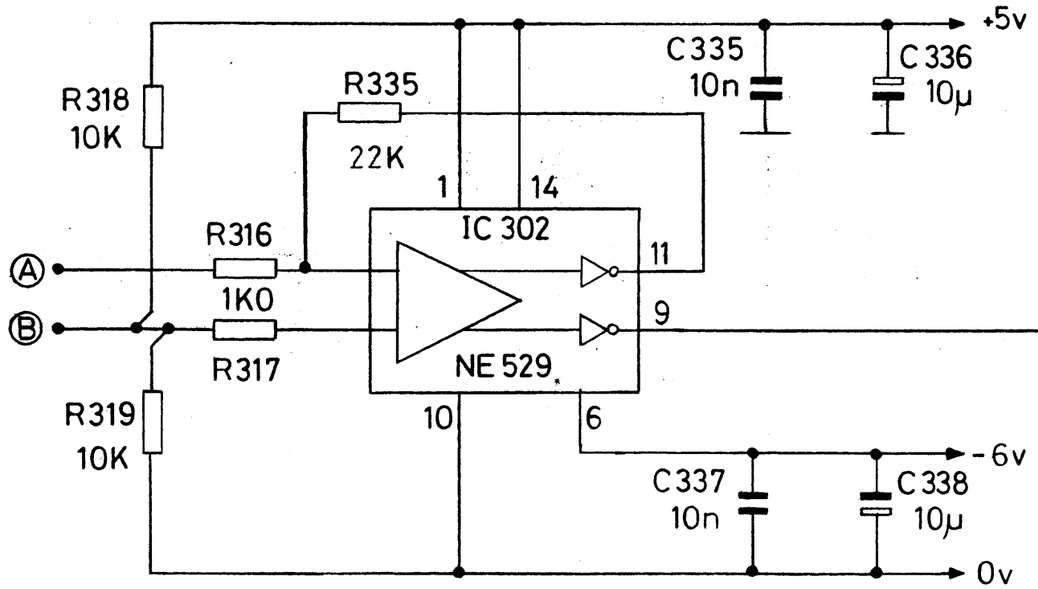
Issue P1 →

Drawn by P. Newton

C02/0022 2 OF 4

IC 301 = 74HCU04





ARCAM DELTA BLACK BOX

INPUT BOARD

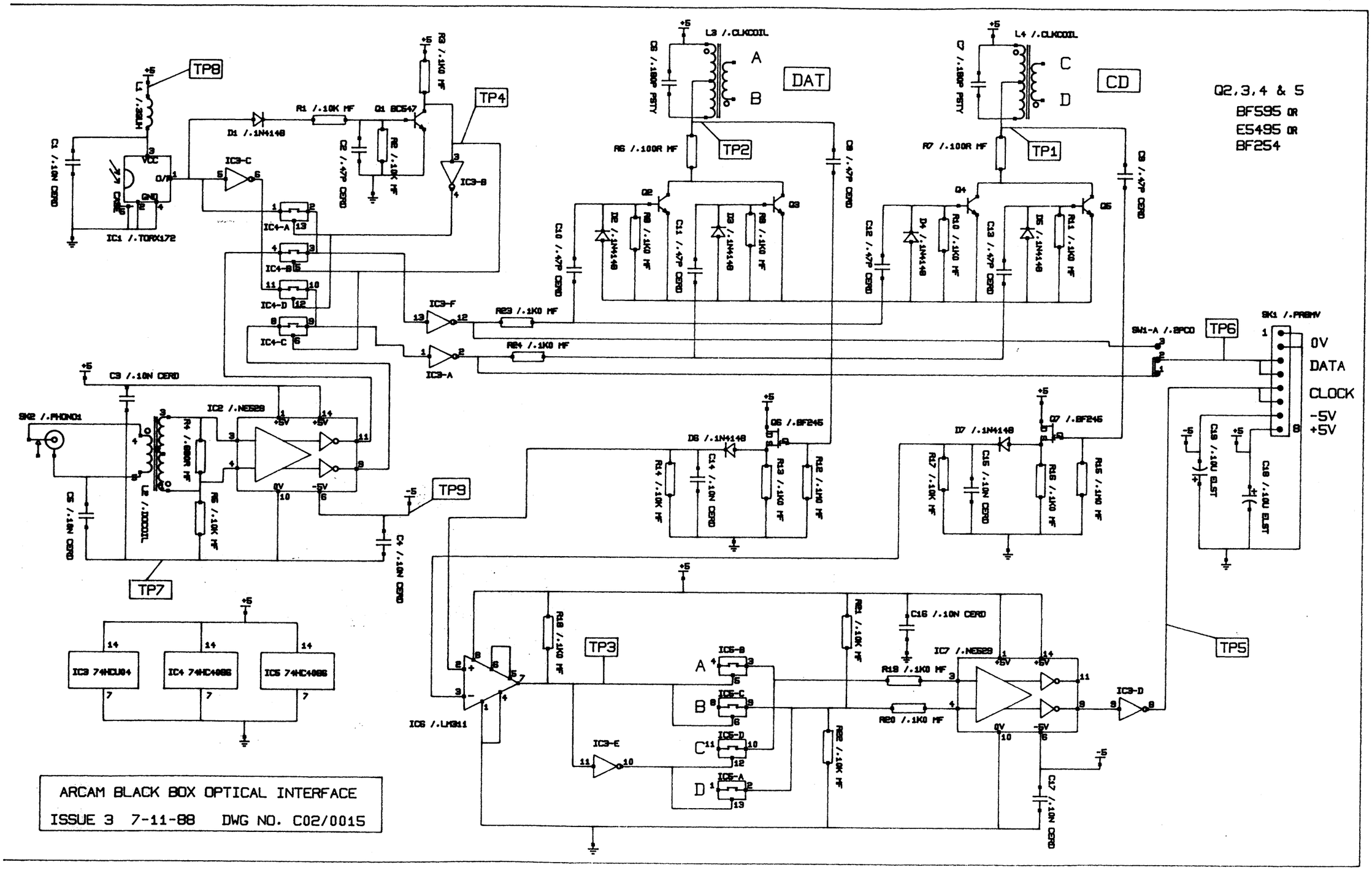
Issue P5 S/N 321 →

Date Oct 88

Drawn by P Newton

C02/0022 3 OF 4

+5v (VCO)
C303 10n
C304 10µ
IC 303 VCO
74HCT4046
V_{DD}
VCO out
V_{SS}
C_1
R_1
R_2
C301 100pF
R301 6K8
R302 10K
R334 4M7
C302 4n7F
R304 22K
R303 120K
D311 1N4148
from input board
IC 304 CUSTOM CHIP
data
clock
VCO in
PC2 out
5·6MHz out
CLK 5P6
PPEN
INV
deem Dout
Din
V_{DD}
WSAB
CLAB
DAAB
EFAB
SCAB
+5v basic
sw2a
R305 120K
R306 120K
0v
R307 120K
C316 4µ7
L303 33µH
L304 33µH
C306 100µ
C305 10n
+5v (basic)
IC 305 DIGITAL FILTER
WSAB
CLAB
DAAB
EFAB
Xin
V_{SS}
V_{DD}
WSBD
CLBD
DABD
DAC
C308 100µ
C307 10n
+5v
R330 4K7
R328 4K7
D310 1N4148
Q304 Q305 BC 547
R329 120K
toR325
A'LOG 0v
C324 2×0·47uF
C330 5×220nF
C315 680pF
msb
lsb
IC 306 DAC TDA 1541
VDD
VDD1
VDD 2
BCK
SCK
WORD SELECT
DABD
CLBD
WSBD
R322
R323
R324
390R
L305 33µH
-6v
C312 100µF
C311 10nF
C317 0·47uF
C323 220nF
C310 22nF
C309 100µF
DIG' 0v
R OUT
L OUT
L306 33µH
-15v
C314 100nF
C313 4n7F
TO EARTH STAR
A'LOG GND
DELTA BLACK BOX
C02/0022 4 OF 4


TP8
TP4
TP2
TP1
TP6
TP9
TP7
TP3
TP5
DAT
CD
L3 /.CLKCOIL
L4 /.CLKCOIL
A
B
C
D
Q2,3,4 & 5
BF595 OR
E5495 OR
BF254
IC1 /.TORX172
IC2 /.NE529
IC3 74HCU04
IC4 74HC4066
IC5 74HC4066
IC6 /.LM311
IC7 /.NE529
IC3-A
IC3-B
IC3-C
IC3-D
IC3-E
IC3-F
IC4-A
IC4-B
IC4-C
IC4-D
IC5-A
IC5-B
IC5-C
IC5-D
SW1-A /.2PCO
SW2 /.PHONO1
SK1 /.PRSHV
0V
DATA
CLOCK
-5V
+5V
ARCAM BLACK BOX OPTICAL INTERFACE
ISSUE 3 7-11-88 DWG NO. C02/0015